minister each year. The minister regulates the production volumes of both CFCs and "Halons" (bromochlorofluorocarbons, which are similar to CFCs). For CFCs, the regulation started on July 1 this year, with the regulation year running July 1 to June 30. The minister's power is based on Articles 4, 5 and 8–15. The minister is also due to regulate Halon output, starting on January 1, 1992. The regulation will be based on calendar years. The minister is authorized to regulate Halon volumes by Articles 16, 17 and 19–21.

Users who plan to import CFCs are subject to the Foreign Exchange and Foreign Trade Control Law, also starting July 1. The import volume quota is set by the July 1–June 30 regulation year. Imports from non-protocol members are prohibited.

There is an agreement that annex documents will be compiled which will list the products containing CFCs within three years from the date the protocol took effect. Importing of the products on the list will be prohibited within one year after the documents take effect.

(3) CFC destruction technology

The protocol also stipulates that when a nation develops a technology to convert CFCs into harmless substances and wins approval from other protocol member countries, the "destroyed" (or converted) CFC volume will be deducted from the production volume.

This point is mentioned in the Japanese law, too. When a company destroys CFCs with the means regulated by Articles 11 and 19, it will be allowed to produce an equal volume following confirmation and approval from the MITI minister.

The destruction technology will hopefully crack (or decompose) CFCs already in the atmosphere, thus reducing the effect of these chemicals on the ozone layer. Japan is making technological efforts which were compiled by a committee at the Chemical Product Council and submitted to UNEP's Helsinki meeting.

(4) Emission control and rationalization of usage

Article 23 of the law allows the director general of the Environment Agency and MITI minister to set guidelines for CFC emission control and rationalizing consumption. Based on the provision, the two announced the guidelines on January 4 of this year.

The guidelines do not force primary users into rational use of CFCs. Instead, they give the primary users broad advice on how they could rationalize the use of CFCs. Japanese CFC users are being called on make strenuous efforts so that Japan can honor the convention and the protocol in anticipation of stringent regulations in the years to come.

(5) Government support

Article 24 of the law states that the government will strive for the development of alternative products and equipment effective in emission control and rational use. MITI developed various measures for these objectives for fiscal year 1989, as mentioned in Table 1.

Articles 25 and 26 encourage the observation of the ozone layer and other surveys and research projects. The efforts in this area include development of equipment that will be put in the *ADEOS* (advanced earth observing satellite) to observe the layer.

(6) Other efforts

MITI designated the month of July "CFCs Month" to promote rational use of CFCs. Publicity campaigns will be conducted to urge the private sector to cut CFC consumption and introduce alternative substances. Various industrial organizations have formed a joint group to promote rational CFC use.

Hisashi Shingai is an officer at the CFCs Policy Office of the Basic Industries Bureau of the Ministry of International Trade and Industry.

Seeking a Substitute

By Yasumasa Ogawa

Japan began to regulate chlorofluorocarbons (CFCs) from July 1 under a law to protect the ozone layer enacted in May 1988.

CFCs are widely used both in the home and in industry as coolants in refrigerators and automobile air-conditioners, as blowing agents for polyurethane and polystyrene, as cleaning agents for semiconductors and precision machine parts and as propellants in aerosols. Industrial users alone are said to total more than 30,000 companies.

CFC consumption had been growing at an annual rate of over 10%, which means the consumption volume has to be cut by 30% during 1989 because the rule stipulates that this year's use has to be held to the 1986 level. The regulations cover CFC-11, -12, -113, -114 and -115. The consumption of these CFCs as of 1986 is shown in Fig. 1, which indicates that efforts for cutting their use have to be made in various fields.

Following is an outline of efforts being made primarily by Du Pont-Mitsui Fluorochemicals Co. There are several products which are likely to replace CFCs relatively soon: Freon SMT and MCA for cleaning agents, HCFC (hydrochlorofluorocarbon)-22 and HCFC-22/152a/114 as refrigerants and HCFC-22 for blowing agent. Other products will require solutions to be sought together with users.

