

**CFCs and the Effects of Recent
Legislation on Refrigeration
Industries**

CFCS AND THE EFFECTS OF RECENT LEGISLATION
ON REFRIGERATION INDUSTRIES

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on Refrigeration Industries**

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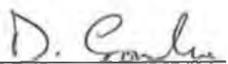
Date submitted: **January 1991.**

DECLARATION

I hereby declare that all the work reported in this thesis was carried out by me at Thermo King Europe in collaboration with Dublin City University during the period October 1989 to January 1991.

To the best of my knowledge, the results presented in this thesis originated from the present study, except where references have been made. No part of this thesis has been submitted for a degree at any other institution.

Signature of candidate


D. Crombie
Dermott Crombie

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ABSTRACT

CFCs and the Effects of Recent Legislation on Refrigeration Industries.

D. Crombie

The aim of this work is to study the background to our present and recent uses of CFCs and HCFCs. The work also aims to offer a strategy for the future, based on the most recent legislation, which is being introduced primarily to combat ozone depletion, but, increasingly, greenhouse warming is being seen as a problem which should be addressed now also.

The need for temperature control is discussed, in particular the recent legislation on foodstuffs in the United Kingdom.

The historical development of modern refrigeration has been presented, along with the current refrigerant families, with an analysis of how modern refrigerants were selected.

Legislation throughout Europe will have the most profound effect on Thermo King Europe, and at present is running ahead of legislation worldwide on CFCs, and in particular, is running ahead of the Montreal Protocol.

The other major change affecting our business from this legislation pertains to foams, primarily in legislation removing CFCs from the foam, and thus placing a different requirement on the refrigeration system to maintain temperature. Possible foam changes are discussed.

The study supports the continued use of HCFCs, in particular R22, whether in pure form, or as a blend, as a medium-term interim CFC replacement refrigerant, until such time as chlorine-free media are proven and freely available.

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Chapter I

Historical Development

Nomenclature for Chemical Formulae.

R12	CCl_2F_2
R22	CHClF_2
69S	CHClF_2 (85%) + C_3F_8 (9%) + C_3H_8 (6%)
R125	C_2HF_5
R134a	$\text{CH}_2\text{F}-\text{CF}_3$
R500	CCl_2F_2 (74%) + CH_3-CHF_2 (26%)
R502	CHClF_2 (49%) + $\text{CClF}_2-\text{CF}_3$ (51%)
CFC	ChloroFluoroCarbon
FRC	Class C transport certification, ie. certified to carry load at -20°C in ambient of 30°C .
GWP	Greenhouse Warming Potential
ODP	Ozone Depletion Potential
OEM	Original Equipment Manufacturer

Chapter 1: Historical development

1.1 The need to maintain temperature

Modern refrigeration is taken for granted. In the home, it is refined to the point that we have a number of different temperature zones in the domestic refrigerator, to cope with a wide variety of products which must be stored under well-defined conditions. These conditions ensure the long shelf life of many items we consume today, allowing us to enjoy fruit, vegetables, meat and dairy products, either outside their traditional seasons, or at great distance from their original source. While other methods of preserving foods have been tried, refrigeration is the most accepted method. Alternatives, such as irradiation, inert gas packaging, and dehydration, are either treated with suspicion, or affect the appearance and attractiveness of the product.

The shelf life of food is decided by many variables, but lowering the temperature to reduce or halt the growth-rate of bacteria is the most widely used and accepted approach.

The following graph shows how two of the most common bacteriological pathogens behave at different temperatures. The rise in their rate of growth is quite marked as the temperature rises.

We can chart out these values as follows:

Temperature	Salmonella
7'C	growing at 10% of its maximum rate
11'C	growing at 25% of its maximum rate
15'C	growing at 50% of its maximum rate

Listeria is even quicker to start growing with a rise in temperature, and it reaches its 10% rate at as low as 4'C.

Temperature	Listeria
4'C	growing at 10% of its maximum rate
10'C	growing at 25% of its maximum rate
15'C	growing at 50% of its maximum rate

Bacteria Growth Rates

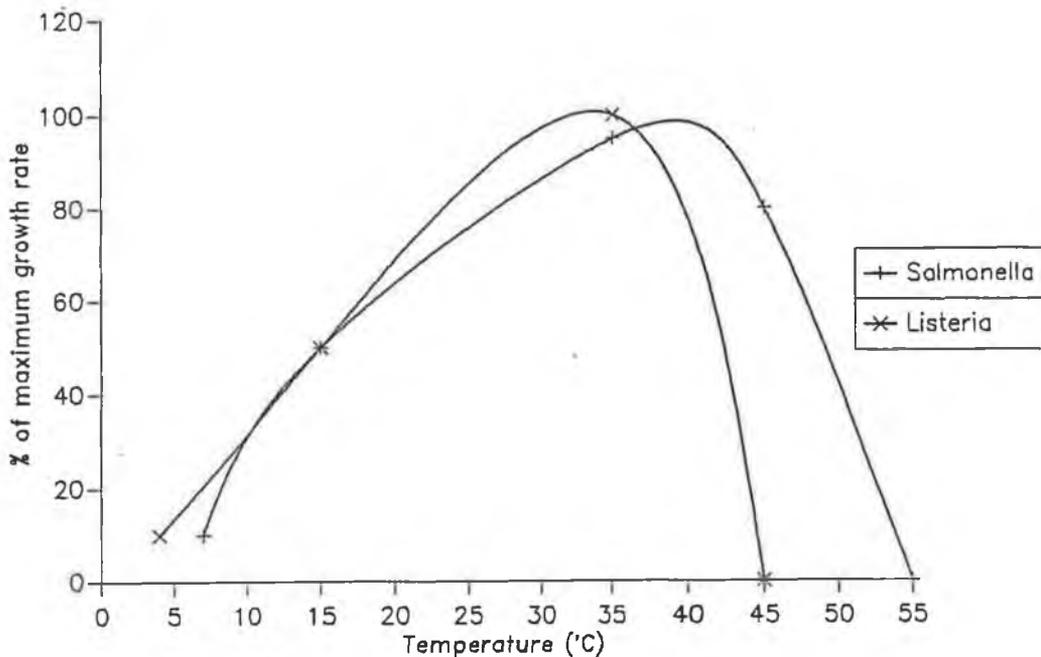


Fig 1.1 Bacteria growth rates versus temperature (°C)

1.1.1 Food Hygiene (Amendment) Regulations UK.

The Food Hygiene (Amendment) Regulations come into effect in the UK in April 1991. These are part of the Food Safety Act which comes into force in January 1991 in the UK. The effect of the Food Hygiene (Amendment) regulations is to introduce a legally enforceable system of temperature controls for chilled food throughout the food chain, to include producer, storage, distribution, and retail outlets.

Briefly, it will be phased in as follows:

April 1, 1991: foods such as soft cheeses, cooked meats, smoked and cured fish, salads, cream cakes, certain pies and pastries, must be kept at or below 8°C throughout the food chain.

April 1, 1993 foods most at risk from contamination with listeria, such as soft cheeses, pates and cooked meats, must be kept at or below 5°C.

April 1, 1991 small delivery vehicles (below 7.5 tonnes GVW) must comply with the 8°C requirement, but those making local deliveries will not have to meet the 5°C requirement above.

Delivery vehicles of more than 7.5 tonnes must comply with the temperatures specified for other parts of the cold chain.

In all cases, the maximum temperature tolerance is 2°C to allow for defrost, breakdown, food movement, or food processing.

Many other products depend on refrigeration to control chemical stability also. The storage of pharmaceutical drugs, of photographic film, of blood for transfusions in medicine, the cooling of computer cores, of tour buses, all use refrigeration to ensure proper storage or the operation of a particular process.

While mechanical means of refrigeration were devised early in the 19th century, the technology to put refrigeration into smaller packages, for use in transport refrigeration, bus airconditioning, domestic refrigeration and domestic air conditioning, are relatively recent innovations. As late as the 1940's, transport 'refrigeration' relied on ice being carried in the trailer to control the load temperature. This had a number of disadvantages: the temperature was not finely controlled, and relied on the change of phase of the ice to absorb the load heat. Further, the amount of ice carried was reducing the amount of load that could be carried. Most importantly, the ice had to be regularly topped up, at ice-factories en-route. If the lorry did not arrive inside the allocated time, there was the danger of load spoilage, as the life of the load was defined by the amount of ice remaining versus the heat gain experienced by the trailer walls.

1.2 Some early solutions to refrigeration

Mechanical refrigeration is based on the evaporation of the working

fluid to a vapour, thereby requiring considerable heat to cause a change of phase, consequently drawing heat from a subject. The vapour may be reused by compressing to a high pressure, then condensing this high pressure vapour thereby expelling the heat previously gained to a suitable heat sink.

Based on this concept, clearly what is required of a refrigerant is that it have a suitable boiling point, and can easily be returned to its liquid phase on compression.

Many fluids have been tried since the principles were established in the late 18th century. Prior to this, cooling was obtained, albeit on a limited scale, by evaporating the working fluid and not recovering it.

An American, Jacob Perkins, patented such a system in 1835. His working fluid was an industrial solvent of the day, and he had built a working model. He received British patent 6662 in 1835 for his design. Another American, Alexander Twining, patented a system in 1850, based on ether, ammonia or carbon dioxide. The primary function at the time was to produce ice by mechanical means. In 1855, Twining had operating a device producing 1 tonne of ice per day¹. (Indeed today, many refrigeration systems, and refrigerant expansion valves, are based on notional "tonnage" of ice.)

James Harrison, having studied the work of his contemporaries, received in 1856 a patent for a device using ether, alcohol or ammonia.

Ether as a working fluid had its disadvantages: to evaporate it needed to be below atmospheric pressure. This is undesirable, as a leak in such circumstances will draw air into the system and upset the cycle. Such systems are referred to as operating in a vacuum. Further, ether is flammable. Nonetheless, equipment continued to be manufactured up to the early 1900's.

Ammonia was widely used in the latter 19th century². Once the higher pressures (relative to ether) were accommodated, and the required dryness of the ammonia was achieved, ammonia became the standard industrial/commercial refrigerant. It was the main fluid used up to the mid-20th century, and is still in use today.

Other refrigerants that saw some actual use include carbon dioxide, sulphur dioxide, methyl chloride, ethyl chloride, propane, butane, and carbon tetrachloride³. A number of others may well have been tried, including petrol⁴!

By the end of the 19th century, domestic refrigerators were seen as the next step in the development of refrigeration. However, the fluids used, while they might be acceptable in industrial plants, with adequate maintenance, were not at all desirable in the home. Those that didn't require high pressures to condense had the disadvantages of acrid smell, toxicity, or were simply flammable. Deaths had occurred in industrial installations, due to inhalation of

methyl chloride⁵. Sulphur dioxide has an irritating acrid smell. Bad publicity, and local laws, discouraged attempts at putting these refrigerants into domestic electric refrigerators. It was well recognised that for any progress to be achieved in placing this technology in the average home, a new refrigerant was needed.

1.3 CFCs

In the 1920's, Dr Thomas Midgley started on the road to developing modern chlorofluorocarbons as refrigerants, in response to industrial needs. He had previously developed tetraethyl lead as an antiknock agent for petrol.

Midgley was attracted to finding a compound containing fluorine with suitable refrigerant properties. This was due to literature reporting the boiling point of carbon tetrafluoride (CF₄) as -128°C. He synthesised all 15 possible 1-carbon combinations of fluorine, hydrogen and chlorine.

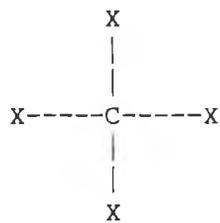
Midgely studied the refrigerants then in use, and noted they all contained relatively few elements. These elements were closely

related in the periodic table as follows:-

			H
C	N	O	F
		S	Cl
			Br
			I

The table is a section of the periodic table (see page 1.10). In these tables, elements are arranged so that vertical columns contain elements with equal numbers of electrons absent from their outer-most shells, therefore causing them to have similar properties. Thus, F can replace Cl in molecules, and vice versa, or either could replace H in molecules.

Midgely found that the heat of formation of compounds containing carbon and halogens increased from iodine to fluorine. Higher heats of formation indicate greater stability in the compound. The family of compounds he was investigating all had a central carbon atom (C), but with varying combinations of four atoms, selected from the elements hydrogen (H), fluorine (F), and chlorine (Cl).



The carbon atom combined with four hydrogen atoms is the compound methane, and all the other compounds synthesised from this are referred to as the methane family.

Chapter II

Modern Refrigerants

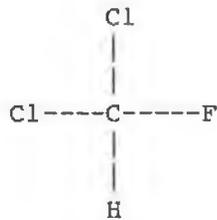
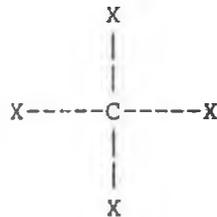
CHAPTER I I

This chapter covers the two current refrigerant families, namely the methane and the ethane series. It explains the relationships between the CFCs, HCFCs and HFCs, and how they were, initially, selected to be refrigerants.

Chapter 2: Modern Refrigerants.

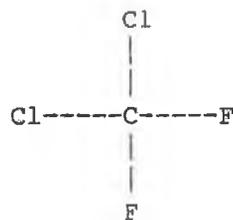
2.1 The methane family.

As mentioned previously (Chap.1), the methane family of freons are all variations on the basic CH_4 molecule, shown below with an 'X' in place of the four hydrogen (H) atoms. These 'X's can be replaced with various combinations of chlorine and fluorine, in any or all of the hydrogen locations. There are 15 possible such combinations.



This is an example of a possible combination, CHCl_2F , or R21.

The constituents include hydrogen H, so the molecule is said to be partly halogenated, i.e. it is not entirely composed of halogens.



This next example is CCl_2F_2 or R12. It contains only halogens, so is said to be fully-halogenated.

We can arrange all the 1-carbon compounds containing hydrogen, chlorine and fluorine as follows:-

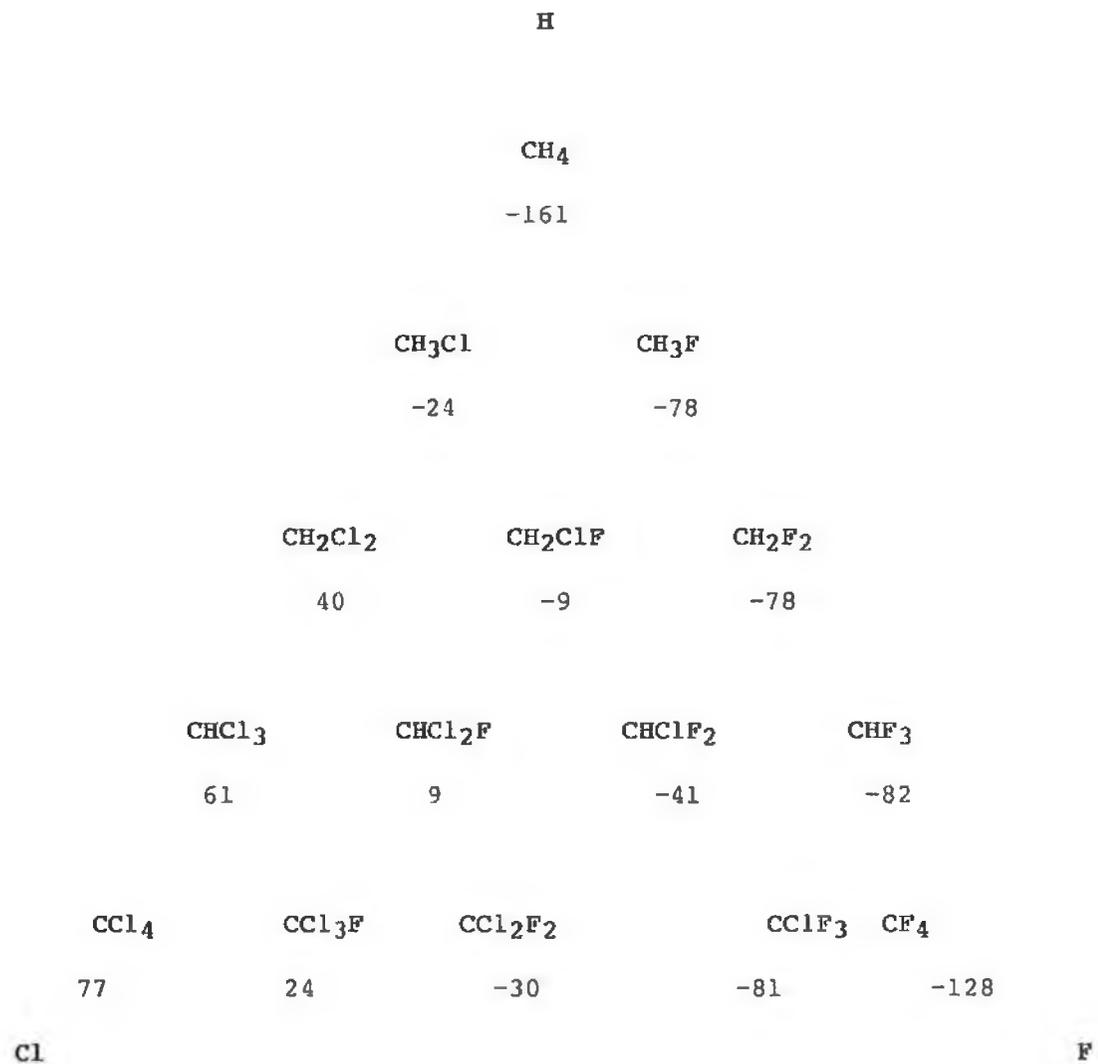


Fig 2.1: Methane Family of Refrigerants ('C B.P. at 1013mbar).

Under each compound is listed its boiling point('C), at 1013mbar. At the top of the triangle, compounds are richest in hydrogen, moving down

to the left they are richest in chlorine, and to the right richest in fluorine.

The refrigerants are denoted by 'R' numbers, designated as follows:- the lowermost row are designated R_{lx}, where l denotes the lowest row, and x denotes the position of the molecule reading from left to right. beginning with zero on the left.

The 2 or 3 digit 'R' number refers to the constituents as follows:-

The 'units' digit equals the number of fluorine (F) atoms

The 'tens' digit minus 1 equals the number of hydrogen (H) atoms

The 'hundreds' digit plus 1 equal the number of carbon (C) atoms

The remaining empty locations are occupied by chlorine (Cl) atoms

Thus, CCl₄ is R₁₀, CCl₂F₂ is R₁₂, and so on. The next row up are the R_{2x} group, above these the R_{3x}, and so on.

It can be seen that raising the chlorine concentration (moving towards the bottom left corner) raises the boiling point. Clearly, the fully halogenated compounds will occupy the bottom row.

These fully halogenated (ie. containing halogens, but no hydrogen) are referred to as ChloroFluoroCarbons, or CFCs. Thus there are 3 single-carbon CFCs, these being:

CCl ₃ F	CCl ₂ F ₂	CClF ₃
R ₁₁	R ₁₂	R ₁₃

The R numbers are simply a quick reference method to the compounds.

All compounds above the bottom row contain hydrogen, in varying amounts. This point is important to our overall understanding of refrigerants. Once a refrigerant contains hydrogen, it is no longer a CFC: it is either a HCFC (HydroChloroFluoroCarbon), or a HFC (HydroFluoroCarbon). Thus none of the other compounds above the bottom row are chemically CFCs.

The next row up are the R2x group, as follows:

CHCl_3	CHCl_2F	CHClF_2	CHF_3
R20	R21	R22	R23

Those familiar with refrigeration will have recognised two of the more popular refrigerants, known as R12 & R22.

It can be seen that compounds exhibit boiling points similar to their immediate neighbours. In the same way, they have related toxicity and flammability properties. Those richest in hydrogen are most flammable, those rich in chlorine are more toxic, and this leaves us looking towards the bottom right-hand side of the triangle. Now, from an applications point of view, we need a substance whose boiling point is in the -40°C region. This leaves us with R12 & R22.

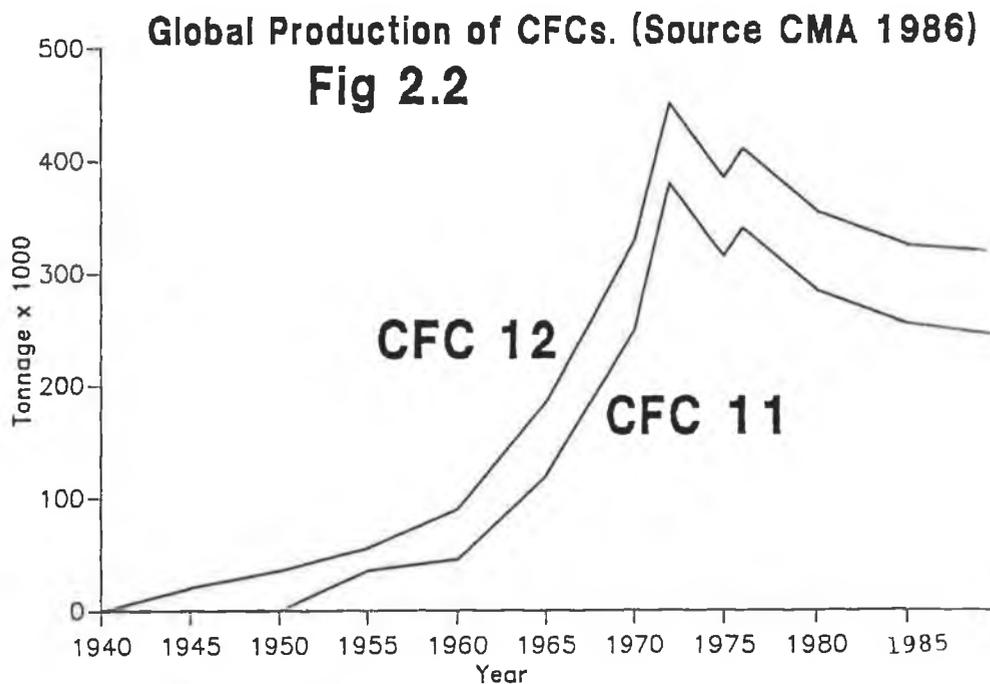
The resulting R12 & R22 are today's most popular refrigerants. They have served us well in their time. Both are toxicologically very safe.

At Midgley's 1930 announcement of R12, he took a lungful of R12 and extinguished a candle with it, showing it to be non-toxic and non-combustible⁶.

Midgley worked throughout this period with General Motors. Later, DuPont joined with General Motors to form a company Kinetic Chemicals Inc to develop a commercial process for the production of CFCs. In 1949, DuPont bought out G.M., and acquired all manufacturing and distribution rights for Kinetic Chemicals' products.

CFCs were not patentable, as they had been widely reported in the chemical trade, however various production techniques, and the handling and preparation of various ingredients, were patented, as was their use.

With increasing worldwide acceptance of R12, demand increased. The graph (fig 2.2) shows worldwide production of R12 from 1940 to 1985.



The 1985 estimate of R11/R12 production is 800,000 tonnes.

If we look at the uses of R11/R12:

	CFC 11(%)	CFC 12(%)
Refrigeration	8	49
Aerosols	31	32
Foam - rigid	36	8
- flexible	19	5
Other	6	6

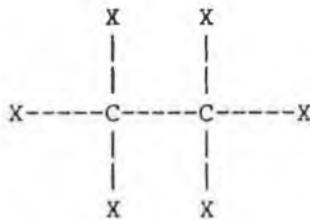
The chemical inertness of CFCs allows their use as aerosol propellants. Being inexpensive, and non-toxic, they were used in everything from air fresheners to medical asthma inhalers.

The 'foam' category is due to another of CFCs' useful properties: it is an excellent thermal insulator. As such, it is used to fill the closed cells of blown foams, to reduce the thermal conductivity of the foam. It is widely used in thermal insulation in trailers, cold stores and refrigerators.

It is worth noting that any reduction in the insulating effect available in the walls of a cold store will be reflected in a greater demand on the refrigeration system to maintain temperature.

2.2 The ethane family.

The ethane family of freons are all variations of the basic ethane molecule C_2H_6 molecule, shown below with an 'X' in place of the six hydrogen (H) atoms. These 'X's can be replaced with various combinations of chlorine and fluorine, in any or all of the hydrogen locations. There are 28 possible such combinations.



A further variation, however, is now possible, in that a given set of atoms may arrange themselves in more than one way physically, to give compounds with identical ingredients, but slightly different properties. These are known as isomers, and are denoted by a small alphabetic character in the chemical's name. Thus R134 constituents may be re-arranged to give R134a, while R132 has three other possible combinations or isomers, denoted R132a, R132b, & R132c.

As before, we can organise these in triangular fashion.

H						
R170						
-89						
		R160			R161	
		13			-37	
		R150,a	R151,a			R152,a
		84/57	53/16			31/-25
	R140,a	R141,a,b	R142,a,b			R143,a
	114/74	76/32	35/-9			5/-48
	R130,a	R131,a,b	R132,a,b,c	R133,a,b		
	146/131	103/88	59/47	17/12		
	R120	R121,a	R122,a,b	R123,a,b	R124,a	R125
	162	117/116	72/73	27/28	-12/-10	-48
	R110	R111	R112,a	R113,a	R114,a	R115
	185	137	93/92	48/47	4/3	-39
						R116
						-78
C1						F

Fig 2.3: Ethane Family of Refrigerants ('C B.P. at 1013mbar).

Including isomers (denoted as a, b, or c) we have 55 chemicals in all in the ethane series CFCs.

Again it will be seen that the familiar R reference numbers are based on R11x for the lowest row, R12x for the next highest row, and so on. The 2 or 3 digit 'R' number refers to the constituents as follows:-

The 'units' digit equals the number of fluorine (F) atoms

The 'tens' digit minus 1 equals the number of hydrogen (H) atoms

The 'hundreds' digit plus 1 equal the number of carbon (C) atoms

The remaining empty locations are occupied by chlorine (Cl) atoms

In this case, a three-digit code denotes the 2 carbon atoms in the basic structure of each molecule (a 2-digit code denoted the 1-carbon centre atom of the methane-based molecules.)

Under each compound is listed its boiling point('C), at 1013mbar. At the top of the triangle, compounds are richest in hydrogen, moving down to the left they are richest in chlorine, and to the right richest in fluorine. It will be noted that typically the isomers are similar in boiling point.

It can be seen that raising the chlorine concentration (moving towards the bottom left corner) raises the boiling point. Clearly, the fully halogenated compounds will occupy the bottom row. All this is as before.

Again, the CFCs occupy the bottom row, by definition. All others are HCFCs, or HFCs. If we take the diagonal connecting the F corner with the H apex of the triangle, we cross all the HFCs, i.e. those compounds which are chlorine-free.

Again, the groupings to the top are most flammable, those to the bottom left are more toxic, leaving us looking for compounds nearest to the bottom right, but with a suitable boiling point of around -40°C . We see that the R134a isomer has a boiling point almost identical to that of R12 (-27°C vs. -30°C). If we refer to the methane family chart (p.2.2) we can see that none of the HFCs there have a boiling point high enough to be of use to us.

It can be seen that R152a, R125 and R143a also hold hope as alternative chlorine-free refrigerants, based on their boiling points.

2.3 The propane family.

The next logical grouping of refrigerants is based on C_3H_8 , and it will be obvious the size of the family, plus the increased possible isomers, makes a chart unwieldy. Suffice to say that we can assemble a family of refrigerants based on propane C_3H_8 . The range of materials available begins at R210 (C_3Cl_8), at the bottom left of the triangle, to R218 (C_3F_8 , octofluoropropane) at the bottom right, to R290 (propane), at the apex of the triangle.

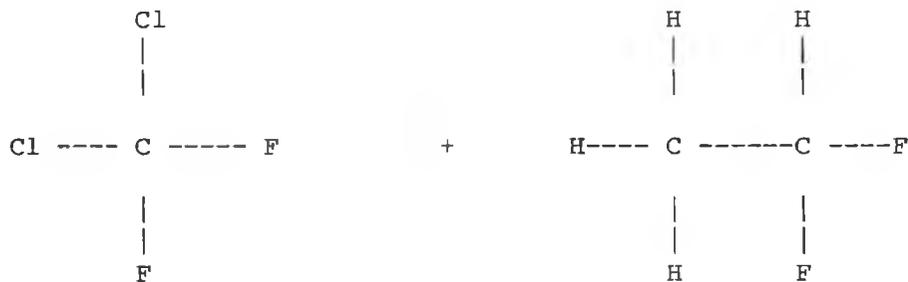
2.4 Azeotropes.

It will be noted that two of the most frequently mentioned refrigerants, R500 & R502, have not appeared so far in this chapter. In fact, both of these are mixtures of CFCs and HCFCs. They are not chemical compounds, in that the constituents are not chemically bonded together, but since they behave as though they were compounds for our purposes, they are referred to as azeotropes. An important feature of an azeotrope is that should a leak occur the components will not leak in such a way as to change the ratio of the mix. Some blends approach these requirements, and are referred to as near-azeotropes.

Mixtures which do not exhibit these properties are referred to as non-azeotropes (or more correctly, zeotropes), and are unsuitable for our business.

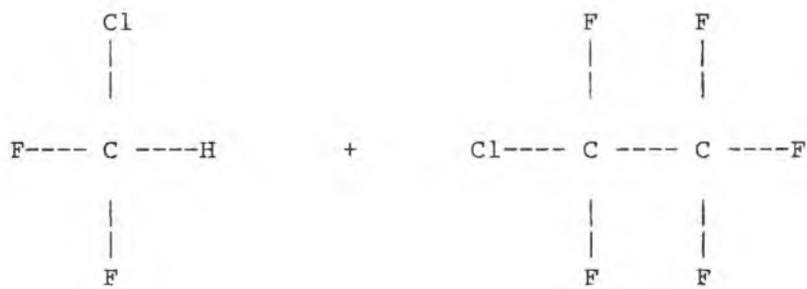
We can look briefly at the constituents of R500 & R502.

R500 ($\text{CCl}_2\text{F}_2/\text{CH}_3\text{-CHF}_2$)



When mixed, these two form an azeotrope. (74% CFC-12 + 26% HFC-152a)

R502 (CHClF₂/CClF₂-CF₃)



Azeotropic mixture (49% HCFC-22 + 51% CFC-115)

Chapter III

Monitoring Ozone Levels

CHAPTER III

This chapter explains the need for the ozone layer in the atmosphere, the mechanism by which it is created and destroyed and how chlorine contributes to its destruction. It refers to some of the research carried out, in particular the now famous work of Rowland and Molina, and attempts to establish some of the criteria by which we should decide on a realistic recovery or healing process for the ozone layer.

Chapter 3: Monitoring ozone levels.

3.1 The importance of ozone.

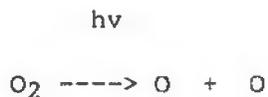
The atmosphere on earth is a crucial component in what is known as the biosphere. This is a layer of the earth which sustains life. Various forms of living organisms have evolved over time to the conditions prevailing in this biosphere. The amount of oxygen and carbon dioxide present, the abundance of water, the ability of carbon to combine in so many ways to produce organic compounds, all contribute to the diversity of life on our planet.

Equally, the distance earth is from the sun, in conjunction with our atmosphere, ensures a climate which again has been a deciding factor in the evolution of life. All the forms of electromagnetic radiation emanating from the sun contribute to the biosphere. We have the visible wavelengths, for light, the near and far IR for heat. The UV end of the sun's spectrum has both near and far UV elements. The lower energy near UV rays are those that cause sun-tanning. The far UV rays are by definition of a higher energy than the near UV rays. This higher energy radiation emanating from the sun can cause changes in molecules, under certain conditions. Over time, these high energy far ultra-violet photons have caused splitting of O_2 molecules (atmospheric oxygen) into $O + O$, these then combine with other O_2 molecules to form O_3 , or ozone. This splitting of O_2 absorbs the UV photon,

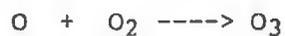
thereby preventing it reaching the earth's surface. The life forms on earth, therefore, have never had to adapt to high levels of far-UV radiation on the surface of the planet.

Typically, UV radiation from the sun strikes the earth's atmosphere at high altitude, and begins the formation of ozone. Thus, the ozone tends to reside naturally at high altitude, typically 15-30 km up. 90% of atmospheric ozone occurs in the stratosphere even though just 10% of the total mass of the atmosphere occurs in the stratosphere. In the same way UV of a suitable wavelength causes the formation of ozone, UV of other wavelengths causes its destruction. Further, ozone is unstable and recombines in time to normal oxygen. Over a period of time, a steady state has evolved, such that the rate of ozone destruction equals the rate at which it is being generated. The cycle outlined above absorbs much of the harmful UV radiation from the sun, thereby acting as a barrier, and protecting life on the surface from its harmful effects. Life has evolved on earth on this premise, namely that certain UV radiation does not reach the surface in harmful quantities. A significant reduction of this ozone layer could result in increased incidence of skin cancer and damage to food crops and aquatic life.

If we look at the reactions which produce, and control, the ozone content of the stratosphere, we can write the reactions typically as follows (where $h\nu$ is a photon of UV):

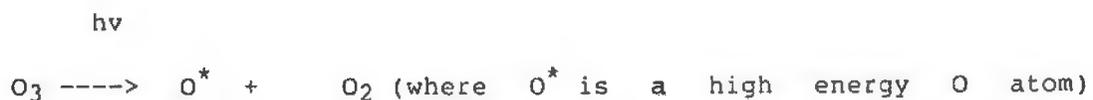


This is followed by:-



Thus, oxygen is converted into ozone by a photon of UV light.

Destruction is typically as follows:-



Followed by:-



This hydroxyl radical combines easily with almost every molecular species in the atmosphere, rendering a water-soluble product, which is removed from the atmosphere by precipitation.

3.2 Rowland and Molina⁷

In 1974 two chemists working at the University of California at Irvine postulated that if significant quantities of chlorine (Cl) could reach the upper atmosphere where the ozone resides, the natural balance of ozone creation and destruction could be upset, with serious implications for UV levels on the surface of the earth.

Chlorine is easily dissolved in rain water, and so does not easily reach the upper atmosphere in nature. However, if a mechanism existed whereby the chlorine could be transported up to the upper atmosphere and then released, there could be a problem. CFCs are very stable chemical compounds, and this stability is in part their downfall. If a CFC molecule is transported to the upper atmosphere, it runs the possibility of being split by high-energy UV radiation. The constituents of the CFC are then free to combine with other species around. Rowland and Molina postulated that CFCs would split under high energy UV in the stratosphere, and release their constituents, in particular the Cl. They postulated that Cl would contribute to ozone depletion as follows:-



Then, most importantly:-



The result is that as ozone molecules are removed (converted to oxygen

molecules) the chlorine is freed to react again.

The chlorine may eventually be removed from the atmosphere by:-



thus interrupting the cycle. The result is chlorine nitrate.

We can chart the postulated cycle as follows:-

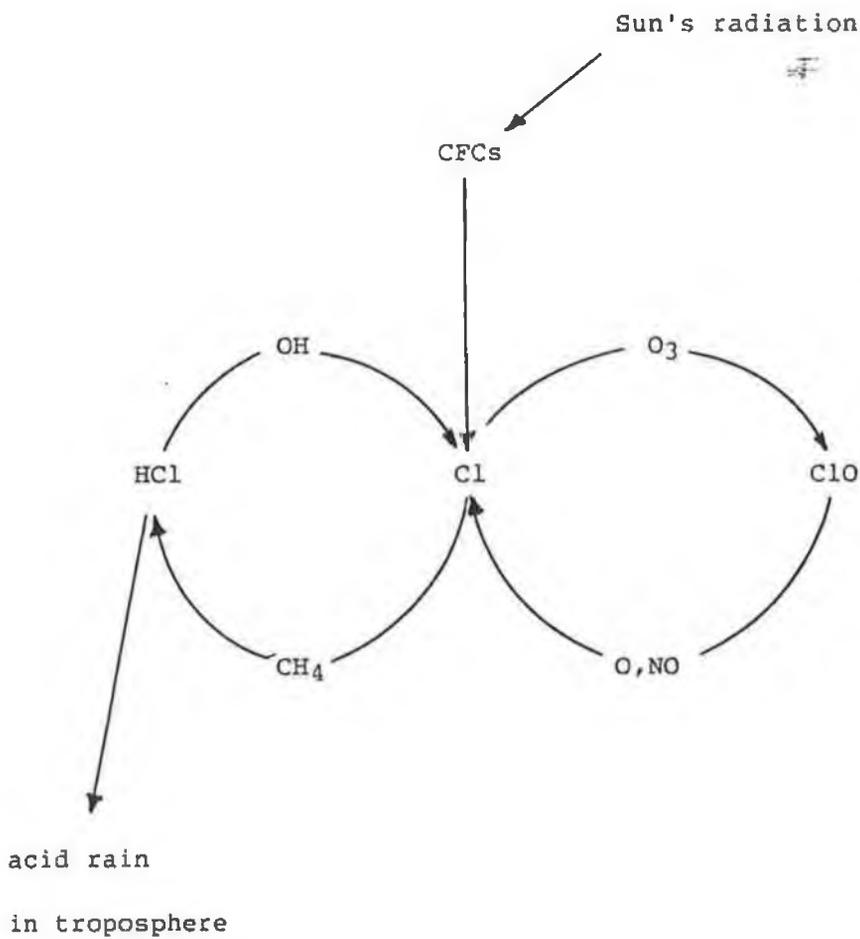


Fig 3.1: Ozone Removal Process

As the ozone layer was originally in a state of dynamic equilibrium, with ozone constantly being formed and an equal amount decaying, then Rowland & Molina had to examine how the CFCs would change this state of equilibrium.

Rowland and Molina published their original work in 1974. They pointed out that if their predictions were true, it would pose a threat to life on earth as we know it.

The possibility that Rowland and Molina were correct prompted the U.S. government to ban CFCs from aerosol cans in the late 1970s.

3.3 The Antarctic Ozone Hole.

In 1978 the NASA Nimbus satellite looked at the ozone concentration over the South Pole. The changes noted from then to the early 1980s were disregarded as incorrect readings, initially. This was apparently due to the severe ozone reduction noted in the measurements. It seemed too great to be credible¹¹.

In 1983-85, a British Antarctic expedition saw a similar ozone reduction, and the results published in 1985 eventually prompted a major emergency field study. In 1987, two aircraft, one a converted spyplane suitable for flying at 70,000ft, the other a DC-8, were instrumented and sent from Punta Arenas, Chile, out to fly through the Antarctic atmosphere.

Their findings confirmed the 'Ozone Hole', as it has been dubbed. Over an area the size of Europe, ozone concentrations had dropped, in places and at certain times of the year, by as much as 50%. The Hole is confined to the Antarctic by a set of vortex winds. Most importantly, in their studies throughout the area, they found, along with ozone depletion, the CFCs and the free Cl atoms, the ClO molecules, all correlating to allow an accurate connection between cause and effect. Where the ozone depletion was greatest, the Cl concentration was likewise highest.

The depletion has been most dramatic over Antarctica. During the southern spring, stratospheric ozone levels have decreased by up to 50%, over an area roughly the size of Europe. This effect has been most noticeable since 1975. In the northern hemisphere springtime, depletions of 2% to 10% have been measured, the greater decline occurring in the more northerly latitudes.

The cause of this relationship with polar wintertime is explained as follows. NO_x gases tend to combine easily with Cl atoms to produce ClNO₃. This removes Cl from the atmosphere. But during the polar winters, freezing temperatures cause ice crystals to form, and these crystals trap NO_x molecules, allowing Cl atoms to catalytically destroy the ozone.

A vortex of polar winds confines the hole to a region over the South Pole, keeping its size constant from year to year. Within this area, the percentage depletion varies with Cl concentration, & temperature.

The United Nations Environment Programme (UNEP) has prepared a report in conjunction with four panels of experts, set up under the Montreal Protocol. According to the report of the Environmental Effects Panel, a 3% worldwide increase in human non-melanoma skin cancer, and 100,000 cases of blindness due to cataracts, will be caused by every 1% reduction in total column ozone. Further, significant damage to sea and land foodchains is likely.

The Ozone Trends Panel has identified a 2% global-scale ozone reduction since 1970, and identified at least a part of this as being caused by CFCs.

3.4 Ozone Depletion Potential (ODP).

R11 is the reference material against which all CFCs are compared, both in terms of their ability to deplete the ozone layer, or ozone depletion potential (ODP) and greenhouse warming potential(GWP). The ODP is a result not just of the chlorine content of the molecule, but also of its ability to transport the chlorine to the upper atmosphere. Thus, by definition, ODP for R11 is 1.0, and GWP for R11 is 1.0.

The chlorine in CFCs is the source of the problem. For this chlorine to cause harm, it must be transported to the upper atmosphere. Only those chemicals which are relatively stable will survive long enough in the lower atmosphere to be transported to the stratosphere.

A measure of a chemical's ODP is dependant therefore not just on its chlorine, but on its atmospheric lifetime. If it is easily decomposed, then it will likely happen when it is low in the atmosphere. Its atmospheric lifetime has been shown to be related to its hydrogen content. Hydrogen decreases the stability of the chlorofluorocarbons. Thus, while HCFCs, such as R22, contain Cl, they are capable of doing just 1/20th the harm of R12 due to being broken down in the lower atmosphere. The hydrogen atom in the molecule is a site at which hydroxyl radicals may react, and the resulting oxidation by-products degrade in the troposphere.

If we limit ourselves to a discussion of the most popular refrigerants, we can look at their ODPs below:

Name	Cat.	Chemical formula	ODP
R12	CFC	CF ₂ Cl ₂	1.0
R11	CFC	CFCl ₃	1.0
R500	mix	(CFC-12/HFC-152a azeotrope)	0.74
R502	mix	(HCFC-22/CFC-115 azeotrope)	0.30
R115	CFC	CClF ₂ -CF ₃	0.6
R22	HCFC	CHClF ₂	0.05
R134a	HFC	CH ₂ F-CF ₃	0.0
R152a	HFC	CH ₃ -CHF ₂	0.0

The ODP of R500 is due entirely to its R12 content, diluted by the HFC-152a, in the ratio of 74/26.

The ODP of R502 is due to its R115 and its R22, which are mixed in the ratio of 51/49.

If we look at the above table, we note that the CFCs 11 & 12 we see are fully halogenated, i.e. the original hydrogen atoms which were part of the ingredients have been replaced by halogens. The same applies to CFC-115, which is a constituent of CFC-502. Lastly, CFC-12 is a constituent of CFC-500. Thus, all of CFC-11, -12, -500 & -502 have constituents which are fully halogenated.

The next chemical grouping is that of HCFC-22, which is not fully halogenated. It has retained a hydrogen atom.

Finally, we have the HFCs, which contains no chlorine. These are HFC-134a & -152a.

The first group mentioned, the fully halogenated CFCs, are very stable. They are of low toxicity, and are chemically inert at normal temperatures. This stability is in part their downfall. When released into the atmosphere, they do not decompose easily, unless a suitably large energy input is available. This typically does not occur unless they are carried to the upper atmosphere, where high energy UV rays cause their break-up. In so doing, chlorine is released, where it acts as a catalyst in the destruction of ozone molecules. It is important to note that it is acting as a catalyst: thus it does not react in itself, but is available to repeatedly cause the breakdown of many ozone molecules. It will eventually combine, typically with hydrogen, to form HCl. Before so doing, a single chlorine atom may cause the destruction of 100,000 ozone molecules.

The second group are the partially halogenated or HCFCs. The one of interest to the refrigeration business is the HCFC-22. It retains a hydrogen atom, resulting in a far less stable molecule. It is most unlikely to remain a molecule until it reaches the upper atmosphere. Thus, while it contains chlorine, its ability to cause damage to the ozone layer is greatly reduced.

