Designing a Program to Recover CFCs

From Domestic Appliances

Environmental Protection Branch

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Catalogue No. En 40-521/1996E
ISBN 0-662-24935-6

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NOTE: In this manual, the provinces are listed in geographical order, from east to west.

Purpose of the Manual

This manual is designed mainly for municipalities responsible for disposal of discarded home appliances that contain chlorofluorocarbons (CFCs) or any other ozone-depleting substances (ODS). Over the last few years, several Canadian provinces have developed regulations requiring the recovery of CFCs from home appliances before these are discarded. The present manual has been developed to help municipalities set up programs for the recovery of CFCs from home appliances. In addition, the manual could be of interest to organizations and institutions that intend to perform the task of recovering CFCs from appliances internally.

The first part of the manual includes general information on CFCs, their impact on the ozone layer and how to reduce CFC emissions, as well as information on the regulations to which they are subject.

The second part deals with the various steps in developing and implementing a program to recover CFCs from home appliances.

The third part lists the various resource persons who may be contacted during the implementation of the program. These resource persons include government representatives, manufacturers, recyclers, and municipal officials in charge of existing programs.

Finally, the fourth part summarizes the planning for your municipality.

1 The CFC Problem

What are CFCs?

Chlorofluorocarbons (CFCs) are synthetic gases discovered in 1892 that contain chlorine, fluorine and carbon. At that time they were considered ideal industrial chemicals. CFCs are non-toxic, do not accumulate at ground level, are long-lasting, and absorb heat very well.

In 1928, CFC-12, better known as Freon (trademark of E.I. Dupont de Nemours & Company), gained preference as a refrigerant gas over sulphur dioxide and ammonia, which were too toxic and flammable. Later, CFCs with different properties were perfected for use in a wide range of appliances. CFCs are mainly used as refrigerants in refrigerators, freezers and air conditioners, as solvents in stain removers and cleaning products, as diluents in sterilizing gas mixtures and as blowing agents for the production of foams.

What is the effect of CFCs on the ozone layer?

Ozone is a colourless gas made up of three oxygen atoms (O_3). Most ozone is found in the stratosphere, at an altitude of 15 to 40 km above sea level, and constitutes the ozone layer. This layer absorbs ultraviolet radiation (UV) from the sun and protects us against the harmful effects of overexposure. In recent years, scientists have noted a significant thinning of the ozone layer. Since then, it has been proven beyond doubt that emissions of CFCs at the Earth's surface are the main cause of stratospheric ozone depletion.

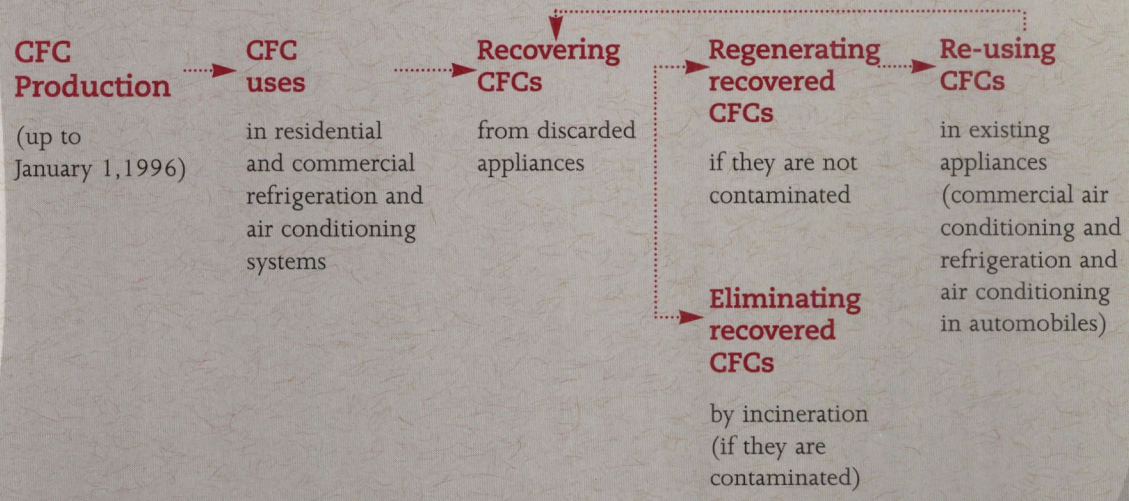
The ozone destruction process is a fairly complex phenomenon. First of all, CFCs released at ground level rise until they reach the stratosphere. There, because of their high stability, they are bombarded by the sun's ultraviolet rays and lose an atom of chlorine. The free chlorine atom then attacks an ozone molecule and thereby sets off a chain reaction. Each chlorine atom can destroy up to 100 000 ozone molecules.