Refrigerants

Automobile air-conditioners

A few alternative substances are being developed to replace CFC-12 in car air-conditioners, as shown in Table 1.

The use of HFC (hydrofluorocarbon)-134a would be possible after development of leak-free rubber hoses, acceptable refrigerator oils and packing materials. Our company is making efforts for these developments.

The ternary blended refrigerant, HCFC-22/152a/124(114) was developed by Du Pont Co. for possible use as a replacement in cars. It can be used in existing air-conditioners without capacity deterioration.

Refrigerators

Candidate materials to replace CFCs already exist as shown in Table 1. Various companies are considering beginning evaluation programs.

Turbo-refrigerators

Du Pont replaced CFC-11 as a chilling refrigerant with HCFC-123 in the air-conditioner of its own buildings in 1988. No problems have been reported so far. The company continues to obtain technical data regarding this test use.

Blowing agents

Polyurethane

Rigid urethane foam is widely used as an insulation material in refrigerators and cool warehouses. Its consumption volumes also show an uptrend. Table 1 shows candidate alternative materials to CFC-11. A considerable volume of research data has been published so far indicating that producers are testing prototype products.

Tests are also being conducted to confirm the safety of HCFC-123 and -141b.

Photo: Du Pont Japan Ltd.

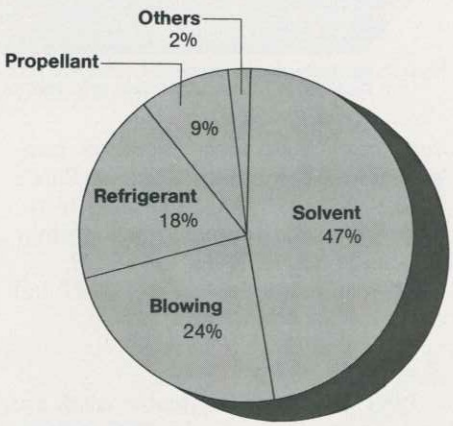
Du Pont engineers in search of materials to replace CFCs. The company has decided to totally replace CFCs with alternative materials by the end of this century.

Table 1 Potential Alternative Products to CFCs

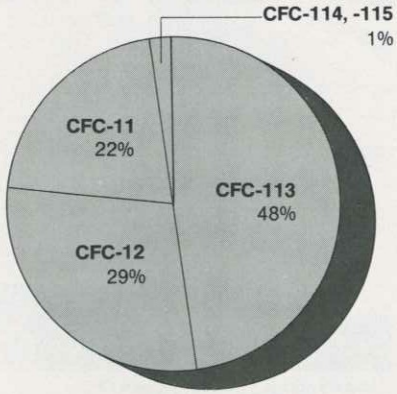
Areas	Use	CFC	Potential alternatives (HCFC or HFC)
Refrigerants	Car air-conditioners	12	134a, 22/152a/124(114)
	Refrigerators	12	134a, 22/152a/124(114), 502, 22, etc.
	Turbo-refrigerators	11, 114	123, 134a, etc.
Blowing agents	Urethane	11	123, 141b, etc.
	Polyethylene/ polystyrene	12, 11, 114	Formacel S, 142b, 123, 141b, etc.
Solvents	Cleaning	113	KCD-9434, KCD-9438 Freon SMT, MCA
Aerosol	Propellants	12, 11	Dymel 22, 152, 142, etc.

Notes: 1. HCFC-124 is not yet used because of pending toxicity registration. Instead CFC-114 is blended for the present time.
2. KCD-9434 is a mixture of 141b, 123, methanol and stabilizer.
3. KCD-9438 is semiaqueous.
4. Formacel, Freon and Dymel are registered brand names of Du Pont Co.

Fig. 1 The Consumption of CFCs in Japan as of 1986



The Consumption by CFC Types as of 1986



Source: Industry reports

Testing of their chronic toxicity will take an estimated four to five years to complete. As a result, the possibility is being considered of mixing CFC-11 with another ingredient (thus reducing the CFC volume) or diluting CFC-11 with water.