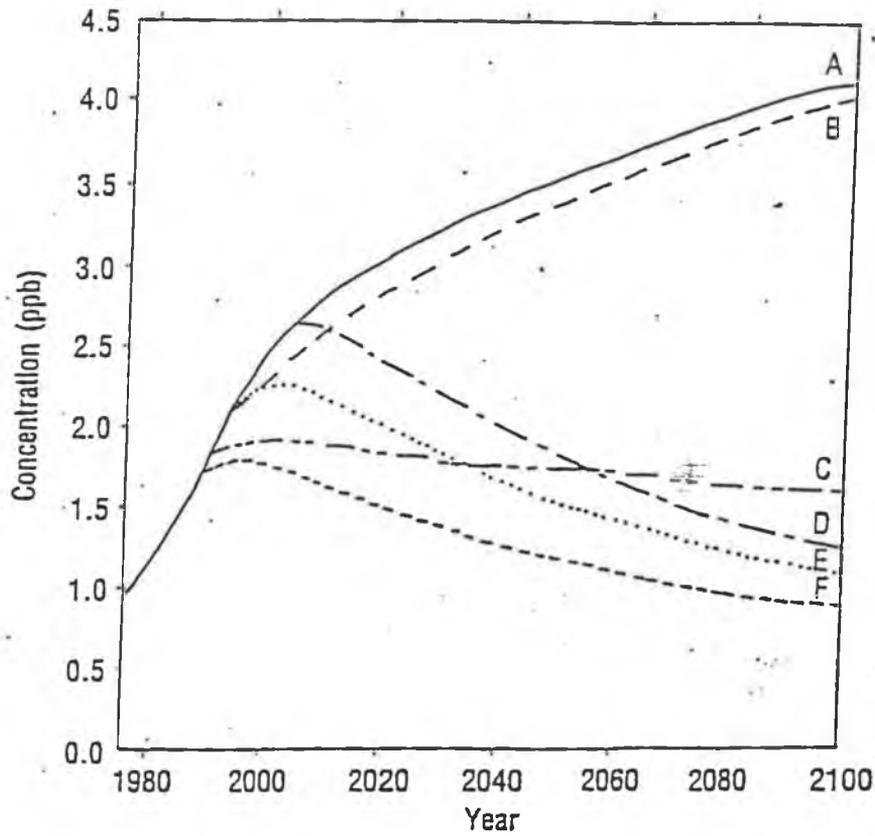
The third group of chemicals, the HFCs, contain no chlorine, therefore they have no ODP.

3.5: Chlorine Concentration in the Atmosphere.

The accompanying graph (fig 3.2) indicates several scenarios on CFC controls and how these would affect atmospheric concentrations of Cl in ppb. If our aim is to reduce the atmospheric Cl concentrations to those pertaining in the 1970's, then it will be seen that an immediate 95% cut would cause this to occur by the end of the next century, 2100.

Due to the mechanism by which chlorine is removed from the atmosphere (see fig 3.2, page 3.12), the next most effective way of reducing Cl is not the next most immediately severe reduction (of 85%) proposed in scenario C. In fact one can almost equal the recovery rate of scenario F with an immediate freeze, followed by progressive cuts of 20%, 50%, and 95% (this last as late as the year 2003), and still see significant reductions in atmospheric Cl by the end of the next century.

Fig 3.2 Atmospheric Chlorine from CFCs
Source: DuPont



CFC Consumption

	1989	1993	1998	2003	2100
—————	Freeze	-20%	-50%		A
- - - - -	-20%	-50%			B
- . - . -	-85%				C
- - - - -	Freeze	-20%	-50%	-95%	D
.....	-20%	-50%	-95%		E
- - - - -	-95%				F

It is interesting to note that a 50% reduction, either by 1993 or 1998 would have equal effects as to atmospheric Cl., and in each case the Cl ppb would continue to rise throughout the next century.

Chapter IV

Legislation

CHAPTER IV

This chapter charts some of the current world and European Community legislation in regard to the phase-out of ozone depleting substances.

It should be remembered throughout that the transport refrigeration industry consumes just 1% of total CFC production, so while some countries legislate specifically for transport, others have written legislation covering the broader production and use of these products.

Chapter IV: Introduction to Legislation

Governments around the world are waking up to their environmental duties and not just to gather more votes. They finally believe that the Ozone Hole exists, and that it is as serious as the pundits claim. The situation, as of late 1990, is the different responses to the problem. Some countries, not recently known for their environmental policies, are now pushing to the forefront of the CFC phase-out in Europe, faster than, for instance, the Montreal Protocol calls for. On the other hand, large producers in the developing world acknowledge the existence of the problem, but take the view that the West created it, the West can help bail them out now also.

Fig 4.1 (pg.4.10) shows phase-out proposals for CFCs/HCFCs in Europe as they apply to Thermo King from now up to the year 2000. It should be noted that some countries were quite specific in legislating for transport refrigeration, while others legislated just for refrigeration and yet others simply legislated for production and/or consumption.

4.1 The Montreal Protocol (summarized).

On the strength of Rowland and Molina's theories, and observed ozone

depletion in the Antarctic atmosphere, the major industrialised nations realized that they could no longer sit idly by and risk the possibility of major global climatic changes due to Cl emissions. Thus, in 1987 the Montreal Protocol was signed by 80 countries. Briefly, it sought to limit CFC emissions by limiting production in producing states and consumption amongst consumers. It came into effect on Jan 1st 1989, addressing the following chemicals:

Group	Substance	ODP*
Group I	CFCl ₃ (CFC-11)	1.0
	CF ₂ Cl ₂ (CFC-12)	1.0
	C ₂ F ₃ Cl ₃ (CFC-113)	0.8
	C ₂ F ₄ Cl ₂ (CFC-114)	1.0
	C ₂ F ₅ Cl (CFC-115)	0.6
Group II	CF ₂ BrCl (Halon-1211)	3.0
	CF ₃ Br (Halon-1301)	10.0
	C ₂ F ₄ Br ₂ (Halon-2402)	(to be determined)

* these ODPs are estimates, which will be reviewed and revised periodically.

The Montreal Protocol is contained in the appendix, p. A1.

The intent of the Protocol is to control manufacture of these substances, relative to the levels produced in 1986.

Article 3 of the Protocol determines how the control levels are to be calculated for each Group of substances.

Production:

(i) multiplying its annual production of each controlled substance by the ODP specified in the above table

(ii) adding, for each such Group, the resulting figures.

This means, in effect, that in Group I, a kg of R12 could be replaced by 1.66kg of CFC-115, and produce the same nett calculated level. As CFC-115 is a constituent of R502, whose overall ODP is 0.3, then we could replace 1kg of R12 with 3.33kg of R502 and still have the same calculated level on Group I.

The Protocol came into effect on Jan 1st 1989, with the following limits:

1. from 1.July.1989 must not exceed calculated level of 1986.
2. from 1.July.1993 must not exceed 80% of calculated level of 1986.
3. from 1.July.1998 must not exceed 50% of calculated level of 1986.

This concept of calculated levels has been referred to elsewhere as the basket approach. Reduction in high ODP freons may be counteracted by proportionally greater production in low ODP freons.

Or put another way, we can achieve the reductions required by the Protocol by switching to lower ODP freons.

A number of countries, most notably China and India, did not sign the Montreal Protocol. Reasons put forward include not being convinced of the seriousness of the problem, and "the West generated the problem, they can pay for the solution". China & India are heavily dependant on R12.

In June 1990 the Montreal Protocol signatories reconvened in London at a planned review of the Protocol. In the years since the original Protocol was signed, no evidence had come to light refuting the original theory that CFCs were contributing to ozone depletion, and greenhouse warming.

For our purposes, the Montreal Protocol, revised 1990 states:

50% cut in CFCs production by 1995

85% cut in CFCs production by 1997

100% cut in CFCs production by 2000

HCFCs are not controlled, but should be used carefully and prudently with a phase-out planned somewhere between 2020 & 2040.

Importantly for the purpose of the Protocol, two of the world's largest manufacturers of CFCs, India and China, did not sign the original Protocol. Primarily, they could not afford financially to drop CFCs from their internal development. The 1990 Review sought to make funds available to developing countries, totalling \$180m over three years, with an extra \$60m if India and China sign. India and China have since signed.

The signatories agreed to a further review in mid-1991.

4.2 EC Position on Substances that Deplete the Ozone Layer.

The European Commission Proposal of January 1990 is attached in the appendix p. A28. It speaks of reducing production of CFCs:

50% reduction by Jan 1st 1992

85% reduction by end of 1996

cessation of production by end 1997

It omitted to include R-22.

This would effectively have given the transport industry until at least the end of 1997 to continue using CFCs, and the option of using HCFCs indefinitely.

December 1990 the EC is considering bringing forward its CFC phase-out date by one year, to the end of 1996. It is also considering HCFC controls. Its initial stance would most likely be to at least bring it into line with the Montreal Protocol on HCFCs, i.e. phase-out around 2030-2040.

(Feb '91: EC agrees to CFC production and consumption phase-out by mid-1997.)

This scenario however was overtaken by two things:

- i. the West German draft decree on CFCs and Halons (appendix p. A56)
- ii. the re-unification of East & West Germany.

4.3 German Legislation.

The draft decree by what is probably the wealthiest member of the EC was devised that it could not be over-turned by EC law. The explanation as to this is included in the decree (page A58 in the appendix). Thus while the EC might go with slightly more lenient regulations, West Germany would effectively force the issue from its position as the world's greatest exporter (ahead of USA, and Japan). Re-unification of West Germany with the strongest financial member of the former East Bloc could only strengthen its lead.

Originally, West Germany took the lead in European CFC legislation, with a proposal that:

CFCs be banned from Jan 1st 1992 in new equipment with >5kg

CFCs be banned from Jan 1st 1995 in new equipment with <5kg

HCFCs be banned from Jan 1st 1998 in new equipment.

After a number of hearings in Bonn, the West German Gov't relaxed its position on the transport industry, in that it added two years to the lifespans both of CFCs (from 1st Jan '92 to 1st Jan '94) and of HCFCs from 1st Jan '98 to 1st Jan 2000). The details of this change can be read on page A83 of the appendix Directive 83/189/CEE Notification Nr 90/142/D entitled Notification of the CFC-Halon ban.

Thus for our purposes, the current German position is:

5 kgs+ of CFCs will be banned from new units from 1st Jan 1994

CFCs will be banned from new units from 1st Jan 1995

HCFCs will be banned from new units from 1st Jan 2000

CFCs and HCFCs will be available for servicing existing equipment for the life of the unit, or until a viable drop-in replacement is devised.

Currently, late November 1990, the proposal is in Brussels with the EC for consideration. Assuming the EC does not modify it, it will likely come before the German parliament in early/mid 1991, with an implementation date around September 1991. This will allow all its aspects to be applied as scheduled.

4.4 Austrian Legislation.

The proposed Austrian legislation is contained in the Appendix. Also contained therein is the Austrian transport industry's response to this proposed legislation.

Like Switzerland, Austria does not manufacture CFCs, so their intentions are to control the importation of CFCs.

The text is confusing. While CFCs may not be sold from 1.1.91, there appears to be a relaxation of the rules until 1.1.92 for transport refrigeration. They go a step further than other countries, in also prohibiting the sale of used units from 1.1.93.

They further allow the use of CFCs for the maintenance of existing equipment for its lifetime.

The only current refrigerant not controlled is R22.

The final legislation is contained on page A84. It applies to CFCs, whether used in pure form or in mixtures.

Briefly, it applies to our industry as follows:-

from 1.1.91 until 1.1.94, maximum of 4kg R12, or 8kg R502.
R12 & R502 prohibited from 1.1.1994.

Units imported prior to these dates may be sold/used with CFCs as deemed necessary on technical grounds, until a replacement fluid becomes available.

4.5 Swiss Legislation (pg.A93).

Firstly, the Swiss point out that none of the Montreal Protocol listed substances are produced in Switzerland. Thus, their controls apply exclusively to consumption.

1986 consumption of CFCs was over 8000 tonnes. The aim is to reduce this to 2000 tonnes in 1991, to a few hundred tonnes in 1995, i.e. a 90%+ drop. 'It is envisaged that the remaining quantities necessary for the maintenance of existing installations can be eliminated by the end of the decade'.

Foams: CFCs banned from mid-1991

HCFCs banned from 1996.

CFCs banned from refrigeration appliances from 1994.

Refrigerants: CFCs banned from 1994

HCFCs allowed beyond that date.

Anybody using CFCs and HCFCs must have a special permit (to include special training) from 1993.

4.6 Other Legislation.

We can briefly summarise other legislation on CFCs as follows. At the time of writing, Norway looks set to stick with their proposal, however the Netherlands may yet allow a longer life for R12/R502 for the transport industry, much as Germany did.

Britain: proposed 1.1.1997 CFC phase-out of useage and consumption.(RAC

Netherlands: CFC phase-out 1.1.92 (HCFCs not included.) (B Hollander)

Norway: CFC ban on new units mid-1991. (Kjel Berge)

Sweden: CFC ban from 1.1.95 on new units. (Gunnar Smedbro).

USA: The 1992 Clean Air Act will make it an offence to vent CFCs, and legislation is in place to reduce CFC production to 15% of 1986 figures by 1997, with a complete phase-out of production by the turn of the century.

Country	Date & Comments (SOURCE)	CFC/ HCFC	Spec Ref	Activity	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2000+
Austria	90 July proposed legislation (SERVO KING)	CFC	R12 R502	Use in new units	<---max 4 kg	<---max 8 kg									
		HCFC		No regulations at present											
EEC	91 Feb agreement Concerns PRODT'N to 95 & CONSUMPN from 1996 on.	CFC		PRODUCTION red to 50%--> red to 15% <-----> red to 0% , <---->											
		HCFC		Production: Phase out by											phase-out by 2030-2040
Germany	'91 legislation: concerns useage for new units. from 1996 on. Allows existing equipment use CFCs/HCFCs until drop-ins available	CFC		Use-new units over 5kgs all qtys											
		HCFC		Production: Phase out by											<-banned from 1.1.2000
Norway	Proposed legisin (KJEL BERGE)	CFC													
		HCFC		No regulations at present											
Sweden	Proposed legisin (GUNNAR SMEDBRO) (SOURCE)	CFC													
		HCFC		No regulations at present											
		HCFC Ref		Activity 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2000+											
Switzld	Proposed legisin + users to be licensed 1993 (FROEHLICH)	CFC													
		HCFC		No regulations at present											

4.10

Some European CFC/HCFC legislation
Fig 4.1

Chapter V

Recycling

CHAPTER V

This chapter outlines the methods by which refrigerants can be recycled. This will become increasingly important, as taxes, and scarcity, of CFCs begin to bite. Further, as replacements become available, the likely higher costs will encourage recycling as a new growth industry. Much of the refrigerants in circulation in the near future will likely be recycled from in-service units or from obsolete equipment.

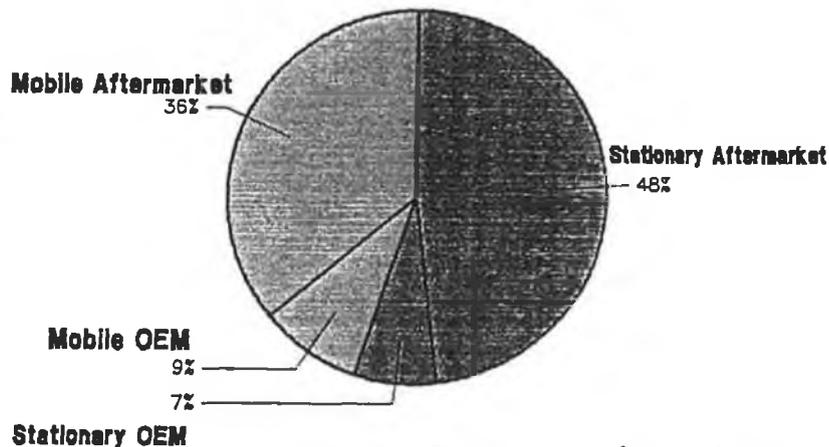
Chapter 5: Recycling

5.1 Why Recycle?

The present concern with ozone depletion and with greenhouse effects of refrigerants, is based on the assumption that any CFCs produced will be emitted into the atmosphere in time. This may have been true in some applications, e.g. when CFCs were used as aerosol propellants, or to a lesser degree when used in connection with foam manufacture. However, when used in refrigeration, it is vital to the operation of the piece of equipment that the CFCs remain in the equipment. Nonetheless, much of the refrigerant consumption in years past has been sold into the aftermarket for service, where, presumably, the original charge either leaked, or was simply blown to atmosphere as the freon was so cheap. See fig 5.1 for the USA CFC refrigerant useage.

USA CFC Refrigerant Market 1986

Fig. 5.1



German regulations (June 1990) are allowing new units with CFCs to be sold up to 1.1.94, with HCFCs up to 1.1.2000. Further, they have accepted that CFCs, and HCFCs, should be made available for the life of the equipment, or until a suitable drop-in replacement becomes available. As useage generally drops, the cost of CFCs will inevitably rise, by as much as 50%/annum. This is happening already in Europe. DuPont are committed to stopping CFC production by 2000, at the latest. On top of manufacturers' price increases, the US government has added a tax which almost doubles the cost of R12 in the USA. The U.S. government is proposing that reclaimed freon not suffer the tax, further encouraging the reclamation of refrigerants. The tax has not so far been applied in Europe, but will almost certainly occur in the next few years.

The 1992 US Clean Air Act will make it an offence to vent CFCs.

Thus, both as a hedge against price increases, and as our industry's response to controlling emissions of CFCs, it would be very timely to encourage a prudent useage & control of our current CFC stocks. Indeed, the very price of new CFC materials will undoubtedly create a new business in the recovery of CFCs from old equipment.

5.2 Can all refrigerants be re-cycled?

Refrigerants, as mentioned earlier, are chemically quite stable. This means, effectively, they do not break down in themselves in the normal course of operation of the refrigeration system. The most common problem

with them is contamination⁵. Typically, this would be:

- a) compressor oil
- b) moisture
- c) air
- d) particulate matter
- e) acid

There is a situation where CFCs do break down relatively easily, in semi-hermetic electric motor driven compressors. A failure in the electric windings of the compressor may cause a spark which results in the chemical break down of CFCs. This does not apply to our belt- or shaft-driven compressors.

Compressor oil is not detrimental to the re-use of the CFCs, unless it has been damaged through running too hot. It is easily removed by a mechanical filter.

All these materials can be removed by a combination of mechanical filtering, adsorption of moisture via a dryer, and distillation to remove other trace materials⁹.

The newer HFC refrigerants can also be recycled, however at present this is done via the manufacturers, to ensure the recovered material is as free of moisture & chlorine as necessary.

DuPont will take back any CFCs recovered from equipment, and either re-sell it after cleaning, or store it until it can be destroyed.

The US Environmental Protection Agency made recommendations which have become the 1992 Clean Air Act. In doing so, they are encouraging the recycling of refrigerants. ARI have set out in their ARI 700 purity standards for the recycled material. They are further working on ARI 740P, a standard for recovery/recycling equipment.

Some parts of the industry considers the ARI 700 standard too stringent and the EPA is asking ARI to look again at ARI 700. The concern is that too tight a standard on recycled material will not encourage the popular reuse of refrigerants.

Chapter VI

Leaks & Their Elimination

CHAPTER VI

This chapter examines some of the current methods for finding leaks, and some of the methods being tried out in Thermo King Europe. It charts the successes of helium as a leak detection medium.

Chapter 6

Chapter 6: Leaks and their Elimination

6.1 Introduction

The quest for a leak-free unit has never been more important. In years gone by, the industry used R12 freely, due both to its low cost, and apparent inertness.

In more recent years, taxes have begun to increase the cost significantly (U.S. taxes equal US\$1.38/lb R12, on a material price of US\$1.00/lb. This is intended to rise to US\$2.65/lb by 1994, and rise by US\$0.45/lb each year thereafter.)

This tax is only the beginning, as plans are afoot to increase the taxes in the U.S.A., and eventually in Europe, to ensure a more prudent use of R12. Further, as use of R12 declines, due to its elimination as an aerosol propellant, and due to replacements becoming available in various applications, then the production costs will rise as the equipment used to manufacture it is under-utilised.

6.1.1. Units of leak-rate.

The international unit of leak-rate measurement is the millibar.litre per second, or mbar.l/s. By definition, an object has a leak-rate of

1 mbar.l/s, IFF it has a volume of 1 litre, and its internal pressure changes (up or down) by 1 mbar in 1 second. In practice, in our business, we are interested in ozs. or grms. of freon lost per annum. If we take R12, which has a molecular mass of 121 a.m.u., and assume that at 20'C and 1013 mbar (S.T.P.) the molar volume is 24 ltr, then

$$121\text{g CF}_2\text{Cl}_2 = 1,013 \times 24 \text{ mbar ltr}$$

$$1\text{g CF}_2\text{Cl}_2 = 201 \text{ mbar litre}$$

Finally, to give grammes per annum, divide by the number of seconds in a year (31.5×10^6 sec):

$$1\text{grm R12/annum} = 6.4 \times 10^{-6} \text{mbar.l/s}$$

6.2 Finding leaks in Assembly

Historically, it was felt that a leak was only a problem to a unit if it affected the performance of the unit. Thus, a leak of 2oz/yr would not affect an SBII R12 for the first year at least, assuming it was on the high-pressure side of the system, and so didn't result in moisture ingress into the unit. On R502 units, the whole system tends to stay above atmospheric pressure, and so it was felt that it really didn't matter if an SBII R502 had a 2oz/yr leak.

All this is changing, for the following reasons.

The first concern with an apparently innocuous 2oz/yr leak is that it is unlikely to get better, and quite likely to get much worse. This is due to the vibration the unit will see in use over the road.

Setting a 2oz/yr leak spec and then setting a leak detector to 2oz/yr assumes the total leak is captured by the leak detector. This is unlikely.

Even if the whole leak was captured by the sniffer, any number of, say, 1.8 oz/yr leaks could exist on a particular refrigeration unit and none individually would trigger the leak detector 'FAIL'.

The fourth reason is the spiralling cost of the refrigerant needed for repairs.

It follows that what is needed is a tighter standard than might appear at first necessary, and ensuring that it can easily be met.

6.2.1. The halide torch leak detector.

The traditional way of finding freon leaks on charged systems was with a halide torch, where a copper plate acted as a catalyst in a gas flame causing the flame to turn green-blue whenever halides were drawn into

the flame. The weaknesses of this system are many:

The sensitivity of the equipment depended greatly on operator judgement. A slight colour change to one user might not be obvious to another operator.

As time passed, the copper plate oxidised, reducing the sensitivity of the torch.

The best realistic leak rates that could be detected were of the order of a few ozs/yr, so the equipment was, at best, working on its limit even at 2oz/yr. This deteriorated as the copper plate oxidised.

6.2.2. The electronic halide detector.

The next solution was to use the same principle as above but in an electronic detector. This had the advantage of repeatability, and could easily be calibrated. In this case, gases containing chlorine molecules influence the emission of alkaline ions from a hot platinum surface (Langmuir-Taylor effect). If a platinum anode is heated to 800°C, the small positive ion current increases greatly in the presence of chlorine ions, producing an electrical signal at the cold cathode. The resulting current is amplified and measured. This system is capable of working down to 10^{-7} mbar.l/s.

The advantages of this system over the halide torch are:

Repeatability.

Lower minimum leak rate measurement.

Additional electronics allow for automatic calibration.

Relatively inexpensive.

The method has a number of disadvantages:

The detector is sensitive to anything that can produce the ionising effect over the platinum catalyst. It can 'see' amongst other things, cigarette smoke, solvent vapour, and human breath.

While the equipment can be applied to finer leak rates than the halide torch, controlling the freon background level in a refrigeration plant to allow the detector be set to say, 0.1oz/yr requires special care.

The concept of using freons, the 'guilty party', as the leak test medium is unlikely to be allowed long-term.

These detectors work only on CFCs and HCFCs, as they actually react with the chlorine in the gas. Thus, they cannot 'see' HFCs. This means their life expectancy is limited.

6.3. Helium leak detection.

The most modern method of detecting leaks is to fill the test piece with helium, and check for helium leaks using a helium detector. Helium is available in varying degrees of purity, from balloon gas at 95%+, to medical helium at 99.9999% pure. What is important to medical users is the minimising of impurities, therefore the 99.9999% is critical to their application. From our point of view, we are only looking at the diluting effects of any impurities: on a logarithmic scale, anything over 90% pure will not behave differently to 100% pure helium. However, balloon gas is far cheaper than medical helium. Thus, we can safely operate with balloon gas, referred to hereafter as 'pure' helium, albeit only 95% pure.

Because of its atomic structure, helium normally exists only as a gas. (It liquifies at -269°C). Thus, any helium used in a process has been extracted from the atmosphere. For this reason, venting helium simply returns it to whence it came. As it is inert, it is non-combustible, so no special safety controls are required. As it is lighter than air, it rises from a leak. Helium leak-testing should therefore always begin at the bottom of the test object.

As helium is an inert gas, of atomic mass 4, it can be detected only by using a mass-spectrometer. A number of companies supply mass-spectrometers for this purpose.

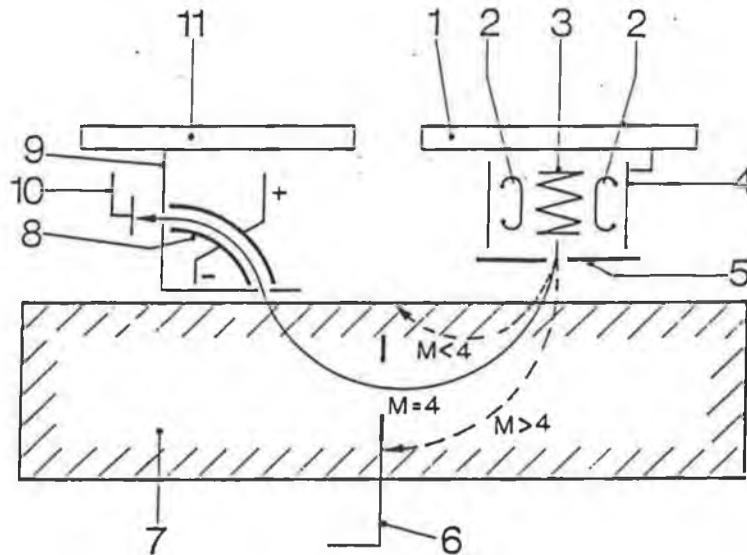


Fig. 6.1 Schematic diagram of a double focusing mass spectrometer as used in leak detectors
 1 Flange of the ion source unit
 2 Cathodes
 3 Anode (heated)
 4 Shield tube
 5 Diaphragm
 6 Intermediate diaphragm
 7 Magnetic field
 8 Cylindrical condenser
 9 Diaphragm
 10 Ion collector
 11 Flange of the deflector unit

Figure 6.1 Helium Mass Spectrometer

The principle on which the mass spectrometer works is as follows: the gas to be analysed is fed into a chamber where it is ionised (see fig 6.1 1-5), the resulting ions are accelerated by a potential difference on 5. The moving charged ions experience a force as they travel through a magnetic field, 7. The force is a function of the charge on the ion and its velocity. These are equal for all the ions in the beam. However, the amount by which they are deflected will be a function of the force applied, and the mass of the ion. This varies for the different species in the beam. Thus the heavier ions will be deflected less than the helium, while light ions will be deflected more. A slit, 9, is situated where the helium ions should theoretically exit the field, and this slit allows the helium ions only to travel through a further curve, to ensure

a very specific ion selection for helium. The resulting ion beam is then fed onto a receiving plate (fig 6.1 item 10) where it registers as a current. This current is amplified to produce a useable signal. The current resulting is proportional to the helium in the gas sample fed into the system. The gas sample has to be at a very low pressure (below 10^{-4} mbar) to allow the above process operate properly.

This method allows partial pressures of helium down to 10^{-12} mbar be measured. Losses in sniffing probes result in a practical minimum leak rate measurement of 10^{-8} mbar.l/s, or 1 gramme of freon in 80 years, or 1oz R12 in 2240 years! This is not a theoretical limit, but a true practical limit, assuming we can control the helium environment we operate in.

A mass-spectrometer by its nature needs to work in a vacuum. But the test gas we are sampling for helium content is at atmospheric pressure. The method by which the atmospheric gas sample is fed into the mass-spec. is primarily what differentiates the different makers' equipment.

The factory floor is traditionally not the place for sensitive hi-tech equipment. Thus, the helium detector must be able to live in a relatively dirty atmosphere, and the hand-held parts must be robust.

6.3.1 Leybold UL100

At TK-E we tried out different types of gas transfer mechanisms to see which would last the course in this application. We first used a Leybold UL100 with sniffer, over a period of 2 months. The Leybold equipment utilises a gas transfer pump to take a sample of gas from the sniffer probe to a mass filter made of ceramic material (fig 6.2). Behind this ceramic filter lies the vacuum system of the helium mass spec. The filter pore-size is of the same order of magnitude as the helium atoms, so acts as a first 'amplification' or helium enrichment stage. The helium atoms then travel into the medium vacuum (see fig 6.2) of the backing pump, and as the turbo-molecular pump has a poor compression ratio for helium, some helium migrates through the turbo pump to the mass spec¹⁵.

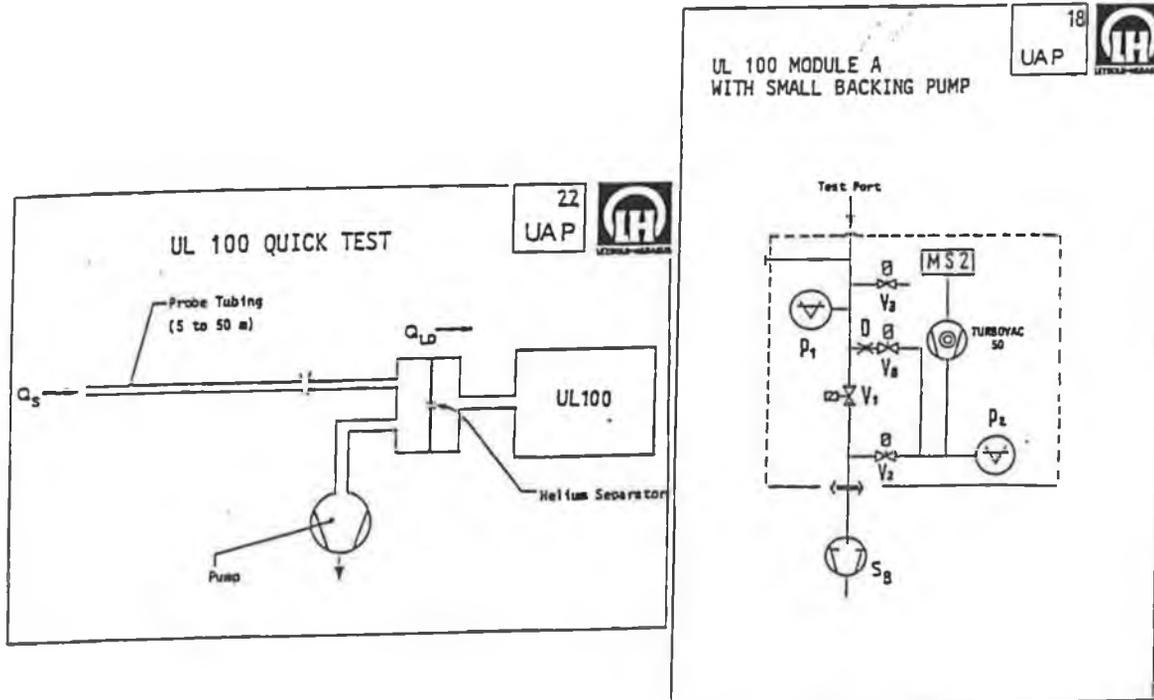


Figure 6.2 Leybold UL100 leak detector

The amount of helium reaching the mass spec is directly proportional to the amount in the medium vacuum region between the turbo and the backing pump, the ratio being decided by the compression ratio the turbo has for helium. (These turbos are specially de-rated to reduce their compression ratio for helium: one compression stage has been removed, and the pump speed is down to 50,000rpm from 70,000rpm.) The amount of helium crossing the ceramic mass filter is directly proportional to the conductivity of the filter, and the pressure difference across it. Thus, once the pressures are correct, and the turbo pump is up to speed, we can measure atmospheric helium accurately. So says the theory.

The problems that arose were as follows:

1. The sniffer probe consists of a fine bore tube through which the sample gas is drawn. This tube reduces the pressure of the gas from atmospheric to the pressure above the ceramic filter. A piece of dirt could, and did, easily block this tube. There was no indication on the leak detector that this pressure was then incorrect.
2. The second, and more difficult, problem, relates to the ceramic mass filter. This is simply unsuitable for use on a factory floor. The pore size is intended, as mentioned earlier, to concentrate the helium by excluding other larger atoms/molecules. This it does: however, oil vapour is composed of molecules larger than helium, and these oil molecules effectively block the filter, rendering the

unit 'blind'. Again, there is no indication that the pressures in the system have changed.

6.3.2 Varian PortaTest II

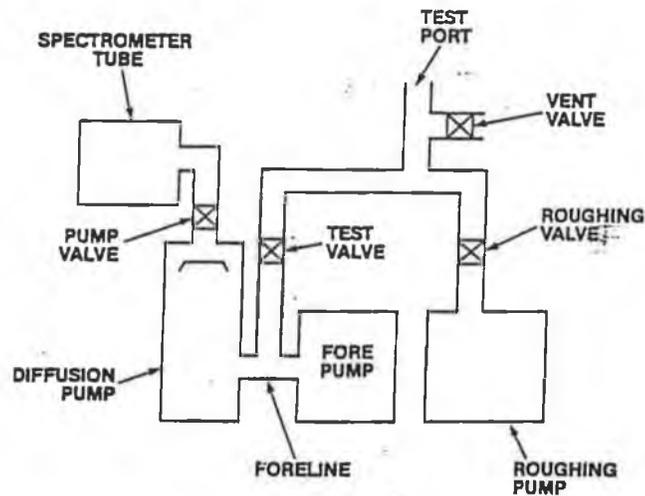


Figure 6.3 Varian PortaTest II

The next system we tried was a Varian PortaTest II (fig 6.3). This unit uses a different gas transfer system. Gas is sniffed through a 'gun', which is fitted with a needle valve, behind which is a relatively large-bore tube. This large bore tube runs at the same medium vacuum as the mass spec backing pump. Further, the pressure in this tube is available constantly on the readout. Thus, if the needle valve gets blocked, there is a change in backing pressure, and the needle valve

can be adjusted. Grit in the tube is not a problem as the tube is large. Finally, oil ingression (from oiled joints) is simply drawn through the needle valve, into the tube, thence into the backing pump, where it mixes harmlessly with the backing-pump oil.

The trials of the Leybold UL100 and the Varian PortaTest II lasted 8-10 weeks, initially. This was in early 1989. The Varian was, without doubt, the more robust and reliable. The Leybold unit never ran more than a few hours without serious blockage of its ceramic filter. Worse, this only showed if one tried to calibrate the unit through the sniffer, as there was no indication on the UL100 that the backing pressure was low.

The Varian unit behaved well. There is a cheaper Varian unit which might appear to fulfill the above requirements. This is the 938-41. It lacks a number of features, which reflect in its lower price. Firstly, it has very little electronics. Thus, it does not monitor its own ion source pressure and protect it in the event of a rise in pressure in the ion source. Such a rise shortens the life of the ion source. Further, it can cause backstreaming if an oil diffusion pump is used in the system. These pumps are extremely simple and so are very reliable, relative to the turbo-molecular pump favoured by Leybold. However, in the event of a system vacuum failure, they can contribute to ion source contamination, requiring specialist knowledge to clean up. It can occur due to a power outage, a system malfunction, or an operator error. Should this happen, the PortaTest II shuts its electromagnetic valves to isolate the ion source from the gas inlet

system.

More importantly, the PortaTest II has a logarithmic output scale, which allows the operator to work over a band of leak sizes from 0.001oz/yr to 1000oz/yr, approximately. The advantage of this, over a simple 'PASS' or 'FAIL' in the 938-41, is that the operator can detect an increase in helium partial pressure, resulting from a leak, even though the 'FAIL' level is not reached. This means that even if the operator is moving the sniffer gun quickly, too fast for a 'FAIL' level to be reached, he/she would still be aware of a leak, and can then look more closely at a suspect area.

The PortaTest II has an audio output as well as a bar segment LED readout. When an operator is behind a test unit, such as an SBIII, he can 'hear' the leak on a set of radio headphones we installed, as the audio output varies in frequency as the leakrate varies.

Our leakfree percentage reaching the final test area is running at 91% on the line using helium, compared to 73% on Puerto Rico lines. Further, to reach 0.1 oz/yr leak levels on a freon detector requires a controlled atmosphere, in the form of a test booth inside which the unit is checked for leaks. The air for this booth, ideally, must be drawn from outside the plant, so requiring heating/cooling as appropriate.

The cost of such a system puts the freon detector and the helium almost on a par as regards installation costs. The cost of running the helium system is typically US\$1.00 per SBII, but we reduced this to US\$0.40 per SBII with a helium charging/recovery system we installed.

6.3.3 Automating the helium cycle.

The work of filling the refrigeration system with helium, later removing it, ensuring the helium does not vent inside the plant, and being certain that the system test pressure and helium purity is maintained, was all effected by the line operators for the first 6 months after installing the helium leak detector. The three operators initially trained up on operating the system were extremely diligent, and very co-operative. Without their help the concept of trying to find leaks using helium would have been doomed to failure. However, we sought to simplify the operating cycle for the operator, and at the same time reduce the helium consumption (of approx 240 std. litres of balloon gas helium per SBII) by automating the cycle.

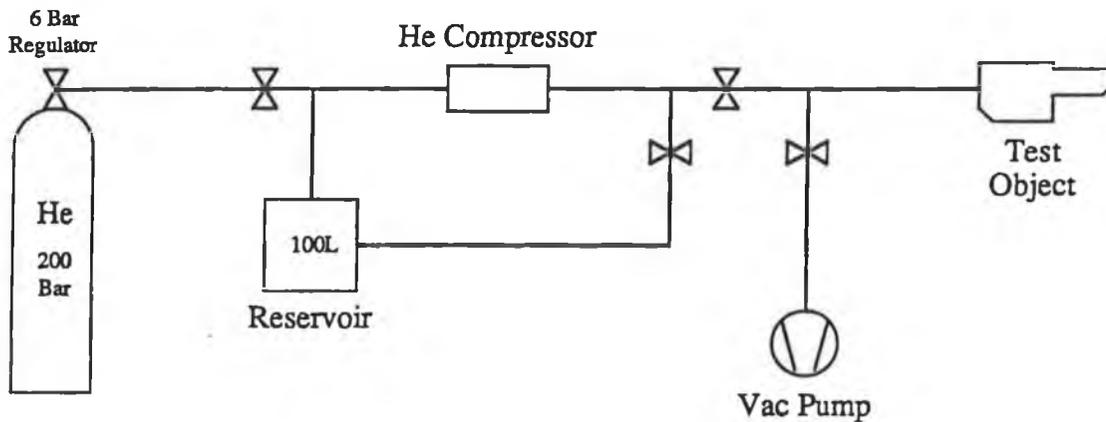


Figure 6.4 Automatic helium charging/recovery station

To this end we procured an air-receiver, to be used as a storage vessel, of 100 litres volume. This we evacuated of air, and filled with 'pure' helium. The automatic cycle then carries out the following steps:

1. Remove air from test unit (SBII) to produce a rough vacuum.

This step is not to evacuate per se, rather to ensure that when helium is introduced into the unit, it will not be diluted, and most importantly, air upstream of the helium does not prevent helium from reaching all the recesses of the tubing system.

2. Connect the helium resevoir to the test unit, which has the effect of producing a test pressure of approx. 35 psig in the unit.

This allows the operator to do a quick sniff for gross helium leaks prior to going up to full test pressure. In the event of a gross leak occuring, it will have less effect on the helium background in the atmosphere.

3. When the operator is satisfied that the unit does not have a gross leak, he signals the system to raise the helium pressure to 100psig. On reaching this pressure, the system signals having reached 100psig and allows leak sniffing, via the PortaTest II, for any period of time, until the operator is satisfied that he has thoroughly searched the unit for leaks.

4. All leaks found are logged, and repaired. Mechanical joints are simply tightened, and solder joints may be soldered only after the

pressure in the unit is reduced to atmospheric. However, as the helium search gas is inert, it allows soldering without the risk of oxidisation of tubes/joints, so saves having to fill with dry nitrogen for repairs.

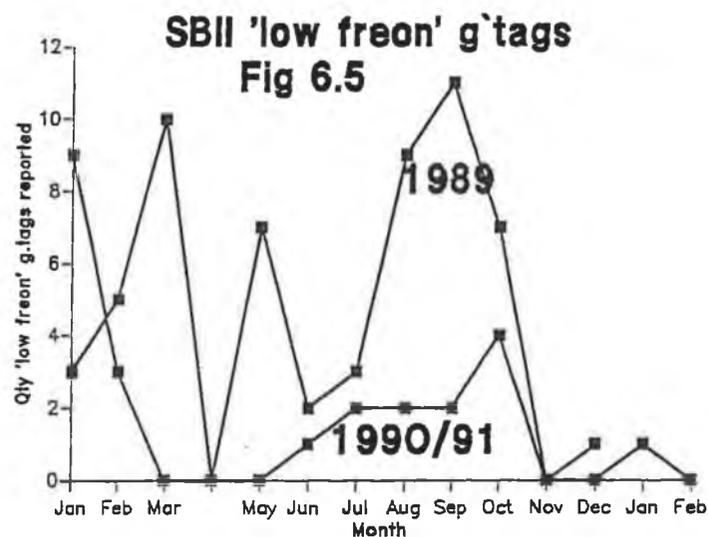
5. On completion of the sniffing cycle, the operator signals the station to recover the helium. First, it allows the unit pressure to equalize with the storage vessel pressure. When this is complete, the helium compressor removes the remaining helium from the unit and compresses it into the storage vessel. It does not recover all the helium, but returns the unit at approximately atmospheric pressure. This allows soldering repairs to be carried out safely, and results in a helium recovery rate of 15 psia/115psia or 87%, when compared to simply venting the helium after use.

6. On completion of the cycle, the system tops up its helium vessel from the helium supply line (fed from a 15 bottle pallet). This is controlled via a pressure regulator based on a timed interval. While the helium recovered from the unit will have a small amount of air in it, causing it to be diluted, the top-up of 'pure' helium tends to restore the concentration to an acceptable level. It should be remembered that working on a logarithmic scale, there is very little difference in readout between a leak releasing 100% pure helium, and the same leak releasing 80% pure helium.

6.3.4 Preliminary results.

We started using helium on our SBII line in Galway in January 1990. We experimented with it over a few months prior to this. The first most obvious improvement was the lowering of freon levels inside the plant, as shown by the freon detectors used elsewhere not showing an alarm signal as often.

The second positive result was from dealers noting a marked improvement in leaks/low charge units delivered. This was gratifying, as it takes up to 18 months to see a 'cause and effect' in warranty costs due to leaks/low charge. To quantify this, we examined the green tag returns for all SBII's for 1989/1990 (fig 6.5). There is a marked improvement, apparent from early 1990. This is consistent with January shipments of units being installed over the following months. To date the graph has stayed low. This graph is specific to SBII, and reflects the users' favourable comments on improvements seen at installation. The new tubing on the SBII did not begin in TK-E until March '90, so it would not be a contributory factor in the improvement.



6.4 Eliminating Leaks

Leaks found using helium at assembly were noted as to size, location, and frequency. Those that could be resolved in-house were fed back to the appropriate station. Where necessary, a different assembly sequence was tried. If a leak was shown to be operator-related, training was given, and if an improvement could not be achieved, the operator was moved to another station.

In some cases, swage joints were being left loose, in other cases the same joints were being over-tightened, resulting in tube damage and a leak. To resolve this, the Leak Task Force established torques for these joints.

Joints that were difficult to make were in some cases simply eliminated. This was made possible in great part due to computer-aided design (CAD) capability. In fact, long intricate tubes that resulted were only possible to manufacture by DNC-driven tube benders, driven by the same CAD drawing that designed the new tube. In this way, many joints were eliminated altogether from SBII, and this is being extended to other units.

Gasket joints could now be tested to much finer levels. A head gasket in the early stages of failure could, in some cases, be detected at the helium leak station. Three-way valves, throttling valves, and compressor problems were fed back to the TK manufacturing plant. It is noteworthy that the compressor shaft seal does not show as a frequent leak problem, irrespective of the compressor having been run or not.

Non-TK vendors of components were also included. Coils, which had had a very good record on leaks in the old system of leak detection, began to show small leaks inside the fins. Such leaks, of say 0.5oz per annum, would appear at the surface of the coil as far less, but the operator of the helium system would be aware of their presence. We went from zero rejects to up to 5/month on coils. All this was fed back to the vendor.

Areas of the unit which might be leak-tight at dispatch, but leak later were examined by the Leak Task Force. The result was the fitting of new engine mounting systems to reduce vibration, routing of tubes to lessen the likelihood of problems, and upgrading of some components. The equalizer line from the suction line to the accumulator was changed from a braided steel hose to a copper tube. The heat rod hooks, which were blamed for cutting the evaporator tubes in the past, were re-designed.