For further information regarding CFCs and their effect on the ozone layer, consult the following documents:

- ENVIRONMENT CANADA. *A Primer on Ozone Depletion*, Ottawa, 1993, 76 p.
- ENVIRONMENT CANADA. *Canada's Ozone Layer Protection Program*, Ottawa, 1994, 22 p.
- ENVIRONMENT CANADA. *The State of Canada's Environment*, Ottawa, 1991, paginated by chapter.

What is the life cycle of CFCs?

Figure 1 *Life Cycle of CFCs in Home Appliances*



How can CFC emissions be reduced?

Since CFCs were identified as the principal agents responsible for the depletion of the ozone layer, a number of measures have been undertaken to phase out their use and reduce their release into the atmosphere.

One of the first steps was to restrict the use of CFCs to those applications for which no alternative products were available. At the same time, replacement products less damaging to the ozone layer were developed, such as HCFCs, which are a temporary replacement product. While they are in many ways similar to CFCs, they contain more hydrogen. The carbon and hydrogen form less stable links than carbon and halogens (chlorine, bromine, etc.). HCFCs are largely broken up by sunlight and chemical processes before reaching the stratosphere. Nevertheless, as HCFCs contain a chlorine atom, they represent a threat to the ozone layer but are less of a danger than CFCs.

In 1987, Canada was instrumental in the signing of the *Montreal Protocol* which had the objective of progressively limiting the production and consumption of ozone-depleting substances, including CFCs. After subsequent meetings with signatories, the *Montreal Protocol* was amended a number of times in order to accelerate the schedule for phasing out CFCs. Canada, for its part, banned the production, import and export of CFCs after January 1, 1996. Efforts must now be focused on recovery of CFCs from discarded appliances, and reclaiming and re-using them in existing appliances that still use CFCs to extend their life. When their life cycle is over, CFCs must be eliminated in an appropriate manner. Generally, they are destroyed through incineration.

As a consumer, anyone can help to reduce the quantity of CFCs in circulation. Any person with an appliance containing CFCs should make sure the CFCs are removed from the appliance before disposing of it. Prior to buying a new appliance, we recommend that the consumer check to see if a CFC alternative model is readily available in their region, or their market.

Do regulations exist for recovering CFCs from home appliances in Canada?

In light of the danger CFCs pose to the ozone layer and in order to respect certain commitments made by Canada through the *Montreal Protocol*, most provinces and territories have adopted regulations governing the use of ozone-depleting substances, including CFCs.

Table 1 lists the provinces and territories that have regulations on the recovery of CFCs from home appliances as well as the dates the regulations came into effect.

As these regulations generally ban the disposal of air conditioners, refrigerators or any other item containing ozone-depleting substances, you should first ensure that the ozone depleting substance (ODS) has been previously removed for recycling, conversion, or destruction[1].

[1] GOVERNMENT OF MANITOBA. *The Ozone Depleting Substances Regulation*, Queen's Printer for the Province of Manitoba, 1994, D-103-94.