Polystyrene and polyethylene

HCFC-22 was developed to replace CFC-12, -11 and -114 as a blowing agent in thermoplastic resins. Du Pont Co. has already won approval from the U.S. Food and Drug Administration for the use of its product for plastic food trays. Many U.S. companies are using the Du Pont blowing agent.

Various other candidate products including HCFC-142b, -123 and -141b have appeared, as shown in Table 1. Producers are conducting tests to seek optimal conditions for extrusion (a process to make the end-use products).

In this category, CFC-12 may be replaced by liquefied petroleum gas (LPG), even though it is flammable. For safety reasons, HCFC or HFC seem better alternative products.

Cleaning agents

As Fig. 1 shows, CFC in Japan is consumed mostly for a cleaning agent.

Table 2 shows that producers and users will take a gradual step-by-step approach. Initially, recovery of CFCs and saving consumption are most important measures. Next, new products, like Du Pont's Freon SMT, MCA are expected to replace CFC-113. Eventually, the users may be able to use KCD-9343 or -9438.

Physical properties of Freon SMT and MCA are shown in Table 3.

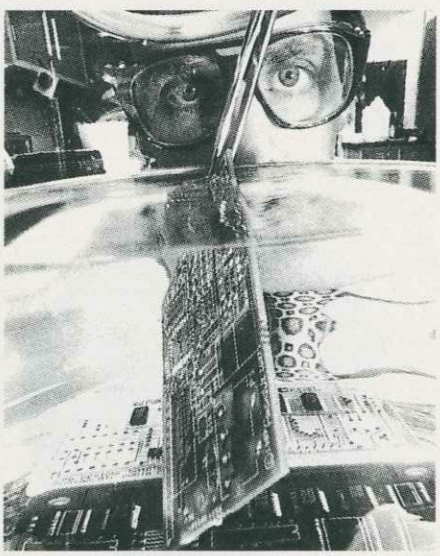


Photo: Du Pont Japan Ltd.

Cleaning agents that are to replace CFCs in examination processes

Table 2 Ways to Cope with CFC-113 Regulations in Cleaning Area

Recovery and saving	• Design of cleaning equipment • Cleaning operation • Distillation and regeneration • Recovery by adsorption and regeneration
Switching to existing blended cleaning agents	• Example: Freon TF to Freon TE(S), TMS, TMC, etc.
Development and use of new blended cleaning agents	• Examples: Freon SMT, Freon MCA
Development of alternative products	• HCFC, HFC (e.g., KCD-9434) • Organic solvents (e.g., KCD-9438)

Note: Freon is a registered brand name of Du Pont Co.

Table 3 Physical Properties of Du Pont's Products

	KCD-9434	Freon SMT	Freon MCA
Ozone destruction factor (CFC-11=1.0)	0.07	0.55	0.50
Boiling point (degrees Celsius)	30.0	38.4	44.2
Liquid density (g/ml at 25°C)	1.28	1.384	1.420
Vapor pressure (kg/cm^2 at 25°C)	0.893	0.682	0.609
Surface tension (dynes/cm at 25°C)	19	20.6	20.8
Latent heat (calories/gram)	51.4	55.9	42.5
Liquid specific heat (cal/g. °C at 25°C)	0.242	0.256	0.241
Viscosity (centipoise at 25°C)	0.42	0.52	0.48
Combustion	No	No	No
Permissible concentration (ppm)	105 (AEL)	300	307

Notes: 1. AEL (allowable exposure level) is the level set by Du Pont Co., not the officially allowed level.
2. Freon is a registered brand name of Du Pont Co.

Aerosols

LPG and other flammable gases are expected to be used as a CFC replacement in increasing quantity as in Europe and the U.S., and the regulations on high-pressure gas have already been amended. From the safety viewpoint, though, Du Pont's Dymel-22, -142 and -152, rather than gases, may be used.

Yasumasa Ogawa is group manager of the Alternatives Market Development Division at Du Pont-Mitsui Fluorochemicals Co.