Components, such as gauges, which could be moved to a new location to minimise vibration-related failures, were resited.

Longer-term concepts, such as elimination of service valves, and of compound gauges, are under investigation, with a view to offering long-term leak warranty.

Chapter VII

Greenhouse Effect

CHAPTER VII

This chapter examines the problem of greenhouse warming, where certain gases trap IR from the sun, and prevent its re-radiation back into space. While this process is unrelated to ozone depletion, the gases which contribute to ozone depletion coincidentally behave as very good IR absorbers, contributing to a postulated atmospheric warming, which may in time have catastrophic effects on our climate and on sea levels.

The greenhouse theory was first proposed by the Swedish scientist Arrhenius in 1896. He postulated that a doubling of atmospheric CO₂ would raise earth's temperature by 5°C. He saw industrial pollution as causing this increase.

While the connection between CO₂ and actual earth temperature is not yet proven, it would be prudent to better manage output of all greenhouse gases until the matter is better understood.

Chapter 7: The Greenhouse Effect.

7.1 Introduction.

Earth has a relatively stable temperature on its surface, due to the relationship between incoming radiant energy and outgoing radiant energy. The earth's surface has an average temperature of 15.5°C, due to its atmosphere trapping heat, rather than it all re-radiating into space. Without this effect, the earth's surface would have a temperature of -18°C. Some sunlight is reflected, some absorbed by the atmosphere, and some reaches ground level. Of the energy that reaches ground level, some is converted to different wavelengths, in the IR region of the spectrum, and re-radiated to space.

The atmosphere is composed primarily of nitrogen (N₂), oxygen (O₂), argon (Ar) and carbon dioxide (CO₂). CO₂ composes 0.035% of the total, and methane (CH₄) just 0.0002%. Both these gases absorb strongly in the infra red (IR) end of the spectrum. However, their percentages are quite small, therefore their nett effect is small.

The gases which absorb infra-red radiation, and thus prevent it re-radiating into space, the so-called greenhouse gases, compose just 0.04% of the total atmosphere. Of this 0.04%, 0.035% is CO₂.

7.2 Greenhouse Warming Potential (GWP).

The remaining 0.035% is made up primarily of methane, nitrogen dioxide, tropospheric ozone, and CFCs. If we look at the table below, we can see why these minute traces of greenhouse gases are so critical. Their ability, relative to CO₂, to absorb IR, explain why they are on a par with CO₂ as regards GWP, and their atmospheric lifetime, and current rates of increase, are further causes for concern in this area.

Major Contributors to Greenhouse Warming

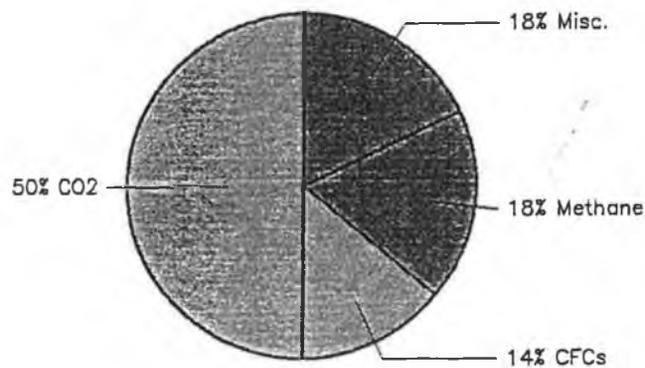


Fig 7.1

GAS	GWP	Life	Annual rise % by volume	
CO ₂	1	7yr	0.5%	0.035
CH ₄	27	10yr	1.0%	0.00017
N ₂ O	160	170yr	0.4%	0.000031
O ₃	2000	Renewed	2.0%	0.002-0.01
CFCs	10000	110yr	6.0%	0.00000006
HFC-134a	900	15yr		
HFC-152a	90	1.7yr		

7.3 Evidence to Date.

In the mid 19th century, CO₂ was circa 270ppm of the atmosphere. Today, it is 375ppm, an increase of 39%. CO₂ is produced in industrial smoke stacks, car exhausts, burning of fossil fuels, and clearing tropical forest by burning. This last item has a double detrimental effect: the forests if left intact act as a CO₂ 'sink' absorbing CO₂ from the atmosphere in normal plant growth. Clearing of forests, in what is known as 'slash & burn' farming, contributes 10⁹ tonnes/annum of CO₂ to the atmosphere. Since the industrial revolution, the CO₂ content of the atmosphere has risen by 25%.

Methane is produced by plant decay, natural gas, and livestock farming. Rice fields produce a lot of methane, however the intensive farming of cattle, particularly to satisfy the US burger market, is adding the greatest amount of methane to the atmosphere. The world cattle population has almost doubled in the last 50 years, from 700,000,000 to 1,300 million today. Atmospheric methane is now approx. 1.7ppm. Gas bubbles found in Greenland sheet ice are true samples of the atmosphere as it existed in the past. Studies show that methane levels remained steady at 700ppb from 8000 BC to the 1600s. A slow rise began from then until 100 years ago, when a rapid rise began to today's 1700 ppb. With its greenhouse strength of 0.009, this is equivalent to 51ppm CO₂. Since the beginning of the industrial revolution, methane levels in the atmosphere have doubled¹⁰.

CFCs constitute a few ppb. This is approximately 100's of times less

than the level of methane. But multiplied by its greenhouse strength of 10,000 it is of comparable size to the methane contribution.

Fig 7.1 shows the relative contributors to global warming. CO₂ is half the problem, but CFCs are almost on a par with methane. CFCs also contribute in that refrigeration efficiency has a bearing on the CO₂ output, either directly, from internal combustion engine drive, or via the use of energy from power stations using fossil fuels.

7.4 Energy Efficiency Considerations.

The importance of ensuring minimum secondary greenhouse effects cannot be ignored. For instance, if the domestic refrigerator/freezer could be made 40% more efficient (20% from improved cycle, and 20% from better insulation), it would reduce the greenhouse effect globally by 1.4%. To put this in context, if we doubled the world's car fleet energy efficiency, there would be a 3% reduction in the greenhouse effect.

Car fuel consumption will also be affected by the choice of refrigerants used in the car's air-conditioning.

The significance for the transport industry is that the fluids we intend going to, to replace CFCs, may become scarce as other user groups change fluids based on energy considerations.

Every extra kW of power needed of a diesel engine to drive a compressor, due to the choice of refrigerant causing higher energy consumption, will cause 600grms/hour of CO₂ output at the engine exhaust¹⁶.

This is the so-called secondary greenhouse effect.

Consider a 38-tonne artic running at 90km/hr, requiring 150kW to hold it speed. Typically, a large diesel produces 600g CO₂/kWh. Then this engine will produce 1000grms/km travelled. Over a distance of 1 million kilometers, this engine will produce 1000 tonnes CO₂. This has a greater greenhouse effect than losing all the refrigerant charge (typically 7 kgs per trailer unit) many times over. The answer to CO₂ from engines may be resolved through alternative fuels such as ethanol, methanol, hydrogen, amongst others. These are all very long-term proposals.

Not all observers believe gas emissions are responsible for global warming. Average global temperatures have risen by approx. 0.6'C over the past 100 years. The correlation between this rise and the CO₂ concentrations in the atmosphere is good, however an equally convincing correlation with sunspots (since the 18th century) has been established.

Further, the Milankovitch cycle, which suggest that the earth's orbit varying from circular to elliptical and back again with a cycle of 100,000 years would cause cyclical changes in climate, is also gaining credibility.

Nonetheless, it would be foolhardy to ignore the present emissions' levels as likely being a major factor in global warming.

7.5 Global plans for CO₂ Emissions Controls.

The Intergovernmental Panel on Climate Change (IPCC) is the forum in which climate change is addressed. It operates under the auspices of the UNEP and the World Meteorological Organisation.

As carbon dioxide accounts for about half of the greenhouse effect, the IPCC is attempting to reach agreement on stabilisation of CO₂ emissions no later than the year 2000, with measures to protect the tropical forests, and encourage re-afforestation. It would further wish to reduce CO₂ output by 20% by the year 2005. It is likely that 1989-1990 will be used as reference years.

To date, no global plan has been agreed. The major industrialized nations, including the USA, Canada, Japan and the United Kingdom, were reported to be openly hostile to initial proposals made at the IPCC's third plenary meeting of February, 1990.

Chapter VIII

New Fluids

CHAPTER VIII

This chapter discusses the programmes which are underway to find and evaluate replacements for CFCs, and also examines in some detail the more likely candidates currently being assessed.

Chapter 8: New Fluids.

8.1 Introduction.

Fluids to replace CFCs are now being pursued with great vigour. If we look at the split of R11/R12 useage, based on 1986 figures for Europe, we see that approximately 66% were used between foams, aerosols, and solvents, with the remaining 33% used in refrigeration. Already, the aerosols' useage of CFCs has stopped, with the exception of medical use (e.g. as asthma drug propellants), while foams may move to a mixture of R22/water, or pure R22, or CO₂. The net effect is that most of the easier applications already have alternatives.

The biggest quest is for an alternative to R12 in refrigeration systems. It is only now being seen just how perfect a solution R12 is to the refrigeration business, with its toxicity, chemical inertness, solubility, and good thermal properties. To find a suitable replacement with the same properties is proving quite difficult.

8.1.1 AFEAS

AFEAS (Alternative Fluorocarbon Environmental Acceptability Study) is a programme funded jointly by the twelve biggest chemical producers to determine the potential environmental effects of alternative fluorocarbons and their degradation products. AFEAS was initiated

in December 1988. It further sought to indentify gaps in present-day knowledge.

Its results were presented at the United Nations Environment Programme (UNEP) which met in Nairobi in August 1989, and these results were incorporated as an appendix to the Scientific Assessment under the Montreal Protocol on Substances that Deplete the Ozone Layer.

The sponsors of AFEAS are now funding the next phase of research at universities, government agencies and private laboratories. Research is being co-ordinated to compliment world-wide research, as well as the industry-sponsored Programme for Alternative Fluorocarbon Testing (PAFT).

AFEAS member companies are:

Akzo Chemicals BV (Netherlands)

Allied-Signal Inc., (USA)

Asahi Glass Co. Ltd., (Japan)

Atochem (France)

Daikin Industries Ltd., (Japan)

E.I. DuPont de Nemours & Co. Inc., (USA)

Hoechst AG (FRG)

ICI Chemicals and Polymers Ltd., (UK)

Kali-Chemie AG (FRG)

LaRoche Chemicals Inc., (USA)

Montefluos S.p.A. (Italy)

Rhone Poulenc Chemicals/ISC Division (UK)

AFEAS Admin. organisation: Science and Policy Associates Inc., (USA).

The AFEAS experts studied the proposed CFC alternatives to determine:

- o the potential of the proposed CFC alternatives to affect stratospheric ozone.
- o their potential to affect tropospheric ozone.
- o their potential to contribute to model-calculated global warming.
- o how the products degrade in the atmosphere.
- o the potential environmental effects of the degradation products in air, water and soil.

8.2 Possible Alternatives to CFCs.

The areas from which the alternatives to CFCs will most likely come are the HCFCs, and the HFCs. As explained in chapter 2, these are chemicals related to CFCs, and their chemical make-up is well-known. The problems are to identify, along with the above 5 points, their suitability as refrigerants, toxicity, oil compatibility, and ease of manufacture.

The most promising potential alternatives are the following:

Alternative	Formula	Replacing	Application
HFC 125	CHF_2CF_3	R502	Refrigerant
HFC 134a	CH_2FCF_3	R12	Refrigerant/foam blowing?
HFC 152a	CH_3CHF_2		Domestic refrigerant use
HCFC 22	CHClF_2	R12/R502	Refrigerant/foam blowing
HCFC 123	CHCl_2CF_3	R11	Foam blowing agent
HCFC 124	CHClFCF_3		
HCFC 141b	$\text{CH}_3\text{CCl}_2\text{F}$	R11	Foam blowing agent
HCFC 142b	CH_3CClF_2		
HCFC 225ca	$\text{CHCl}_2\text{CF}_2\text{CF}_3$		
HCFC 225cb	$\text{CHClFCF}_2\text{CClF}_2$		

HCFCs and HFCs Address Both Ozone Depletion and Global Warming Concerns.

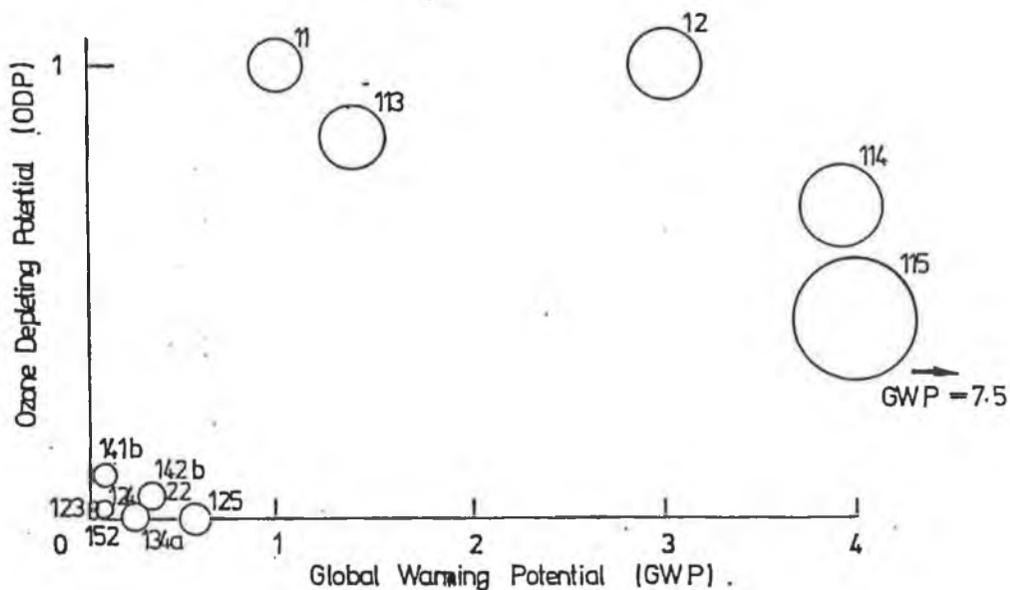


Fig 8.1: ODP & GWP for AFEAS materials.

We can rank all the current, and potential, refrigerants by ODP, GWP and atmospheric lifetime, as follows:-

Compound/ODP	Compound/Life(years)	Compound/GWP
CTC 1.1	CFC-115 400	CFC-115 7.5
CFC-12 1.0	CFC-114 200	CFC-114 4
CFC-11 1.0	CFC-12 120	CFC-12 3
CFC-113 0.8	CFC-113 90	CFC-113 1.4
CFC-114 0.7	CFC-11 60	CFC-11 1
CFC-115 0.6	CTC 50	HFC-143a 0.7
MeClf 0.15	HFC-143a 41	HFC-125 0.6
HCFC141b 0.1	HFC-125 28	HCFC142b 0.4
HCFC142b 0.06	HCFC142b 19	CTC 0.35
HCFC-22 0.05	HFC-134a 15	HCFC-22 0.35
HCFC-124 0.02	HCFC-22 15	HFC-134a 0.3
HCFC-123 0.02	HCFC141b 8	HFC-32 0.1
HFC-152a 0	HFC-32 7	HCFC-124 0.1
HFC-134a 0	HCFC-124 7	HCFC141b 0.09
HFC-125 0	MeClf 6	HCFC152a 0.03
HFC-143a 0	HFC-152a 2	MeClf 0.02
HFC-32 0	HCFC-123 2	HCFC-123 0.02

Notes MeClf: methyl chloroform CTC: carbon tetrachloride

Fig 8.2: ODP, Atmospheric lifetime, & GWP.

If we rank the best nine from best to worst in these categories, we can see:

ODP	Lifetime	GWP
32	123	123
152a	152a	MeClf
134a	MeClf	152a
125	124	141b
143a	32	124
123	141b	32
124	22	134a
22	134a	22
142b	142b	CTC/142b

A quick glance at this chart explains the US EPA's thinking behind supporting R152a as a domestic refrigerant/car air-conditioning/etc.

Figure 8.1 shows the relative ODP and GWP of current CFCs, and the various HCFCs and HFCs. From an overview, it can be seen that the proposed alternatives are all a vast improvement over CFCs.

The large circles at the top and right show the relatively large ozone depleting and global warming potentials of the CFCs. The small unshaded circles at the bottom left of the graph show the reduced ODP and GWP of the HCFCs and HFCs. The area of each circle is pro-

portional to the atmospheric lifetime of the compound.

Note: R11 is the reference compound and so has an ODP and GWP of 1.

To quote from the AFEAS group:

"All information to date suggest that the proposed substitutes are significantly better than the current CFCs relative to protection of the ozone layer. The ODPs and GWPs are much smaller than those for the CFCs, and they should not contribute to tropospheric ozone or acid rain deposition. Consequently, industry is scientifically justified in proceeding rapidly towards the commercialisation of these chemicals".

R. Watson, M. Prather, and D. Albritton

UNEP/02L.Pro.WG.II(1)CRP.1 13 Nov.1989.

8.2.1. R22

R22 is a member of the HCFC family. It should thus always be borne in mind that it is NOT a CFC. It is not included in the original lists of substances under the Montreal Protocol. At present (Nov 90) it is the only freely available refrigerant with a reasonable future. Under German legislation (see appendix page A83,) R22 was granted a stay in the transport business, which allows its use in new equipment up to the end of the century. German legislation is currently the driving force in the European scene, much as Californian legislation would be seen as the most progressive in the U.S.A.

R22 is a known quantity: while there are problems in using it in transport refrigeration, at least all the problems are well-understood. Its theoretical capacities should place it above those of R12 and R500. It would be less than R502 on most applications, but could equal R502 at low box temperatures. In practice this is unlikely for the following reasons.

The greatest obstacle to its use is the high discharge temperatures which can occur, particularly at low box temperatures. While R502 may reach 160'C, R22 can go as high as 200'C. This has two detrimental effects:

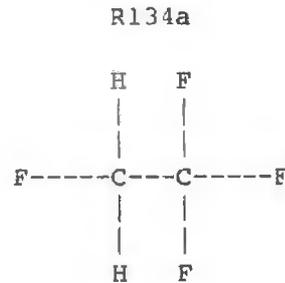
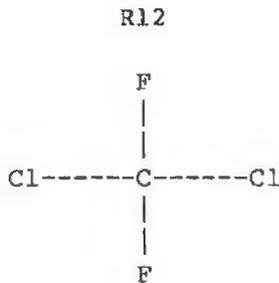
- i. damage to lubricating oil in compressor.
- ii. damage to compressor discharge valves.

The question of high discharge temperatures is handled in stationary refrigeration applications by the use of water-cooled heads. For very low temperature applications, two-stage compressors are used. These are costly and bulky for transport use. The solution in transport applications is a combination of the following:

- i. remove heat-exchanger from circuit.
- ii. insulate suction line, to reduce superheating.
- iii. increase condensing capacity, to lower discharge pressure/temp.
- iv. liquid injection of the compressor, controlled by the disch. temp. This is likely to significantly reduce capacity at low box temperatures.

8.2.2. R134a

If we compare R134a with R12, we find the following structure:



120.9	Molecular weights	102.0
1.0	ODP	0.0
3.0	GWP	0.28

Note: it must be pointed out here that the GWP of 0.28 for R134a is considered to be unacceptably high for long-term use, in particular by the State of California EPA.

Among the problems with using R134a are the following¹²:

- o as the R134a molecule has no F-Cl structure, it results in higher frictional properties.
- o it reacts with aluminium to cause corrosion, thereby having higher requirements of lubricating oils.
- o insoluble in current refrigerant oils, therefore requiring

special oils to be developed.

o the additional H atoms give it higher polarity, and increased water solubility, requiring the development of special hoses on automotive applications.

Various tests carried out by different manufacturers suggest that R134a will perform within 5% of R12, across the same temperature range in which we currently use R12.

R134a still has a year of PAFT testing to complete.

ICI UK are currently operating an R134a small-scale production plant at Runcorn, U.K. with a second larger plant due on-line at St.Gabriel, USA in 1992. DuPont completed their first R134a plant in Sept, 1990 at Corpus Christi, Texas, USA. DuPont are also looking at Dordrecht, and Japan as possible further R134a production sites.

8.2.2.1 R134a Lubrication⁸

R134a is not compatible with current refrigeration oils. It does not dissolve correctly for use in a refrigeration cct. To satisfy this requirement, polyalkylglycol (PAG) oils were examined. These oils have been used widely as brake fluid, since the 1950's. While they resolve the question of solubility, they are very hygroscopic. If water does get into a PAG-oiled R134a system, it encourages chemical reactions which tend to copper-plate the discharge valves (or other hot areas). The same reaction will occur if free chlorine exists in the system. Bringing R134a/PAG units to market would require a major plan to ensure that:

- (a) no moisture entered the system during operation/servicing. This would require careful training of mechanics, new procedures to ensure a new dryer was used when necessary.
- (b) no chlorine was introduced into the system. This would most likely come from contamination of service equipment with CFCs. The solution here may be to use unique fittings to handle R134a and PAG oils.

A second family of oils, the esters, are holding more hope as the solution to this problem, possibly allowing retrofitting to R12 systems. Ansells UK (beer coolers) advise that Castrol's Icematic SW32 can be used to allow R134a be retrofitted into an R12 system. The system is first flushed with Icematic SW32, then it is also used as a lubricant for the R134a.

A third family of oils, the amides, are also being examined, to address the problems posed by PAGs.

8.2.2.2 R134a Elastomer Compatability

In the appendix can be found a DuPont publication on the elastomer compatability requirements for R134a (see appendix page A123), and a Material Safety Data Sheet (MSDS) on pg A115.

8.2.3. R123

As R11 is no longer used in much of the Western world as a refrigerant, a replacement has not been sought with the same vigour as for R12. The most suitable appears to be R123 (CHCl_2CF_3), ODP 0.05, about the same as R22, and its GWP is less than 0.1. It is non-flammable, and should cost less than R134a. It is likely to be used in foaming, where its biggest contribution would be the continued availability of good quality thermal insulation.

DuPont planned to bring their Maitland, Oregon, Canada plant on-stream late in 1990.

8.2.4. R125

R125 (CHF_2CF_3) has a boiling point of -48.5°C , so may be a possible R502 alternative. Little has been done in pursuing this as initially R502's ODP of 0.3 was thought low enough to not be a problem under the initial Montreal Protocol. There has been no effort to make R125 commercially available. DuPont initiated a programme January 1989, but it is unlikely to be available before 1994. A MSDS for R125 is included in the appendix on page A118.

8.2.5. R142b

Has a low order of acute toxicity. There is little record of its use as a refrigerant, except in an R22/R142b mix from Pennwalt, from some years ago, and since withdrawn from the market.

8.2.6. R143a

Another possible R502 replacement, R143a (CH_3CF_3) has a boiling point of -47.6°C . No work has been done to commercialise it, and it is reported to be flammable.

8.2.7. R152a

HCFC-152a is strongly touted as a domestic refrigerant by the USA EPA, despite it being flammable. This is based on its reduced secondary GWP, along with low GWP, zero ODP and very short atmospheric lifetime. As a 26% component of R500, it is available in quantity.

8.2.8. Ternary Blend.

Developed by DuPont, this is composed of HCFC-22, HFC-152a, and HCFC-124. It has the advantage that it may be used with conventional lubricants, but HCFC-124 is in short supply, and still has extensive toxicity testing to complete. It is also being pushed as a domestic refrigerant. It is not an azeotrope, but described by DuPont as a near-azeotrope.

There are two blends available: 9439 and 9466. The latter shows the most promise as an R12 drop-in replacement for our business, given the range of temperatures we work across. It still has approximately three years of PAFT testing to complete, but received TOSCA* listing early in 1991, allowing it be offered for sale in the USA. It should remain cheaper than R134a.

Tests in respect of repeated leakage, and topping up with new material, suggest that the mixture ratio does not cause it to move into a flammable range. It settles at approximately 85% of its original effectiveness as a refrigerant. It requires alkyl benzene oil.

9439 = 50% R22/20% R152a/30% R124.

9466 = 60% R22/15% R152a/25% R124.

Flammability occurs if the R152a component exceeds 23% (Source:DuPont).

*TOSCA: TOxicity Substances Control Act.

8.2.9. Starton 69 (Isceon 69S).

A possible R502 short-term drop-in replacement with ODP less than R22. Developed jointly by Rhone Poulenc Chemicals of Bristol - formerly the ISC Chemicals Division of RTZ - and Star Refrigeration, it is made from R22, propane (R290) and perfluoropropane (R218). According to the makers the hazardous properties of the propane are neutralized in the mixture, so giving a more or less constant boiling mixture, non-flammable and non-toxic. It is said to have refrigerating capacities similar to R502, but with higher discharge temperatures, and higher efficiency. It may also be a possible R22 alternative where discharge temps are a problem, the new mixture giving lower temps than R22. Its ODP is 0.0425, less than R22, due to the diluting effects of the other components.

8.3. Lubrication.

The requirements of an oil in a refrigeration system are primarily:

- o reduce friction
- o assist in preventing welding between surface asperities
- o primary coolant in the compressor for bearings, pistons, etc.
- o sealant between high- and low-pressure areas
- o prevention of corrosion

PAGs, esters, and amides each possess the range of R134a solubility, viscosity, and thermal stability necessary to merit their examination as compressor lubricants. Additives may be required in any or all of these oils to ensure good compressor life.

It is interesting to note that R12 itself behaves as an additive for mineral oils. Mineral oils on their own would probably be a poor lubricant, were it not for this effect⁹.

8.3.1 Solubility

To ensure lubricant can reach all the parts of a system properly, the oil is required to be able to dissolve the refrigerant. This will ensure oil reaches the exp valve, for instance. However, as the evaporator temperature drops, the ability of the gas flow to return the oil to the compressor lessens. As the evaporator temperature drops, the oil vapour condenses in the evap tubes, forming an insulating layer, and trapping the compressor oil. In severe circumstances, it may get to the point where there is a serious oil shortage in the compressor. Thus the conflicting requirements of oil/refrigerant solubility and the need

to maintain a minimum oil quantity in the compressor must be addressed in any solution. This may partly be handled by an oil separator on the compressor discharge. This question of oil solubility is the reason for looking at new oil types for R134a, as it does not dissolve in mineral oil. Poor oil return at low evaporator temperatures when using esters is the primary reason for concentrating on PAGs at present.

8.4 Costs.

Oil costs are still unavailable, as the oils themselves are still under development. However, it seems likely the new oils will be many times the cost of the present lubricants.

Chapter IX

Foams/Insulation

CHAPTER IX

This chapter discusses the use of CFCs as thermal insulators in foams. It looks at the need for foams, why CFCs are used in their manufacture, the detrimental effect lower thermal insulating gases would have on the greenhouse effect, and some of the methods by which the ozone depletion of these foams can and is being improved.

Foams.

9.1. The Need for Foams.

The efficient control of temperatures in trucks, trailers and containers depends heavily on the thermal insulation of the walls of the box. Rll, trapped in the bubbles of polyurethane foam, has given an excellent solution to the problem, from the points of view of thermodynamics, toxicity, structural strength, and flammability. With the advent of the ozone problem, Rll has a limited lifespan remaining. Any new solutions for this application will not only have to meet the above criteria, but also the ODP problem, the direct GWP problem, and last but certainly not least, the indirect GWP contribution. By this is meant the added energy which may need to be dissipated by the engine/motor of the refrigeration system to maintain the box temperature with the newer proposed foams. The more frequent running of the diesel engine contributes directly to the greenhouse effect by the emission of CO₂, or via the electricity generating station in the case of an electric-driven compressor.

Trailer wall insulation is measured, in Europe, in watts per sq.m. per °C, i.e. the number of watts that will traverse a square metre of wall for a 1°C temperature difference across the wall. In practice, an average figure is calculated for the trailer as a whole, to allow

for poor insulation, such as at steel door-frames, and good insulation on uninterrupted wall sections.

From the average figure, we multiply by the total surface area of the box (defined as the geometric mean of the inner and outer surfaces of the walls), and get a refrigeration requirement per °C for the box.

In order to meet FRC requirements, to allow the carriage of goods at -20°C, in a 30°C ambient, we multiply the above by 50°C, to give a total theoretical cooling requirement. On to this we add either:

35% safety factor, if the refrigeration system is certified with the box,

75% safety factor, if the refrigeration system is certified independently of the box.

Finally, FRC requirements are a maximum K-value ($W/m^2 \cdot ^\circ C$) of 0.4. If we look at how this applies to a 40ft trailer in Europe, then With an average surface area of $150m^2$, typically we need:

$$0.4W/m^2 \cdot ^\circ C \times 150m^2 \times 50^\circ C = 3000W, \text{ for } -20^\circ C/30^\circ C$$

plus 35% = 4050W for joint certification

or 75% = 5250W for separate certification

If a trailer is tested in conjunction with the unit, the actual trailer

K-value is taken into account, rather than the theoretical maximum of 0.4. Thus, a true 0.32 trailer would further reduce the cooling capacity requirements:

$$0.32\text{W/m}^2 \cdot \text{C} \times 150\text{m}^2 \times 50\text{C} = 2400\text{W, for } -20\text{C}/30\text{C}$$

plus 35% = 3240W for joint certification

In practice this limits the certificate to that series of trailer, so is rarely used as it would lead to a large number of individual tests having to be done to cover the trailers available in the market.

9.2 Foam and CFCs.

Rigid polyurethane foam blown with CFC-11 is the primary material currently used to insulate trailers. Along with its insulating properties it has excellent structural strength¹³. It also has self-adhesive properties which make it useful with a number of construction materials, including aluminium and fibreglass-reinforced plastic.

The three basic components of polyurethane foam are:

an isocyanate

a polyol

a blowing agent (CFC-11).

The isocyanate and polyol are mixed and react exothermically. The heat resulting causes the CFC-11 to boil, forming bubbles which froth the polyol/isocyanate mixture. The reacting mixtures polymerizes, trapping

the blowing agent in the resulting closed-cell structure¹⁴. The closed-cell structure retains, in theory, the CFC-11 in the foam. In practice, some CFC-11 is lost at the time of blowing. Further, if for any reason the foam is cut (as might be for assembling in block form) then further CFC-11 will escape.

If we look at the figures for the manufacture of a 20ft insulated container, we see:

- i. each container requires 35kgs (77lbs) of R11.
- ii. about 2kg (4.4lbs) of the R11 is lost during foaming.

We should relate these figures to an average 6.5kgs (14.3lbs) of R12 in the refrigeration system, of which almost nothing is lost during assembly of the refrigeration unit. As against this, the total world consumption for refrigerated containers alone (not including trucks and trailers) amounted to 2275 tonnes of R11 for 1989, with 130 tonnes lost during manufacture. This is more than the total consumption by TK-E, of which almost none is lost!

The foam in European trailers continues to use CFCs, but some users are switching to sealed blocks of foam, which are less prone to losing their CFC content. Their concerns are primarily those of losing thermal insulation in the walls of the trailer. The present legislation for FRC certification (to carry food at -20°C in a 30°C ambient) calls for an average wall insulation of $0.4\text{W/m}^2/^\circ\text{C}$ maximum. In practice, most European body-builders exceed this, with K-values as low as $0.29\text{W/m}^2/^\circ\text{C}$. The effect these numbers have on fuel consumption in

the refrigeration unit is cited as part of the reason why almost no bodybuilders have gone away from CFCs.

The bodybuilders point out that they don't build the foam panels (in fact some who claimed not to, actually do), so the problem/solution is not theirs directly.

9.3 Clean-up of present Foams.

The German government is planning that from early next year all new CFC foam supplied will have to be recycled by its manufacturer at the end of its life.

9.4 Interim Low-ODP Foams.

The following solutions to reducing ODP of foams are either currently available, or are being laboratory-tested. They are based largely on existing technology.

9.4.1 R11/CO₂ foam.

According to ICI Polyurethanes Belgium (Mike Jeffs), good foam can be manufactured with up to 50% of the R11 being replaced by CO₂. This is achieved by adding water to the foam system blend. The water reacts with the isocyanate during foaming to generate CO₂.

While laboratory measurements suggested that CO₂-blown foam has a lower thermal insulating effect than foam blown with 100% R11, in

practice tests have shown the R11/CO₂ foam to be significantly better than laboratory projections. This is due to improvements in overall foam structure.

9.4.2 R22/CO₂ foam. (NDT-906S)

This type of foam is interesting in that it contains no CFCs. It is currently standard throughout TK-E as a foaming method for bulkheads. It uses HCFC-22 (R22) and CO₂, generated as before through the addition of water to the mix.

It remains to be seen how long it will be allowed to be used, but at present it is a very big step forward in the road to eliminating CFCs.

The mixture has an ODP of approximately 0.03, compared to R11 at 1.0. Its physical properties are equal to those of R11-blown foams. The biggest problem it suffers from is its 20% poorer insulation value, as compared to R11-blown foams. This extra cooling/heating requirement in an insulated container will cause longer running cycles in the refrigeration system, contributing to the greenhouse effect indirectly.

9.4.3 R123

R123 is under investigation as an alternative to R11 as a foam blowing agent. It compares with R11 as follows:

	CFC-11	HCFC-123
Boiling point('C)	23.8	28.0
Molecular weight	137.4	152.9
Thermal conductivity (BTu.in/ft ² .h.'F	0.0045	0.0054
Flammable	No	No
Toxicity	Low	Incomplete
ODP	1.0	0.02
GWP	1.0	<0.1

If we compare foams blown with R123 versus R11, we find:

K-factor	7% higher than R11
Density	8% higher than R11
Required amount of blowing agent	11% more than R11
Demould time	same
Compressive strength	same

We can see that the higher vapour thermal conductivity is contributing to the 7% higher thermal conductivity of the resulting foam, as against CFC-11. This 7% higher thermal conductivity results in 3-4% increase in energy consumption in trials using MDI (diphenylmethane di-isocyanate) polyurethane foam, the most common domestic insulating foam. Due to the different molecular weight, 11% more HCFC-123 is required by weight than CFC-11.

Thus, the overall ODP contribution is 0.22 compared to R11, the GWP is <0.1 compared to R11, and there would be an increase of 3-4% in indirect greenhouse emissions, assuming a straight comparison.

9.4.4. R141b

R141b is under investigation as an alternative to R11 as a foam blowing agent. It compares with R11 as follows:

	CFC-11	HCFC-141b
Boiling point('C)	23.8	32.0
Molecular weight	137.4	117.0
Thermal conductivity (BTu.in/ft ² .h.'F	0.0045	0.0053
Flammable	No	Yes
Toxicity	Low	Incomplete*
ODP	1.0	0.1
GWP	1.0	<0.1

* weak mutagen in Ames Test.

If we compare foams blown with r141b versus R11, we find:

K-factor	7% higher than R11
Density	8% higher than R11
Required amount of blowing agent	15% less than R11

Demould time same

Compressive strength same

We can see that the higher vapour thermal conductivity is contributing to the 7% higher thermal conductivity of the resulting foam, as against CFC-11. This 7% higher thermal conductivity results in 3-4% increase in energy consumption in trials using MDI (diphenylmethane di-isocyanate) polyurethane foam, the most common domestic insulating foam. Due to the different molecular weight, 15% less HCFC-141b is required by weight than CFC-11.

Thus, the overall ODP contribution is 0.065 compared to R11, the GWP is <0.1 compared to R11, and there would be an increase of 3-4% in indirect greenhouse emissions.

While standard equipment has been used to foam using R141b, for proper commercial use, equipment may have to be flame-proofed, due to R141b being flammable.

9.5 Long-term zero ODP foams.

9.5.1 CO₂ blown foam.

Schmitz, body builders in Germany have worked with CO₂. They point out that the foam must be enclosed in a vapour-proof metal skin, both inside and out. The resulting panels are about 15% less than R11 in thermal insulation.

Such panels must be glued or welded together, as bolts and rivets allow CO₂ escape from the sealed panel. Any such leaks would reduce the effectiveness of the panel still further.

There have been attempts to use R134a as a foam-blowing agent, and there are also attempts to introduce vacuum panels for insulation. Neither of these methods has progressed very far at the time of writing. The integrity of vacuum panels would be a major engineering challenge for the designers to allow them be used in transport refrigeration.

We have seen that foams were a major contribution to the release of CFC to the atmosphere, and that existing foam is a major store of CFCs. German legislation is planning to force foam manufacturers to be responsible for de-commissioning foam panels at the end of their life.

Any moves to lower ODP/GWP blowing agents must also consider the effects these changes would have on energy consumption, and thereby the secondary greenhouse effect via fossil fuels consumption.

Chapter X

Recommendations

CHAPTER X

This chapter outlines the positive steps Thermo King has taken to minimise our total basket ODP. In doing this, we should be mindful of our other main responsibility: to carry, safely and reliably, the foods and other goods through the cold chain.

It also proposes the short-term and long-term steps which we should consider taking to ensure our position as the world leader in transport temperature control.

Chapter 10: Recommendations.

10.1 Thermo King Design Advantage

Thermo King refrigeration systems are inherently a more efficient design than those of our main competitor, Carrier Transicold. For instance, our SBII unit has a charge of 7.2kg, whereas a EuroPhoenix has a charge of 13.2kgs. We should thus always consider the total ODP of a particular system, i.e. the product of the charge weight by the ODP of the refrigerant.

10.2 In-house CFC management.

In the last eighteen months, Thermo King has taken a number of steps to greatly reduce the useage of CFCs in-house.

A major programme was undertaken to eliminate losses in-house, by installing refrigerant recovery systems in all unit test areas, and thus ensuring that no charge need be dumped.

The second big step was the introduction of helium as a leak search gas, in place of the traditional R12/nitrogen mix. Thus, no longer would CFCs be filled into a unit which had not already been leak-tested. (See ch.6). Further, the leak tightness of all units was far greater than could heretofore be assured.

Thirdly, all CFC hoses were fitted with double-ended Schraeder valves. This means that even the CFCs in the hoses are not lost after charging is complete. While the amounts are small, the elimination of losses at every opportunity has been taken.

10.3 Planning for the Future.

For Thermo King, the three refrigerants R12, R500, & R502 have a short lifespan remaining, on the strength of the current Protocol. Their demise is likely to be accelerated based on current thinking to be applied to the mid-1991 review of the Protocol. There is a likelihood that R134a can be made a drop-in replacement for R12, but much work remains on its special lubrication requirements. More importantly, some sources suggest that R134a may be only an interim solution, as its direct and indirect GWP are unacceptably high. The so-called third generation refrigerants are intended to answer this concern.

This then begs the question what happens to the equipment which is currently being produced, and which will be produced in the next few years, based on R12/R502? This equipment has a potential working life of at least 10 years. But typically, half way through its lifespan, refrigerant for these units will be either prohibitively expensive, or simply unavailable.

What is required, at least to bridge this gap between present units

reaching the end of their lives and the whole population of transport units having been converted to HFCs, is a working fluid which can be retrofitted (perhaps with some modifications), and which is compatible with present-day lubricants. Further this fluid must not be among those listed in the Montreal Protocol. A strong contender has to be HCFC-22. Many agencies have gone to great effort to stress that HCFC-22 must be seen as part of the solution, and not part of the problem. Seven of the ten compounds on the AFEAS list (Ch 8) are HCFCs.

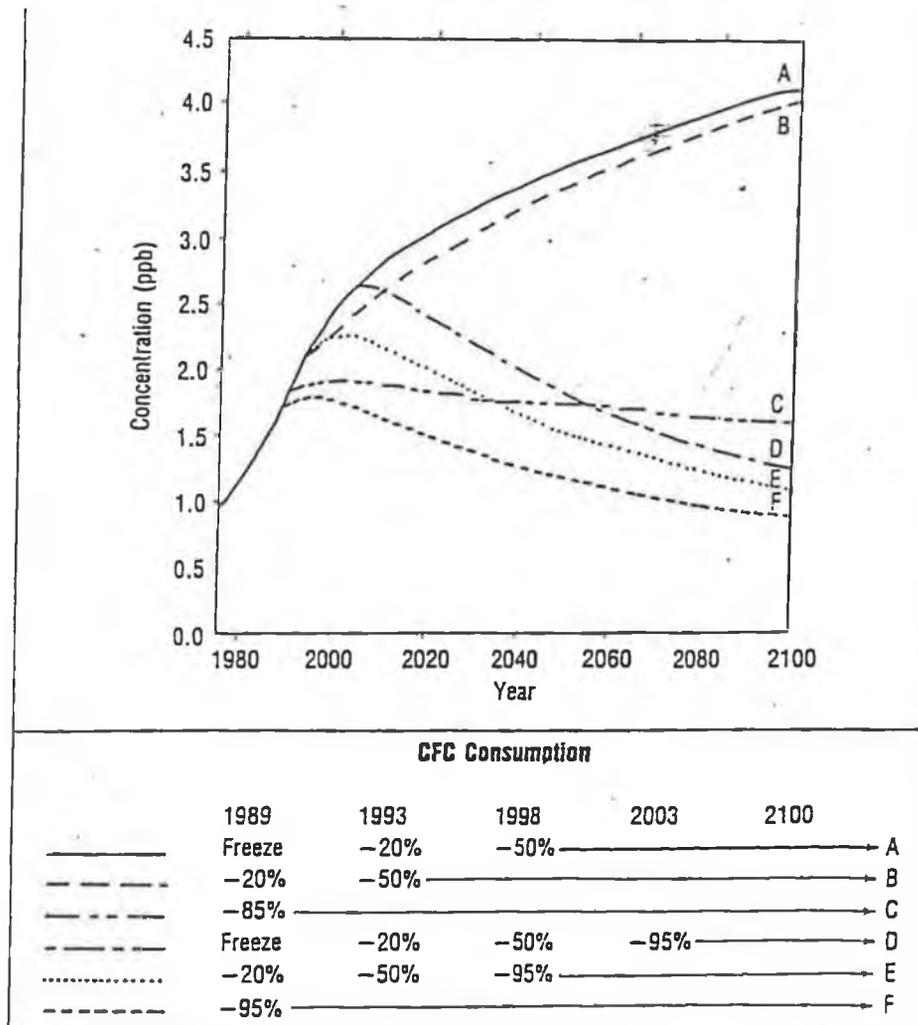


Fig 10.1 Chlorine Reduction Scenarios (Source: DuPont)

If we look at the current predictions for chlorine levels, versus the various scenarios under consideration, we can see that following curve E (fig 10.1) on the following graph, ozone recovery rates will not be reduced (delayed), but current equipment could have an extended life. This would be further improved upon with HCFC22's ODP of just 0.05.

In conclusion, we must investigate the use of R22, and/or R22 blends, as an interim solution to CFC legislation worldwide. In addressing ODP, we must also take stock of the direct GWP of any refrigerant we consider, and further we should look at the secondary greenhouse warming effect, via the diesel engine, of our candidates.

For present units, we should consider offering an R22 retro-fit pack, to at least reassure the market, until an R502 drop-in replacement becomes available. DuPont's will not be available until 1994.

For new units, we should investigate the total effect of using the unit, over its estimated lifetime, on the environment. We could develop a model which accurately describes the ODP, the GWP, and secondary greenhouse warming, of each unit with any interim or longterm refrigerants, across a typical range of load/ambient temperatures, and projected for the life of the unit. Along with efficient low/zero ODP refrigerants, we could then also project the advantages of Cycle Sentry, efficient engine designs, and show the total environmental impact advantage of using a Thermo King refrigeration system over any other.

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Appendix

MONTREAL PROTOCOL ON
SUBSTANCES THAT DEplete THE OZONE LAYER

FINAL ACT

1987

FINAL ACT

1. The Conference of Plenipotentiaries on the Protocol on Chlorofluorocarbons to the Vienna Convention for the Protection of the Ozone Layer was convened by the Executive Director of the United Nations Environment Programme (UNEP) pursuant to decision 13/18 adopted by the Governing Council of UNEP on 23 May 1985.
2. The Conference met at the Headquarters of the International Civil Aviation Organization, Montreal, with the kind support of the Government of Canada, from 14 to 16 September 1987.
3. All States were invited to participate in the Conference. The following States accepted the invitation and participated in the Conference:

Algeria, Argentina, Australia, Austria, Belgium, Brazil, Burkina Faso, Byelorussian Soviet Socialist Republic, Canada, Chile, China, Colombia, Congo, Costa Rica, Czechoslovakia, Denmark, Democratic Yemen, Egypt, Finland, France, Germany, Federal Republic of, Ghana, Greece, Indonesia, Israel, Italy, Japan, Kenya, Korea, Republic of, Luxembourg, Malaysia, Mauritius, Mexico, Morocco, Netherlands, New Zealand, Nigeria, Norway, Panama, Peru, Philippines, Portugal, Senegal, Spain, Sweden, Switzerland, Thailand, Togo, Tunisia, Uganda, Ukrainian Soviet Socialist Republic, Union of Soviet Socialist Republics, United Kingdom of Great Britain and Northern Ireland, United States of America, Venezuela.
4. The European Economic Community also participated.
5. Observers from the following States attended the proceedings of the Conference:

Dominican Republic, Ecuador, Hungary, India, Kuwait, Poland.

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6. Observers from the following United Nations bodies, specialized agencies, intergovernmental and non-governmental organizations also attended the Conference:

World Meteorological Organization (WMO), General Agreement on Tariffs and Trade (GATT), International Civil Aviation Organization (ICAO), Organization of African Unity (OAU), Council of the European Communities (CEC), Organization for Economic Co-operation and Development (OECD), International Chamber of Commerce (ICC), Federation of European Aerosol Associations, European Chemical Industry Federation, Chemical Manufacturers Association, Natural Resources Defense Council, World Resources Institute, Environmental Defense Fund, Greenpeace, Friends of the Earth, Seattle Foundation (Canada), Mammouth International Humanitarian Societies Square Projects Inc. (Canada), Watto Laboratories International (Canada), Dr. F.A. Homonnay and Associates (Canada), International Organization of Automobile Manufacturers, Alliance for Responsible CFC Policy, Air-Conditioning and Refrigeration Institute (USA), Environmental Protection Agency (USA), Institute for European Environment Policy, National Fire Protection Association, Dupont Canada, The Beloff Group (Canada), Produits Chimiques Allied Canada Inc., United States Air Force.

7. The Conference was formally opened by Dr. Mostafa K. Tolba, the Executive Director of UNEP. In the course of the inaugural ceremony, the Conference heard a welcoming address by the Honourable Tom McMillan, P.C., M.P., Minister of the Environment, on behalf of the Government of Canada.

8. Dr. Mostafa K. Tolba served as Secretary-General of the Conference and Dr. Iwona Rummel-Bulska (UNEP) served as Executive Secretary.

9. The Conference unanimously elected Ambassador W. Lang (Austria) as its President.

10. The Conference also elected the following officers:

Vice-Presidents: Ambassador E. Hawas (Egypt)
 Dr. V. Zakharov (Union of Soviet Socialist Republics)

Rapporteur: Mr. C.R. Roque (Philippines)

11. The Conference adopted the following agenda:

1. Opening of the Conference.

2. Organizational matters:

- (a) Adoption of the rules of procedures;
- (b) Election of the President;
- (c) Election of Vice-Presidents and Rapporteur;
- (d) Adoption of the agenda;
- (e) Appointment of the members of the Credentials Committee;
- (f) Appointment of the members of the Drafting Committee;
- (g) Organization of the work of the Conference.

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3. Consideration of the draft Protocol to the Vienna Convention for the Protection of the Ozone Layer.
4. Report of the Credentials Committee.
5. Adoption of the Protocol to the Vienna Convention for the Protection of the Ozone Layer.
6. Adoption of the Final Act of the Conference.
7. Signature of final instruments.
8. Closure of the Conference.

12. The Conference adopted as its rules of procedure document UNEP/IG.79/2 proposed by the secretariat.

13. In conformity with the rules of procedure, the Conference established the following Committees:

Committee of the Whole:

Chairman: The President of the Conference

General Committee:

Chairman: The President of the Conference

Members: The Vice-Presidents of the Conference, the Rapporteur and the Chairman of the Drafting Committee

Drafting Committee:

Chairman: Mr. Jon J. Allen (Canada)

Members: Argentina
Australia
France
Japan
United Kingdom
United States

Credentials Committee:

Chairman: Ambassador Jose M. Bustani (Brazil)

Members: Finland
Germany, Federal Republic of
Indonesia
Kenya
Mexico
Norway

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14. The main documents which served as the basis for the deliberations of the Conference were:

- Seventh Revised Draft Protocol on [Chlorofluorocarbons] [and Other Ozone Depleting Substances], UNEP/IG.93/3 and Rev. 1;
- Reports of the Ad Hoc Working Group of Legal and Technical Experts for the Elaboration of a Protocol on Chlorofluorocarbons to the Vienna Convention for the Protection of the Ozone Layer (Vienna Group), UNEP/WG.151/L.4, UNEP/WG.167/2 and UNEP/WG.172/2.

15. In addition, the Conference had before it a number of other documents that were made available to it by the Secretariat of UNEP.

16. The Conference approved the recommendation of its Credentials Committee that the credentials of the representatives of the participating States as listed in paragraph 3 should be recognized as being in order.

17. On the basis of the deliberations of the Committee of the Whole, the Conference, on 16 September 1987, adopted the Montreal Protocol on Substances that Deplete the Ozone Layer. The Protocol, which is appended to this Final Act, will be open for signature at the Ministry for External Affairs of Canada in Ottawa from

17 September 1987 to 16 January 1988 and at the United Nations Headquarters in New York from 17 January 1988 to 15 September 1988.

18. The Conference also adopted the following resolutions which are appended to this Final Act:

1. Resolution on the Montreal Protocol.
2. Resolution on the exchange of technical information.
3. Resolution on the reporting of data.
4. Tribute to the Government of Canada.

IN WITNESS WHEREOF the representatives have signed this Final Act.

DONE at Montreal, this sixteenth day of September one thousand nine hundred and eighty seven in one original in the Arabic, Chinese, English, French, Russian and Spanish languages, each language version being equally authentic. The original text will be deposited with the Secretary-General of the United Nations.

1. RESOLUTION ON THE MONTREAL PROTOCOL

The Conference,

Having adopted the Montreal Protocol on Substances that Deplete the Ozone Layer,

Noting with appreciation that the Protocol was opened for signature in Montreal on 16 September 1987,

Recalling the Vienna Convention for the Protection of the Ozone Layer, adopted on 22 March 1985,

Bearing in mind the Resolution of the Conference of Plenipotentiaries on the Protection of the Ozone Layer adopted on the same day which urged in the sixth operative paragraph "all States and regional economic integration organizations, pending entry into force of a protocol, to control their emissions of CFCs, inter alia in aerosols, by any means at their disposal, including controls on production or use, to the maximum extent practicable",

1. Calls upon all States and regional economic integration organizations that have not yet done so to implement the sixth paragraph, bearing in mind the special situation of the developing countries;
2. Appeals to all States to become Parties to the Vienna Convention for the Protection of the Ozone Layer;
3. Urges all States and regional economic integration organizations, including those that have not participated in this Conference, to sign and become Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer;
4. Requests the Executive Director of the United Nations Environment Programme to forward this Resolution to the Secretary General of the United Nations and to circulate it to all States and regional economic integration organizations.

2. RESOLUTION ON THE EXCHANGE OF TECHNICAL INFORMATION

The Conference,

Having adopted the Montreal Protocol on Substances that Deplete the Ozone Layer,

Realizing the importance of reducing as quickly as possible the emissions of these substances,

Recognizing the need for an early exchange of information on technologies and strategies to achieve this,

1. Requests the Executive Director of the United Nations Environment Programme (UNEP), pending the first meeting of the Parties, to make appropriate arrangements to facilitate the exchange of information on technology referred to in Articles 9 and 10 of the Protocol;
2. Appeals to interested States and regional economic integration organizations to sponsor, at the earliest opportunity, in cooperation with UNEP, a workshop with the aim of:
 - (a) exchanging information on technologies and administrative strategies for reducing emissions of the substances listed in Annex A to the Protocol and for developing alternatives, taking into account paragraph 2 of Annex II to the Vienna Convention for the Protection of the Ozone Layer; and
 - (b) identifying areas in which further research and technical development are required,
3. Urges all interested parties to participate in and contribute to such a workshop and to make expeditious use of the information so gained in order to reduce the emissions of those substances and to develop alternatives.

3. RESOLUTION ON REPORTING OF DATA

The Conference,

Having adopted the Montreal Protocol on Substances that Deplete the Ozone Layer,

Convinced that the timely reporting of complete and accurate data on the production and consumption of controlled substances is critical to the effective and efficient implementation of this Protocol,

1. Calls upon all Signatories to take, expeditiously, all steps necessary to acquire data and report on the production, import and export of controlled substances in a complete and timely fashion in accordance with Article 7 of the Protocol and taking into account paragraph 1 of Article 4 of the Vienna Convention for the Protection of the Ozone Layer;
2. Invites Signatories to consult with other Signatories, and to seek advice and assistance from the United Nations Environment Programme (UNEP) and other relevant international organizations, as necessary, in designing and implementing data reporting systems;
3. Calls upon the Executive Director of UNEP to convene, within six months of the adoption of this Resolution, a meeting of governmental experts with the assistance of experts from relevant international organizations to make recommendations for the harmonization of data on production, imports and exports to ensure consistency and comparability of data on controlled substances.

4. TRIBUTE TO THE GOVERNMENT OF CANADA

The Conference,

Having met in Montreal from 14 to 16 September 1987 at the gracious invitation of the Government of Canada,

Convinced that the efforts made by the Government of Canada and by the civic authorities of Montreal in providing facilities, premises and other resources contributed significantly to the smooth conduct of its proceedings,

Deeply appreciative of the courtesy and hospitality extended by the Government of Canada and the City of Montreal to the members of the delegations, observers and the secretariat attending the Conference,

Expresses its sincere gratitude to the Government of Canada, to the authorities of Montreal and, through them, to the Canadian people and in particular to the population of Montreal for the cordial welcome which they accorded to the Conference and to those associated with its work and for their contribution to the success of the Conference.

MONTREAL PROTOCOL ON SUBSTANCES THAT DEplete THE OZONE LAYER

The Parties to this Protocol,

Being Parties to the Vienna Convention for the Protection of the Ozone Layer,

Mindful of their obligation under that Convention to take appropriate measures to protect human health and the environment against adverse effects resulting or likely to result from human activities which modify or are likely to modify the ozone layer,

Recognizing that world-wide emissions of certain substances can significantly deplete and otherwise modify the ozone layer in a manner that is likely to result in adverse effects on human health and the environment,

Conscious of the potential climatic effects of emissions of these substances,

Aware that measures taken to protect the ozone layer from depletion should be based on relevant scientific knowledge, taking into account technical and economic considerations,

Determined to protect the ozone layer by taking precautionary measures to control equitably total global emissions of substances that deplete it, with the ultimate objective of their elimination on the basis of developments in scientific knowledge, taking into account technical and economic considerations,

Acknowledging that special provision is required to meet the needs of developing countries for these substances,

Noting the precautionary measures for controlling emissions of certain chlorofluorocarbons that have already been taken at national and regional levels,

Considering the importance of promoting international co-operation in the research and development of science and technology relating to the control and reduction of emissions of substances that deplete the ozone layer, bearing in mind in particular the needs of developing countries,

HAVE AGREED AS FOLLOWS:

ARTICLE 1: DEFINITIONS

For the purposes of this Protocol:

1. "Convention" means the Vienna Convention for the Protection of the Ozone Layer, adopted on 22 March 1985.
2. "Parties" means, unless the text otherwise indicates, Parties to this Protocol.
3. "Secretariat" means the secretariat of the Convention.
4. "Controlled substance" means a substance listed in Annex A to this Protocol, whether existing alone or in a mixture. It excludes, however, any such substance or mixture which is in a manufactured product other than a container used for the transportation or storage of the substance listed.
5. "Production" means the amount of controlled substances produced minus the amount destroyed by technologies to be approved by the Parties.
6. "Consumption" means production plus imports minus exports of controlled substances.
7. "Calculated levels" of production, imports, exports and consumption means levels determined in accordance with Article 3.
8. "Industrial rationalization" means the transfer of all or a portion of the calculated level of production of one Party to another, for the purpose of achieving economic efficiencies or responding to anticipated shortfalls in supply as a result of plant closures.

ARTICLE 2: CONTROL MEASURES

1. Each Party shall ensure that for the twelve-month period commencing on the first day of the seventh month following the date of the entry into force of this Protocol, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group I of Annex A does not exceed its calculated level of consumption in 1986. By the end of the same period, each Party producing one or more of these substances shall ensure that its calculated level of production of the substances does not exceed its calculated level of production in 1986, except that such level may have increased by no more than ten per cent based on the 1986 level. Such increase shall be permitted only so as to satisfy the basic domestic needs of the Parties operating under Article 5 and for the purposes of industrial rationalization between Parties.
2. Each Party shall ensure that for the twelve-month period commencing on the first day of the thirty-seventh month following the date of the entry into force of this Protocol, and in each twelve month period thereafter, its calculated level of consumption of the controlled substances listed in Group II of Annex A does not exceed its calculated level of consumption in 1986. Each Party producing one or more of these substances shall ensure that its calculated level of production of the substances does not exceed its calculated level of production in 1986, except that such level may have increased by no more than ten per cent based on the 1986 level. Such increase shall be permitted only so as to satisfy the basic domestic needs of the Parties operating under Article 5 and for the purposes of industrial rationalization between Parties. The mechanisms for implementing these measures shall be decided by the Parties at their first meeting following the first scientific review.
3. Each Party shall ensure that for the period 1 July 1993 to 30 June 1994 and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group I of Annex A does not exceed, annually, eighty per cent of its calculated level of consumption in 1986. Each Party producing one or more of these substances shall, for the same periods, ensure that its calculated level of production of the substances does not exceed, annually, eighty per cent of its calculated level of production in 1986. However, in order to satisfy the basic domestic needs of the Parties operating under Article 5 and for the purposes of industrial rationalization between Parties, its calculated level of production may exceed that limit by up to ten per cent of its calculated level of production in 1986.
4. Each Party shall ensure that for the period 1 July 1998 to 30 June 1999, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group I of Annex A does not exceed, annually, fifty per cent of its calculated level of consumption in 1986. Each Party producing one or more of these substances shall, for the same periods, ensure that its calculated level of production of the substances does not exceed, annually, fifty per cent of its calculated level of production in 1986. However, in order to satisfy the basic domestic needs of the Parties operating under Article 5 and for the purposes of industrial rationalization between Parties, its calculated level of production may exceed that limit by up to fifteen per cent of its calculated level of production in 1986. This

paragraph will apply unless the Parties decide otherwise at a meeting by a two-thirds majority of Parties present and voting, representing at least two-thirds of the total calculated level of consumption of these substances of the Parties. This decision shall be considered and made in the light of the assessments referred to in Article 6.

5. Any Party whose calculated level of production in 1986 of the controlled substances in Group I of Annex A was less than twenty-five kilotonnes may, for the purposes of industrial rationalization, transfer to or receive from any other Party, production in excess of the limits set out in paragraphs 1, 3 and 4 provided that the total combined calculated levels of production of the Parties concerned does not exceed the production limits set out in this Article. Any transfer of such production shall be notified to the secretariat, no later than the time of the transfer.

6. Any Party not operating under Article 5, that has facilities for the production of controlled substances under construction, or contracted for, prior to 16 September 1987, and provided for in national legislation prior to 1 January 1987, may add the production from such facilities to its 1986 production of such substances for the purposes of determining its calculated level of production for 1986, provided that such facilities are completed by 31 December 1990 and that such production does not raise that Party's annual calculated level of consumption of the controlled substances above 0.5 kilograms per capita.

7. Any transfer of production pursuant to paragraph 5 or any addition of production pursuant to paragraph 6 shall be notified to the secretariat, no later than the time of the transfer or addition.

8. (a) Any Parties which are Member States of a regional economic integration organization as defined in Article 1(6) of the Convention may agree that they shall jointly fulfil their obligations respecting consumption under this Article provided that their total combined calculated level of consumption does not exceed the levels required by this Article.
- (b) The Parties to any such agreement shall inform the secretariat of the terms of the agreement before the date of the reduction in consumption with which the agreement is concerned.
- (c) Such agreement will become operative only if all Member States of the regional economic integration organization and the organization concerned are Parties to the Protocol and have notified the secretariat of their manner of implementation.

9. (a) Based on the assessments made pursuant to Article 6, the Parties may decide whether:
- (i) adjustments to the ozone depleting potentials specified in Annex A should be made and, if so, what the adjustments should be; and
 - (ii) further adjustments and reductions of production or consumption of the controlled substances from 1986 levels should be undertaken and, if so, what the scope, amount and timing of any such adjustments and reductions should be.
- (b) Proposals for such adjustments shall be communicated to the Parties by the secretariat at least six months before the meeting of the Parties at which they are proposed for adoption.
- (c) In taking such decisions, the Parties shall make every effort to reach agreement by consensus. If all efforts at consensus have been exhausted, and no agreement reached, such decisions shall, as a last resort, be adopted by a two-thirds majority vote of the Parties present and voting representing at least fifty per cent of the total consumption of the controlled substances of the Parties.
- (d) The decisions, which shall be binding on all Parties, shall forthwith be communicated to the Parties by the Depositary. Unless otherwise provided in the decisions, they shall enter into force on the expiry of six months from the date of the circulation of the communication by the Depositary.
10. (a) Based on the assessments made pursuant to Article 6 of this Protocol and in accordance with the procedure set out in Article 9 of the Convention, the Parties may decide:
- (i) whether any substances, and if so which, should be added to or removed from any annex to this Protocol; and
 - (ii) the mechanism, scope and timing of the control measures that should apply to those substances;
- (b) Any such decision shall become effective, provided that it has been accepted by a two-thirds majority vote of the Parties present and voting.
11. Notwithstanding the provisions contained in this Article, Parties may take more stringent measures than those required by this Article.

ARTICLE 3: CALCULATION OF CONTROL LEVELS

For the purposes of Articles 2 and 5, each Party shall, for each Group of substances in Annex A, determine its calculated levels of:

- (a) production by:
 - (i) multiplying its annual production of each controlled substance by the ozone depleting potential specified in respect of it in Annex A; and
 - (ii) adding together, for each such Group, the resulting figures;
- (b) imports and exports, respectively, by following, mutatis mutandis, the procedure set out in subparagraph (a); and
- (c) consumption by adding together its calculated levels of production and imports and subtracting its calculated level of exports as determined in accordance with subparagraphs (a) and (b). However, beginning on 1 January 1993, any export of controlled substances to non-Parties shall not be subtracted in calculating the consumption level of the exporting Party.

ARTICLE 4: CONTROL OF TRADE WITH NON-PARTIES

1. Within one year of the entry into force of this Protocol, each Party shall ban the import of controlled substances from any State not party to this Protocol.

2. Beginning on 1 January 1993, no Party operating under paragraph 1 of Article 5 may export any controlled substance to any State not party to this Protocol.

3. Within three years of the date of the entry into force of this Protocol, the Parties shall, following the procedures in Article 10 of the Convention, elaborate in an annex a list of products containing controlled substances. Parties that have not objected to the annex in accordance with those procedures shall ban, within one year of the annex having become effective, the import of those products from any State not party to this Protocol.

4. Within five years of the entry into force of this Protocol, the Parties shall determine the feasibility of banning or restricting, from States not party to this Protocol, the import of products produced with, but not containing, controlled substances. If determined feasible, the Parties shall, following the procedures in Article 10 of the Convention, elaborate in an annex a list of such products. Parties that have not objected to it in accordance with those procedures shall ban or restrict, within one year of the annex having become effective, the import of those products from any State not party to this Protocol.

9. (a) Based on the assessments made pursuant to Article 6, the Parties may decide whether:
- (i) adjustments to the ozone depleting potentials specified in Annex A should be made and, if so, what the adjustments should be; and
 - (ii) further adjustments and reductions of production or consumption of the controlled substances from 1986 levels should be undertaken and, if so, what the scope, amount and timing of any such adjustments and reductions should be.
- (b) Proposals for such adjustments shall be communicated to the Parties by the secretariat at least six months before the meeting of the Parties at which they are proposed for adoption.
- (c) In taking such decisions, the Parties shall make every effort to reach agreement by consensus. If all efforts at consensus have been exhausted, and no agreement reached, such decisions shall, as a last resort, be adopted by a two-thirds majority vote of the Parties present and voting representing at least fifty per cent of the total consumption of the controlled substances of the Parties.
- (d) The decisions, which shall be binding on all Parties, shall forthwith be communicated to the Parties by the Depositary. Unless otherwise provided in the decisions, they shall enter into force on the expiry of six months from the date of the circulation of the communication by the Depositary.
10. (a) Based on the assessments made pursuant to Article 6 of this Protocol and in accordance with the procedure set out in Article 9 of the Convention, the Parties may decide:
- (i) whether any substances, and if so which, should be added to or removed from any annex to this Protocol; and
 - (ii) the mechanism, scope and timing of the control measures that should apply to those substances;
- (b) Any such decision shall become effective, provided that it has been accepted by a two-thirds majority vote of the Parties present and voting.
11. Notwithstanding the provisions contained in this Article, Parties may take more stringent measures than those required by this Article.

ARTICLE 3: CALCULATION OF CONTROL LEVELS

For the purposes of Articles 2 and 5, each Party shall, for each Group of substances in Annex A, determine its calculated levels of:

- (a) production by:
 - (i) multiplying its annual production of each controlled substance by the ozone depleting potential specified in respect of it in Annex A; and
 - (ii) adding together, for each such Group, the resulting figures;
- (b) imports and exports, respectively, by following, mutatis mutandis, the procedure set out in subparagraph (a); and
- (c) consumption by adding together its calculated levels of production and imports and subtracting its calculated level of exports as determined in accordance with subparagraphs (a) and (b). However, beginning on 1 January 1993, any export of controlled substances to non-Parties shall not be subtracted in calculating the consumption level of the exporting Party.

ARTICLE 4: CONTROL OF TRADE WITH NON-PARTIES

1. Within one year of the entry into force of this Protocol, each Party shall ban the import of controlled substances from any State not party to this Protocol.
2. Beginning on 1 January 1993, no Party operating under paragraph 1 of Article 5 may export any controlled substance to any State not party to this Protocol.
3. Within three years of the date of the entry into force of this Protocol, the Parties shall, following the procedures in Article 10 of the Convention, elaborate in an annex a list of products containing controlled substances. Parties that have not objected to the annex in accordance with those procedures shall ban, within one year of the annex having become effective, the import of those products from any State not party to this Protocol.
4. Within five years of the entry into force of this Protocol, the Parties shall determine the feasibility of banning or restricting, from States not party to this Protocol, the import of products produced with, but not containing, controlled substances. If determined feasible, the Parties shall, following the procedures in Article 10 of the Convention, elaborate in an annex a list of such products. Parties that have not objected to it in accordance with those procedures shall ban or restrict, within one year of the annex having become effective, the import of those products from any State not party to this Protocol.

5. Each Party shall discourage the export, to any State not party to this Protocol, of technology for producing and for utilizing controlled substances.
6. Each Party shall refrain from providing new subsidies, aid, credits, guarantees or insurance programmes for the export to States not party to this Protocol of products, equipment, plants or technology that would facilitate the production of controlled substances.
7. Paragraphs 5 and 6 shall not apply to products, equipment, plants or technology that improve the containment, recovery, recycling or destruction of controlled substances, promote the development of alternative substances, or otherwise contribute to the reduction of emissions of controlled substances.
8. Notwithstanding the provisions of this Article, imports referred to in paragraphs 1, 3 and 4 may be permitted from any State not party to this Protocol if that State is determined, by a meeting of the Parties, to be in full compliance with Article 2 and this Article, and has submitted data to that effect as specified in Article 7.

ARTICLE 5: SPECIAL SITUATION OF DEVELOPING COUNTRIES

1. Any Party that is a developing country and whose annual calculated level of consumption of the controlled substances is less than 0.3 kilograms per capita on the date of the entry into force of the Protocol for it, or any time thereafter within ten years of the date of entry into force of the Protocol shall, in order to meet its basic domestic needs, be entitled to delay its compliance with the control measures set out in paragraphs 1 to 4 of Article 2 by ten years after that specified in those paragraphs. However, such Party shall not exceed an annual calculated level of consumption of 0.3 kilograms per capita. Any such Party shall be entitled to use either the average of its annual calculated level of consumption for the period 1995 to 1997 inclusive or a calculated level of consumption of 0.3 kilograms per capita, whichever is the lower, as the basis for its compliance with the control measures.
2. The Parties undertake to facilitate access to environmentally safe alternative substances and technology for Parties that are developing countries and assist them to make expeditious use of such alternatives.
3. The Parties undertake to facilitate bilaterally or multilaterally the provision of subsidies, aid, credits, guarantees or insurance programmes to Parties that are developing countries for the use of alternative technology and for substitute products.

ARTICLE 6: ASSESSMENT AND REVIEW OF CONTROL MEASURES

Beginning in 1990, and at least every four years thereafter, the Parties shall assess the control measures provided for in Article 2 on the basis of available scientific, environmental, technical and economic information. At least one year before each assessment, the Parties shall convene appropriate panels of experts qualified in the fields mentioned and determine the composition and terms of reference of any such panels. Within one year of being convened, the panels will report their conclusions, through the secretariat, to the Parties.

ARTICLE 7: REPORTING OF DATA

1. Each Party shall provide to the secretariat, within three months of becoming a Party, statistical data on its production, imports and exports of each of the controlled substances for the year 1986, or the best possible estimates of such data where actual data are not available.

2. Each Party shall provide statistical data to the secretariat on its annual production (with separate data on amounts destroyed by technologies to be approved by the Parties), imports, and exports to Parties and non-Parties, respectively, of such substances for the year during which it becomes a Party and for each year thereafter. It shall forward the data no later than nine months after the end of the year to which the data relate.

ARTICLE 8: NON-COMPLIANCE

The Parties, at their first meeting, shall consider and approve procedures and institutional mechanisms for determining non-compliance with the provisions of this Protocol and for treatment of Parties found to be in non-compliance.

ARTICLE 9: RESEARCH, DEVELOPMENT, PUBLIC AWARENESS
AND EXCHANGE OF INFORMATION

1. The Parties shall co-operate, consistent with their national laws, regulations and practices and taking into account in particular the needs of developing countries, in promoting, directly or through competent international bodies, research, development and exchange of information on:

- (a) best technologies for improving the containment, recovery, recycling or destruction of controlled substances or otherwise reducing their emissions;
- (b) possible alternatives to controlled substances, to products containing such substances, and to products manufactured with them; and
- (c) costs and benefits of relevant control strategies.

2. The Parties, individually, jointly or through competent international bodies, shall co-operate in promoting public awareness of the environmental effects of the emissions of controlled substances and other substances that deplete the ozone layer.

3. Within two years of the entry into force of this Protocol and every two years thereafter, each Party shall submit to the secretariat a summary of the activities it has conducted pursuant to this Article.

ARTICLE 10: TECHNICAL ASSISTANCE

1. The Parties shall, in the context of the provisions of Article 4 of the Convention, and taking into account in particular the needs of developing countries, co-operate in promoting technical assistance to facilitate participation in and implementation of this Protocol.

2. Any Party or Signatory to this Protocol may submit a request to the secretariat for technical assistance for the purposes of implementing or participating in the Protocol.

3. The Parties, at their first meeting, shall begin deliberations on the means of fulfilling the obligations set out in Article 9, and paragraphs 1 and 2 of this Article, including the preparation of workplans. Such workplans shall pay special attention to the needs and circumstances of the developing countries. States and regional economic integration organizations not party to the Protocol should be encouraged to participate in activities specified in such workplans.

ARTICLE 11: MEETINGS OF THE PARTIES

1. The Parties shall hold meetings at regular intervals. The secretariat shall convene the first meeting of the Parties not later than one year after the date of the entry into force of this Protocol and in conjunction with a meeting of the Conference of the Parties to the Convention, if a meeting of the latter is scheduled within that period.
2. Subsequent ordinary meetings of the Parties shall be held, unless the Parties otherwise decide, in conjunction with meetings of the Conference of the Parties to the Convention. Extraordinary meetings of the Parties shall be held at such other times as may be deemed necessary by a meeting of the Parties, or at the written request of any Party, provided that, within six months of such a request being communicated to them by the secretariat, it is supported by at least one third of the Parties.
3. The Parties, at their first meeting, shall:
 - (a) adopt by consensus rules of procedure for their meetings;
 - (b) adopt by consensus the financial rules referred to in paragraph 2 of Article 13;
 - (c) establish the panels and determine the terms of reference referred to in Article 6;
 - (d) consider and approve the procedures and institutional mechanisms specified in Article 8; and
 - (e) begin preparation of workplans pursuant to paragraph 3 of Article 10.
4. The functions of the meetings of the Parties shall be to:
 - (a) review the implementation of this Protocol;
 - (b) decide on any adjustments or reductions referred to in paragraph 9 of Article 2;
 - (c) decide on any addition to, insertion in or removal from any annex of substances and on related control measures in accordance with paragraph 10 of Article 2;

- (d) establish, where necessary, guidelines or procedures for reporting of information as provided for in Article 7 and paragraph 3 of Article 9;
- (e) review requests for technical assistance submitted pursuant to paragraph 2 of Article 10;
- (f) review reports prepared by the secretariat pursuant to subparagraph (c) of Article 12;
- (g) assess, in accordance with Article 6, the control measures provided for in Article 2;
- (h) consider and adopt, as required, proposals for amendment of this Protocol or any annex and for any new annex;
- (i) consider and adopt the budget for implementing this Protocol; and
- (j) consider and undertake any additional action that may be required for the achievement of the purposes of this Protocol.

5. The United Nations, its specialized agencies and the International Atomic Energy Agency, as well as any State not party to this Protocol, may be represented at meetings of the Parties as observers. Any body or agency, whether national or international, governmental or non-governmental, qualified in fields relating to the protection of the ozone layer which has informed the secretariat of its wish to be represented at a meeting of the Parties as an observer may be admitted unless at least one third of the Parties present object. The admission and participation of observers shall be subject to the rules of procedure adopted by the Parties.

ARTICLE 12: SECRETARIAT

For the purposes of this Protocol, the secretariat shall:

- (a) arrange for and service meetings of the Parties as provided for in Article 11;
- (b) receive and make available, upon request by a Party, data provided pursuant to Article 7;
- (c) prepare and distribute regularly to the Parties reports based on information received pursuant to Articles 7 and 9;

- (d) notify the Parties of any request for technical assistance received pursuant to Article 10 so as to facilitate the provision of such assistance;
- (e) encourage non-Parties to attend the meetings of the Parties as observers and to act in accordance with the provisions of this Protocol;
- (f) provide, as appropriate, the information and requests referred to in subparagraphs (c) and (d) to such non-party observers; and
- (g) perform such other functions for the achievement of the purposes of this Protocol as may be assigned to it by the Parties.

ARTICLE 13: FINANCIAL PROVISIONS

1. The funds required for the operation of this Protocol, including those for the functioning of the secretariat related to this Protocol, shall be charged exclusively against contributions from the Parties.
2. The Parties, at their first meeting, shall adopt by consensus financial rules for the operation of this Protocol.

ARTICLE 14: RELATIONSHIP OF THIS PROTOCOL TO THE CONVENTION

Except as otherwise provided in this Protocol, the provisions of the Convention relating to its protocols shall apply to this Protocol.

ARTICLE 15: SIGNATURE

This Protocol shall be open for signature by States and by regional economic integration organizations in Montreal on 16 September 1987, in Ottawa from 17 September 1987 to 16 January 1988, and at United Nations Headquarters in New York from 17 January 1988 to 15 September 1988.

ARTICLE 16: ENTRY INTO FORCE

1. This Protocol shall enter into force on 1 January 1989, provided that at least eleven instruments of ratification, acceptance, approval of the Protocol or accession thereto have been deposited by States or regional economic integration organizations representing at least two-thirds of 1986 estimated global consumption of the controlled substances, and the provisions of paragraph 1 of Article 17 of the Convention have been fulfilled. In the event that these conditions have not been fulfilled by that date, the Protocol shall enter into force on the ninetieth day following the date on which the conditions have been fulfilled.

2. For the purposes of paragraph 1, any such instrument deposited by a regional economic integration organization shall not be counted as additional to those deposited by member States of such organization.

3. After the entry into force of this Protocol, any State or regional economic integration organization shall become a Party to it on the ninetieth day following the date of deposit of its instrument of ratification, acceptance, approval or accession.

ARTICLE 17: PARTIES JOINING AFTER ENTRY INTO FORCE

Subject to Article 5, any State or regional economic integration organization which becomes a Party to this Protocol after the date of its entry into force, shall fulfil forthwith the sum of the obligations under Article 2, as well as under Article 4, that apply at that date to the States and regional economic integration organizations that became Parties on the date the Protocol entered into force.

ARTICLE 18: RESERVATIONS

No reservations may be made to this Protocol.

ARTICLE 19: WITHDRAWAL

For the purposes of this Protocol, the provisions of Article 19 of the Convention relating to withdrawal shall apply, except with respect to Parties referred to in paragraph 1 of Article 5. Any such Party may withdraw from this Protocol by giving written notification to the Depositary at any time after four years of assuming the obligations specified in paragraphs 1 to 4 of Article 2. Any such withdrawal shall take effect upon expiry of one year after the date of its receipt by the Depositary, or on such later date as may be specified in the notification of the withdrawal.

ARTICLE 20: AUTHENTIC TEXTS

The original of this Protocol, of which the Arabic, Chinese, English, French, Russian and Spanish texts are equally authentic, shall be deposited with the Secretary-General of the United Nations.

IN WITNESS WHEREOF THE UNDERSIGNED, BEING DULY AUTHORIZED TO THAT EFFECT, HAVE SIGNED THIS PROTOCOL.

DONE AT MONTREAL THIS SIXTEENTH DAY OF SEPTEMBER, ONE THOUSAND NINE HUNDRED AND EIGHTY SEVEN

- - - - -

ANNEX A

CONTROLLED SUBSTANCES

Group	Substance	Ozone Depleting Potential *
Group I		
	CFC1 ₃ (CFC-11)	1.0
	CF ₂ Cl ₂ (CFC-12)	1.0
	C ₂ F ₃ Cl ₃ (CFC-113)	0.8
	C ₂ F ₄ Cl ₂ (CFC-114)	1.0
	C ₂ F ₅ Cl (CFC-115)	0.6
Group II		
	CF ₂ BrCl (halon-1211)	3.0
	CF ₃ Br (halon-1301)	10.0
	C ₂ F ₄ Br ₂ (halon-2402) (to be determined)	

* These ozone depleting potentials are estimates based on existing knowledge and will be reviewed and revised periodically.

COMMISSION
DES
COMMUNAUTÉS EUROPÉENNES

Secrétariat général

Bruxelles, le 9 janvier 1990

COM(90) 3

a) OJ 995 - 17 janvier 1990

b) Réunion spéciale des
Chefs de Cabinet

TEXTE E

SUBSTANCES QUI APPAUVRISSENT

LA COUCHE D'OZONE

(Communication de M. RIPA DI MEANA)

- Cette question est inscrite à l'ordre du jour de la 995ème réunion de la Commission, le mercredi 17 janvier 1990.

Destinataires : MM. les Membres de la Commission

MM. BRINKHORST
KRENZLER
BRAUN
CASPARI
FASELLA
CHUMAS
MAYHEW
DEWOST

SUMMARY

1. The Draft Council Regulation No/... of on Substances that Deplete the Ozone Layer revises the Council Regulation (EEC) No 3322/88 (1) of 14 October 1988 on Certain Chlorofluorocarbons and Halons which Deplete the Ozone Layer. It includes measures that are considered to be adequate for the protection of the ozone layer on the basis of recent scientific evidence.

2. More concretely, it provides for more stringent controls on CFCs and halons which include their phase out by 1997 and 1999 respectively, as well as controls on carbon tetrachloride, methyl chloroform and other fully halogenated CFCs.

(1) OJ L 297, 31 October 1988, p. 1

COMMUNICATION FROM MR RIPA DI MEANA TO THE COMMISSION

Subject: Draft Council Regulation (EEC) No/.. of ..
..... on substances that deplete the ozone layer

1. The Community concluded the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer with the Council Decision 88/540/EEC (1) of 14 October 1988. The Montreal Protocol is implemented in the Community through the Council Regulation (EEC) No 3322/88 (2) of 14 October 1988 on Certain Chlorofluorocarbons and Halons which Deplete the Ozone Layer.
2. Recent scientific evidence has, however, indicated that the control measures provided for in it are not adequate. This evidence concerns mainly the Antarctic ozone hole, the perturbed Arctic chemistry and the long-term ozone decreases in the northern hemisphere of 3 to 5.5% from 1969 to 1988 in the winter months. The same evidence has also shown that carbon tetrachloride and methyl chloroform deplete the ozone layer.
3. In this context, the Council concluded on the 2 March 1989 that there is a need, both within the Community and at a global level, for a reduction of at least 85% as soon as possible in the current level of production and use of the CFCs with a view to their being eliminated towards the end of the century.
4. On the basis of the scientific evidence and the expressed political will, the Commission submits a proposal for the revision of the Council Regulation (EEC) No 3322/88 on certain chlorofluorocarbons and halons which deplete the ozone layer and for the adoption of measures that are considered to be adequate for the protection of the ozone layer. More concretely, the Commission proposes more stringent controls on CFCs and halons which include their phase-out by 1997 and 1999 respectively as well as controls on carbon tetrachloride, methyl chloroform and other fully halogenated CFCs.
5. Consequently, the Commission is requested:
 - to adopt the draft Regulation;
 - to transmit it to the Council;
 - and to publish it in the Official Journal.

(1) OJ L 297, 31 October 1988, p. 8

(2) OJ L 297, 31 October 1988, p. 1

EXPLANATORY MEMORANDUM

1. The Community concluded the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer with the Council Decision 88/540/EEC (1) of 14 October 1988. The Montreal Protocol is implemented in the Community through the Council Regulation (EEC) No 3322/88 (2) of 14 October 1988 on Certain Chlorofluorocarbons and Halons which Deplete the Ozone Layer.
2. The Montreal Protocol was signed in September 1987. Its scientific basis was the theoretical prediction that if CFC and halon abundances continue to grow for the next few decades, there would eventually be substantial ozone layer depletion.
3. Recent scientific evidence has, however, indicated that the control measures provided for in it are not adequate. This evidence concerns mainly the Antarctic ozone hole, the perturbed Arctic chemistry and the long-term ozone decreases in the northern hemisphere of 3 to 5.5% from 1969 to 1988 in the winter months. The same evidence has also shown that carbon tetrachloride and methyl chloroform deplete the ozone layer.
4. In this context, the Council concluded on 2 March 1989 that there is a need, both within the Community and at a global level, for a reduction of at least 85% as soon as possible in the current level of production and use of the CFCs with a view to their being eliminated towards the end of the century.
5. At the London Conference on "Saving the Ozone Layer" the Commission's position was the reduction of 85% to be achieved before 1995 and the total elimination well before the end of the century, in 1996 or 1997.
6. On the basis of the scientific evidence and the expressed political will, the Commission submits a proposal for the revision of the Council Regulation (EEC) No 3322/88 on certain chlorofluorocarbons and halons which deplete the ozone layer and for the adoption of measures that are considered to be adequate for the protection of the ozone layer. More concretely, the Commission proposes more stringent controls on CFCs and halons which include their phase-out by 1997 and 1999 respectively as well as controls on carbon tetrachloride, methyl chloroform and other fully halogenated CFCs.

(1) OJ L 297, 31 October 1988, p. 8

(2) OJ L 297, 31 October 1988, p. 1



COMMISSION
OF THE EUROPEAN
COMMUNITIES

5/1 1990

Directorate-General
Environment, Nuclear Safety
and Civil Protection

XI/A/2

DRAFT COUNCIL REGULATION (EEC) No. / ..

of

on substances that deplete the ozone layer,

replacing Council Regulation (EEC) No 3322/88 of 14 October
1988 on certain chlorofluorocarbons and halons which deplete
the ozone layer

THE COUNCIL OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Economic
Community, and in particular Article 130S thereof,

Having regard to the proposal from the Commission,

Having regard to the opinion of the European Parliament(1),

Having regard to the opinion of the Economic and Social
Committee(2),

Whereas the Community together with several of its Member
States signed, on 22 March 1985, the Vienna Convention for the
protection of the ozone layer;

Whereas it is established that continued emissions of ozone
depleting substances at current levels cause significant
damage to the ozone layer; whereas there is an international
consensus that significant reductions in both production and
consumption of such substances are necessary; whereas
Decisions 80/372/EEC(3) and 82/795/EEC(4) provide controls
which are of limited effect and which cover only two such
substances (CFC 11 and CFC 12);

Whereas a Protocol supplementary to the Vienna Convention, the
Montreal Protocol on substances that deplete the ozone layer,
was negotiated and adopted on 16 September 1987; whereas the
Protocol has been signed by the Community and by all of its
Members States;

(1)...

(2)...

(3) O.J. L90, 3.4.1980, p. 45

(4)...

Whereas in view of the responsibilities of the Community for the environment and trade, the Community has approved by Decision 88/540/EEC(5) the Vienna Convention and the Montreal Protocol;

Whereas it is necessary for action to be taken at Community level to carry out the Community's obligations under the Convention and the Protocol, in particular to control production and consumption within the Community of certain chlorofluorocarbons and halons;

Whereas, in accordance with Article 130T of the Treaty, the adoption of such Community action will not prevent any Member State from maintaining or introducing more stringent measures for the protection of the environment compatible with the Treaty;

Whereas the Protocol also requires certain restrictions to be imposed on trade with States which are not Parties to the Protocol, and requires certain data to be reported;

Whereas Regulation (EEC) 3322/88 (5) provided for controls on certain chlorofluorocarbons and halons which deplete the ozone layer;

Whereas the more recent scientific evidence indicates that for the adequate protection of the ozone layer a higher degree of control of chlorofluorocarbons and halons is required than that provided by Regulation (EEC) 3322/88; whereas the same evidence indicates that additional controls should be placed on all other fully halogenated chlorofluorocarbons, carbon tetrachloride and methyl chloroform;

Whereas on 2 March 1989 the Council concluded that there is a need for a reduction of at least 85% as soon as possible in the current level of production and use of chlorofluorocarbons with a view to their being eliminated towards the end of the century;

Whereas bearing in mind the market structure for chlorofluorocarbons, other fully halogenated chlorofluorocarbons, halons, carbon tetrachloride and methyl chloroform, it is appropriate to control consumption of these substances by controlling supply rather than demand; whereas supply can be controlled by limiting sales and use by producers in the Community, and by limiting imports;

Whereas it is necessary to keep under review the evolution of the market for the above substances, particularly with regard to sufficient supply for essential uses, and the state of development of appropriate substitutes;

Whereas additional Community measures may be needed to carry out the Community's obligations under the Protocol in respect of research and development, and technical assistance,

(5) O.J. L297, 31.10.1988, p. 8

HAS ADOPTED THIS REGULATION:

Article 1

This Regulation applies to the importation, exportation, production and consumption of all chlorofluorocarbons, other fully halogenated chlorofluorocarbons, halons, carbon tetrachloride and methyl chloroform referred to in Annex I.

Article 2

Definitions

- 'the Protocol' means the Montreal Protocol on substances that deplete the ozone layer,
- 'chlorofluorocarbons' means the substances listed in Group I of Annex I,
- 'fully halogenated chlorofluorocarbons' means saturated compounds containing all of, and only carbon fluorine and chlorine except those whose normal boiling or sublimation point has been shown to be in excess of 150 degrees Celsius,
- 'halons' means the substances listed in Group II of Annex I,
- 'carbon tetrachloride' means the substance listed in Group III of Annex I,
- 'methyl chloroform' means the substance listed in Group IV of Annex I,
- 'producer' means any natural or legal person manufacturing fully halogenated chlorofluorocarbons, halons, carbon tetrachloride or methyl chloroform within the Community,
- 'undertaking' means any natural or legal person which produces or uses in the Community fully halogenated chlorofluorocarbons, halons, carbon tetrachloride or methyl chloroform for industrial or commercial purposes or which imports those substances into, or exports them from, the Community for industrial or commercial purposes,
- 'ozone-depleting potential' means the figure specified in the final column of Annex I representing the potential effect of each substance on the ozone layer,
- 'calculated level' means a quantity determined by multiplying the quantity of each substance by the ozone-

depleting potential of that substance specified in Annex I and by adding together, for each group of substances in Annex I separately, the resulting figures,

- 'industrial rationalization' means the transfer either between Parties to the Protocol or within a Member State of all or a portion of the calculated level of production of one producer to another, for the purpose of achieving economic efficiencies or responding to anticipated shortfalls in supply as a result of plant closures.

PART I

Import Regime

Article 3

1. The importation into the Community of chloro-fluorocarbons, other fully halogenated chlorofluorocarbons, halons, carbon tetrachloride and methyl chloroform originating in third countries shall be subject to quantitative limits.
2. For this purpose the Community shall open the quotas set out in Annex II which shall be applicable during the period laid down in that Annex.
3. The Commission, according to the procedure set out in Article 10, may modify the quotas set out in Annex II.

Article 4

1. With effect from 1 January 1991, the importation into the Community of chlorofluorocarbons, other fully halogenated chlorofluorocarbons, halons, carbon tetrachloride and methyl chloroform originating in third countries not Parties to the Protocol is prohibited.

2. By derogation from paragraph 1 above, the importation into the Community of chlorofluorocarbons, other fully halogenated chlorofluorocarbons, halons, carbon tetrachloride and methyl chloroform originating in a third country not a Party to the Protocol may be permitted by the Commission if that country is determined by a meeting of the Parties to the Protocol to be in full compliance with Articles 2 and 4 of the Protocol, and has submitted data to that effect as specified in Article 7 of the Protocol. The Commission shall act in accordance with the procedure set out in Article 10.

Article 5

1. Subject to the decision referred to in paragraph 2, the importation into the Community of products originating in third countries which are not Parties to the Protocol, containing chlorofluorocarbons, other fully halogenated chlorofluorocarbons, halons, carbon tetrachloride and methyl chloroform is prohibited with effect from 1 January 1993.

2. The Council, on the proposal of the Commission, shall adopt before that date the list of these products in the light of the list established by the Parties to the Protocol. The Council shall act by a qualified majority.

Article 6

In the light of the decision of the Parties to the Protocol, the Council, on the proposal of the Commission, shall adopt rules applicable to the importation into the Community of products originating in third countries which are not Parties to the Protocol, which are produced with chlorofluorocarbons, other fully halogenated chlorofluorocarbons, halons, carbon tetrachloride and methyl chloroform but which do not contain these substances. The Council shall act by a qualified majority.

Article 7

1. The release into free circulation in the Community of chlorofluorocarbons, other fully halogenated chlorofluorocarbons, halons, carbon tetrachloride and methyl chloroform which are subject to the quotas referred to in Article 3 shall be subject to presentation of an import licence issued by the competent authority of the Member State in which these substances are to be released into free circulation in the Community. This licence shall be issued in accordance with the quotas allocated to importers by the Commission following the procedure set out in Article 10.

2. A request for a licence shall contain:
- (a) the name and address of the importer;
 - (b) the description of each substance stating:
 - the commercial description,
 - the heading in the combined nomenclature,
 - the country of origin,
 - the country from which the substance is imported;
 - (c) a statement of the quantity of each substance to be imported in tonnes;
 - (d) the place and date of proposed importation, if known.

PART II

Article 8

Control of production

1. Each producer shall, subject to the provisions of paragraphs 5 and 6, ensure that:

- the calculated level of its production of chloro-fluorocarbons in the period 1 January to 31 December 1992 and in each 12-month period thereafter, does not exceed 50% of the calculated level of its production in 1986;

- the calculated level of its production of chloro-fluorocarbons in the period 1 January to 31 December 1996 and in each 12-month period thereafter, does not exceed 15% of the calculated level of its production in 1986;

- there is no production of chlorofluorocarbons after 31 December 1997.

The Commission, according to the procedure set out in Article 10, will determine the quantities of chloro-fluorocarbons that could be produced in the Community after this date for the purposes of essential uses or for the provision of developing countries.

2. Each producer shall, subject to the provisions of paragraphs 6 and 7, ensure that:

- the calculated level of its production of other fully halogenated chlorofluorocarbons in the period 1 January to 31 December 1992 and in each 12-month period thereafter, does not exceed 50% of the calculated level of its production in 1986;
- the calculated level of its production of other fully halogenated chlorofluorocarbons in the period 1 January to 31 December 1996 and in each 12-month period thereafter, does not exceed 15% of the calculated level of its production in 1986;
- there is no production of other fully halogenated chlorofluorocarbons after 31 December 1997.

The Commission, according to the procedure set out in Article 10, will determine the quantities of other fully halogenated chloro-fluorocarbons that could be produced in the Community after this date for the purposes of essential uses or for the provision of developing countries.

3. Each producer shall, subject to the provisions of paragraphs 6 and 7, ensure that:

- the calculated level of its production of halons in the period 1 January to 31 December 1992 and in each 12-month period thereafter does not exceed the calculated level of its production of halons in 1986;
- the calculated level of its production of halons in the period 1 January to 31 December 1996 and in each 12-month period thereafter does not exceed 50% of the calculated level of its production of halons in 1986;
- there is no production of halons after 31 December 1999.

The Commission, according to the procedure set out in Article 10, will determine the quantities of halons that could be produced in the Community after this date for the purposes of essential uses or for the provision of developing countries.

4. Each producer shall, subject to the provisions of paragraphs 6 and 7, ensure that:

- the level of its production of carbon tetrachloride in the period 1 January to 31 December 1992 and in each 12-month period thereafter will not exceed 50% of the level of its production in 1986;
- there is no production of carbon tetrachloride after 31 December 1997, except for its use as a feedstock for the production of other industrial products.

5. Each producer shall, subject to the provisions of paragraphs 6 and 7, ensure that:

- the level of its production of methyl chloroform in the period 1 January to 31 December 1992 and in each 12-month period thereafter does not exceed the level of its production in 1986;

- the level of its production of methyl chloroform in the period 1 January to 31 December 1998 and in each 12-month period thereafter does not exceed 80% of its level of production in 1986;

- the level of its production of methyl chloroform in the period 1 January to 31 December 2000 and in each 12-month period thereafter does not exceed 60% of its level of production in 1986.

6. A producer may be authorized by the Commission in agreement with the competent authority of the Member State in which it is situated, to exceed the calculated levels of production set out in paragraphs 1, 2, 3, 4 and 5 for the purposes of industrial rationalization between Parties to the Protocol or so as to satisfy the basic domestic needs of States operating under Article 5 of the Protocol, provided that the calculated levels of production of chloro-fluorocarbons, other fully halogenated chlorofluorocarbons, halons, carbon tetrachloride and methyl chloroform respectively of the Member State concerned do not exceed the levels permitted by Article 2 of the Protocol for the periods in question.

In the case of authorization for industrial rationalization, the agreement of the competent authority of the Member State in which it is intended to reduce production shall also be required.

7. A producer may exceed the calculated levels of production set out in paragraphs 1, 2, 3, 4 and 5 for the purposes of industrial rationalization within the Member State in whose territory the producer is established, provided that the obligations of that Member State under the Protocol are not thereby infringed. The competent authority of the Member State and the Commission shall be notified beforehand.

Article 9

Control on consumption through control of supply in the Community

1. Each producer shall ensure that the quantity of chloro-fluorocarbons which it places on the market or uses for its own account within the Community from quantities produced by it shall not exceed:

- in the period 1 January to 31 December 1992, and in each 12-month period thereafter, 50% of the calculated level of the quantity which it placed on the market or used for its own account within the Community in 1986.

- in the period 1 January to 31 December 1996, and in each 12-month period thereafter, 15% of the calculated level of the quantity which it placed on the market or used for its own account in 1986,

2. Each producer shall ensure that it does not place on the market or uses for its own account within the Community from quantities produced by it any quantity of chlorofluorocarbons after 31 December 1997.

The Commission, according to the procedure set out in Article 10, shall determine the quantities of chlorofluorocarbons that could be placed on the market or are used for his own account by each producer for the purposes of essential uses and for the provision of developing countries.

3. Each producer shall ensure that the quantity of other fully halogenated chlorofluorocarbons which it places on the market or uses for its own account within the Community from quantities produced by it shall not exceed:

- in the period 1 January to 31 December 1992, and in each 12-month period thereafter, 50% of the calculated level of the quantity which it placed on the market or used for its own account within the Community in 1986,

- in the period 1 January to 31 December 1996, and in each 12-month period thereafter, 15% of the calculated level of the quantity which it placed on the market or used for its own account in 1986,

4. Each producer shall ensure that it does not place on the market or uses for its own account within the Community from quantities produced by it any quantity of other fully halogenated chlorofluorocarbons after 31 December 1997.

The Commission, according to the procedure set out in Article 10, shall determine the quantities of other fully halogenated chlorofluorocarbons that could be placed on the market or are used for his own account by each producer for the purposes of essential uses and for the provision of developing countries.

5. Each producer shall ensure that the quantity of halons which it places on the market or uses for its own account within the Community shall not exceed:

- in the period 1 January to 31 December 1992, and in each 12-month period thereafter, the calculated level of the quantity which it placed on the market or used for its own account within the Community in 1986,

- in the period 1 January to 31 December 1996, and in each 12-month period thereafter, 50% of the calculated level of the quantity which it placed on the market or used for its own account within the Community in 1986.

6. Each producer shall ensure that it does not place on the market or uses for its own account within the Community from quantities produced by it any quantity of halons after 31 December 1999.

The Commission, according to the procedure set out in Article 10, shall determine the quantities of halons that could be placed on the market or are used for his own account by each producer for the purposes of essential uses and for the provision of developing countries.

7. Each producer shall ensure that the quantity of carbon tetrachloride which it places on the market or uses for its own account within the Community from quantities produced by it shall not exceed in the period 1 January to 31 December 1992, and in each 12-month period thereafter, 50% of the quantity which it placed on the market or used for its own account within the Community in 1986.

8. Each producer shall ensure that it does not place on the market or uses for its own account within the Community from quantities produced by it any quantity of carbon tetrachloride after 31 December 1997 except for its use as a feedstock for the production of other industrial products.

9. Each producer shall ensure that the quantity of methyl chloroform which it places on the market or uses for its own account within the Community from quantities produced by it shall not exceed:

- in the period 1 January to 31 December 1992, and in each 12-month period thereafter, the quantity which it placed on the market or used for its own account within the Community in 1986;

- in the period 1 January to 31 December 1998, and in each 12-month period thereafter, 80% of the level of the quantity which it placed in the market or used for its own account within the Community in 1986;

- in the period 1 January to 31 December 2000, and in each 12-month period thereafter, 60% of the level of the quantity which it placed in the market or used for its own account within the Community in 1986.

10. Any imports permitted in accordance with Part I of this Regulation shall be in addition to the quantities which producers may place on the market or use for their own account in accordance with this Article.

11. Beginning with the control period 1 January to 31 December 1993, the quantities resulting from the application of paragraphs 1 to 7 will be reduced in a given 12-month control period thereafter by the quantities of fully halogenated chlorofluorocarbons, halons, carbon tetrachloride or methyl chloroform as appropriate that were exported to countries not Parties to the Protocol during that 12-month control period.

12. The quantities resulting from the application of paragraphs 1 to 7 may be increased by the Commission if imports of these substances into the Community in any 12-month period to which paragraphs 1 to 7 apply shall be less than the respective quantitative limits fixed in Annex II.

The Commission shall act in accordance with the procedure set out in Article 10.

13. Any producer having the right to place on the market or use may transfer its right in respect of all or any of the quantity fixed in accordance with this Article to any other producer within the Community. The producer acquiring the right shall immediately notify the Commission. A transfer of the right to place on the market or use does not imply additional right to produce.

PART III

Management, data reporting and final provisions

Article 10

The Commission shall be assisted by a committee composed of the representatives of the Member States and chaired by the representative of the Commission.

The representative of the Commission shall submit to the committee a draft of the measures to be taken. The committee shall deliver its opinion on the draft within a time limit which the chairman may lay down according to the urgency of the matter. The opinion shall be delivered by the majority laid down in Article 148 (2) of the Treaty in the case of decisions which the Council is required to adopt on a proposal from the Commission. The votes of the representatives of the Member States within the Committee shall be weighted in the manner set out in that Article. The chairman shall not vote.

The Commission shall adopt measures which shall apply immediately. However, if these measures are not in accordance with the opinion of the committee, they shall be communicated by the Commission to the Council forthwith. In that event, the Commission may defer application of the measure which it has decided for a period of not more than one month from the date of such communication.

The Council, acting by a qualified majority, may take a different decision within the time limit referred to in the third paragraph.

Article 11

Data reporting

1. Each producer, importer and exporter of chloro-fluorocarbons, other fully halogenated chlorofluorocarbons, halons, carbon tetrachloride and methyl chloroform shall communicate to the Commission, with a copy to the competent authority of the Member State concerned, not later than 28 February of every year the figures of its:

- production,
- quantities placed on the market or used for the producer's own account within the Community,
- imports into the Community,
- exports from the Community, separately to countries Parties and non-parties to the Montreal Protocol,
- stocks,
- quantities destroyed, in accordance with technologies approved by the Parties to the Protocol,

of each of the chlorofluorocarbons, other fully halogenated chlorofluorocarbons, halons, carbon tetrachloride and methyl chloroform listed in Annex I in respect of the period 1 January to 31 December 1991 and for each 12-month period thereafter.

2. Each company which produced, imported or exported carbon tetrachloride, methyl chloroform or any fully halogenated chlorofluorocarbon other than CFC-11, CFC-12, CFC-113, CFC-114 and CFC-115 in 1986 shall communicate to the Commission the data referred to in paragraph 1 in respect of that year not later than 30 November 1990.

3. The communications referred to in the last indent of paragraph 1 shall be made to the Commission for the first time on 28 February of the subsequent year following the date on which approval is granted.

4. The Commission will take the appropriate measures to protect the confidentiality of the submitted data.

Article 12

Inspection

1. In carrying out the tasks assigned to it by this Regulation, the Commission may obtain all necessary information from the governments and competent authorities of the Member States and from undertakings.

2. When sending a request for information to an undertaking the Commission shall at the same time forward a copy of the request to the competent authority of the Member State in whose territory the seat of the undertaking is situated, together with a statement of why this information is required.

3. The competent authorities of the Member States will undertake the investigations which the Commission considers to be necessary under this Regulation.

4. If agreed by the Commission and the competent authority of the Member State in whose territory the investigation is to be made, the officials of the Commission shall assist the officials of such authority in carrying out their duties.

5. The Commission will take the appropriate measures to protect the confidentiality of information obtained pursuant to this Article.

Article 13

Member States shall take appropriate legal or administrative action in case of infringement of the provisions of this Regulation.

Article 14

This Regulation shall come into force on 1 January 1991. After its entry into force, the Council Regulation (EEC) No 3322/88 of 14 October 1988 on certain chlorofluorocarbons and halons which deplete the ozone layer becomes nul and void.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at, .. .

For the Council

The President

ANNEX I

Substances covered by the Regulation

The Regulation applies to the the substances listed in this Annex, whether alone or in a mixture; it does not apply to any such substance which is in a manufactured product other than a container used for the transport or storage of the substance listed.

Group	Substance	Ozone-depleting potential (1)
Group I	CFCl ₃ (CFC- 11)	1,0
	CF ₂ Cl ₃ (CFC- 12)	1,0
	C ₂ F ₃ Cl ₃ (CFC-113)	0,8
	C ₂ F ₄ Cl ₂ (CFC-114)	1,0
	C ₂ F ₅ Cl (CFC-115)	0,6
Group II	CF ₂ BrCl (halon-1211)	3,0
	CF ₃ Br (halon-1301)	10,0
	C ₂ F ₄ Br ₂ (halon-2402)	6,0
Group III	CCl ₄ (carbon tetrachloride)	1,1 (2)
Group IV	CCl ₃ CH ₃ (methyl chloroform)	0,1 (2)

- (1) These ozone-depleting potentials are estimates based on existing knowledge and will be reviewed and revised periodically.
- (2) Provisional figure pending decision of the Parties to the Protocol.

ANNEX II

Quantitative limits on imports from third countries

Description (2)	Units	For 12-month periods from 1 January 1992 to 31 December 1995	For 12-month periods from 1 January 1996 to 31 December 1997	From 1 January 1998
Group I of Annex I (Fully halogenated chlorofluorocarbons)	Weighted tonnes (1)	1 161 (b)	348 (c)	0
Group II of Annex I (Halons)	Weighted tonnes (1)	For 12-month periods from 1 January 1992 to 31 December 1995 700 (a)	For 12-month periods from 1 January 1996 to 31 December 1999 350 (b)	From 1 January 2000 0
Group III of Annex I (carbon tetra-chloride)	Weighted tonnes (1)	For 12-month periods from 1 January 1992 to 31 December 1997 x (b)	From 1 January 1998 0	
Group IV of Annex I (methyl chloro-form)	Weighted tonnes (1)	For 12-month periods from 1 January 1992 to 31 December 1997 y(a)	For 12-month periods from 1 January 1998 to 31 December 1999 z1(d)	For 12-month periods from 1 January 2000 50 z2(e)

- (a) Equals imports in 1986.
 (b) Equals imports in 1986 minus 50%.
 (c) Equals imports in 1986 minus 85%.
 (d) Equals imports in 1986 minus 20%.
 (e) Equals imports in 1986 minus 40%.
 (1) Weighted according to the ozone-depleting potentials specified in Annex I. This is equivalent to the calculated levels mentioned in the Regulation.
 (2) The codes and the descriptions of the combined nomenclature are indicated in Annex III.

ANNEX III

Codes and descriptions of the combined nomenclature
for the substances referred to in Annexes I and II

CN code	Description
2903 40 10	- - - Trichlorofluoromethane
2903 40 20	- - - Dichlorofluoromethane
2903 40 30	- - - Trichlorotrifluoroethane
2903 40 40	- - - Dichlorotetrafluoroethane
2903 40 50	- - - Chloropentafluoroethane
2903 40 70	- - - Bromotrifluoromethane
2903 40 80	- - - Dibromotetrafluoroethane
2903 40 91	- - - Bromochlorodifluoromethane
ex 3823 90 96	Mixtures containing products falling within codes 2903 40 10, 2903 40 20, 2903 40 30, 2903 40 40 or 2903 40 50
ex 3823 90 97	Mixtures containing products falling within codes 2903 40 70, 2903 40 80, 2903 40 91 or 3823 90 96

* codes and descriptions of the combined nomenclature for the new controlled substances to be added

ISH BUSINESS BUREAU
7 RUE DES DEUX EGLISES, B-1150 7
1040 BRUSSELS
TEL: 230 96 85
FAX: 231 10 32

II

(Acts whose publication is not obligatory)

Boyle/
Eu-Colep
+file

COMMISSION

COMMISSION RECOMMENDATION

of 27 June 1990

on the reduction of chlorofluorocarbons used by the Community's foam plastics industry

(90/437/EEC)

THE COMMISSION OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Economic Community, and in particular Article 155 thereof,

Whereas the Community has signed the Vienna Convention for the protection of the ozone layer, together with all of its Member States;

Whereas the Community has signed the Montreal Protocol on substances that deplete the ozone layer, together with all of its Member States;

Whereas the Council has adopted on 14 October 1988 Decision 88/540/EEC⁽¹⁾ for the conclusion and ratification of the Vienna Convention and the Montreal Protocol;

Whereas the Council has adopted on 14 October 1988 Regulation (EEC) No 3322/88⁽²⁾ for the implementation at Community level of the Montreal Protocol;

Whereas recent scientific studies have confirmed that some depletion of ozone layer has already occurred and that the observed changes may be due, wholly or in part, to the increased atmospheric abundance of trace gases, particularly chlorofluorocarbons (CFCs);

Whereas it is important to achieve the greatest feasible substitution of the CFCs listed in Annex I and halons in all areas of their use;

Whereas a number of Member States have reached voluntary agreements with the manufacturers of plastic foams

for the progressive reduction with a view to possible elimination of the CFCs listed in Annex I from these products;

Whereas the Council resolution of 14 October 1988 for the limitation of use of chlorofluorocarbons and halons⁽³⁾ invites the Commission, in cooperation with the Member States, to initiate discussions on voluntary agreements at the Community level with all the industries concerned, wherever feasible to substitute the CFCs listed in Annex I and halons in products or in equipment or processes using them;

Whereas, pending the availability of new substances, the reductions set out in Annex II will depend upon the commercial availability and use of alternative substances which have a positive but relatively low ozone-depletion potential (ODP) and which are environmentally acceptable in other respects;

Whereas the Council of Ministers concluded on 2 March 1989 that there is a need for a reduction of at least 85 % as soon as possible in the current level of production and use of the CFCs covered by the Montreal Protocol with a view to their being eliminated towards the end of the century, and for the said Protocol to be strengthened accordingly,

HEREBY RECOMMENDS:

I. to the Community's foam plastics manufacturers to seek:

⁽¹⁾ OJ No L 297, 31. 10. 1988, p. 8.

⁽²⁾ OJ No L 297, 31. 10. 1988, p. 1.

⁽³⁾ OJ No C 285, 9. 11. 1988, p. 1.

1. to limit the use of the fully halogenated chlorofluorocarbons listed in Annex I in foam plastics and to phase them out before the end of the century ;
2. to reduce the use of fully halogenated chlorofluorocarbons by at least 35 % by the end of 1991 and by at least 65 % by the end of 1993 with respect to the 1986 consumption. In 1986 the Community use of the chlorofluorocarbons listed in Annex I for the manufacture of plastic foams was 85 400 ODP weighted tonnes. The breakdown of the above reductions for each sector of the foam plastics industry is set out in Annex II. Progress in reduction will be monitored by the annual sales statistics for the substances listed in Annex I issued by the producers in the Community ;

II. to the federations mentioned in Annex III :

1. to use their best endeavours to ensure that the foam plastics industry within the Community minimizes its use of the controlled substances and achieves the reductions referred to in I.2 ;
2. to use their best endeavours to ensure that the industrial sectors they represent minimize their use of the controlled substances and achieve the reductions referred to in Annex II ;
3. to present to the Commission an annual report on the progress made in respect of the target reductions listed in Annex II, including statistics where practicable, and starting with the year 1989 ;

III. to the Community's manufacturers of raw materials for the foam plastics for which any of the fully halo-

genated chlorofluorocarbons listed in Annex I are used as blowing agents, including the manufacturers of these blowing agents and the associations of both of these industrial sectors listed in Annex IV :

1. to pursue the development of materials, formulations and technology for the commercial production of foam plastics with reduced usage of the substances listed in Annex I, and to promote the utilization of such materials, formulations and technology for the manufacture of foam plastics ;
2. to pursue programmes of research and development directed towards providing environmentally acceptable materials and technology which will enable foam plastics to be produced commercially without the use of any of the substances listed in Annex I ;
3. to present to the Commission an annual report on the technical progress made in respect of III.1 and III.2 including statistics where practicable and starting with the year 1989 ;

IV. to Member States to use their best endeavours to ensure that the aims of the recommendation are achieved by contributions from their respective territories.

Done at Brussels, 27 June 1990.

For the Commission

Carlo RIPA DI MEANA

Member of the Commission

ANNEX I

Substances covered by this recommendation

Substance	Ozone depleting potential (ODP)
CFC-11	1,0
CFC-12	1,0
CFC-113	0,8
CFC-114	1,0
CFC-115	0,6

ANNEX II

Foam plastics industry

(1)	(2)	(3)	(4)
1. Polyurethane foam sector			
1.1. Flexible — slabstock	9 692	- 50 %	- 50 % (*)
1.2. Flexible — moulding	6 550	- 50 %	- 80 %
1.3. Rigid — appliances	9 250	- 45 %	- 50 %
1.4. Rigid — building / industrial	27 950	- 10 %	- 50 %
1.5. Others	6 950	-25 %	- 65 %
2. Extruded polystyrene foam sector			
2.1. Extruded polystyrene board insulating boardstock	7 000	- 50 %	- 100 %
2.2. Extruded polystyrene foam packaging	6 000	- 100 %	- 100 %
3. Polyolefin foams	5 000	- 50 %	- 100 %
4. Phenolic foams	1 600	- 10 %	- 50 %

(1) Different sectors of the foam plastics industry.

(2) Mean values of estimates of CFCs used by each sector in European Economic Community (1986).

(3) Estimated percentage changes in CFC usage by the end of 1991 with respect to consumption in 1986.

(4) Estimated percentage changes in CFC usage by the end of 1993 with respect to consumption in 1986.

(*) Industry have indicated that a much higher reduction is expected to be achieved by 1993, but an exact figure could not be set.

EEC - PROPOSAL FOR A COUNCIL REGULATION ON CFCS

Each Producer to ensure that :

Production in the period :	Shall not exceed:
1 July '91 to 31 December '92	1986 Actual
1 January '93 to 31 December '93	50% of 1986
1 January '94 to 31 December '94	50% of 1986
1 January '95 to 31 December '95	32.5% of 1986
1 January '96 to 31 December '96	15% of 1986
1 January '97 to 30 June '97	7.5% of 1986
After 30 June '97	Nil

Derogations for:

Export to LDC's

Essential Uses

e.g. Medical Aerosols

I

(Acts whose publication is obligatory)

COUNCIL REGULATION (EEC) No 594/91

of 4 March 1991

on substances that deplete the ozone layer

THE COUNCIL OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Economic Community, and in particular Article 130s thereof,

Having regard to the proposal from the Commission ⁽¹⁾,

Having regard to the opinion of the European Parliament ⁽²⁾,

Having regard to the opinion of the Economic and Social Committee ⁽³⁾,

Whereas it is established that continued emissions of ozone depleting substances at current levels cause significant damage to the ozone layer; whereas there is an international consensus that significant reductions in both production and consumption of such substances are necessary; whereas Decisions 80/372/EEC ⁽⁴⁾ and 82/795/EEC ⁽⁵⁾ provide controls which are of limited effect and which cover only two such substances (CFC 11 and CFC 12);

Whereas in view of the responsibilities of the Community for the environment and trade, all Member States and the Community have become Parties to the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer;

Whereas Regulation (EEC) No 3322/88 ⁽⁶⁾ provides for controls on certain chlorofluorocarbons and halons which deplete the ozone layer;

Whereas, in the light of more recent scientific evidence, the Parties to the Montreal Protocol have adopted at their second meeting, at which the Community and the

Member States played a leading role, additional measures for the protection of the ozone layer;

Whereas, in the light of more recent scientific evidence, the Parties to the Montreal Protocol have adopted at their second meeting, at which the Community and the Member States played a leading role, additional measures for the protection of the ozone layer;

Whereas it is necessary for action to be taken at Community level to carry out the Community's obligation under the Convention and the amended Protocol, in particular further to control production and consumption within the Community of certain chlorofluorocarbons and halons and other ozone-depleting substances;

Whereas, in the light notably of scientific evidence, it is appropriate in certain cases to introduce control measures which are more severe than those of the amended Protocol;

Whereas, bearing in mind the market structure for chlorofluorocarbons, other fully halogenated chlorofluorocarbons, halons, carbon tetrachloride and 1,1,1-trichloroethane, it is appropriate — to ensure fulfilment of the Community's obligation under the amended Protocol — to control consumption of these substances by controlling supply rather than demand; whereas supply can be controlled by limiting sales and use by producers in the Community, and by limiting the release into free circulation of imports;

Whereas it is necessary to keep under review the evolution of the market for the above substances, particularly with regard to sufficient supply for essential uses, and the state of development of appropriate substitutes;

Whereas additional Community measures may be needed to carry out the Community's obligations under the Protocol in respect of research and development, and technical assistance;

Whereas Regulation (EEC) No 3322/88 has become superfluous and should therefore be repealed,

⁽¹⁾ OJ No C 86, 4. 4. 1990, p. 4.

⁽²⁾ OJ No C 19, 28. 1. 1991.

⁽³⁾ OJ No C 332, 31. 12. 1990, p. 14.

⁽⁴⁾ OJ No L 90, 3. 4. 1980, p. 45.

⁽⁵⁾ OJ No L 329, 25. 11. 1982, p. 29.

⁽⁶⁾ OJ No L 297, 31. 10. 1988, p. 1.

ANNEX I

Substances covered by the Regulation

Group	Substance	Ozone-depleting potential ⁽¹⁾
Group I	CFCl ₃ (CFC-11)	1,0
	CF ₂ Cl ₂ (CFC-12)	1,0
	C ₂ F ₃ Cl ₃ (CFC-113)	0,8
	C ₂ F ₄ Cl ₂ (CFC-114)	1,0
	C ₂ F ₅ Cl (CFC-115)	0,6
Group II	CF ₃ Cl (CFC-13)	1,0
	C ₂ FCl ₃ (CFC-111)	1,0
	C ₂ F ₂ Cl ₄ (CFC-112)	1,0
	C ₃ FCl ₅ (CFC-211)	1,0
	C ₃ F ₂ Cl ₄ (CFC-212)	1,0
	C ₃ F ₃ Cl ₃ (CFC-213)	1,0
	C ₃ F ₄ Cl ₂ (CFC-214)	1,0
	C ₃ F ₅ Cl (CFC-215)	1,0
	C ₃ F ₆ Cl ₂ (CFC-216)	1,0
	C ₃ F ₇ Cl (CFC-217)	1,0
	Group III	CF ₃ BrCl (halon-1211)
CF ₃ Br (halon-1301)		10,0
C ₂ F ₄ Br ₂ (halon-2402)		6,0
Group IV	CCl ₄ (carbon tetrachloride)	1,1
Group V	C ₂ H ₃ Cl ₃ (?) (1,1,1-trichloroethane)	0,1
Group VI	CHFCl ₂ (HCFC-21)	
	CHF ₂ Cl (HCFC-22)	
	CH ₂ FCl (HCFC-31)	
	C ₂ HFCl ₃ (HCFC-121)	
	C ₂ HF ₂ Cl ₂ (HCFC-122)	
	C ₂ HF ₃ Cl (HCFC-123)	
	C ₂ HF ₄ Cl (HCFC-124)	
	C ₂ H ₂ FCl ₃ (HCFC-131)	
	C ₂ H ₂ F ₂ Cl ₂ (HCFC-132)	
	C ₂ H ₂ F ₃ Cl (HCFC-133)	
	C ₂ H ₂ FCl ₂ (HCFC-141)	
	C ₂ H ₂ F ₂ Cl (HCFC-142)	
	C ₂ H ₂ FCl (HCFC-151)	
	C ₂ HFCl ₄ (HCFC-221)	
	C ₂ HF ₂ Cl ₃ (HCFC-222)	
	C ₂ HF ₃ Cl ₂ (HCFC-223)	
	C ₂ HF ₄ Cl (HCFC-224)	
	C ₂ HF ₅ Cl (HCFC-225)	
	C ₂ HF ₆ Cl (HCFC-226)	
	C ₂ H ₂ FCl ₃ (HCFC-231)	
	C ₂ H ₂ F ₂ Cl ₂ (HCFC-232)	
	C ₂ H ₂ F ₃ Cl (HCFC-233)	
	C ₂ H ₂ F ₄ Cl (HCFC-234)	
	C ₂ H ₂ F ₅ Cl (HCFC-235)	
	C ₂ H ₂ FCl ₂ (HCFC-241)	
	C ₂ H ₂ F ₂ Cl (HCFC-242)	
	C ₂ H ₂ F ₃ Cl (HCFC-243)	
	C ₂ H ₂ F ₄ Cl (HCFC-244)	
	C ₂ H ₂ FCl (HCFC-251)	
	C ₂ H ₂ F ₂ Cl ₂ (HCFC-252)	
C ₂ H ₂ F ₃ Cl (HCFC-253)		
C ₂ H ₂ FCl ₂ (HCFC-261)		
C ₂ H ₂ F ₂ Cl (HCFC-262)		
C ₂ H ₂ FCl (HCFC-271)		

(¹) These ozone-depleting potentials are estimates based on existing knowledge and will be reviewed and revised periodically in the light of decisions taken by the Parties to the Protocol.

(²) This formula does not refer to 1,1,2-trichloroethane.

ANNEX II

Quantitative limits on imports from third countries

(calculated levels expressed in tonnes)

Substance	Group I	Group II (% of 1989 imports) (¹)	Group III	Group IV (% of 1989 imports) (¹)	Group V (% of 1989 imports) (¹)
For 12 month periods from 1 January to 31 December :					
1991	2 322 (²)				
1992		50 %	700	50 %	100 %
1993	1 161	50 %	700	50 %	100 %
1994	1 161	50 %	700	50 %	100 %
1995	755	32,5 %	350	15 %	70 %
1996	348	15 %	350	15 %	70 %
1997	174 (³)	7,5 % (³)	350	15 %	70 %
1998			350	0 %	70 %
1999			350		70 %
2000			0		30 %
2001					30 %
2002					30 %
2003					30 %
2004					30 %
2005					0 %

(¹) These percentages will be replaced by absolute figures as soon as these figures are available. They will be published by the Commission in the Official Journal.

(²) For the period 1 July 1991 to 31 December 1992.

(³) For the period 1 January to 30 June 1997. Thereafter there will not be any imports of the substances concerned.

Notice
from the Government of the Federal Republic of Germany
to the Commission of the European Communities
dated 1st June 1990

Subject: Information procedure in the field of standards and technical provisions (Council Directive 83/189/EEC, in the version of Council Directive 88/182/EEC);
in this instance: Notification of the CFC/Halon Prohibition Order

In accordance with Article 8 para. 1 of the above Directive on an information procedure in the field of standards and technical provisions, the draft of the CFC/Halon Prohibition Order is enclosed herewith in triplicate.

The making of this Order will improve the protection of mankind and the environment from the effects of certain chlorofluorocarbons (CFCs), chlorinated hydrocarbons and halons on the stratospheric ozone layer and the climate of the earth. The ruling is a further step towards reducing the emissions of substances which play a major part in the depletion of the ozone layer.

CFCs and halons are highly resistant to biotic and abiotic degradation. They therefore pass into the atmosphere in an undecomposed state and enter the stratosphere.

In November 1988, the Enquete Commission on "Provisions for the protection of the earth's atmosphere" of the German Bundestag expounded the scientific finding which has since been further substantiated, that the hole in the ozone layer above the Antarctic was partly caused by the groups of CFC and halon substances and that CFCs also made a major contribution to the greenhouse effect. The latest scientific discoveries, presented at the most recent international conferences, regarding the potential for damaging the ozone layer and the harmful effects this is likely to cause, serve to confirm the necessity for abandoning with all possible speed the production

and use of CFCs and other comparable harmful substances. In particular, these discoveries make it clear that the reduction quotas and reduction periods laid down in the Montreal Protocol in 1987 are insufficient to prevent the further depletion of the ozone layer effectively and in time.

The depletion of the ozone layer above the Antarctic caused by CFC and halon emissions has already led to a clearly measurable increase in the intensity of UVB radiation. Negative effects on the aquatic ecosystem have been demonstrated. The fear is that, if the ozone layer is further reduced globally, there will be effects on the health of mankind, such as increased skin cancers, as well as negative effects on terrestrial ecosystems. Moreover, CFCs and halons play a significant part in the greenhouse effect.

There is no doubt that the CFCs and halons covered to date by the Montreal Protocol are hazardous substances within the meaning of Section 3 a para. 1 No. 16 in conjunction with Section 3a para. 2 of the Chemicals Act. The list of substances covered is currently being expanded.

The purpose of this Order is to introduce, quickly and with a specific purpose, measures on a national level which do not simply go far beyond the commitments agreed to in 1987 by the parties signing the Montreal Protocol, but which also go beyond the increased stringency measures discussed in connection with the 2nd Conference of the contracting countries to this Protocol in June 1990 in London. Therefore, on the basis of the principle of precaution, five substances which deplete the ozone layer and which have not yet been regulated in the Montreal Protocol will be included in the Order and the reduction periods will be considerably shortened in comparison with the Montreal Protocol. With this Order, the Federal Republic of Germany is doing all it can nationally to reduce those substances which deplete the ozone layer, and is thus making a contribution to solving the worldwide ozone problem which is appropriate to its responsibility and economic capacity. There is also the effect of the example set by such legislation on the behaviour of other countries, especially the industrial nations.

Grading, packing and marking substances in accordance with the provisions of the Chemicals Act cannot in themselves sufficiently counteract the dangers for the health of mankind and the environment as a result of the substances specified in Section 1. It is therefore necessary to adopt

prohibitions on the basis of Section 17 of the Chemicals Act. At the same time, the Order is also based on Section 14 of the Refuse Act, so that those who put on the market the substances or preparations specified in Section 1 of the Order are subsequently obliged to take them back.

The Order is within the bounds of the opportunity provided by "Regulation (EEC) No. 3322/88 on certain chlorofluorocarbons and halons" (ABL. EC No. L 297/1 dated 31.10.1988) in conjunction with EEC Treaty law, to take more extensive protection measures within the Member States of the Community.

The two regulatory instruments complement one another. Whilst the EC Regulation regulates the supply of the substances in question, the national Order covers demand, i.e. use of the substances will be permitted only in areas where this is considered essential by the Federal Government. On the other hand, the EC ruling would, for example, allow the continued use of all permitted products in open areas of use, such as in the case of sprays or solvents.

Since the EC Regulation is based on Article 130 s of the EEC Treaty, in accordance with Article 130 t of the Treaty the Member States are not prevented from taking or retaining more stringent measures to protect the environment which are compatible with the Treaty.

B M U

THE FEDERAL MINISTER FOR
THE ENVIRONMENT, NATURE CONSERVATION AND REACTOR SAFETY
Kennedyallee 5, 5300 Bonn 2, Tel. (0228) 305-0

- IG II 5 -

PROVISION OF THE
FEDERAL CABINET

dated 30th May 1990

Order for the Prohibition

of certain

Halogenated Hydrocarbons

which deplete the Ozone Layer

(CFC/HALON PROHIBITION ORDER)

BMU

Bonn, 23rd May 1990

IG II 5 - 61 021/13

Order for the Prohibition
of certain
Halogenated Hydrocarbons
which deplete the Ozone Layer
(CFC/Halon Prohibition Order)

By virtue of Section 14 para. 1 No. 3(a), Section 17 para. 1 sentence 1 No. 1(a) and (b) and Section 21 para. 2 a No. 1 of the Chemicals Act in the version of the promulgation of 14th March 1990 (Federal Law Gazette I p. 521) and of Section 14 para. 1 No. 3 and para. 2 No. 3 of the Refuse Act of 27th August 1986 (Federal Law Gazette I p. 1410), the Federal Government, after hearing those involved, orders as follows:

Section 1

Scope

- (1) This Order applies to the following substances, and to preparations and substances containing these substances:
 2. Dichlorodifluoromethane (R 12),
 3. Chlorotrifluoromethane (R 13),
 4. Tetrachlorodifluoroethane (R 112),
 5. Trichlorotrifluoroethane (R 113),
 6. Dichlorotetrafluoroethane (R 114),
 7. Chloropentafluoroethane (R 115),
 8. Bromochlorodifluoromethane (Halon 1211),
 9. Bromotrifluoromethane (Halon 1301),
 10. Dibromotetrafluoroethane (Halon 2402),
 11. Tetrachloromethane (carbon tetrachloride)
 12. 1,1,1 trichloroethane (methyl chloroform)

- (2) The Order shall apply to the partly-halogenated substance chlorodifluoromethane (R22) in the circumstances described in greater detail.

- (3) This Order shall not apply to production, putting into circulation or use for research, development or analysis purposes.

- (4) This Order shall not apply:
 1. on ocean-going vessels under foreign flags or on ocean-going vessels for which the Federal Minister of Transport, in accordance with Section 10 of the Law of the Flag Act in the amended version as published in the Federal Law Gazette Part III, Classification No. 9541-1, has granted authorisation to fly the Federal flag only for the first trip to transfer to a different port,

 2. on board watercraft, provided the home location of these watercraft does not fall within the area of application of this Order,

3. in aircraft which are not registered and licensed within the area of application of this Order.

Section 2

Compressed gas packs

(1) The manufacture or putting into circulation of compressed gas packs containing substances specified in Section 1 para. 1 and 2, with a content totalling more than 1 per cent by weight, is prohibited. The provisions of Section 4 do not apply to structural foams in compressed gas packs.

(2) The prohibition in accordance with para. 1 does not apply to the extent that, at the time of this Order coming into effect, a licence in accordance with the Medicines Act exists, but only until a decision is made as to the extension of this licence. The Federal Health Office may, on application, authorise exceptions to the prohibition in accordance with para. 1 for a fixed period under the procedure for deciding whether to grant or extend the licence in accordance with the Medicines Act, if the medicines in question are for the treatment of serious ailments and the use of the substances specified in Section 1 para. 1 and 2 is essential for the use of the medicine.

(3) The Federal Environment Office, in consultation with the Federal Institute for Materials Research and Testing, may, on application, authorise exceptions to the prohibition in accordance with para. 1 for a fixed period for special technical applications, if the substances specified in Section 1 para. 1 and 2 do not serve as propellant gases in the application for which they are intended, and if their use is essential.

Section 3

Refrigerants

(1) The putting into circulation or use of refrigerants with a content totalling more than 1 per cent by weight of the substances specified in Section 1 para. 1 and 2 is prohibited.

(2) The production or putting into circulation of products containing refrigerants specified in para. 1 is prohibited.

Section 4

Foams

(1) The use of the substances specified in section 1 para. 1 and 2 for the manufacture of:

1. Packing materials and tableware made of foams,
 2. Insulating materials in which the substances specified in Section 1 paras. 1 and 2 are included in the application for which they are intended,
 3. Structural foams in compressed gas packs, or
 4. Other foam materials
- is prohibited.

(2) The putting into circulation of foams which could release or contain the substances specified in Section 1 para. 1 and 2 and their products which are made of such foams, is prohibited.

Section 5

Cleaning agents and solvents

(1) The manufacture, putting into circulation or use of cleaning agents or solvents with a content totalling more than 1 per cent by weight of the substances specified in Section 1 paras. 1 and 2 is prohibited.

(2) The prohibition in accordance with para. 1 does not apply to the extent that:

1. for technical reasons, the substance specified in Section 1 para. 1 No. 11 cannot be replaced by other less hazardous substances, preparations or products as a solvent for chlorination processes in closed systems,

2. the cleaning agents and solvents may be used in plants in accordance with the Second Order to Implement the Federal Immission Protection Act, and are intended exclusively for use in such plants.

The regulation under No. 2 shall apply accordingly to surface treatment plants, dry cleaning plants and textile finishing plants, and to extraction plants which are parts of plants or ancillary facilities of plants requiring approval in accordance with the Fourth Order to Implement the Federal Immission Protection Act.

- (3) The Federal Environment Office may, on request, authorise exceptions to the prohibition in accordance with para. 1 in respect of the substances specified in Section 1 para. 1 No. 11 and 12 for a fixed period if the use of such substances is essential.

Section 6

Extinguishing agents

- (1) The manufacture, putting into circulation or use of extinguishing agents with a content totalling more than 1 per cent by weight of the substances specified in Section 1 para. 1 No. 8 to 10 is prohibited.

- (2) The authority responsible for licensing the equipment and systems for fire fighting, in consultation with the Federal Environment Office, may, on application, authorise exceptions to the prohibition in accordance with para. 1 for a fixed period, if the substances are essential in fire fighting for the protection of human life and health.

Section 7

Marking

- (1) Compressed gas packs in accordance with Section 2 para. 3, refrigerants in accordance with section 3 in drums, products in accordance with Section 3 para. 2, insulating materials in accordance with section 4 para. 1 No. 2 and cleaning agents and solvents in accordance with Section 5 in drums may,

provided they contain substances in accordance with Section 1 para. 1 No. 1 to 7 or para. 2, be put into circulation only if these are identified by printing, stamping or with stickers in a readily legible and recognisable manner with the following marking:

"Contains ozone-depleting CFCs"

This shall not apply to insulating materials in accordance with Section 4 para. 1 No. 2 to the extent that they contain the substance in accordance with Section 1 para. 2.

(2) Extinguishing agents in accordance with Section 6 may be put into circulation in drums only if they are marked by printing, stamping or with stickers in a readily legible and recognisable manner in the following way:

"Contains ozone-depleting halon".

Section 8

Operation, maintenance, putting out of operation, obligation to take back

(1) Allowing the substances contained within them to escape to the atmosphere when operating, performing maintenance work on or putting out of operation products containing refrigerants in accordance with Section 3 or extinguishing agents in accordance with Section 6, in contravention of the rules of the art, is prohibited, except in the case of the use as intended of extinguishing agents.

(2) Those putting on to the market the substances and preparations specified in section 1 paras. 1 and 2 are obliged to take these substances and preparations back after use, or to ensure that they are taken back by a third party designated by them. Sentence 1 does not apply to the extent that the provisions of the Order on the disposal of used halogenated solvents are applicable.

Section 9

Criminal offences and infringements

(1) In accordance with Section 27 para. 1 No. 1 and paras. 2 to 4 of the Chemicals Act, any person who deliberately or negligently commits any of the following will suffer the penalty:

1. in contravention of Section 2 para. 1 sentence 1, section 3, section 4 para. 2, section 5 para. 1 or section 6 para. 1, manufactures, puts into circulation or uses substances, preparations or products specified therein, or
2. in contravention of Section 4 para. 1, uses substances specified therein for the production of foam materials.

(2) Any person who, in contravention of Section 7 para. 1 sentence 1 or para. 2, deliberately or negligently puts into circulation substances, preparations or products specified therein without the prescribed marking shall be guilty of an infringement within the meaning of Section 26 para. 1 No. 5(c) of the Chemicals Act.

(3) Any person who, in contravention of Section 8 para. 1, when operating, performing maintenance work on or putting out of operation products containing refrigerants in accordance with Section 3 or solvents in accordance with Section 6, deliberately or negligently allows the substances contained in them to escape to the atmosphere, in contravention of the rules of the art, shall be guilty of an infringement within the meaning of Section 26 para. 1 No. 7 of the Chemicals Act.

(4) Any person who, in contravention of Section 8 para. 2 sentence 1, deliberately or negligently does not take back a substance or a preparation after use, or does not ensure that it is taken back by a third party, shall be guilty of an infringement within the meaning of Section 18 para. 1 No. 11 of the Refuse Act.

Section 10

Transitional provisions

(1) Products in accordance with Section 2 of this Order may be put into circulation for up to six months after Section 2 comes into force.

(2) Refrigerants in accordance with Section 3 para. 1 may be manufactured, put into circulation and used for the purpose of use in products which were manufactured before Section 3 came into effect, until the products are put out of operation, unless refrigerants with a lower potential for depleting the ozone layer can be used in these products in accordance with the state of the art.

(3) Products in accordance with section 3 para. 2 and foams and products in accordance with section 4 which were manufactured before the prohibition on manufacture came into effect, may continue to be put into circulation.

(4) Cleaning agents and solvents in accordance with section 5 may be put into circulation for up to six months after the prohibition on manufacture comes into effect and may be used for up to nine months.

(5) Extinguishing agents in accordance with Section 6 may be put into circulation and used for the purpose of use in equipment and systems for fire fighting which were manufactured before Section 6 came into effect:

1. whereby the substance specified in Section 1 para. 1 No 8 may be used for up to 24 months, and
2. the substance specified in Section 1 para. 1 No. 9 may be used until the equipment and systems are put out of operation.

Section 11

Berlin Clause

In accordance with Section 14 of the Third Transference Law in conjunction with Section 30 of the Chemicals Act and Section 31 of the Refuse Act, the Order shall also apply in the Land of Berlin.

Section 12

Entry into force

(1) Except as provided in paras. 2 and 3, this Order shall come into force on the first day of the third calendar month following its promulgation.

(2) Notwithstanding para. 1, the following provisions shall come into force on the following dates:

1. on the first day of the sixth calendar month following promulgation, Section 8 para. 2;
2. on 1st January 1992, Section 3, except as provided in No. 4, for refrigerants and products which contain these refrigerants in a quantity of 5 kg or more; Section 4 para. 1 No. 4 and para. 2 for foams in accordance with Section 4 para. 1 No. 4 or products comprising such foams; Section 5 and Section 6 for extinguishers with a content totalling more than 1 per cent by weight of the substance specified in Section 1 para. 1 No. 8;
3. on 1st January 1993, Section 4 para. 1 No. 3, to the extent that the substance specified in Section 1 para. 2 is used;
4. on 1st January 1994, Section 3 for the use of refrigerants and products in mobile refrigerating plants which contain these refrigerants in a quantity of 5 kg or more;
5. on 1st January 1995, Section 3 for refrigerants and products which contain these refrigerants in a quantity of less than 5 kg; Section 4 para. 1 No. 2 and para. 2 for foams in accordance with Section 4 para. 1 No. 2 or products comprising such foams;
6. on 1st January 1996, Section 6 for extinguishing agents with a content totalling more than 1 per cent by weight of the substances specified in Section 1 para. 1 No. 9 and 10.

- 11 -

(3) Notwithstanding para. 2, the provisions of Section 3, section 4 para. 1 No. 2 and 4, and para. 2 for foams in accordance with Section 4 para. 1 No. 2 and 4 or products comprising such foams, shall come into force on 1st January 2000 for the substance specified in Section 1 para. 2 and for preparations which contain this substance but none of the substance specified in Section 1 para. 1.

The Bundesrat has agreed.

Bonn, dated:

The Federal Chancellor

The Federal Minister for the
Environment, Nature Conservation and
Reactor Safety

Grounds:A. General

The making of this Order will improve the protection of mankind and the environment from the effects of certain chlorofluorocarbons (CFCs), chlorinated hydrocarbons and halons on the stratospheric ozone layer and the climate of the earth. The ruling is a further step towards reducing the emissions of substances which play a major part in the depletion of the ozone layer (see "Act relating to the Montreal protocol of 16th September 1987 on substances which lead to depletion of the ozone layer", Federal Law Gazette 1988 II, p. 1014).

CFCs and halons are highly resistant to biotic and abiotic degradation. They therefore pass into the atmosphere in an undecomposed state and enter the stratosphere.

In November 1988, the Enquete Commission on "Provisions for the protection of the earth's atmosphere" of the German Bundestag expounded the scientific finding which has since been further substantiated, that the hole in the ozone layer above the Antarctic was partly caused by the groups of CFC and halon substances and that CFCs also made a major contribution to the greenhouse effect.

The latest scientific discoveries, presented at the most recent international conferences, regarding the potential for damaging the ozone layer and the harmful effects this is likely to cause, serve to confirm the necessity of abandoning with all possible speed the production and use of CFCs and other comparable harmful substances. In particular, these discoveries make it clear that the reduction quotas and reduction periods laid down in the Montreal Protocol in 1987 are insufficient to prevent the further depletion of the ozone layer effectively and in time.

The depletion of the ozone layer above the Antarctic caused by CFC and halon emissions has already led to a clearly measurable increase in the intensity of UVB radiation. Negative effects on the aquatic ecosystem have been demonstrated. The fear is that, if the ozone layer is further reduced globally, there will be effects on the health of mankind, such as

increased skin cancers, as well as negative effects on terrestrial ecosystems. Moreover, CFCs and halons play a significant part in the greenhouse effect.

There is no doubt that the CFCs and halons covered to date by the Montreal Protocol are hazardous substances within the meaning of Section 3 a para. 1 No. 16 in conjunction with Section 3a para. 2 of the Chemicals Act. The list of substances covered is currently being expanded.

The purpose of this Order is to introduce, quickly and with a specific purpose, measures on a national level which do not simply go far beyond the commitments agreed to in 1987 by the parties signing the Montreal Protocol, but which also go beyond the increased stringency measures discussed in connection with the 2nd Conference of the contracting countries to this Protocol in June 1990 in London. Therefore, on the basis of the principle of precaution, five substances which deplete the ozone layer and which have not yet been regulated in the Montreal Protocol will be included in the Order and the reduction periods will be considerably shortened in comparison with the Montreal Protocol. With this Order, the Federal Republic of Germany is doing all it can nationally to reduce those substances which deplete the ozone layer, and is thus making a contribution to solving the worldwide ozone problem which is appropriate to its responsibility and economic capacity. There is also the effect of the example set by such legislation on the behaviour of other countries, especially the industrial nations.

Grading, packing and marking substances in accordance with the provisions of the Chemicals Act cannot in themselves sufficiently counteract the dangers for the health of mankind and the environment as a result of the substances specified in Section 1. It is therefore necessary to adopt prohibitions on the basis of Section 17 of the Chemicals Act. At the same time, the Order is also based on Section 14 of the Refuse Act, so that those who put on the market the substances or preparations specified in Section 1 of the Order are subsequently obliged to take them back.

Implementation of the Order may involve costs for the Federal Government, regional governments and local authorities. It is anticipated particularly in the case of the Länder that they will incur additional costs of execution as a result of increased administrative work. The extent of such costs cannot be adequately quantified to date.

In the areas of industry affected, cost increases, in some cases considerable, may be anticipated as a result of the necessary change-over to substitute substances or alternative technologies. It may be possible to pass on part of the extra cost by way of prices.

The additional costs cannot be quantified in detail, but effects on the overall price level, especially the consumer price level, are not anticipated, or are expected to be small, since the proportion of the regulated substances in the value creation of the end product is small.

The Order is within the bounds of the opportunity provided by "Regulation (EEC) No. 3322/88 on certain chlorofluorocarbons and halons" (ABL. EC No. L 297/1 dated 31.10.1988) in conjunction with EEC Treaty law, to take more extensive protection measures within the Member States of the Community.

The two regulatory instruments complement one another. Whilst the EC Regulation regulates the supply of the substances in question, the national Order covers demand, i.e. use of the substances will be permitted only in areas where this is considered essential by the Federal Government. On the other hand, the EC ruling would, for example, allow the continued use of all permitted products in open areas of use, such as in the case of sprays or solvents.

Since the EC Regulation is based on Article 130 s of the EEC Treaty, in accordance with Article 130 t of the Treaty the Member States are not prevented from taking or retaining more stringent measures to protect the environment which are compatible with the Treaty.

B. Regarding the individual provisions

Re Section 1

Paras. 1 and 2 list the substances covered by the Order. These are the substances mentioned in the Decision of the German Bundestag (BT-Drs. 11/4133) and, in addition, the fully-halogenated chlorofluorocarbons R 13 and R 112 and the chlorinated hydrocarbons tetrachloromethane (carbon tetrachloride) and 1,1,1 trichloroethane (methyl chloroform).

The fully-halogenated CFCs and halons, which have a particularly great potential for the depletion of ozone, are included in para. 1 with the two chlorinated hydrocarbons referred to above. The substance tetrachloromethane has an ozone depletion potential which is 20% higher than R 11. The ozone depletion potential of 1,1,1 trichloroethane however is only approx. 14% of that of R 11. According to information from industry, the domestic consumption of 1,1,1 trichloroethane was approx. 30,000 t in 1989. Of this, it is estimated that 50% was emitted. Approx. 4,000 to 5,000 t of the total used was for open applications.

The partly-halogenated CFC R22 has an ozone depletion potential 95% lower, and a greenhouse potential 90% lower, than substance R 12, which, in some cases, it can replace. Because of these properties, R 22 can be considered as a substitute for fully-halogenated CFCs as an interim measure and it is therefore listed separately in para. 2.

Para. 3 provides for a general exception clause for research, development and analysis purposes, as also contained in the PCB, PCT and VC Prohibition Order of 18th July 1989 (Federal Law Gazette I p. 1482). An exception regulation directed at individual cases is not appropriate, since the regulated substances are not hazardous as working substances and the small amounts required in research, development and analysis do not represent a threat to the environment.

Due to existing commitments on the part of the Federal Republic of Germany in this area under international law, para. 4 contains an exception for circumstances relating to foreign countries. This is operative law in the cases, similar in this respect, of plants requiring supervision in accordance with Section 24 of the Trading Regulations (e.g. Section 1 para. 3 of the Steam Boiler Order, Section 1 para. 3 of the Acetylene Order, and Section 1 para. 3 of the Licensed Premises Order dated 27.11.1989 (Federal Law Gazette I p. 2044)).

Re Section 2

The Order covers all the substances specified in Section 1 which are used in compressed gas packs. Primarily, these are aerosol products which operate on the spray can principle and are used in medicine and in the technical field (e.g. asthma, cleaning, separating and freezing sprays).

In the Federal Republic of Germany, consumption of these products represented approx. 4,760 t CFCs in 1988. By contrast, consumption in 1989 was 2,650 t, of which approx. 700 t were used in medicine. Compared with the consumption of previous years, this represents a significant reduction, which is based on voluntary commitments on the part of the aerosol industry. However, this does not exhaust all the possibilities for reduction, particularly in the technical field.

Finally, the provision covers compressed gas "hooters" which are used frequently at sports events to produce noise.

Structural foams in compressed gas packs are regulated in Section 4 (Foams) for systematic reasons.

Today, there are many substitute propellants to replace the substances specified in Section 1. For example, instead of chlorofluorocarbons, propane/butane, dimethyl ether, carbon dioxide, nitrogen, etc. may be used as propellants. Pump-type sprays are used as an alternative to compressed gas packs. In addition, there are alternative methods of applying the particular active agent (e.g. dipping and brushing in the technical sphere, rollers for household use and in small-scale trade).

The provision prohibits the manufacture and putting into circulation of compressed gas packs. Para. 2 sentence 2 allows exceptions in the field of medicine, as more fully described, to the extent that no substitute products have been developed which are equally reliable medically. For example, in the case of acute, life-threatening dyspnoea, the usual pump systems do not reliably guarantee immediate, effective application. Moreover, the pack sizes in these areas are relatively small (10 ml). In accordance with para. 2 sentence 1, there is to be no interference with existing licences in accordance with the Medicines Act. This also applies to currently "fictitiously" licensed drugs.

Para. 3 allows exceptions for technical/industrial aerosols in which CFCs do not serve as the propellant gas in the application for which they are intended, but are used on the basis of other technical properties, e.g. in cleaning and maintenance sprays, or as separating agents. The exceptions are to be granted for a fixed period and must be applied for in every case.

Re Section 3

The provision prohibits the putting into circulation and use of refrigerants containing substances specified in Section 1. At the same time, it prohibits the manufacture and putting into circulation of products containing such refrigerants. In the case of air conditioning and refrigerating plants, substitute refrigerants appropriate to the size of the plant, the refrigerating capacity and the area of application are currently available only to a limited extent. Therefore, the prohibitions of this provision are to come into force over a period as provided for in Section 12 paras. 2 and 3.

The way the introduction is staggered is based on the following divisions:

a) Industry, large-scale trade (slaughterhouses, etc.)

Ammonia compressors and absorbers and lithium bromide/water absorbers represent systems which do not damage the environment. The provision in accordance with Section 12 para. 3 takes account of the possible necessity of using the partly-halogenated R 22. The provision can therefore come into force for this area on 1st January 1992 in accordance with Section 12 para. 2 No. 2.

b) Small-scale trade (domestic refrigerators, display cases, etc.), air conditioning systems in buildings, heat pumps, transport vehicles

It appears that chlorine-free substitutes which can be used in the long term will not be available in sufficient quantities until approx. 1993. In order for the prohibition of fully-halogenated chlorofluorocarbons to be possible from 1st January 1992 in accordance with Section 12 para. 2 No. 2, it would seem to be expedient not to allow the provision in respect of the partly-halogenated R 22, which is also used in this area, to come into force until 1st January 2000 in accordance with Section 12 para. 3.

In partial areas of mobile refrigeration plants, the provision in accordance with Section 12 para. 2 No. 4 is to come into force two years later, in order to allow a direct change-over from fully-halogenated CFCs to chlorine-free refrigerants in these areas. This will take account of the current state of development.

2. Products with less than 5 kg refrigerant content:

Household appliances, small-scale trade, car air-conditioners, etc.

It is anticipated that chlorine-free substitutes which can be used in the long term will not be available in this area either until approx. 1993. Since abandoning the substitute R 22 is possible only to a limited extent in these systems for technical reasons, the provision regarding fully-halogenated CFCs is to come into force on 1st January 1995 in accordance with Section 12 para. 2 No. 5. Where R 22 is used, the provision is to come into force on 1st January 2000 in accordance with Section 12 para. 3, as is also the case for products with a refrigerant content of 5 kg or more.

Re Section 4

The provision prohibits the use of CFCs to manufacture foams and to put into circulation these foams and corresponding products.

Substitute propellants are available for use in the field of application regulated in Section 4 para. 1 No. 1 instead of the substances specified in Section 1. For example, nowadays extruded polystyrene, which is used, amongst other things, for the production of packaging material and plastic tableware, is, in some cases, already being expanded with pentane instead of R 11 or R 12. Pentane has proved itself in practice as a substitute propellant and is being used widely. Production using R 22, which can also be used in these foams almost without restriction, is also to be avoided in this connection. Since substitute propellants which do not harm the environment are available, the provision in para. 1 No. 1 is to come into force simultaneously with the Order.

The provision also relates to all foams expanded with CFCs, especially polyurethane foam (PUR), which is used, amongst other things, as a thermal insulation material in domestic refrigerators and as an integral foam in the automobile industry.

In contrast to the open-celled soft foams, in the case of the hard polyurethane foams for thermal insulation regulated in para. 1 No. 2, the greater proportion of the chlorofluorocarbons used remains in the product,

where it contributes to the insulating effect of these products owing to its low thermal conductivity. Substitute propellants with comparable properties are currently under development. In some cases, they will very soon be available on the German market. However, thermal insulation can also be produced in corresponding quality using other materials, although the thickness of the insulation material is then greater. This fact is allowed for in the date in Section 12 para. 2 No. 5 for the coming into force of this provision on 1st January 1995.

In the case of structural foams in accordance with para. 1 No 3, R 22 is already in general use as a propellant. Therefore, the abandonment of fully-halogenated CFCs can be regulated to coincide with the coming into force of this Order. With regard to the use of R 22, the prohibition is to come into force on 1st January 1993, since substitute solutions in the form of propellants which do not harm the environment, or alternative techniques of use, are under trial and will be available by the end of 1992.

In the case of other foams, such as soft PUR foam or hard polystyrene foam, CFC-free manufacturing methods are available. Therefore, the provision in accordance with para. 1 No. 4 is to come into force as early as 1st January 1992 in accordance with Section 12 para. 2 No. 2. In accordance with Section 12 para. 3, the use of R 22 is to be permitted until 1st January 2000.

The foams specified in para. 2 are those which are produced with the aid of the substances specified in Section 1 paras. 1 and 2. In such foams, the substances specified in Section 1 paras. 1 and 2 are either included permanently in the application for which they are intended, or they are released following the manufacturing process.

Products are to be subject to the provision if they comprise foams in accordance with para. 2, such as upholstered furniture or car seats. In this way, a clear distinction is drawn between products which comprise the regulated foams only in part, such as motor vehicles.

Re Section 5

The provision in accordance with para. 1 prohibits the manufacture, putting into circulation and use of cleaning agents and solvents which contain, for example, R 112, R 113 or 1,1,1 trichloroethane, by virtue of Section 17 para. 1 sentence 1 No. 1(a) of the Chemicals Act.

The phrase "with a content of more than 1 per cent by weight" is intended to exclude from the prohibition preparations containing corresponding substances simply as impurities.

In the manufacture of regulated substances, a distinction must be drawn between objective production and the unintentional, automatic creation of regulated substances, e.g. in coupling processes. Thus, if a regulated substance, such as tetrachloromethane, is necessarily produced during the intentional manufacture of a certain product, this does not involve an infringement of the prohibition on manufacture in accordance with para. 1, even if the substance necessarily produced could be used as a solvent under certain circumstances.

Para. 2 sentence 1 No. 1 takes account of the use of carbon tetrachloride, which is still necessary in certain chlorination processes, whereby account is taken of the substitution requirement in accordance with Annex III No. 1 of the Hazardous Substances Order.

Para. 2 sentence 1 No. 2 takes account of the scope of regulation of the Second Order to Implement the Federal Immission Protection Act (2. BImSchV), passed by the Federal Cabinet on 18th May 1990.

Para. 2 sentence 2 clarifies the fact that surface treatment plants, dry cleaning plants and textile finishing plants, together with extraction plants which are parts of plants or ancillary facilities of plants requiring approval in accordance with the 4th BImSchV, are legally equivalent to plants in accordance with the 2nd BImSchV, i.e. substances which may be used in a certain plant in accordance with the 2nd BImSchV may also be used in a similar plant in accordance with the 4th BImSchV.

Since Annex III of the Hazardous Substances Order already contains a prohibition on use and a substitution requirement in respect of tetrachloromethane, the remaining part of the consumption and the manufacture and putting into circulation in accordance with Section 5 para. 3 can be placed under the reservation of licence.

A corresponding reservation of licence also exists in respect of 1,1,1 trichloroethane to the extent that the use of this substance in areas of application which do not come under the exception in accordance with para. 2 is essential.

Re Section 6

The provision contains a prohibition on the manufacture, putting into circulation and use of certain extinguishing agents containing the substances specified in Section 1 para. 1 No. 8 to 10. Halons have an ozone-depleting potential which is considerably greater than that of CFCs.

Since suitable substitutes are currently not available in all areas of application in fire fighting, para. 2 provides for the possibility of exceptions. This circumstance is also allowed for in the envisaged coming into force of the provision on 1st January 1996 for halons 1301 and 2402 in accordance with Section 12 para. 1 No. 6.

Tested extinguishing agents not containing halon are available for use in hand-held fire extinguishers. Therefore, the manufacture and use of halon 1211 is to be prohibited as early as 1st January 1992 (Section 12 para. 2 No. 2).

Re Section 7

The marking provision is founded on the legal basis of Section 14 para. 1 No. 3(a) of the Chemicals Act. This provision of the Order is intended to enable the consumer to recognise products containing CFCs or halons, in order to be able to decide in favour of environment-friendly products when making his purchase. At the same time, the substitution process will be accelerated by the change in demand and the application of Section 8 will also become easier.

Re Section 8

The provision is based on Section 17 para. 1 sentence 1 No. 1(b) of the Chemicals Act and Section 14 para. 1 No. 3 and para. 2 No. 3 of the Refuse Act.

In order to reduce CFC and halon emissions in the use of these substances, additional requirements are to be placed on the user. The provision of para. 1 is aimed at a reduction in emissions in the areas of refrigerants and extinguishing agents in which losses are possible during operation, repair, maintenance and putting out of operation. In the remaining areas, standardisation of the relevant measures is not expedient.

The obligation to take back in accordance with para. 2 makes proper disposal easier. In addition, the CFCs and halons obtained in this way can be re-used. This is linked with a reduction in demand on the manufacturing side.

Re Section 9

Para. 1 fills the penalty gap in Section 27 para. 1 No. 1 and paras. 2 to 4 of the Chemicals Act, in order that infringements of Section 2 para. 1 sentence 1, Section 3, Section 4, Section 5 para. 1 or Section 6 para. 1 of the Order can be punished.

In paras. 2 to 4, the opportunities for punishing infringements in accordance with Section 26 para. 1 No. 5(c) and No. 7 of the Chemicals Act and in accordance with Section 18 para. 1 No. 11 of the Refuse Act in the event of violation of Section 7 and Section 8 of this Order are covered.

Re Section 10

Taking into account the existing substitution options and in accordance with the principle of relativity, the provision provides transitional regulations and thus protection of the continued existence of certain products manufactured before the Order came into force and the substances required for this. The provision in para. 2 is intended to ensure that, in

the event of maintenance work which makes a large or complete substitution of the refrigerant necessary, a substitute refrigerant with lower potential for destroying the environment is used in accordance with the state of the art.

The provision in para. 3 ensures that products which have already been put into circulation, such as used refrigerants or upholstered furniture, can continue to be sold. A time limit appears in such cases to be inappropriate.

Re Section 11

Section 11 contains the usual Berlin Clause.

Re Section 12

The provision is to come into force on the first day of the third calendar month following promulgation.

In implementing the Decision of the German Bundestag of 9th March 1989 (BT-Drs. 11/4133), this provision provides for a system of gradual coming into force in stages of the individual prohibition provisions. In the grounds relating to the relevant provisions, details are given in each case.

Para. 3 allows the use of the partly-halogenated CFC R 22 as a substitute in the areas specified therein for an interim period.

Effect on Usage of CFCs/HCFCs after 30.5.90 Decision of the Federal Cabinet over the Ministry* decree on CFCs-halons of 23.5.90.

Art.3 Para.1 Refrigerants	Art.12 Para.2&3 Quantities	Art.12 Para.2&3 Forbidden to supply product per Art.3 Para.2 (ie. equipment and units)	Para.10 Art.3 Forbidden to bring product into circulation according to Art.3 Para.2 (ie. equipment and units)	Art.10 Para. 2 Forbidden to put into circulation and use, refrigerants according to Art.3 Para. 1 (for equipment and units)
per Art.1 Para.1 R11, R12, R13, R112, R113, R114, R115, Halon 1301 (R13B1), R500, R502	>5 kg	1.1.92 (except for mobile refrigeration equipment)	1.1.92 for products produced after this date	Supply, circulation and use of refrigerants until technology devises acceptable lower ODP drop-in refrigerants
		1.1.94 for mobile** refrigeration equipment	1.1.94 for products produced after this date	
	<5 kg	1.1.95	1.1.95 for products produced after this date	
per Art.1 para.2: R22	>5 kg <5 kg	1.1.2000	1.1.2000 for products produced after this date	

- Rémarks:
- *) The Cabinet Decision has been conveyed to the EC. The parliament's decision with or without amendments - follows after the summer recess.
 - ***) By this is meant: ships under the German flag, railcars of German Rail (DB) tour buses, refrigerated transport.

Federal Ministry for Environment, Youth and Family

Zl. 03 3672/3-II/4/90

Draft

Regulations of the Ministry For Environment, Youth And Family, dated, on Restrictions and Prohibitions of the Use, Manufacture and Distribution of Fully Halogenated Chlorofluorocarbons

On the basis of § 14, sec. 1, Chemicals Law, BGBl.No. 326/1987, in the version of Federal Law BGBl.No. 300/1989, the following regulations are enacted in agreement with the Federal Ministry for Economic Affairs:

Prohibitions and Restrictions

§ 1. (1) Use of fully halogenated chlorofluorocarbons will be prohibited from 1 January 1991, unless sections 2 to 4 or § 3 stipulate otherwise.

(2) Use of fully halogenated chlorofluorocarbons will be prohibited for the following purposes from the respective dates given:

1. as cleaning agent for textiles from 1 January 1995;
2. for drying tracer pins, scanners and magnetic tape guiding units as well as diluents in magnetic trace gauging from 1 January 1994;

§ 2. (1) Manufacture and distribution of fully halogenated chlorofluorocarbons will be prohibited from 1 January 1991, for the purposes named in § 1, sec. 2 from respective dates given. For maintenance of refrigeration, heating and air conditioning units manufactured before 1 January 1992, manufacture and distribution of fully halogenated chlorofluorocarbons may, however, be continued to the required degree.

(2) From the respective dates given in § 1 sec. 2 no. 6 to 9, manufactureres and importers are prohibited from distributing foams which are manufactured with fully halogenated chlorofluorocarbons. Rigid polyurethane foams must not be distributed by manufacturers and importers from 1 January 1991, if the limited quantities for use of fully halogenated chlorofluorocarbons stipulated in the appendix are exceeded during manufacture.

(3) From 1 January 1993, distribution of finished products containing, as a component, foams subject to a prohibition according to section 2, will be prohibited. Those finished products in circulation may, however, be traded until 31 December 1993.

Exemptions

§ 3. (1) The Federal Minister for Environment, Youth and Family may grant exemptions from the prohibitions pertaining to manufacture, distribution or use of fully halogenated chlorofluorocarbons, if their use is necessary for medical purposes or due to technical reasons for the purpose named in §1 sec. 2 no. 2, provided that the state of technology does not allow substitution by other substances, the manufacture, use and disposal of which are not or less hazardous to human life and health or the environment. Where required, restrictions for handling fully halogenated chlorofluorocarbons are to be stipulated in the decision; exemptions must be restricted by a time limit.

(2) Fully halogenated chlorofluorocarbons used as propellants in aerosols or designated for this purpose are exempt from the prohibitions of § 1 sec. 1 and § 2 sec. 1, insofar as distribution of such aerosols is further permitted acc. to the Regulations of the Federal Minister for Environment, Youth and Family dated 10 January 1989, BGBI.No. 55.

Obligation to Report

§ 4. Manufacturers and importers of fully halogenated chlorofluorocarbons designated for one of the purposes permitted under the present regulations (§ 2 sec. 1 second sentence and § 3), must furnish the Federal Minister for Environment, Youth and Family, with a written report for every calendar year, within three months after the end of that year at the latest, specifying:

1. kind and quantity (weight and volume) of distributed chlorofluorocarbons,
2. envisaged purpose.

Federal Ministry for Environment, Youth and Family

Zl. 03 3672/23-II/4/89

Draft

C o m m e n t s

There are no more doubts about the harmful effect of chlorofluorocarbons on the protective global ozone layer. Taking this into account, the Montreal Protocol to the Vienna Convention on the protection of the ozone layer, ratified by Austria, envisages a phased reduction of CFC consumption worldwide.

As regards fully halogenated CFCs with an especially high damaging potential, these measures are certainly not far-reaching enough. Following the Swedish example, Austria should therefore aim for a, possibly complete, renunciation of the use of these chemical compounds. A first step was taken by prohibiting fully halogenated CFCs as propellants in aerosols (regulations of the Federal Ministry for Environment, Youth and Family of 10-1-1989, BGBl.No. 55). The present regulations are now intended to cover all possible applications. The regulations are to come into force in the shortest possible time. Not only the Swedish regulations served as an example, but so did a relevant resolution by the Federal German Parliament which, in parts, states shorter time limits.

The core of the regulations is a general prohibition of use with extended time limits for certain individual applications. Textiles (§ 1 sec. 2 no. 1) are all finished textile products (garments) and unfinished textiles, including especially leather garments, for the cleaning of which fully halogenated CFCs are used at present. The regulations do not cover use in air conditioning units which were manufactured before 1 January 1992 and cannot be adapted. For rigid PUR-foams, a transitional solution is envisaged, while the proportion of fully halogenated CFCs is to be reduced by half.

With the exception of those applications named in § 1 sec. 2 no. 2, which are necessary for technical reasons, exemptions from this prohibition are permissible only in the medical area and they require a special permit. The exemptions, acc. to regulations BGBl.No. 55/1989, pertaining to the use in aerosols for which presentation of the relevant specialist report is considered sufficient remain unaffected.

In addition to the prohibition on use of fully halogenated CFCs, manufacture and distribution are prohibited with the exception of applications permitted acc. to the present regulations. Also a prohibition of distribution of foams manufactured without these restrictions seems necessary to avoid competitive disadvantages for foams manufactured in accordance with these regulations.

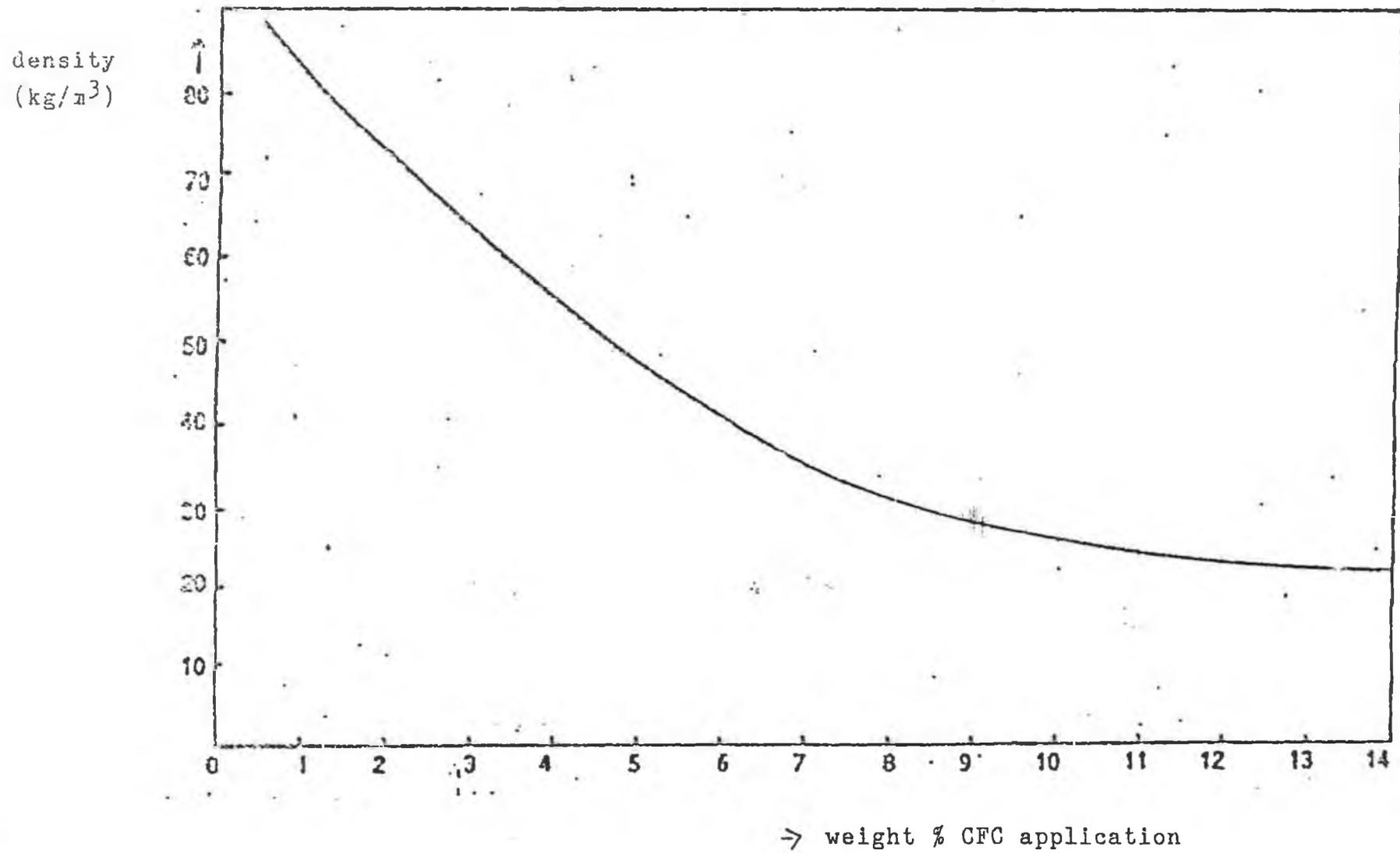
It is necessary to stipulate an obligation to report regarding fully halogenated CFCs to be able to monitor their consumption in accordance with the obligations accepted under the Montreal Protocol.

These regulations cover a total of 4,000 tons of fully halogenated CFCs. On the basis of the figures presently available to the Federal Ministry for Environment, Youth and Family, pertaining to consumption of CFCs in areas of exemption, it must be assumed that a maximum of 100 - 200 tons is exempt, which is equivalent to a reduction in consumption by approx. 95%.

In conjunction with the cited prohibition of fully halogenated CFCs as propellants in aerosols, by which total consumption of fully halogenated CFCs in Austria has already been reduced by half, i.e. from 8,000 tons to 4,000 tons per annum, use of these

substances which pose such hazard to the stratospheric ozone layer can thus be diminished considerably.

Application of CFCs in relation to density of PUR-foam



Appendix
to § 1 sec. 3

Austrian Association for Refrigeration and Air Conditioning
Technology (ÖKKV)
P.O. Box 352, A-1045 Vienna,
Zentralsparkasse und Kommerzialbank Account No. 647092105

To the
Federal Ministry for Environment,
Youth and Family
Attn. Dr. Eichinger

16 February 1990

Radetzkystraße 2
A-1030 Vienna

Re.: Draft regulations: restrictions and prohibitions of
use, manufacture and distribution of fully halogenated CFCs;
comments

The ÖKKV comments on the above-named draft regulations on
restrictions and prohibitions of use, manufacture and distribution
of fully halogenated CFCs as follows:

Acc. to the present state of information or acc. to the present
state of refrigerant technology respectively, no statements can be
made as to when and to what extent substitute cooling agents
(cooling agents replacing fully halogenated CFCs) will be
available, though the present draft prohibits use of fully
halogenated chlorofluorocarbons from 1 January 1991. We also state
that Austria has no national production of cooling agents and
therefore no direct influence on research and development of
substitute cooling agents.

Although further use of partly halogenated R 22 is permitted acc.
to the present draft regulations and although conversion of R 12
installations to R 22 is possible in some areas, setting up new
installations entails the problem that, from the present point of
view, it cannot be predicted which substitute cooling agents will
be available in the near future.

Nor do we have information on the installation technology required
for substitute cooling agents; only when cooling agents are
available in technically viable quantities can components for
refrigeration units or the required installation technology be
developed.

Thus companies installing or operating installations are faced
with the serious problem that, in respect of such installations,
no planning for the future can be carried out, though - provided
the present regulations will come into force - use of fully
halogenated CFCs will be prohibited from 1 January 1991.

Re. the present draft regulations Zl. 03 3672/3-II/4/90, operators
and installers face e.g. the following problems which the
regulations must take into account:

1.) It is not clear whether the use of cooling agent R 502 will further be permitted (R 502 also contains fully halogenated CFCs which are to be prohibited under the draft regulations).

This fact necessitates to demand that § 1 sec. 1 should be worded more precisely insofar as substances covered by the regulations should be listed in detail; this device would lead to important clarifications, especially in the area of "expert assessments".

In § 1 sec. 2 no. 4, the term "domestic refrigeration appliances" should be substituted by "refrigeration appliances". From a technical point of view, it is as impossible to convert commercial refrigeration appliances for use of substitute cooling agents within the set time limit.

Furthermore, it is urgently demanded to change the exemptions under § 1 sec. 2 no. 4 pertaining to the cooling volume (500 l). It is the obvious aim of the regulations to reduce the CFC mass used. At this point, it is more useful to set a maximum limit for the cooling agent mass used than for the cooling volume, particularly since the cooling volume admits only limited conclusions as to the quantity of cooling agents used. A possible suggestion would be to allow exemptions up to a maximum value of 5 kg fully halogenated CFCs.

§ 1 sec. 2 no. 4 could then read:

"As a medium for heat transfer in refrigeration appliances up to a cooling agent mass of 5 kg fully halogenated CFCs used."

2.) § 1 sec. 4 regulates operation of old installations (installations produced before 1 January 1992). In the interest of a clearer wording of the above-named section, we suggest the following:

"As a medium for heat transfer in refrigeration, heat and other air conditioning installations manufactured before 1 January 1992, fully halogenated chlorofluorocarbons remain permissible as long as use of a substitute medium for heat transfer (medium allowing further operation of the installation without conversion) is not possible."

3.) § 2 sec. 3 regulates distribution of finished products containing foams manufactured with fully halogenated chlorofluorocarbons.

The present wording prevents the sale of used refrigeration appliances from 1 January 1993. Here, too, the regulations contradict their underlying intention to reduce CFCs in that renewed distribution of used domestic refrigeration appliances already contribute considerably to reducing use of fully halogenated CFCs. (The only alternative to re-selling used domestic refrigeration appliances is their environmentally appropriate disposal - an area of problems as of yet unsolved in Austria.)

The present term "... distribution ..." should be replaced by "...manufacture and import ...".

4.) § 3 of the draft regulations deals with exemptions.

Although the point of view of the concerned parties has been stressed repeatedly, no installations of the refrigeration trade are listed in the regulations. Here, particularly those installations should be included for which, from a technical point of view, conversion for use of substitute cooling agents will not be possible in the near future. These are the following installations:

- * small compressors with an engine power under 400 watts
- * mini refrigeration appliances with an engine power under 400 watts
- * air conditioning appliances for motor cars
- * high temperature heat pump appliances
- * low temperature refrigeration appliances for shock freezing

5.) Re. the obligation to report stipulated in § 4, it should be binding for manufacturers and importers of fully halogenated CFCs, in any case, to furnish the Federal Ministry with documentation on distribution that can be checked. The following wording is suggested:

"Fully halogenated CFCs may only be sold to authorized companies; a list of the supplied purchasers must be kept. The purchasing companies must keep a record of quantities acquired and sold to the consumer."

With kind regards
on behalf of the
Austrian Association for Refrigeration and Air Conditioning
Technology
Technical Advisory Council

Engineer F. Wagner

1

FEDERAL DEPARTMENT OF THE INTERIOR

3003 Berne, 12 June 1990

To the Economic and
Expert Organisations

Amendments to Regulations on Substances (Stoffverordnung);
measures for the protection of the ozone layer. Invitation to
public hearing.

Dear Madam/Sir,

we enclose an amendment to the Regulations on Substances for your
comment. The purpose of the amendment is summarized in a report
which we also enclose.

Please make your comments available to us by September 28. We
would also like to point out to you that comments will be
publicized after evaluation.

We thank you in advance for your interest and your efforts, ladies
and gentlemen, and remain

Yours respectfully

Federal Department of the Interior
(Signed) Flavio Cotti
Member of Parliament

Encl.:

- List of authorities and organisations addressed
- Draft
- Report

FEDERAL DEPARTMENT OF THE INTERIOR

Amendment to the Regulations on Substances; measures for the
protection of the ozone layer

List of authorities and organisations addressed for public
hearing.

1. Offices of the Canton Governments
2. Economic and expert organisations

(See pages 2-5 of original)

Press Release Berne, 15 June 1990
Package of Measures for the Protection of the Ozone Layer released
for Public Hearing

The Federal Parliament intends to prohibit CFCs, halons and other substances depleting the ozone layer. The amendment to the Regulations on Substances is intended to considerably reduce the use of these substances immediately and to completely eliminate their use within a few years with the help of a graduated plan. A staggered schedule of prohibition is necessary as in some areas alternatives tolerated by the environment are not immediately available. In addition to aerosols which are already regulated at present, the package of measures primarily concerns the areas of application of foams, refrigeration and air conditioning technology, technical cleaning agents and solvents as well as fire protection. The Federal Department of the Interior submits the amendment to the cantons and interested circles in economy, environmental protection, consumer protection etc. for comment.

New drastic regulations impose themselves since scientific findings of recent years have proved that the substances to be regulated are causative of the depletion of the global ozone layer and are especially causative of the ozone hole over Antarctica. A depletion of the ozone layer leads to an increase in those elements in the ultraviolet radiation from the sun which are hazardous to living beings. The CFCs and related substances also contribute considerably to the warming of the global atmosphere (greenhouse effect).

The present package of measures serves as the Swiss guideline for the Montreal Protocol negotiations scheduled for the end of June, concerning more stringent regulations on substances leading to the depletion of the ozone layer. In this area, Switzerland thus counts among the most progressive countries worldwide.

The regulations comprise all ozone depleting substances, i.e. all CFCs, all halons, all partly halogenated chlorofluorocarbons (HCFCs), trichloroethane and tetrachlorocarbon. None of these substances is produced in Switzerland. Prohibitions for the individual areas are scheduled to come into force from the following years:

- Aerosols: from 1991; HCFCs and trichloroethane from 1993.
- Foams (especially heat insulation materials): from mid-1991; HCFCs from 1996; CFCs in insulation of refrigeration appliances from 1994.
- Solvents (especially for cleaning of metals, electronic circuits and textiles): from 1993; for cleaning of textiles only from 1996, provided that effective measures for prevention of emission have been taken before 1992; trichloroethane only from 2000, provided that effective measures for prevention of emission have been taken before 1991.

- Cooling agents (refrigeration appliances, air conditioning installations, heat pumps): from 1994; HCFCs allowed further; persons dealing with cooling agents, e.g. producers, fitters and service technicians, must have a special permit (special training) from 1993.
- Fire protection: from 1991, import and sale of halon hand fire extinguishers as well as import of halon; from 1992, new stationary fire extinguishing installations with halon; from 1994, refilling of existing installations with halon.
- Other applications: from mid-1991.

This package of measures is intended to reduce consumption of CFCs from over 8000 tons in 1986 to approx. 2000 tons in 1991 and to a few hundred tons in 1995, which would be equivalent to a reduction of over 90%; it is envisaged that the remaining quantities necessary for the maintenance of existing installations can be eliminated by the end of the decade. Import of halons will cease in the course of 1991 (100% reduction). Use of trichloroethane (1986: almost 6000 tons) which is less hazardous to the ozone layer is also intended to cease by the end of the decade, with a reduction to under 1000 tons by 1995.

Federal Department of the Interior
Press and Information Service

Information:

Christoph Rentsch, Division Substances Hazardous to the Environment, Federal Department of Environment, Forest and Landscape; Phone 031 61 93 64

Regulation
on substances hazardous to the environment

Draft May 1990
hn/414

Amendment of

The Federal Parliament of Switzerland

decrees:

I

The regulations of June 9, 1986¹ on substances hazardous to the environment (Regulations on Substances, SToV) is amended as follows:

Article 45, section 1, letter c (new)

1. The following activities may only be carried out under the supervision of specialists:
 - c. Use of cooling agents in production, installation, maintenance or decommissioning of appliances or installations which are employed for refrigeration, air conditioning or heat recovery.

Article 75

1. The activities listed in article 45, section 1, letters a and b may be carried out without special permit only until August 31, 1991.

1) SR 814.013

REPORT ON THE DRAFT AMENDMENT
TO THE REGULATIONS ON SUBSTANCES;
MEASURES FOR THE PROTECTION OF THE OZONE LAYER

MAY 1990

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 - B. Amendment of appendix 4.9 "Aerosols"
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 - E. New appendix 4.15 "Cooling agents" and special permit for the use of cooling agents
 - F. New appendix 4.16 "Quenching agents"
3. Adaptation of the regulations on cadmium in plastics

1. Starting position

In Montreal, on September 16, 1987, the international community of states signed a protocol on substances leading to a depletion of the ozone layer. It was agreed that by the year 2000 the use of some chlorofluorocarbons (CFCs) should be reduced, step by step, by 50% and that there should be no further increase in the use of halon. Though Switzerland deemed this protocol not far-reaching enough it was signed by this country and ratified at the end of the year 1988. Since then, all states have come to realize that the treaty does not suffice for effective protection of the ozone layer. At their meeting of May 1989, the parties to the treaty have therefore agreed on a thorough revision of the Protocol (Declaration of Helsinki). Production and consumption of chlorofluorocarbons (CFCs) and halons is to cease by the end of the century. Additionally, other ozone-depleting substances are to be reduced or prohibited as early as possible. These are the partly halogenated CFCs (HCFCs), trichloroethane, and tetrachlorocarbon. On June 27-29, 1990, a diplomatic conference in London will decide on the revised Protocol.

The Swiss Parliament is aiming to reduce the consumption of CFCs and halons by over 90% by 1995. This means a reduction from approx. 8,400 tons in 1986 to less than 800 tons in 1995. In its endeavours to protect the ozone layer, the Parliament can rely on the support of the Federal Councils (declaration of the Upper Chamber dated 30-9-1987 and declaration of the National Council dated 6-12-1988). At the beginning of 1990, an action committee launched a nationwide "Petition for Saving the Ozone Layer" which found strong support in wide political circles. In relation to ozone-depleting substances, in Switzerland, so far the use of CFCs is regulated only in the area of aerosols. With appendix 4.9 "Aerosols" to the Regulation on Substances, CFCs are prohibited from 1991; medical sprays as well as special products especially permitted on application remain exempt.

Table 1 gives an overview of the development of imports of ozone-depleting substances to date and of the development expected on the basis of the present amendment to the Regulations. Since none of the substances is produced in this country and since, at present, reliable statistics on consumption are available only for few areas of application, import figures are the best available measure for consumption of these substances and for their emission into the environment.

Table 1: Development of imports of ozone-depleting substances to Switzerland.

1. Chlorofluorocarbons (CFCs)

	aerosols t	other CFC-applications t	total CFCs t	%
1978	6,000	2,000	8,000	
1986	3,600	4,800	8,400	100
1990	500	3,500	4,000	48
1991	< 200	< 2,000	< 2,200	< 26
1995	< 100	< 700	< 800	< 10
2000	0	0	0	0

2. Partly halogenated CFCs (HCFCs) and trichloroethane

	HCFCs		trichloroethane	
	t	%	t	%
1986	< 1,000		5,700	
1990	< 1,000	100	3,000	100
1995	< 700	70	< 1,000	< 35
2000	500	50	0	0

3. Halons (quenching agents)

	t	%
1978	50	
1986	200	100
1990	80	40
1991	< 50	< 25
1995	0	0
2000	0	0

4. Tetrachlorocarbon

Tetrachlorocarbon is carcinogenic and is no longer of any importance in Switzerland. At present, approx. 20 tons of this substance are still imported per year.

A breakdown of CFC quantities into the various areas of application is shown in table 2. Due to the dynamics of changing to CFC-free systems, the prognosis for 1992 is not very exact.

Table 2: Use of imported CFCs in the various areas of application
(in tons)

1986: figures supplied by importers; 1990: prognosis by the BUWAL

	aerosols	cooling agents	solvents	foams
1986	3,600	500	1,800	2,500
1990	500	400	1,500	1,600

As regards reduction, first priority is given to those substances with the highest ozone-depleting potential: CFCs, halons, and tetrachlorocarbon (cf table 3). Once these substances have reached the environment, it takes decades to centuries until they are broken down to such a degree that they are no longer harmful. Every year that they are still used to the present extent, delays recovery of the atmosphere by approx. five more years. Substances with an ozone-depleting potential in the lower layers of the atmosphere have a weaker and shorter effect. They, too, reach the higher atmosphere (stratosphere), however, and there cause depletion of the naturally present ozone.

Substances causing depletion of the ozone layer are, as a rule, also very effective greenhouse gases (cf table 3). Thus the 8,400 tons of CFCs consumed in Switzerland in 1986 contribute to warming of the global atmosphere to the same degree as the 43 million tons of carbon dioxide (CO₂) emitted in this country during the same year. Strict regulation of ozone-depleting substances therefore contributes considerably to the reduction of the greenhouse effect.

Table 3: Some environmentally relevant figures on ozone-depleting substances

substance/ group of substances	ODP	GWP	T (years)
CFCs	0.6 - 1	1 - 8	60 - >200
HCFCs	0.02 - 0.1	0.02 - 0.4	1 - 20
halons	3 - 10		25 - 110
trichloroethane	0.15	0.02	7
tetrachlorocarbon	1.2	0.35	60

ODP = ozone-depleting potential; ODP of CFC1₃ (CFC 11) = 1.0

GWP = greenhouse warming potential; GWP of CFC1₃ (CFC 11) = 1.0;
GWP of 1 kg CFC = GWP of approx. 5 tons CO₂

T = medium lifetime in the atmosphere = time after which approx.
1/3 of emitted quantity still remains in the air

Substances causing depletion
of the ozone layer

Appendix 3.4

(Art. 9, 11, 35, and
61)
407

1 Terms

1. The following substances are considered to cause depletion of the ozone layer (ozone-depleting substances):
 - a. fully halogenated chlorofluorocarbons with up to three carbon atoms (FCs or CFCs) such as:
 1. Trichlorofluoromethane (F 11),
 2. Dichlorodifluoromethane (F 12),
 3. Tetrachlorodifluoroethane (F 112),
 4. Trichlorotrifluoroethane (F 113),
 5. Dichlorotetrafluoroethane (F 114), and
 6. Chloropentafluoroethane (F 115).
 - b. partly halogenated chlorofluorocarbons with up to three carbon atoms (HCFCs) such as:
 1. Chlorodifluoromethane (F 22),
 2. Dichlorotrifluoroethane (F 123),
 3. Dichlorofluoroethane (F 141), and
 4. Chlorodifluoroethane (F 142).
 - c. fully halogenated bromine-containing fluorocarbons with up to three carbon atoms (halons) such as:
 1. Bromochlorodifluoromethane (Halon 1211),
 2. Bromotrifluoromethane (Halon 1301), and
 3. Dibromotetrafluoroethane (Halon 2402).
 - d. Trichloroethane (both isomers).
 - e. Tetrachlorocarbon.
2. Treated as equal to the ozone-depleting substances are:
 - a. simple mixtures of substances according to section 1;
 - b. products containing substances according to section 1, if they are kept in containers used exclusively for transportation and storage of these products.

2 Prohibitions

21 Use

1. Ozone-depleting substances must not be used for purposes other than:
 - a. manufacture of products or items which may be distributed or imported according to regulations under clause 22 as well as appendices 4.9, 4.11, 4.14, 4.15, and 4.16;
 - b. use in those areas for which regulations on application are detailed in appendix 4;
 - c. use as intermediate products for further chemical processing;
 - d. use for researching their properties.
2. The Federal Office may grant temporary exemptions for other uses if:
 - a. at the state of technology, no substitute for the ozone-depleting substance is available, and
 - b. the quantities used of such substances do not exceed the quantities required for the particular purpose.

22 Manufacture and Import

It is prohibited:

- a. to manufacture ozone-depleting substances according to clause 1, section 1;
- b. to import ozone-depleting substances; this prohibition does not apply to importation from countries complying with regulations of the Montreal Protocol of September 16, 1987¹ on substances causing depletion of the ozone layer (Protocol) ratified by Switzerland;

1) SR 0.814.021; AS 1989 477

- c. to import products and items which contain ozone-depleting substances or are manufactured with ozone-depleting substances and which are listed in an appendix to the Protocol; this prohibition does not apply to importation from countries complying with regulations of the Protocol ratified by Switzerland nor to importation for own private use.

23 Lists

The Federal Office keeps a record of these countries, substances, products, items, and uses.

3 Importers' Obligation to Report

1. Importers must inform the Federal Office yearly by March 31 of:
 - a. quantities of ozone-depleting substances imported as raw materials (clause 1, section 1); a break-down of the data into individual substances must be supplied;
 - b. the imported quantities of ozone-depleting substances in simple mixtures of substances (clause 1, section 2, letter a) specifying proportional weight of individual substances;
 - c. the imported quantities of ozone-depleting substances in products if they are kept in containers used exclusively for transportation and storage of these products (clause 1, section 2, letter b), specifying proportional weight of individual substances.
2. Data must relate to the previous year and they must include the envisaged purpose.

4 Transitional Regulations

1. The prohibition according to clause 21 comes into force on (6 months after coming into force of this amendment).
2. The prohibition according to clause 22, letter c comes into force one year after coming into force of the relevant appendices to the Protocol.
3. 1990 is the first year for which importers must supply data according to clause 3. Where available, data for 1989 must also be supplied.

Cooling Agents

Appendix 4.15

(Art. 9, 11, 35, and 61)
406

1 Term

Cooling agents are substances or products which transport heat from a lower to a higher temperature in appliances or installations.

2 Manufacture, Distribution and Import

21 Prohibition

Appliances or installations containing cooling agents with fully halogenated chlorofluorocarbons (CFCs) must not be manufactured, imported or distributed by a manufacturer.

22 Exceptions

1. The prohibition according to clause 21 does not apply to importation for own private use.
2. The Federal Office may, after justified application by a manufacturer, grant permission to import certain appliances or installations or to distribute them if:
 - a. at the state of technology, CFC-free substitutes are not available for certain regulated applications or
 - b. the CFC-free substitute uses substantially more energy.

23 Information for Consumers

Manufacturers and dealers of refrigeration appliances must supply the consumer with written information, on the label or in another appropriate form, on cooling agents contained in the appliance.

3 Transitional Regulations

1. The prohibition according to clause 1 comes into force on January 1, 1994.
2. Refrigeration appliances which do not comply with regulations under clause 23 may be distributed until December 31, 1991.

2. Amendment to Regulations

2.1 Principles

Regulated substances

In accordance with the Declaration of Helsinki, the intention of the proposed regulations is to generally eliminate all industrially produced substances which cause a depletion of the ozone layer:

- Fully halogenated chlorofluorocarbons (CFCs, FCs)
- Partly halogenated chlorofluorocarbons (HCFCs)
- Fully halogenated bromine-containing fluorocarbons (halons)
- Trichloroethane
- Tetrachlorocarbon.

These regulations do not apply to applications of these substances during which they are chemically changed or destroyed.

Schedule

Use of ozone-depleting substances will be prohibited as soon as possible, i.e. as a rule, no longer than 6 months after regulations come into force. A phased schedule is proposed where, to date, substitute systems better tolerated by the environment do not exist or not to a sufficient extent. Too tight a schedule would in many cases lead to replacing one evil with another.

Phasing-out is effected with the help of transitional periods. Because of the urgent need to protect the ozone layer, these periods will generally be short. Experience shows that there will always be individual cases in which keeping to the transitional periods would entail disproportionate measures. The present draft regulations empower BUWAL, for every area of application, to extend, on justified application, the deadline for adjustment of a regulation as far as necessary in individual cases. The guidelines for granting an exemption are laid down in the wording of the relevant individual regulations. Applications on predominantly economic grounds are not granted.

Alternatives

Generally, such alternatives are to be chosen that reduce hazards not only to the ozone layer but also to the environment and humans as an entity (no shifting of the problem from the ozone layer to layers of air close to the ground; taking into account of energy consumption, safety problems, health protection etc.). The changes should also be used as a particular opportunity to support measures, required by the Parliament's clean-air concept, to drastically reduce volatile organic compounds (VOC or HC). Since ozone-depleting substances count among the group of VOCs, a preferable solution to the problem is to avoid VOCs altogether. The question "How can ozone-depleting substances be substituted?" is therefore put wrongly; it must rather be: "By which products,

methods or measures can the use of VOCs or VOC-containing materials be avoided?"

The Regulations on Substances do not specify in which way substitution of ozone-depleting substances is to be avoided in practice. They stipulate, however, that tolerance of the environment towards possible substitutes must be clarified, assessed and taken into account. The above-mentioned phased schedule is intended to enable the parties concerned to take measures for sufficient clarification of possible alternatives.

In a few areas of application, it is useful to find quickly realizable temporary solutions before changing to systems free of ozone-depleting substances. This is the case where technically simple solutions are immediately applicable or where, in the short term, only badly evaluated or unsatisfactory alternatives are available. Such quickly realizable temporary solutions can be:

- use of HCFCs or of mixtures of substances with a low ozone-depleting potential;
- installations for maximum reduction of emissions of ozone-depleting substances into the environment.

In this context, a view held is that HCFCs are "part of the solution" in relation to the ozone layer, i.e. using them instead of CFCs would contribute considerably to reducing the dangers to the ozone layer. According to this view, the relatively small potential danger (cf table 3) justifies wide and long-term application of these substances. In the present draft regulations, however, HCFCs are considered only a transitional solution. They, too, contribute substantially to the harmful substances contained in the higher atmosphere and are therefore "part of the problem". Their use can even prevent that really good solutions are sought and introduced. Solely in the area of refrigeration technology, the application of HCFCs shall be allowed, at least temporarily without deadline, as long as equal alternatives are lacking.

2.2 The Regulations in International Comparison

With the present draft, Switzerland counts among the most progressive countries as regards schedule as well as substances included in the regulations. Table 4 shows the reduction schedule of the Regulations on Substances in comparison with positions of the USA, the EC and the Scandinavian states at the preliminary negotiations of mid-March 1990 on the revision of the Montreal Protocol.

Table 4: Comparison of proposed regulations by USA, EC, and Scandinavian states regarding revision of the Montreal Protocol (version mid-March 1990) including effects of amended Regulations on Substances (figures in % reduction of consumption re. 1986)

	USA	EC	Scandinavian states	Switzerland
<u>CFCs</u>				
1992		50%	50%	> 75%
1993	20%			
1995		85%	85%	> 90%
2000	100%	100%	100%	100%
<u>Halons</u>				
1992				100%
1995	50%	50%	production stop	
2000	100% possibly only 2005	100%	100%	
<u>HCFCs</u>				
2000			only important applications	50% only refriger.
2010-20			100%	
2020-40	100% for new install.			
2035-60	100% for old install.			
<u>Trichloroethane</u>				
1992		no more increase		
1994		25%		> 50%
1995			50%	
1997			85%	ca. 85%
2000	25-100%		100%	100%
<u>Tetrachlorocarbon</u>				
The use of this substance in western industrialized nations is minor (Switzerland: cf table 1)				

Similar to Switzerland, most countries work with regulations which refer to specific applications (aerosols, foams etc.). The EC, however, is preparing a fundamentally different solution: for every category of substances, a schedule is laid down according to which the permitted yearly maximum quantities for import, production, and consumption are gradually phased out (quotas). By cutting out substances progressively, the market will regulate itself in the various areas of application.

2.3 Details of the Regulations

A. Amendment to appendix 3.4 "substances causing depletion of the ozone layer"

The extended appendix details the substances concerned by the package of measures on protection of the ozone layer. It prohibits use of ozone-depleting substances in those areas of application which are not covered by any of the other appendices. These are e.g.:

- use of CFCs for freezing pipes in the area of heating and sanitation (facilitation of welding);
- use of CFCs for making ice and snow on drinking glasses in restaurants;
- use of CFCs as heat stabilizers in certain transformers;
- use of ozone-depleting substances as filling gas in double glazed windows.

Finally, this appendix makes it obligatory for importers of ozone-depleting substances to report to the BUWAL annually imported quantities and their expected use. On the basis of these reports, the BUWAL on the one hand can control the effectiveness of measures taken, on the other hand, Switzerland can produce the proofs for keeping the agreement as required in the Montreal Protocol.

B. Amendment to appendix 4.9 "Aerosols"

The existing appendix 4.9 prohibits use of CFCs in aerosols with the exception of drugs and products especially approved by the BUWAL. The present amendment also includes the other ozone-depleting substances in the prohibition, of which F 22 and trichloroethane are concerned in particular. In future, medical sprays may only contain ozone-depleting substances if no substitute is available according to the state of technology. Whether use of these substances still is to be tolerated in a certain preparation will be assessed by the BUWAL after consulting the Intercantonal Controlling Organization for Medicine (IKS).

C. Amendment of appendix 4.11 "Plastics"

In recent years, annual turnover of CFCs for manufacture of foams amounted to approx. 2,000 tons. 80-90% of this amount were used for manufacturing hard foams, particularly from polyurethane (PUR), to a lesser extent also from polystyrene (PS). These foams

permanently lock up CFCs in their pores, which gives them a very good heat insulating effect compared to other materials. A study

on presently used heat insulating materials in the mainly concerned area of structural engineering as well as latest information by companies show that this area of application can eliminate CFC-containing foams without loss of quality. The Federal construction organizations will therefore no longer apply CFC-containing heat insulation materials. However, the short-term prohibition of CFC-containing heat insulation materials, which is included in the draft amendment, means a considerable loss for manufacturers of hard PUR-foams since manufacture of these materials without CFCs is expected to be feasible from 1993 at the earliest.

The Swiss industry producing foams with open pores can presently manufacture without ozone-depleting substances. The proposed prohibition to manufacture these and other foams for upholstered furniture and mattresses will therefore cause no difficulties at being carried out. On the other hand, a prohibition to import such foams, which would be desirable, among other things, for the protection of Swiss manufacturers, can hardly be controlled by the importer or the authorities; it is very difficult to prove possibly remaining traces of ozone-depleting substances since they escape largely after the production process. Therefore, it has to be tried to win over the economic circles concerned to abandon import voluntarily.

Refrigeration appliances (refrigerators and deep-freezers) are an exception; at present, their outer walls normally contain CFC-containing foams for heat insulation. Here, different alternatives are being developed; but immediate change is not realizable. Furthermore, it should be taken into consideration that approx. 80% of these appliances are manufactured abroad and that Switzerland conducts little research in this field. For refrigeration appliances, the draft regulations therefore schedule a prohibition of CFC-containing insulation materials from 1994 and for HCFC-containing insulation materials from 1996. In the meantime, however, insulation materials containing ozone-depleting substances must be declared.

At the same time as this amendment to the Regulations proposed for the protection of the ozone layer, regulations on the use of cadmium in plastics have to be adjusted to the present state. Cf chapter 3.

D. New appendix 4.14 "Solvents"

Various branches of industry use ozone-depleting substances as solvents and cleaning agents. F 113 is mainly used in the electronic industry and also for cleaning textiles. For trichloroethane, the main areas of application are cleaning of metals, surface technology and, again, the electronic industry.

In virtually all areas, the ozone-depleting substances can be substituted. There is often the possibility to switch to aqueous systems (exception: chemical textile cleaning). But for the following reasons the change requires a certain period of transition: many alternative methods are not yet long enough on the market for the companies to buy them indiscriminately. In future, suppliers and consultation firms will assume special significance since the trade consists of only a few large concerns, but many small and medium size enterprises without a development division of their own. The capacity of these consultation firms is, however, limited. Finally, with the change from volatile organic compounds to aqueous systems, the measures to be taken for protection of the environment and for health protection will change fundamentally, which can entail great technical and conceptual alterations.

In existing installations where more extensive measures of emission control have already been introduced before 1991 trichloroethane may be used until the end of 1999. Assessment is based on compliance with the tighter emission limits proposed in the draft for public hearing issued by the Federal Department of the Interior in March 1990 for revision of the Clean-Air Regulations (Luftreinhalteverordnung, LRV): 20 mg/m³ at a mass flow of 0.1 kg/h or more.

For cleaning of textiles, no alternative method without volatile organic solvents is in sight. In this area of application F 113 and trichloroethane may be used until the end of 1995, provided that effective measures for emission control have been taken before the end of 1992 - again the above-mentioned tighter emission limits of the LRV form the basis for assessment. Due to the lack of alternatives better tolerated by the environment, installations must otherwise be changed over to perchloroethylene which is not depleting the ozone layer and for which normal rehabilitation periods of the revised LRV apply (no later than 5 years after decree order by the cantons). Considering the present structure of the industry with its many small businesses, application of benzene is not useful for safety reasons.

E. New 4.15 "Cooling Agents" and special permits for use of cooling agents

Refrigeration, air-conditioning and energy technology represent by far the smallest area of application of ozone-depleting substances. When handled correctly, ozone-depleting substances can be used in refrigeration and air-conditioning appliances and installations as well as heat pumps without escape of larger quantities. As in many areas of application fully adequate substitutes are not available the draft regulations propose to prohibit only the severely ozone-depleting CFCs (from 1994), and to further allow HCFCs as cooling agents, provided that escape into the environment is prevented as far as possible. Therefore, all persons dealing with cooling agents must acquire a special permit, i.e. they must prove in a test that they have basic knowledge of ecology, relevant legislation, environmentally relevant properties of substances used, of appliances used, and of measures for environmental protection. It is proposed to grant permission for receiving special wastes (Regulations on Dealing with Special Wastes - Verordnung über den Verkehr mit Sonderabfällen=VVS - article 16 and 17) only to such businesses decommissioning refrigeration appliances where the applicant or an employee of his has acquired the special permit.

Similar to declaration of heat insulation (cf. chapter C), cooling agents in refrigeration appliances are to be declared in future.

F. New appendix 4.16 "Quenching agents"

Though consumption of halons is not very high (cf. table 1), rapid substitution of these substances is necessary because of their high potential of damage to the ozone layer (cf. table 3). At present, approx. 1,000 tons of halons are contained in hand fire extinguishers and stationary quenching installations; 10-15 tons of the total are emitted yearly for actual fire-fighting purposes. The halon reservoir is not to increase, and halon must not enter the environment during tests, exercises or fire-fighting. But rather, measures are to be taken so that, as soon as possible, halon is used only where in the event of a fire the safety of persons cannot be guaranteed through other means.

3. Adaptation of the regulations on cadmium in plastics

The present amendment to the Regulations on Substances provides the opportunity to bring the existing appendix 4.11 "Plastics" in line with the latest developments in an area unrelated to the protection of the ozone layer, i.e. the area of cadmium application in plastics. Even at present or in the very near future, the use of cadmium compounds is no longer required for quality guarantee in plastic window frames and drinking vessels. According to the proposed amendment, the use of cadmium in plastics is therefore generally prohibited. An amendment of the maximum limit for quantities tolerated as impurities (provisional reference value of June 1988: 10 mg cadmium/kg plastics) will be discussed again in the course of harmonization talks with the EC.



-- MATERIAL SAFETY DATA SHEET --

REF. 00000007/N/GB
PAGE 1 of 3
PRINT DATE 1990-08-21
APPROVAL DATE 05/11/1990

CHEMICALS AND PIGMENTS DEPARTMENT

COMPANY: Du Pont (U.K.) Limited Wedgwood Way GB-Stevenage, Herts. SG1 4QN		EMERGENCY PHONE NUMBER: (0438) 73 45 55 / 73 40 00 (0925) 37 331	
COMMERCIAL PRODUCT NAME: Fluorocarbon 134A			
END USE: refrigerant			
1.1 Chemical characterisation		CAS-No.	EINECS-Nr.
1,1,1,2-Tetrafluoroethane (R134a)		811-97-2	2133770
1.2 Form: liquefied gas;	1.3 Colour: colourless;	1.4 Odour: slight ether-like;	
2 PHYSICAL AND SAFETY DATA		Tested according to	
2.1 Change in physical state:			
Melting point:		-101,0 °C	
Boiling point:		-26,5 °C	
2.2 Density: (25 °C)		1,21 kg/l	
Bulk density:		kg/m ³	
2.3 Vapour pressure: (25 °C)		670.6 kPa	
(°C)		hPa	
2.4 Viscosity: (°C)		mPa.s	
2.5 Solubility in water: (°C)		g/l	
in:			
2.6 pH value: (at g/l H ₂ O) (°C)			
2.7 Flash point:		does not flash	
2.8 Ignition temperature:		°C	
2.9 Explosion limits	- lower: none	- upper: none	
2.10 Thermal decomposition: No decomposition if used as directed.			
2.11 Hazardous decomposition products: hydrogen halides, traces of carbonyl halides,			
2.12 Hazardous reactions: with alkali metals, alkaline earth metals, powdered metal salts, powdered Al, Zn, Be, etc,			
2.13 Further information: Vapours in contact with fire or red-hot surfaces may form decomposition products as shown under 2.11 with highly irritating and warning effects.			
3 TRANSPORTATION		UN-No: 107B	
ICAO Number: 107B		ICAO Class: 2	
ICAO-Labels: Non-flammable compressed gas			
Proper shipping name: Refrigerant gases, n.o.s. (Tetrafluoroethane (R134a))			
ADR/RID Class: 2		ADR/RID Item: 3(a)	ADR/RID-Labels: none
TREM-CARD: R-20G08-9			
Proper shipping name: Tetrafluoroethane (R134a), 3, 3(a), ADR.			
IMO Class: 2.2		IMDG Page: 2111	
IMO-Labels: Non-flammable compressed gas			
MFAG: 350		EmS: 2-14	
Proper shipping name: Refrigerant gases, n.o.s. (Tetrafluoroethane (R134a))			

n.a. = not applicable
n.d.a. = no data available
n.r. = not regulated

CHEMICALS AND PIGMENTS DEPARTMENT

COMMERCIAL PRODUCT NAME: Fluorocarbon 134A

4 REGULATIONS

According to the CPL regulation 1984, as amended, the product does not need to be labelled. Water contaminating class 2 (self estimation)

5 PROTECTIVE MEASURES, STORAGE AND HANDLING

5.1 Technical protective measures:

- a) Storage: Keep tightly closed in a dry, cool and well-ventilated place.
b) Handling: Use only in well-ventilated areas.

5.2. Personal protective equipment:

Respiration: For rescue- and maintenance work in CFC-tanks use a self-contained breathing apparatus. Vapours are heavier than air and can cause suffocation by reducing oxygen available for breathing.
Eyes: safety glasses
Hands: rubber gloves
Other:

5.3 Industrial hygiene:

5.4 Protection against fire and explosion:

5.5 Disposal: Can be used after re-conditioning.

6 MEASURES IN CASE OF ACCIDENTS AND FIRES

6.1. After spillage/leakage/gas leakage: Evaporates.

6.2 Extinguishing media: Suitable: any
Not to be used:

6.3 First aid:

Inhalation: Move to fresh air. Oxygen or artificial respiration if needed. Do not give adrenaline or similar drugs.
Eye contact: Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.
Skin contact: Wash off immediately with plenty of water. Take all contaminated clothing off immediately.
Ingestion:

6.4 Further information: Fire may cause hydrogen halides to evolve. In case of fire, wear a self contained breathing apparatus.

7 INFORMATION ON TOXICITY

Concentrations substantially above the OEL value may cause narcotic effects. Inhalation of decomposition products in high concentration may cause shortness of breath (lung oedema). Did not show carcinogenic, teratogenic or mutagenic effects in animal experiments. Rapid evaporation of the liquid may cause frostbite.

ALC/inhalation/4h/rat = 567 ml/l.
Du Pont's acceptable exposure limit

-- MATERIAL SAFETY DATA SHEET --

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APPROVAL DATE 05/11/1990

CHEMICALS AND PIGMENTS DEPARTMENT

COMMERCIAL PRODUCT NAME: Fluorocarbon 134A
8 INFORMATION ON ECOLOGICAL EFFECTS
9 FURTHER INFORMATION Before use also read the following Du Pont bulletin(s): H-08910 - Application testing of HCFC-123 and HFC-134A KSS-8281 - 10/79 - Thermodynamic properties of R-134A

This data relates only to the material designated herein and does not apply to use in combination with any other material or in any process. The data is not to be considered as a warranty or quality specification and we assume no liability in connection with its use.

MATERIAL IDENTIFICATIONPENTAFLUOROETHANE

MSDS NUMBER : DU001838
Revision Date : 15-Mar-90
Date Printed : 12-Oct-90
MANUFACTURER/DISTRIBUTOR
PCR INC.
(Used to be Specialty Chemicals)
PHONE NUMBERS
TRANSPORT EMERGENCY : CHEMTREC: 1-800-424-9300
MEDICAL EMERGENCY : 1-800-441-3637
CHEMICAL FAMILY : FLUOROALKANE
TRADE NAMES / SYNONYMS
FC-125
K-125
FREON 125
CAS NAME : PENTAFLUOROETHANE
CAS NUMBER : 354-33-6
FORMULA : C2HF5
MOLECULAR WEIGHT : 120.0
TSCA INVENTORY STATUS : Reported/Included

COMPONENTS

Material	CAS Number	
PENTAFLUOROETHANE	354-33-6	100

PHYSICAL DATA

Boiling Point : -48 deg C (-54 deg F)
Vapor Density : > 1 (Air = 1.0)
Melting Point : -103 deg C (-153 deg F)
Water Solubility : Insoluble
Form : Gas
Color : Clear, colorless

HAZARDOUS REACTIVITY

Instability : Stable at normal temperatures and storage condi.
Incompatibility : Incompatible with active metals.
Decomposition : Decomposes with heat. Hazardous gases/vapors
produced are carbon dioxide, hydrogen fluoride.
Polymerization : Polymerization will not occur.

FIRE AND EXPLOSION DATA

No Information Available.

FIRE AND EXPLOSION HAZARDS

Hazardous gases/vapors produced in fire are toxic fumes or mists of fluoride.

EXTINGUISHING MEDIA

Water. Foam. Dry Chemical. CO₂.

SPECIAL FIRE FIGHTING INSTRUCTIONS

Keep personnel removed & upwind of fire. Wear self-contained breathing apparatus. Wear full protective equipment. Cool tank/container with water spray.

HEALTH HAZARD INFORMATION

Pentafluoroethane has very low inhalation toxicity. However, life-threatening exposure can occur if it is handled carelessly.

Vapors of the compound are heavier than air, posing a hazard of asphyxia if they are trapped in enclosed or low places.

At flame temperatures, this fluorocarbon can decompose to hydrogen fluoride which is fatal at much lower concentrations.

Pentafluoroethane belongs to a class of chemicals which at high concentrations have been known to cause fatal cardiac arrhythmias in animals.

Frostbite may occur on skin contact with the liquid.

ANIMAL DATA

Inhalation 1 hour LC50: > 100,000 ppm in rats

INHALATION

Inactivity after exposure and slight respiratory effects occurred in rats exposed to 50,000 or 100,000 ppm.

HUMAN HEALTH EFFECTS

Skin contact may cause frostbite.

Although no information on this compound could be found, this class of compounds (fluorocarbons) have been known to cause cardiac sensitization in animals. Based on this information, individuals with preexisting diseases of the cardiovascular system may have increased susceptibility to the toxicity of excessive exposures.

CARCINOGENICITY

None of the components in this material is listed by IARC, NTP, OSHA, or ACGIH as a carcinogen.

**EXPOSURE LIMITS
PENTAFLUOROETHANE**

AEL * (Du Pont): 1000 ppm - 8 & 12 Hr. TWA
TLV (ACGIH) : None Established
PEL (OSHA) : None Established

* AEL is Du Pont's Acceptable Exposure Limit.

SAFETY PRECAUTIONS

Avoid breathing gas. Avoid contact with eyes, skin, or clothing. Wash thoroughly after handling. Wash clothing after use.

FIRST AID

INHALATION

If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

SKIN CONTACT

Treat for frostbite if necessary.

EYE CONTACT

In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician.

INGESTION

No specific intervention is indicated as compound is not likely to be hazardous by ingestion. Consult physician if necessary.

NOTES TO PHYSICIAN

Because of a possible increased risk of eliciting cardiac dysrhythmias catechloramine drugs, such as epinephrine, should be used with special caution in situations of emergency life support.

PROTECTION INFORMATION

GENERALLY APPLICABLE CONTROL MEASURES AND PROCEDURES

Keep container tightly closed.

Should be handled in an enclosed area. Handle material in a fume hood.

Use ventilation that is adequate to keep employee exposure to airborne concentrations below exposure limits.

PERSONAL PROTECTIVE EQUIPMENT

Respirator : Air supplied respirator.

EYE/FACE PROTECTION

Wear safety glasses. Wear coverall chemical splash goggles and face shield when possibility exists for eye and face contact due to splashing or spraying material.

RESPIRATORS

Use a positive pressure air-supplied respirator if concentrations may exceed exposure limits. Air-purifying respirators are inadequate for this material.

PROTECTIVE CLOTHING

Wear impervious clothing, such as gloves, apron, boots, or whole bodysuit as appropriate. No vendor recommendation on material of construction for protective clothing.

DISPOSAL INFORMATION

SPILL, LEAK, OR RELEASE

NOTE: Review FIRE AND EXPLOSION HAZARDS and SAFETY PRECAUTIONS before proceeding with clean up. Use appropriate PERSONAL PROTECTIVE EQUIPMENT during clean up.

Keep upwind of leak - evacuate until gas has dispersed.

Ventilate area before reentering.

WASTE DISPOSAL

Treatment, storage, transportation and disposal must be in accordance with applicable Federal, State/Provincial, and Local regulations. Allow to evaporate or disperse leaks in air, making sure gas/vapor is dissipated below lower explosive limit.

STORAGE CONDITIONS

Store in well ventilated area. Keep container tightly closed.

Handle material in a fume hood.

TITLE III HAZARD CLASSIFICATIONS

Acute	:	Yes
Chronic	:	No
Fire	:	No
Reactivity	:	No
Pressure	:	No

ADDITIONAL INFORMATION AND REFERENCES

Technical data, except for health information is based on PCR Inc. MSDS dated 4/22/89.

The data in this Material Safety Data Sheet relates only to the specific material designated herein and does not relate to use in combination with any other material or in any process.

Responsibility for MSDS : E. I. du Pont de Nemours & Co.
Corporate MSDS Office - ERD
Barley Mill Plaza, P14-2150
Wilmington, DE 19880-0014
302-992-6704

FREON

PRODUCT INFORMATION

ARTD-5

Freon® Products Laboratory

E. I. du Pont de Nemours and Company, Inc.

Technical Report

November 7, 1989

COMPATIBILITY OF ELASTOMERS WITH HFC-134a

Introduction:

HFC-134a(CF₃CH₂F) is an alternative to CFC-12(CF₂Cl₂) for refrigeration applications. During the conversion to HFC-134a, proper choices for materials of construction are necessary. To aid in this process, tests have been run with select elastomers.

It is necessary to recognize that the effect of refrigerants on elastomers depends on the nature of the polymer, the compounding formulation used, the curing or vulcanizing condition, the presence of plasticizers or extenders, and other elastomer variables. Thus generalization from the results of this study are difficult to make. None-the-less, these data do serve as a guide.

Object:

Determine the compatibility of the elastomers at 25°C, 80°C, and in some cases at 141°C with HFC-134a after 27 days of immersion ("temporary" data) and after drying in air at 25°C for 14 days ("final" data) using CFC-12 as a control.

Results and Conclusions:

The "temporary" elastomer swell and hardness change were used as the prime determinant of compatibility. The subsequent "final" data was used as a guide to indicate if the seals in a refrigerant system needed to be replaced after equipment tear down. The above conclusions were modified, when necessary, by the qualitative evaluation of property changes as: (1) appearance changes of liquid and elastomer and (2) elastomer elasticity.

The conclusions are shown in Exhibit 1. Key to the ratings are: 0 = no change, 1 = a considered acceptable change of properties, 2 = a borderline change, 3 = slight, unacceptable change, 4 = moderate, unacceptable change, and 5 = severe, unacceptable change. These conclusions are based on the detailed data in Exhibits 2 to 12.

Basis for the relation of linear swell and hardness change to compatibility rating is shown in Exhibit 13.

Experimental:

Clean and dry elastomer specimens (60 mm x 7 mm x about 2 mm) were checked for length (± 0.01 mm), weight (± 0.0001 g), hardness (± 2), appearance and elasticity (by hand). Each Pyrex[®] tube (7/16" I.D. x 5 1/2") was charged with one elastomer and 3 ml of refrigerant and then sealed. The tubes were stored, horizontally, at 25°, 80°, and 141°C. After 27 days, the elastomers were measured while still in the sealed tubes. The tube contents were examined and rated for the noted changes. Each tube was then chilled to just below the refrigerant's melting point and opened. Within three minutes, the specimen surface was flushed briefly with isopropanol and Freon[®] TF, and when the surface first appeared dry, was placed in a sealed, pre-tared vial and weighed. Immediately afterwards, the hardness and elasticity were determined. These data are referred to as "temporary" data.

After storing the elastomers horizontally in open vials in air at 25°C for 14 days, the properties mentioned above were redetermined (the "final" changes).

EXHIBIT 1
ELASTOMER COMPATIBILITY RATINGS

<u>Elastomer</u>	<u>CFC-12</u>			<u>HFC-134a</u>		
	<u>25°C</u>	<u>80°C</u>	<u>141°C</u>	<u>25°C</u>	<u>80°C</u>	<u>141°C</u>
Adiprene® L	1	5		2	5	
Buna N	1*	0*	2*	1	0*	1
Buna S	3	4		3	2	
Butyl Rubber	2	4		0	3(b)	
Hypalon® 48	1	0	0	1*	0	0
Natural Rubber	4	5		0	2	
Neoprene W	0*	1*		0	2	
Nordel® Elastomer	2*	2*		1	1	
Silicone	5	5		2	2	
Thiokol® FA	1	1		1*	0	
Viton® A	5	5		5	5(b)	

* Recommend elastomer replacement after equipment teardown.

EXHIBIT 2COMPATIBILITY OF REFRIGERANTS WITH ADIPRENE® L

Test Conditions: 27 days immersion of the polymer
at 25°C and 80°C in liquid
(temporary) plus 2 weeks drying
in air at about 25°C (final)

<u>Length Change (%)</u>	<u>25°C</u>		<u>80°C</u>	
	<u>12</u>	<u>134a</u>	<u>12</u>	<u>134a</u>
Temporary	1.8	5.5	2.1	5.0
Final	0.3	0.1	(a)	-0.5
<u>Weight Change (%)</u>				
Temporary	8.5	20.	5.2	20.
Final	1.2	0.3	(a)	-0.5
<u>Shore A Hardness</u>				
Original	60	61	60	63
Temporary, Δ SH	-2	-4	(a)	-28
Final, Δ SH	0	1	-	-19
<u>Elasticity Rating</u>				
Temporary	0	0	5(a)	4(b)
Final	0	0	5(a)	5(c)
<u>Visual Rating</u>				
<u>Liquid</u>	0	0	0	0
<u>Polymer</u>				
Temporary	0	0	0	1(d)
Final	0	0	5(a)	2(d)

a - Sample disintegrated

c - Broke when stretched

b - More elastic

d - Sticky

EXHIBIT 3COMPATIBILITY OF REFRIGERANTS WITH BUNA N

Test Conditions: 27 days immersion of the polymer
at 25°C, 80°C and 141°C in liquid
(temporary) plus 2 weeks drying
in air at about 25°C (final)

Results (A,B,C) obtained for 25, 80 and 141°C tests

	<u>12</u>	<u>134a</u>
<u>Length Change (%) (+ 0.5)</u>		
Temporary	2,1,2	2,2,3
Final	0,-1,0	0,0,0
<u>Weight Change (%) (+ 0.5)</u>		
Temporary	7,6,8	8,8,8
Final	0,-1,2	0,0,0
<u>Shore Hardness</u>		
Original	77,76,72	77,74,75
Temporary, Δ SH	-6,-1,9	-5,-1,-3
Final Δ SH	7,9,14	5,7,4
<u>Elasticity Rating</u>		
Temporary	0,1,1(a)	0,1,1
Final	0,0,0	0,0,0
<u>Visual Rating</u>		
<u>Liquid</u>	0,0,0	0,0,0
<u>Polymer</u>		
Temporary	0,1,1(b)	0,0,0
Final	0,1,1(b)	0,0,0

a - More elastic

b - Surface dulled

EXHIBIT 4COMPATIBILITY OF REFRIGERANTS WITH BUNA S

Test Conditions: 27 days immersion of the polymer
at 25°C and 80°C in liquid
(temporary) plus 2 weeks drying
in air at about 25°C (final)

<u>Length Change (%)</u>	<u>25°C</u>		<u>80°C</u>	
	<u>12</u>	<u>134a</u>	<u>12</u>	<u>134a</u>
Temporary	-0.1	1.1	0.7	0.8
Final	-2.5	<0.1	-2.6	0.3
<u>Weight Change (%)</u>				
Temporary	2.8	1.9	2.9	2.5
Final	-6.2	-0.1	-6.2	-0.1
<u>Shore A Hardness</u>				
Original	85	84	83	81
Temporary, Δ SH	-12	-12	-16	-9
Final, Δ SH	8	- 2	-9	-2
<u>Elasticity Rating</u>				
Temporary	0	0	0	1(a)
Final	3(b)	1(b)	3(b)	0
<u>Visual Rating</u>				
<u>Liquid</u>	0	0	0	0
<u>Polymer</u>				
Temporary	0	0	0	0
Final	0	0	0	0

a - More elastic

b - Less elastic

EXHIBIT 5COMPATIBILITY OF REFRIGERANTS WITH BUTYL RUBBER

Test Conditions: 27 days immersion of the polymer
at 25°C and 80°C in liquid
(temporary) plus 2 weeks drying
in air at about 25°C (final)

<u>Length Change (%)</u>	<u>25°C</u>		<u>80°C</u>	
	<u>12</u>	<u>134a</u>	<u>12</u>	<u>134a</u>
Temporary	6.3	0.2	7.6	1.3
Final	-1.2	0	-0.8	0.4
<u>Weight Change (%)</u>				
Temporary	34.	2.0	36.	3.7
Final	-2.6	-0.1	-1.2	0.6
<u>Shore A Hardness</u>				
Original	54	54	57	58
Temporary, Δ SH	-8	-1	-14	-4
Final, Δ SH	-1	-2	-10	-3
<u>Elasticity Rating</u>				
Temporary	1(a)	1(a)	3(a)	0
Final	0	0	2(a)	0
<u>Visual Rating</u>				
<u>Liquid</u>	0	0	3(b)	0
<u>Polymer</u>				
Temporary	0	0	3(c)	4(c)
Final	0	0	1(d)	2(d)

a - More elastic

c - White deposit on elastomer

b - White solids in liquid

d - White film on elastomer

EXHIBIT 6COMPATIBILITY OF REFRIGERANTS WITH HYPALON® 48

Test Conditions: 27 days immersion of the polymer
at 25°C, 80°C and 141°C in liquid
(temporary) plus 2 weeks drying
in air at about 25°C (final)

Results (A,B,C) obtained for 25, 80 and 141°C tests

	<u>12</u>	<u>134a</u>
<u>Length Change (%) (+ 0.5)</u>		
Temporary	1,0,1	0,0,1
Final	0,0,0	0,0,0
<u>Weight Change (%) (+ 0.5)</u>		
Temporary	7,5,9	0,1,2
Final	2,1,4	0,0,1
<u>Shore Hardness</u>		
Original	79,81,81	76,82,82
Temporary, Δ SH	-4,0,0	3,1,1
Final Δ SH	4,2,2	8,1,4
<u>Elasticity Rating</u>		
Temporary	0,0,0	0,0,0
Final	0,0,0	0,0,0
<u>Visual Rating</u>		
<u>Liquid</u>	0,0,0	0,0,0
<u>Polymer</u>		
Temporary	0,1,1(a)	0,0,0
Final	0,1,1(a)	0,0,0

a - Surface dulled

EXHIBIT 7COMPATIBILITY OF REFRIGERANTS WITH NATURAL RUBBER

Test Conditions: 27 days immersion of the polymer
at 25°C and 80°C in liquid
(temporary) plus 2 weeks drying
in air at about 25°C (final)

<u>Length Change (%)</u>	<u>25°C</u>		<u>80°C</u>	
	<u>12</u>	<u>134a</u>	<u>12</u>	<u>134a</u>
Temporary	14.	1.3	14,	2.0
Final	-1.1	-0.3	-0.8	0.4
<u>Weight Change (%)</u>				
Temporary	51.	4.5	55	5.8
Final	-2.6	-0.5	-2.6	-0.6
<u>Shore A Hardness</u>				
Original	55	56	56	57
Temporary, Δ SH	-9	-1	-17	-8
Final, Δ SH	-5	-4	- 8	-4
<u>Elasticity Rating</u>				
Temporary	0	0	1(a)	1(a)
Final	0	0	2(a)	0
<u>Visual Rating</u>				
<u>Liquid</u>	0	0	0	0
<u>Polymer</u>				
Temporary	0	0	0	0
Final	0	0	0	0

a - More elastic

EXHIBIT 8COMPATIBILITY OF REFRIGERANTS WITH NEOPRENE W

Test Conditions: 27 days immersion of the polymer at 25°C and 80°C in liquid (temporary) plus 2 weeks drying in air at about 25°C (final)

<u>Length Change (%)</u>	<u>25°C</u>		<u>80°C</u>	
	<u>12</u>	<u>134a</u>	<u>12</u>	<u>134a</u>
Temporary	0.2	0.7	0.9	1.4
Final	-7.6	-0.5	-7.3	-0.3
<u>Weight Change (%)</u>				
Temporary	6.6	2.3	6.8	2.9
Final	-12.	-0.6	-13.	-1.8
<u>Shore A Hardness</u>				
Original	73	73	73	72
Temporary, Δ SH	-1	0	-5	-7
Final, Δ SH	-10	0	5	-5
<u>Elasticity Rating</u>				
Temporary	2(a)	0	1(b)	0
Final	2(a)	0	2(b)	0
<u>Visual Rating</u>				
<u>Liquid</u>	1(c)	0	1(d)	0
<u>Polymer</u>				
Temporary	0	0	1(e)	0
Final	0	0	0	0

a - Less elastic

c - Clear, yellow

e - White film

b - More elastic

d - Hazy

EXHIBIT 9COMPATIBILITY OF REFRIGERANTS WITH NORDEL® ELASTOMER

Test Conditions: 27 days immersion of the polymer
at 25°C and 80°C in liquid
(temporary) plus 2 weeks drying
in air at about 25°C (final)

<u>Length Change (%)</u>	<u>25°C</u>		<u>80°C</u>	
	<u>12</u>	<u>134a</u>	<u>12</u>	<u>134a</u>
Temporary	-0.6	0.5	-0.4	0.7
Final	-8.2	-0.2	-8.4	0.4
<u>Weight Change (%)</u>				
Temporary	5.5	2.8	6.1	4.4
Final	-22	<0.1	-22	-0.2
<u>Shore A Hardness</u>				
Original	66	66	65	63
Temporary, Δ SH	-4	-3	0	-6
Final, Δ SH	19	-4	20	0
<u>Elasticity Rating</u>				
Temporary	2(a)	0	2(b)	1(b)
Final	2(a)	0	2(b)	0
<u>Visual Rating</u>				
<u>Liquid</u>	0	0	0	1(d)
<u>Polymer</u>				
Temporary	0	0	0	0
Final	0	0	1(c)	0

a - Less elastic

c - White film

b - More elastic

d - Hazy

EXHIBIT 10COMPATIBILITY OF REFRIGERANTS WITH SILICONE

Test Conditions: 27 days immersion of the polymer
at 25°C and 80°C in liquid
(temporary) plus 2 weeks drying
in air at about 25°C (final)

<u>Length Change (%)</u>	<u>25°C</u>		<u>80°C</u>	
	<u>12</u>	<u>134a</u>	<u>12</u>	<u>134a</u>
Temporary	41	6.1	44	5.5
Final	-0.1	0.1	-0.2	-0.2
<u>Weight Change (%)</u>				
Temporary	173	20	187	20.3
Final	0.7	-0.1	-0.7	-0.3
<u>Shore A Hardness</u>				
Original	60	61	60	58
Temporary, Δ SH	-13	-8	-15	-6
Final, Δ SH	-7	-4	-7	-2
<u>Elasticity Rating</u>				
Temporary	0	1(a)	1(a)	0
Final	0	0	0	0
<u>Visual Rating</u>				
<u>Liquid</u>	0	0	0	0
<u>Polymer</u>				
Temporary	5(b)	0	4(b)	0
Final	0	0	0	0

a - More elastic

b - Swollen

EXHIBIT 11COMPATIBILITY OF REFRIGERANTS WITH THIOKOL® FA

Test Conditions: 27 days immersion of the polymer
at 25°C and 80°C in liquid
(temporary) plus 2 weeks drying
in air at about 25°C (final)

<u>Length Change (%)</u>	<u>25°C</u>		<u>80°C</u>	
	<u>12</u>	<u>134a</u>	<u>12</u>	<u>134a</u>
Temporary	1.3	0.8	1.4	-0.2
Final	-0.5	-0.2	-0.5	-0.9
<u>Weight Change (%)</u>				
Temporary	1.9	1.0	3.7	1.9
Final	-0.2	-0.1	-0.8	-0.8
<u>Shore A Hardness</u>				
Original	70	69	74	74
Temporary, Δ SH	-6	-4	-6	0
Final, Δ SH	-5	-6	-1	0
<u>Elasticity Rating</u>				
Temporary	1(b)	1(b)	0	1(b)
Final	0	0	1(a)	2(a)
<u>Visual Rating</u>				
<u>Liquid</u>	0	0	0	0
<u>Polymer</u>				
Temporary	0	0	0	0
Final	0	0	0	0

a - Less elastic

b - More elastic

EXHIBIT 12COMPATIBILITY OF REFRIGERANTS WITH VITON® A

Test Conditions: 27 days immersion of the polymer at 25°C and 80°C in liquid (temporary) plus 2 weeks drying in air at about 25°C (final)

<u>Length Change (%)</u>	<u>25°C</u>		<u>80°C</u>	
	<u>12</u>	<u>134a</u>	<u>12</u>	<u>134a</u>
Temporary	5.5	13.	4.9	12
Final	0.7	-0.1	1.2	0.3
<u>Weight Change (%)</u>				
Temporary	19.	48.	20.	49.
Final	1.8	0.7	2.5	1.2
<u>Shore A Hardness</u>				
Original	74	74	73	73
Temporary, Δ SH	-19	-30	-23	-31
Final, Δ SH	- 7	- 8	-10	- 6
<u>Elasticity Rating</u>				
Temporary	2(b)	2(b)	3(a)	3(a)
Final	0	0	0	0
<u>Visual Rating</u>				
<u>Liquid</u>	0	0	0	0
<u>Polymer</u>				
Temporary	0	1(c)	0	0
Final	0	1(d)	0	5(e)

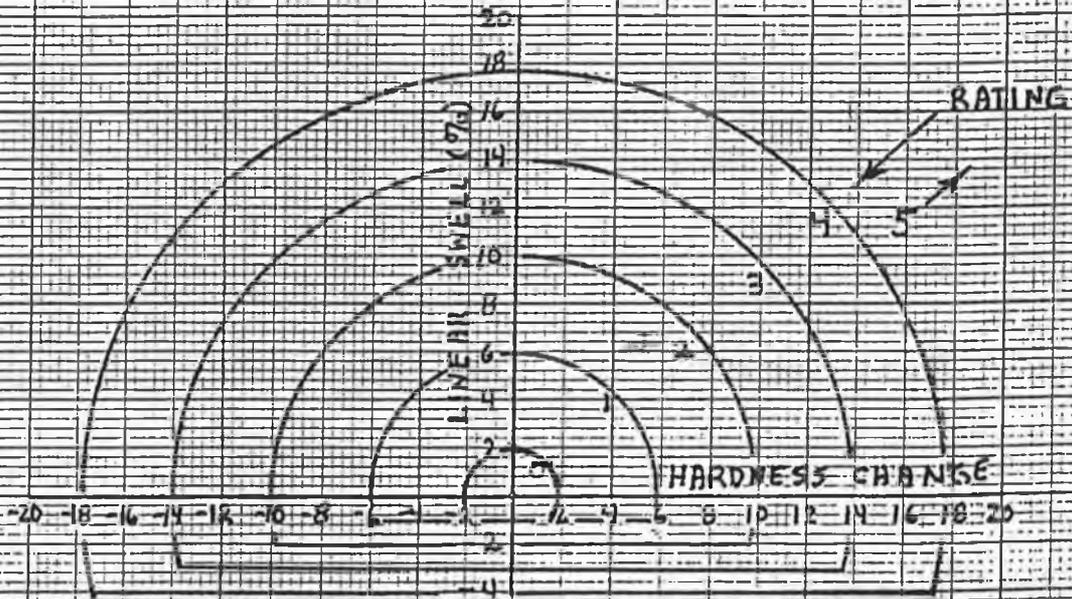
a - Less elastic
 b - More elastic
 c - V. sli. tacky

d - Oily sheen
 e - Puffed mounds - 5% of surface

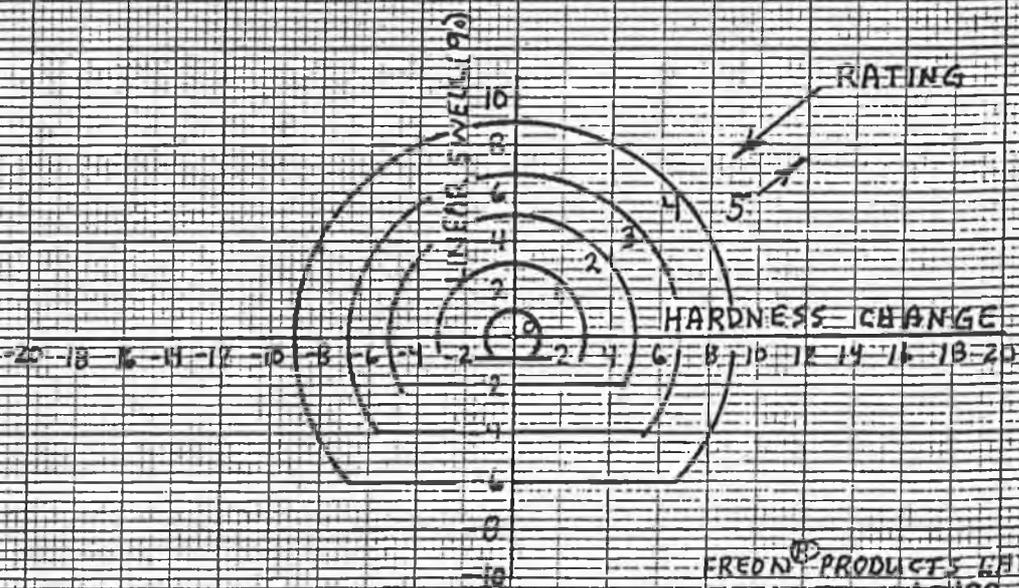
EXHIBIT 15

RELATION OF ELASTOMER SWELL AND HARDNESS CHANGE TO COMPATIBILITY RATING

TEMPORARY ELASTOMER CHANGE



FINAL ELASTOMER CHANGE



FREDN[®] PRODUCTS LAB.
DUPONT, 11/1/89

I

(Acts whose publication is obligatory)

**COUNCIL REGULATION (EEC) No 594/91
of 4 March 1991
on substances that deplete the ozone layer**

THE COUNCIL OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Economic Community, and in particular Article 130s thereof,

Having regard to the proposal from the Commission ⁽¹⁾,

Having regard to the opinion of the European Parliament ⁽²⁾,

Having regard to the opinion of the Economic and Social Committee ⁽³⁾,

Whereas it is established that continued emissions of ozone depleting substances at current levels cause significant damage to the ozone layer; whereas there is an international consensus that significant reductions in both production and consumption of such substances are necessary; whereas Decisions 80/372/EEC ⁽⁴⁾ and 82/795/EEC ⁽⁵⁾ provide controls which are of limited effect and which cover only two such substances (CFC 11 and CFC 12);

Whereas in view of the responsibilities of the Community for the environment and trade, all Member States and the Community have become Parties to the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer;

Whereas Regulation (EEC) No 3322/88 ⁽⁶⁾ provides for controls on certain chlorofluorocarbons and halons which deplete the ozone layer;

Whereas, in the light of more recent scientific evidence, the Parties to the Montreal Protocol have adopted at their second meeting, at which the Community and the

Member States played a leading role, additional measures for the protection of the ozone layer;

Whereas, in the light of more recent scientific evidence, the Parties to the Montreal Protocol have adopted at their second meeting, at which the Community and the Member States played a leading role, additional measures for the protection of the ozone layer;

Whereas it is necessary for action to be taken at Community level to carry out the Community's obligation under the Convention and the amended Protocol, in particular further to control production and consumption within the Community of certain chlorofluorocarbons and halons and other ozone-depleting substances;

Whereas, in the light notably of scientific evidence, it is appropriate in certain cases to introduce control measures which are more severe than those of the amended Protocol;

Whereas, bearing in mind the market structure for chlorofluorocarbons, other fully halogenated chlorofluorocarbons, halons, carbon tetrachloride and 1,1,1-trichloroethane, it is appropriate — to ensure fulfilment of the Community's obligation under the amended Protocol — to control consumption of these substances by controlling supply rather than demand; whereas supply can be controlled by limiting sales and use by producers in the Community, and by limiting the release into free circulation of imports;

Whereas it is necessary to keep under review the evolution of the market for the above substances, particularly with regard to sufficient supply for essential uses, and the state of development of appropriate substitutes;

Whereas additional Community measures may be needed to carry out the Community's obligations under the Protocol in respect of research and development, and technical assistance;

Whereas Regulation (EEC) No 3322/88 has become superfluous and should therefore be repealed,

⁽¹⁾ OJ No C 86, 4. 4. 1990, p. 4.

⁽²⁾ OJ No C 19, 28. 1. 1991.

⁽³⁾ OJ No C 332, 31. 12. 1990, p. 14.

⁽⁴⁾ OJ No L 90, 3. 4. 1980, p. 45.

⁽⁵⁾ OJ No L 329, 25. 11. 1982, p. 29.

⁽⁶⁾ OJ No L 297, 31. 10. 1988, p. 1.

HAS ADOPTED THIS REGULATION:

Article 1

Scope

This Regulation shall apply to the importation, exportation, production and consumption of chlorofluorocarbons, other fully halogenated chlorofluorocarbons, halons, carbon tetrachloride, 1,1,1-trichloroethane. It shall also apply to the reporting of data on these substances and on transitional substances.

Article 2

Definitions

In this Regulation:

- 'the Protocol' means the Montreal Protocol on Substances that Deplete the Ozone Layer, whether in its adjusted or adjusted and amended version,
- 'Party' means any Party to the Protocol. However, as to the rights and obligations resulting from the amendments to the Protocol, States which have not approved those amendments or measures for their implementation are not considered as 'Parties',
- 'controlled substances' means chlorofluorocarbons, other fully halogenated chlorofluorocarbons, halons, carbon tetrachloride and 1,1,1-trichloroethane, whether existing alone or in a mixture. This definition shall not cover any controlled substance which is in a manufactured product other than a container used for the transportation or storage of that substance,
- 'chlorofluorocarbons' means the substances listed in Group I of Annex I, including their isomers,
- 'other fully halogenated chlorofluorocarbons' means the substances listed in Group II of Annex I, including their isomers,
- 'halons' means the substances listed in Group III of Annex I, including their isomers,
- 'carbon tetrachloride' means the substance listed in Group IV of Annex I,
- '1,1,1-trichloroethane' means the substance listed in Group V of Annex I,
- 'transitional substances' means the partially halogenated chlorofluorocarbons, including their isomers listed in Group VI of Annex I whether existing alone or in a mixture. However, it does not cover any transitional substance, mixture or isomer which is in a manufactured product other than a container used for the transportation or storage of that substance,

- 'producer' means any natural or legal person manufacturing controlled or transitional substances within the Community,
- 'production' means the amount of substances produced, minus the amount destroyed by technologies to be approved by the Parties and minus the amount produced for the use as feedstock in the manufacture of other chemicals. Any amount recycled and re-used is not to be considered as 'production',
- 'undertaking' means any natural or legal person which produces, recycles for placing on the market or uses in the Community controlled or transitional substances for industrial or commercial purposes or which releases into free circulation in the Community such imported substances, or exports such substances from the Community for industrial or commercial purposes,
- 'ozone-depleting potential' means the figure specified in the final column of Annex I representing the potential effect of each substance on the ozone layer,
- 'calculated level' means a quantity determined by multiplying the quantity of each substance by the ozone-depleting potential of that substance specified in Annex I and by adding together, for each group of substances in Annex I separately, the resulting figures,
- 'industrial rationalization' means the transfer either between Parties or within a Member State of all or a portion of the calculated level of production of one producer to another, for the purpose of achieving economic efficiency of responding to anticipated shortfalls in supply as a result of plant closures.

PART I

TRADE REGIME

Article 3

Importation of substances from third countries

1. The release into free circulation in the Community of controlled substances, be they virgin, recycled or used, imported from third countries, shall be subject to quantitative limits.
2. For this purpose the Community shall open the quotas set out in Annex II which shall be applicable during the period laid down in that Annex, and allocate them to undertakings in accordance with the procedure set out in Article 12.
3. The Commission, in accordance with the procedure set out in Article 12, may modify the quotas set out in Annex II.

*Article 4***Import licence**

1. The release into free circulation in the Community of controlled substances which are subject to the quotas referred to in Article 3 shall be subject to presentation of an import licence. This licence shall be issued by the Commission. The Commission shall forward a copy of this licence to the competent authority of the Member State into which the importation is expected to take place. To this end, each Member State shall determine its competent authority.

2. A request for a licence shall contain :

- (a) the name and the address of the importer;
- (b) the description of each substance stating :
 - the commercial description,
 - the heading in the combined nomenclature,
 - the country from which the substance is imported;
- (c) statement of the quantity of each substance to be imported in tonnes; and
- (d) the place and date of proposed importation, if known.

*Article 5***Importation of controlled substances from non-parties**

1. The release into free circulation in the Community of chlorofluorocarbons or halons imported from non-Parties shall be prohibited.

2. With effect from 1 January 1993, the release into free circulation in the Community of other fully halogenated chlorofluorocarbons, carbon tetrachloride or 1,1,1-trichloroethane imported from non-Parties shall be prohibited

*Article 6***Importation from non-parties of products containing controlled substances**

1. Subject to the decision referred to in paragraph 3, the release into free circulation in the Community of products imported from non-Parties containing chlorofluorocarbons or halons shall be prohibited with effect from 1 January 1993.

2. Subject to the decision referred to in paragraph 3, the release into free circulation in the Community of products imported from non-Parties containing other fully halogenated chlorofluorocarbons, carbon tetrachloride or 1,1,1-trichloroethane shall be prohibited with effect from 1 January 1996.

3. The Council, on a proposal from the Commission, shall adopt before these dates the list of these products in the light of the list established by the Parties.

The Council shall act by a qualified majority.

*Article 7***Importation from non-parties of products produced with controlled substances**

In the light of the decision of the Parties, the Council, on a proposal from the Commission, shall adopt rules applicable to the release into free circulation in the Community of products imported from non-Parties, which are produced with controlled substances but which do not contain these substances. The Council shall act by a qualified majority.

*Article 8***Exportation of controlled substances to non-parties**

With effect from 1 January 1993, the exportation from the Community of virgin, recycled or used controlled substances to any non-Party shall be prohibited.

*Article 9***Exceptional authorization to trade with non-parties**

By derogation from Articles 5, 6 (1) and (2), 7 and 8, the trade of controlled substances as well as products which contain and/or are produced with one or several of these substances with any non-Party may be permitted by the Commission, to the extent that the non-Party is determined by a meeting of the Parties to be in full compliance with Articles 2, 2a to 2c and 4 of the Protocol and has submitted data to that effect as specified in Article 7 of the Protocol. The Commission shall act in accordance with the procedure set out in Article 12.

PART II**PHASE-OUT SCHEDULE***Article 10***Control of production**

1. Subject to the provisions of paragraphs 6 to 9, each producer shall ensure that :

- the calculated level of its production of chlorofluorocarbons in the period 1 July 1991 to 31 December 1992 does not exceed the calculated level of its production in 1986. However, for those Member States whose calculated level of production of chlorofluorocarbons was less than 15 000 tonnes in 1986, the calculated level of their production of chlorofluorocarbons in the period 1 July 1991 to 31 December 1992 shall not exceed 1.50 % of the calculated level of their production in 1986,

- the calculated level of its production of chlorofluorocarbons in the period 1 January to 31 December 1993, and in the following 12-month period, does not exceed 50 % of the calculated level of its production in 1986,
- the calculated level of its production of chlorofluorocarbons in the period 1 January to 31 December 1995 does not exceed 32,5 % of the calculated level of its production in 1986,
- the calculated level of its production of chlorofluorocarbons in the period 1 January to 31 December 1996, does not exceed 15 % of the calculated level of its production in 1986,
- the calculated level of its production of chlorofluorocarbons in the period 1 January to 30 June 1997 does not exceed 7,5 % of the calculated level of its production in 1986,
- there is no production of chlorofluorocarbons after 30 June 1997.

The Commission, in accordance with the procedure set out in Article 12, shall determine any essential uses of chlorofluorocarbons which may be permitted in the Community after 30 June 1997 and until 31 December 1999 at the latest and any quantities of chlorofluorocarbons which may be produced by each producer for this purpose. Such production shall only be allowed, if adequate alternatives or recycled chlorofluorocarbons are not available.

2. Subject to the provisions of paragraphs 6 to 9, each producer shall ensure that :

- the calculated level of its production of other fully halogenated chlorofluorocarbons in the period 1 January to 31 December 1992, and in each 12-month period thereafter, does not exceed 50 % of the calculated level of its production in 1989,
- the calculated level of its production of other fully halogenated chlorofluorocarbons in the period 1 January to 31 December 1995 does not exceed 32,5 % of the calculated level of its production in 1989,
- the calculated level of its production of other fully halogenated chlorofluorocarbons in the period 1 January to 31 December 1996, does not exceed 15 % of the calculated level of its production in 1989,
- the calculated level of its production of other fully halogenated chlorofluorocarbons in the period 1 January to 30 June 1997 does not exceed 7,5 % of the calculated level of its production in 1989,
- there is no production of other fully halogenated chlorofluorocarbons after 30 June 1997.

The Commission, in accordance with the procedure set out in Article 12, shall determine any essential uses of other fully halogenated chlorofluorocarbons which may be permitted in the Community after 30 June 1997 and until 31 December 1999 at the latest and any quantities of other fully halogenated chlorofluorocarbons which may be produced by each producer for this purpose. Such production shall only be allowed, if adequate alternatives or recycled other fully halogenated chlorofluorocarbons are not available.

3. Subject to the provisions of paragraphs 6 to 9, each producer shall ensure that :

- the calculated level of its production of halons in the period 1 January to 31 December 1992, and in each 12-month period thereafter, does not exceed the calculated level of its production of halons in 1986,
- the calculated level of its production of halons in the period 1 January to 31 December 1995, and in each 12-month period thereafter, does not exceed 50 % of the calculated level of its production of halons in 1986,
- there is no production of halons after 31 December 1999.

In the light of the decision of the Parties, the Commission, in accordance with the procedure set out in Article 12, shall determine any essential uses of halons which may be permitted in the Community from 1 January 2000 and any quantities of halons which may be produced by each producer for this purpose. Such production shall only be allowed, if adequate alternatives or recycled halons are not available.

4. Subject to the provisions of paragraphs 6 to 9, each producer shall ensure that :

- the level of its production of carbon tetrachloride in the period 1 January to 31 December 1992, and in each 12-month period thereafter, does not exceed 50 % of the level of its production in 1989,
- the level of its production of carbon tetrachloride in the period 1 January to 31 December 1995, and in each 12-month period thereafter, does not exceed 15 % of the level of its production in 1989 ;
- there is no production of carbon tetrachloride after 31 December 1997.

The Commission, in accordance with the procedure set out in Article 12, shall determine any essential uses of carbon tetrachloride which may be permitted in the Community from 1 January 1998 and until 31 December 1999 at the latest and any quantities of carbon tetrachloride which may be produced by each producer for this purpose. Such production shall only be allowed, if adequate alternatives or recycled carbon tetrachloride are not available.

5. Subject to the provisions of paragraphs 6 to 9, each producer shall ensure that:

- the level of its production of 1,1,1-trichloroethane in the period 1 January to 31 December 1992, and in each 12-month period thereafter, does not exceed the level of its production in 1989,
- the level of its production of 1,1,1-trichloroethane in the period 1 January to 31 December 1995, and in each 12-month period thereafter, does not exceed 70 % of the level of its production in 1989,
- the level of its production of 1,1,1-trichloroethane in the period 1 January to 31 December 2000, and in each 12-month period thereafter, does not exceed 30 % of its level of production in 1989,
- there is no production of 1,1,1-trichloroethane after 31 December 2004.

6. To the extent permitted by the Protocol, a producer may be authorized by the competent authority of the Member State in which its relevant production is situated, to exceed the calculated levels of production set out in paragraphs 1 to 5 so as to satisfy the basic domestic needs of Parties operating under Article 5 of the Protocol, provided that the additional calculated levels of production of the Member State concerned do not exceed those permitted for this purpose by Article 2a to 2c of the Protocol for the periods in question.

The competent authority of the Member State concerned shall notify the Commission in advance of any such authorization.

7. To the extent permitted by the Protocol, a producer may be authorized by the competent authority of the Member State in which its relevant production is situated, to exceed the calculated levels of its production set out in paragraphs 1 to 6 for the purpose of industrial rationalization within the Member State concerned, provided that the calculated levels of production of that Member State do not exceed the sum of the calculated levels of production of its domestic producers set out in paragraphs 1 to 6 for the periods in question. The competent authority of the Member State concerned shall notify the Commission in advance of any such authorization.

8. To the extent permitted by the Protocol, a producer may be authorized by the Commission, in agreement with the competent authority of the Member State in which its relevant production is situated, to exceed the calculated levels of its production allowed under paragraphs 1 to 7 for the purpose of industrial rationalization between Member States, provided that the combined calculated levels of production of the Member States concerned do

not exceed the sum of the calculated levels of production of their domestic producers set out in paragraphs 1 to 7 for the periods in question. The agreement of the competent authority of the Member States in which it is intended to reduce production shall also be required.

9. To the extent permitted by the Protocol, a producer may be authorized by the Commission, in agreement both with the competent authority of the Member State in which its relevant production is situated, and the government of the third Party concerned, to combine the calculated levels of its production allowed under paragraphs 1 to 8 with the calculated levels of production allowed to a producer in a third Party under the Protocol and its domestic legislation, provided that the combined calculated levels of production by the two producers do not exceed the sum of the calculated levels of production allowed under paragraphs 1 to 8 to the Community producer and the calculated levels of production allowed to the third Party producer under the Protocol and its domestic legislation.

Article 11

Control of consumption through control of supply in the Community

1. Subject to the provisions of paragraph 6, each producer shall ensure that:

- the calculated level of chlorofluorocarbons which it places on the market or uses for its own account in the period 1 July 1991 to 31 December 1992 does not exceed the calculated level of chlorofluorocarbons which it placed on the market or used for its own account in 1986,
- the calculated level of chlorofluorocarbons which it places on the market or uses for its own account in the period 1 January to 31 December 1993, and in the following 12-month period, does not exceed 50 % of the calculated level of chlorofluorocarbons which it placed on the market or used for its own account in 1986,
- the calculated level of chlorofluorocarbons which it places on the market or uses for its own account in the period 1 January to 31 December 1995 does not exceed 32.5 % of the calculated level of chlorofluorocarbons which it placed on the market or used for its own account in 1986,
- the calculated level of chlorofluorocarbons which it places on the market or uses for its own account in the period 1 January to 31 December 1996 does not exceed 15 % of the calculated level of chlorofluorocarbons which it placed on the market or used for its own account in 1986.

- the calculated level of chlorofluorocarbons which it places on the market or uses for its own account in the period 1 January to 30 June 1997 does not exceed 7,5 % of the calculated level of chlorofluorocarbons which it placed on the market or used for its own account in 1986.
- it does not place on the market or use for its own account chlorofluorocarbons after 30 June 1997.

The Commission, in accordance with the procedure set out in Article 12, shall determine any quantities of chlorofluorocarbons that could be placed on the market or used for its own account by each producer after 30 June 1997 and until 31 December 1999 at the latest for the purpose of essential uses.

2. Subject to the provisions of paragraph 6, each producer shall ensure that :

- the calculated level of other fully halogenated chlorofluorocarbons which it places on the market or uses for its own account in the period 1 January to 31 December 1992, and in each 12-month period thereafter, does not exceed 50 % of the calculated level of other fully halogenated chlorofluorocarbons which it placed on the market or used for its own account in 1989,
- the calculated level of other fully halogenated chlorofluorocarbons which it places on the market or uses for its own account in the period 1 January to 31 December 1995 does not exceed 32,5 % of the calculated level of other fully halogenated chlorofluorocarbons which it placed on the market or used for its own account in 1989,
- the calculated level of other fully halogenated chlorofluorocarbons which it places on the market or uses for its own account in the period 1 January to 31 December 1996 does not exceed 15 % of the calculated level of other fully halogenated chlorofluorocarbons which it placed on the market or used for its own account in 1989,
- the calculated level of other fully halogenated chlorofluorocarbons which it places on the market or uses for its own account in the period 1 January to 30 June 1997 does not exceed 7,5 % of the calculated level of other fully halogenated chlorofluorocarbons which it placed on the market or used for its own account in 1989,
- it does not place on the market or use for its own account other fully halogenated chlorofluorocarbons after 30 June 1997

The Commission, in accordance with the procedure set out in Article 12, shall determine any quantities of other

fully halogenated chlorofluorocarbons that could be placed on the market or used for its own account by each producer after 30 June 1997 and until 31 December 1999 at the latest for the purposes of essential uses.

3. Subject to the provisions of paragraph 6, each producer shall ensure that :

- the calculated level of halons which it places on the market or uses for its own account in the period 1 January to 31 December 1992, and in each 12-month period thereafter, does not exceed the calculated level of halons which it placed on the market or used for its own account in 1986,
- the calculated level of halons which it places on the market or uses for its own account in the period 1 January to 31 December 1995, and in each 12-month period thereafter, does not exceed 50 % of the calculated level of halons which it placed on the market or used for its own account in 1986,
- it does not place on the market or use for its own account halons after 31 December 1999

In the light of the decision of the Parties, the Commission, in accordance with the procedure set out in Article 12, shall determine any quantities of halons that could be placed on the market or used by each producer for his own account from 1 January 2000 for the purposes of essential uses.

4. Subject to the provisions of paragraph 6, each producer shall ensure that :

- the calculated level of carbon tetrachloride which it places on the market or uses for its own account in the period 1 January to 31 December 1992, and in each 12-month period thereafter, does not exceed 50 % of the calculated level of carbon tetrachloride which it placed on the market or used for its own account in 1989,
- the calculated level of carbon tetrachloride which it places on the market or uses for its own account in the period 1 January to 31 December 1995, and in each 12-month period thereafter, does not exceed 15 % of the calculated level of carbon tetrachloride which it placed on the market or used for its own account in 1989,
- it does not place on the market or use for its own account carbon tetrachloride after 31 December 1997

The Commission, in accordance with the procedure set out in Article 12, shall determine any quantities of carbon tetrachloride that could be placed on the market or used by each producer for his own account from 1 January 1998 and until 31 December 1999 at the latest for the purposes of essential uses.

5. Subject to the provisions of paragraph 6, each producer shall ensure that:

— the calculated level of 1,1,1-trichloroethane which it places on the market or uses for its own account in the period 1 January to 31 December 1992, and in each 12-month period thereafter, does not exceed the calculated level of 1,1,1-trichloroethane which it placed on the market or used for its own account in 1989;

— the calculated level of 1,1,1-trichloroethane which it places on the market or uses for its own account in the period 1 January to 31 December 1995, and in each 12-month period thereafter, does not exceed 70 % of the level of 1,1,1-trichloroethane which it placed on the market or used for its own account in 1989,

— the calculated level of 1,1,1 trichloroethane which it places on the market or uses for its own account in the period 1 January to 31 December 2000, and in each 12-month period thereafter, does not exceed 30 % of the calculated level of 1,1,1-trichloroethane which it placed on the market or used for its own account in 1989,

— it does not place on the market or use for its own account 1,1,1-trichloroethane after 31 December 2004.

6. The quantities referred to in paragraphs 1 to 5 apply to the amounts which the producer places on the market or uses for its own account within the Community from its own production.

7. The quantities resulting from the application of paragraphs 1 to 5 may be increased by the Commission, if the release into free circulation in the Community of imported substances in any 12-month period to which paragraphs 1 to 5 apply shall be less than the respective quantitative limits fixed in Annex II.

The Commission shall act in accordance with the procedure set out in Article 12.

8. Any producer having the right to place on the market or use for its own account the substances referred to in this Article may transfer its right in respect of all or any quantities fixed in accordance with this Article to any other producer within the Community. The producer acquiring the right shall immediately notify the Commis-

sion. A transfer of the right to place on the market or use does not imply an additional right to produce.

PART III

MANAGEMENT, DATA REPORTING AND FINAL PROVISIONS

Article 12

Management

1. The Commission shall be assisted by a committee composed of the representatives of the Member States and chaired by the representative of the Commission.

2. The representative of the Commission shall submit to the committee a draft of the measures to be taken. The committee shall deliver its opinion on the draft within a time limit which the chairman may lay down according to the urgency of the matter. The opinion shall be delivered by the majority laid down in Article 148 (2) of the Treaty in the case of decisions which the Council is required to adopt on a proposal from the Commission. The votes of the representatives of the Member States within the committee shall be weighted in the manner set out in that Article. The chairman shall not vote.

3. The Commission shall adopt measures which shall apply immediately. However, if these measures are not in accordance with the opinion of the committee, they shall be communicated by the Commission to the Council forthwith. In that event, the Commission may defer application of the measures which it has decided for a period of not more than one month from the date of such communication.

4. The Council, acting by a qualified majority, may take a different decision within the limit referred to in the third paragraph.

Article 13

Data reporting

1. Each producer, importer and/or exporter of controlled or transitional substances shall communicate to the Commission, with a copy to the competent authority of the Member State concerned, not later than 31 March of any year, beginning in 1992, its:

- production,
- quantities recycled,
- quantities destroyed, in accordance with technologies approved by the Parties to the Protocol,
- stocks,

- release into free circulation in the Community of imported substances, separately from Parties and non-Parties,
- exports of produced quantities from the Community, separately to Parties and non-Parties,
- exports of recycled quantities from the Community, separately to Parties and non-Parties,
- produced quantities placed on the market or used for the producer's own account inside the Community,
- recycled quantities placed on the market or used for the undertaking's own account inside the Community,
- amounts produced for use as raw materials

of each of the controlled and transitional substances in respect of the previous period 1 January to 31 December, except for chlorofluorocarbons for which the first data reporting shall cover the period 1 July to 31 December 1991 to be followed by regular annual reporting periods starting on 1 January 1992

Notwithstanding this obligation, the communication referred to in this paragraph for chlorofluorocarbons and other fully halogenated chlorofluorocarbons for the period 1 January to 30 June 1997 shall be done not later than 30 September 1997.

2. Each producer, importer and/or exporter of other fully halogenated chlorofluorocarbons, carbon tetrachloride, 1,1,1 trichloroethane and/or transitional substances in 1989 shall communicate to the Commission with a copy to the competent authority of the Member State concerned, the data referred to in paragraph 1 in respect of that year not later than 30 June 1991.

3. The Commission shall take the appropriate measures to protect the confidentiality of the data submitted.

Article 14

Inspection

1. In carrying out the tasks assigned to it by this Regulation, the Commission may obtain all necessary information from the governments and competent authorities of the Member States and from undertakings.

2. When sending a request for information to an undertaking the Commission shall at the same time forward a copy of the request to the competent authority of the Member State in whose territory the seat of the undertaking is situated, together with a statement of why this information is required.

3. The competent authorities of the Member States shall undertake the investigations which the Commission considers to be necessary under this Regulation.

4. If agreed by the Commission and the competent authority of the Member State in whose territory the investigation is to be made, the officials of the Commission shall assist the officials of such authority in carrying out their duties.

5. The Commission shall take the appropriate measures to protect the confidentiality of information obtained pursuant to this Article.

Article 15

Infringements

Member States shall take appropriate legal or administrative action in case of infringement of the provisions of this Regulation.

Article 16

Entry into force and transitional provisions

This Regulation shall enter into force on the day following its publication in the *Official Journal of the European Communities*. On 1 July 1991 Regulation (EEC) No 3322/88 shall be repealed. However, the data reporting referred to in Article 11 of Regulation (EEC) No 3322/88 for the period 1 January to 30 June 1991 has to be done not later than 31 August 1991 for chlorofluorocarbons only.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at Brussels, 4 March 1991.

For the Council

The President

J. F. POOS

ANNEX I

Substances covered by the Regulation

Group	Substance	Ozone-depleting potential (*)
Group I	CFCl ₃ (CFC-11)	1,0
	CF ₂ Cl ₂ (CFC-12)	1,0
	C ₂ F ₂ Cl ₂ (CFC-113)	0,8
	C ₂ F ₃ Cl ₂ (CFC-114)	1,0
	C ₂ F ₄ Cl ₂ (CFC-115)	0,6
Group II	CF ₂ Cl ₂ (CFC-113)	1,0
	C ₂ F ₂ Cl ₂ (CFC-111)	1,0
	C ₂ F ₃ Cl ₂ (CFC-112)	1,0
	C ₂ F ₄ Cl ₂ (CFC-211)	1,0
	C ₂ F ₃ Cl ₃ (CFC-212)	1,0
	C ₂ F ₄ Cl ₃ (CFC-213)	1,0
	C ₂ F ₅ Cl ₂ (CFC-214)	1,0
	C ₂ F ₆ Cl ₂ (CFC-215)	1,0
	C ₂ F ₆ Cl ₃ (CFC-216)	1,0
	C ₂ F ₆ Cl ₄ (CFC-217)	1,0
Group III	CF ₂ BrCl (halon-1211)	3,0
	CF ₂ Br ₂ (halon-1301)	10,0
	C ₂ F ₃ Br ₂ (halon-2402)	6,0
Group IV	CCl ₄ (carbon tetrachloride)	1,1
Group V	C ₂ H ₂ Cl ₂ (?) (1,1,1-trichloroethane)	0,1
Group VI	CHFCI ₂ (HCFC-21)	
	CHF ₂ Cl (HCFC-22)	
	CH ₂ FCI (HCFC-31)	
	C ₂ HFCI ₂ (HCFC-121)	
	C ₂ H ₂ FCI ₂ (HCFC-122)	
	C ₂ H ₃ FCI ₂ (HCFC-123)	
	C ₂ H ₄ FCI ₂ (HCFC-124)	
	C ₂ H ₅ FCI ₂ (HCFC-131)	
	C ₂ H ₆ F ₂ Cl ₂ (HCFC-132)	
	C ₂ H ₇ F ₂ Cl ₂ (HCFC-133)	
	C ₂ H ₈ F ₂ Cl ₂ (HCFC-141)	
	C ₂ H ₉ F ₂ Cl ₂ (HCFC-142)	
	C ₂ H ₁₀ F ₂ Cl ₂ (HCFC-151)	
	C ₂ HFCI ₃ (HCFC-221)	
	C ₂ HF ₂ Cl ₂ (HCFC-222)	
	C ₂ HF ₃ Cl ₂ (HCFC-223)	
	C ₂ HF ₄ Cl ₂ (HCFC-224)	
	C ₂ H ₂ FCI ₃ (HCFC-225)	
	C ₂ H ₃ FCI ₃ (HCFC-226)	
	C ₂ H ₄ FCI ₃ (HCFC-231)	
	C ₂ H ₅ F ₂ Cl ₂ (HCFC-232)	
	C ₂ H ₆ F ₂ Cl ₂ (HCFC-233)	
	C ₂ H ₇ F ₂ Cl ₂ (HCFC-234)	
	C ₂ H ₈ F ₂ Cl ₂ (HCFC-235)	
	C ₂ H ₉ F ₂ Cl ₂ (HCFC-241)	
	C ₂ H ₁₀ F ₂ Cl ₂ (HCFC-242)	
	C ₂ H ₁₁ F ₂ Cl ₂ (HCFC-243)	
C ₂ H ₁₂ F ₂ Cl ₂ (HCFC-244)		
C ₂ H ₁₃ F ₂ Cl ₂ (HCFC-251)		
C ₂ H ₁₄ F ₂ Cl ₂ (HCFC-252)		
C ₂ H ₁₅ F ₂ Cl ₂ (HCFC-253)		
C ₂ H ₁₆ F ₂ Cl ₂ (HCFC-261)		
C ₂ H ₁₇ F ₂ Cl ₂ (HCFC-262)		
C ₂ H ₁₈ F ₂ Cl ₂ (HCFC-271)		

(*) These ozone depleting potentials are estimates based on existing knowledge and will be reviewed and revised periodically in the light of decisions taken by the Parties to the Protocol.

(?) This formula does not refer to 1,1,2-trichloroethane

ANNEX II

Quantitative limits on imports from third countries

(calculated levels expressed in tonnes)

Substance	Group I	Group II (% of 1989 imports) (¹)	Group III	Group IV (% of 1989 imports) (¹)	Group V (% of 1989 imports) (¹)
For 12 month periods from 1 January to 31 December:					
1991	2 322 (²)				
1992		50 %	200	50 %	100 %
1993	1 361	50 %	200	50 %	100 %
1994	1 161	50 %	200	50 %	100 %
1995	755	32,5 %	350	15 %	70 %
1996	348	15 %	350	15 %	70 %
1997	174 (³)	7,5 % (³)	350	15 %	70 %
1998			350	0 %	70 %
1999			350		70 %
2000			0		30 %
2001					30 %
2002					30 %
2003					30 %
2004					30 %
2005					0 %

(¹) These percentages will be replaced by absolute figures as soon as these figures are available. They will be published by the Commission in the Official Journal.

(²) For the period 1 July 1991 to 31 December 1992.

(³) For the period 1 January to 30 June 1997. Thereafter there will not be any imports of the substances concerned.

COUNCIL REGULATION (EEC) NO 594/91
of 4 March 1991
on substances which deplete the ozone layer

SUMMARY

1. Controlled substances shall be limited in their release to the atmosphere. Quotas have been set in this regulation, but may be modified by the Commission at a later stage.
2. Any release into free circulation of a controlled substance in the Community must be governed by an import licence. This licence shall be issued by the Commission and forwarded to the competent authority in the Member State concerned.
3. Importation from non-parties shall be prohibited by 1 January 1993 for chlorofluorocarbons or halons and by 1 January 1996 for other fully halogenated chlorofluorocarbons, carbon tetrachloride or 1,1,1 trichloroethane.
4. The importation by non-parties of products made using controlled substances shall also be limited.
5. Derogations may be available to non-parties if they are in full compliance with the provisions of the Montreal Protocol.

PRODUCTION CONTROL

6. Production of controlled substances shall be limited as per attached annexes.
7. The Commission shall determine any essential uses of CFCs which may be permitted in the Community after 1997 and up to 31 December 1999, and the volume of CFC which may be produced in each case.
8. Basic domestic needs may require some producers to be authorised to exceed the calculated limits of production. This may be done provided that the additional levels in the Member State concerned do not exceed those permitted by the protocol. The Commission must be notified in advance.
9. Industrial rationalisation may require some deviation by particular producers. This may also be allowed provided that the aggregate production in the Member State does not exceed the limit.
10. Third parties and Member States may combine allowances.

CONTROL OF CONSUMPTION

11. Consumption is subject to the same limits as production. The quantities referred to apply to the amounts which the producer places on the market or uses for its own account within the Community from its own production.
12. Any producer having the right to place controlled substances on the market or use them for its own account may transfer that right in respect of all or any quantities to any other producer in the Community. The producer acquiring this right must notify the Commission. This does not imply an

additional right to produce.

DATA REPORTING

13. Any producer must communicate to the Commission not later than 31 March in any given year its:

- production
- quantities recycled
- quantities destroyed
- stocks
- releases into free circulation
- exports from the Community
- quantities used within the Community
- amounts used as raw material

of the controlled substances for the previous year. In respect of materials whose limit applies to 30 June of any year, this information must be reported by September of that year.