Table 1 *Regulations on the Recovery of CFCs from Home Appliances in Canada*

Provinces	Regulation	Effective date
Newfoundland	Draft legislation	-
Prince Edward Island	Yes	November 1, 1994
Nova Scotia	Yes	April 11, 1995
New Brunswick	Yes	October 31, 1992
Québec	Only applies to equipment with a cooling capacity of over 2 tonnes and not to home appliances.	
Ontario	Yes	April 16, 1994
Manitoba	Yes	May 27, 1994
Saskatchewan	Yes	July 20, 1993
Alberta	Yes	September 1, 1993
British Columbia	Yes	July 1, 1993
Northwest Territories	Draft legislation	-
Yukon Territory	Draft legislation	-

As of spring, 1996

2 Planning Your CFC Recovery Program

The following Part presents the various steps that are required to develop and implement a CFC recovery program for home appliances:

Step 1:

Begin your planning by estimating the quantity of CFCs and metals you will be recovering annually in your municipality or region.

Steps 2 and 3:

Become familiar with the CFC recovery market and scrap metal market and the various technologies for CFC recovery; this information will be useful when the time comes to negotiate with CFC recyclers.

Step 4:

Before approaching contractors with invitations to tender, you will first have to choose the type of CFC recovery program that best suits your needs.

Step 5:

Decide if you plan to use your own building or a contractor's premises for your transfer centre. In the former case, you will have to plan the physical organization of the recovery operation carried out in your transfer centre.

Step 6:

Prepare the invitation to tender for CFC and metal recovery.

Step 7:

When you have selected your CFC and scrap metal recovery contractor(s), estimate the total costs and revenues of the CFC recovery program and choose the appropriate method of financing.

Step 8:

Complete the evaluation by a cost-benefit analysis that studies the benefits and costs of the program for the community.

Step 9:

Develop a promotional campaign that will present the main features of the new CFC recovery program to members of your community.

Step 1 Estimating the quantity of CFCs and metals to be recovered

Estimate the number of appliances disposed of annually

Before establishing a program to recover CFCs from home appliances, it is necessary to know how many appliances are discarded by residents each year. The number of appliances containing CFCs discarded annually varies between 3 and 11 appliances per 1000 residents[1]. This figure may vary according to the size of the municipality, the residents' level of income, the method of collecting appliances, etc. A ratio of 6 appliances per 1000 residents has been used as the basis for calculation for the purpose of these examples only and the municipality should endeavour to use information as accurate as possible for their region.

Example of a municipality with 100 000 residents:

100 000 residents

X

$\frac{\text{6 home appliances/year}}{\text{1000 residents}}$

=

600 home appliances containing CFCs discarded/year

A municipality with a population of 100 000 can therefore expect to collect 600 home appliances containing CFCs per year.

Estimate the quantity of CFCs and metals to be recovered

After calculating the number of home appliances discarded each year, you have to calculate the quantities of CFCs and scrap metal generated by the appliances. The various home appliances containing CFCs are refrigerators, freezers, air conditioners, de-humidifiers, heat pumps, etc. This equipment contains two kinds of CFCs. The first type, usually CFC-12 or HCFC-22, is contained in refrigeration systems and the second type, CFC-11, is contained in foam insulation used in the walls of appliances such as refrigerators. In Canada, only CFCs contained in refrigeration systems are currently recovered.

[1] APPLIED STRATEGIES, THE CORPORATION OF THE CITY OF OSHAWA, KPMG MANAGEMENT CONSULTING. *A Pilot Project for the Province to Review the Implementation of Provincial Regulations to Prevent the Release of Fluorocarbon Refrigerants, Identify Business Development and Job Creation Opportunities*, Oshawa, 1994, 45 p. and appendices.

Table 2 shows the distribution of home appliances by the type of appliance. Refrigerators make up an average of 70% of home appliances containing CFCs. The quantity of CFCs contained in each appliance varies from 0.2 kg for refrigerators to 0.5 kg for air conditioners. On average, there is 0.25 kg of CFCs in every appliance. Metal (steel, aluminum, copper) represents approximately 73% of the average weight of the appliance recovered, or 65 kg on average for all domestic appliances containing CFCs. Let's take the example of a municipality with 100 000 residents:

Example for a municipality with 100 000 residents:

600 home appliances/year

X

0.25 kg of CFCs/appliance

=

150 kg of CFCs recovered/year

600 home appliances/year

X

65 kg of metal/appliance

=

39 000 kg of metal recovered/year

Table 2 *Estimating Amounts of CFCs and Metal to be Recovered*

Type of home appliance containing CFCs	Breakdown by appliance	CFCs per appliance	Weight per appliance	Metal per appliance	Example (Municipality with 100 000 residents)			
					Number of appliances	Amount of CFCs	Total weight of appliances	Amount of metal
	(%)	(kg)	(kg)	(kg)		(kg)	(kg)	(kg)
Refrigerators	70	0.2	100	—	420	84	42 000	—
Freezers	20	0.3	80	—	120	36	9 600	—
Air conditioners	5	0.5	45	—	30	15	1350	—
De-humidifiers	4.5	0.4	22	—	27	11	590	—
Others (Heat pumps, etc.)	0.5	—	20	—	3	—	60	—
Total for all appliances	100	≃ 0.25	89	65[1]	600	≃ 150	53 600	39 000

[1] Equivalent to approximately 73% of the average weight of recovered appliances.

Step 2 Becoming familiar with the market for recovered CFCs and scrap metal

In most cases, the contractor in charge of recovering CFCs also takes care of reselling the CFCs and scrap metal. It is nevertheless a good idea to know the value of these products on the market so that you can take this into consideration when negotiating the costs of recovering CFCs.

Market for CFCs

The ban on the production and importation of CFCs in Canada as of January 1, 1996 does not require the immediate ban on CFC use. Certainly, a large proportion of the new appliances manufactured since 1996 use refrigerants other than CFCs. A certain number of existing appliances, on the other hand, continue to require CFCs when they are repaired. Such equipment, which is basically used for commercial refrigeration, climate-control systems, and motor vehicle air-conditioning units, uses reclaimed CFCs recovered from used appliances. There will be a market for recovered CFCs in Canada for as long as the existing systems using CFCs continue to operate, which could be for about ten or fifteen more years.

During the first few years following the ban on CFC production, it is possible that the price of reclaimed CFCs may be quite high, because of the large number of appliances still using CFCs. In 1995, the price of CFCs doubled, increasing to $31/kg from $15/kg, as the market anticipated the end of production in 1996.

Currently, for each kilogram of CFCs recovered and sent for reclaiming, a $1 to $3 credit is obtained on the purchase of reclaimed CFCs; that is, about $.25 to $.75 per appliance ($1 to $3/kg of CFC x 0.25 kg CFCs/appliance). As the market for reclaimed CFCs develops, it is possible that this credit will vary. This rebate is not given to municipalities but to the contractors responsible for CFC recovery.

Scrap metal market

In the secondary materials recovery and recycling industry, the value of ferrous metals (in the form of sheet metal) delivered to the recycler in the autumn of 1995, was about $90/tonne, a steep increase over 1993 when the price was $45/tonne. The price of aluminum and copper, present in small quantities in home appliances (about 4% of the metal) was much higher (approximately $1600/tonne for aluminum). During recovery of metal from home appliances containing CFCs, however, the price offered by reclaimers is established for a tonne of domestic appliances and not per tonne of metal. As the appliances contain, on average, about 73% metal, the price paid per tonne of appliance is approximately $65 (about $90/tonne of metal x 73%). Readers should contact local dealers to obtain current market values in their area.

Example for a municipality with 100 000 residents:

600 appliances/year

X

89 kg/appliance

=

53 400 kg (53.4 tonnes)

53.4 tonnes

X

$65/tonne

=

$3471 (price for the recovered metal)

$3471/600 home appliances

=

$5.79/appliance (price for the recovered metal)

Therefore, we can calculate, on average, $6/appliance for recovered metal. However, the conditions concerning the market for metals may vary appreciably depending on the region. In 1995, some municipalities obtained close to $9 per appliance from metals recovered.

Step 3 Becoming familiar with the various CFC recovery technologies

Generally, CFC recovery is entrusted to a contractor who specializes in refrigeration. CFC recovery must be carried out according to specifications and guidelines contained in the *Environnemental Code of Practice for Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems*[1]. However, it is possible to train municipal employees for this work by having them obtain provincial accreditation. Recovery of CFCs from home appliances can be effected according to two different techniques, either recovery under vacuum or recovery by adsorption.

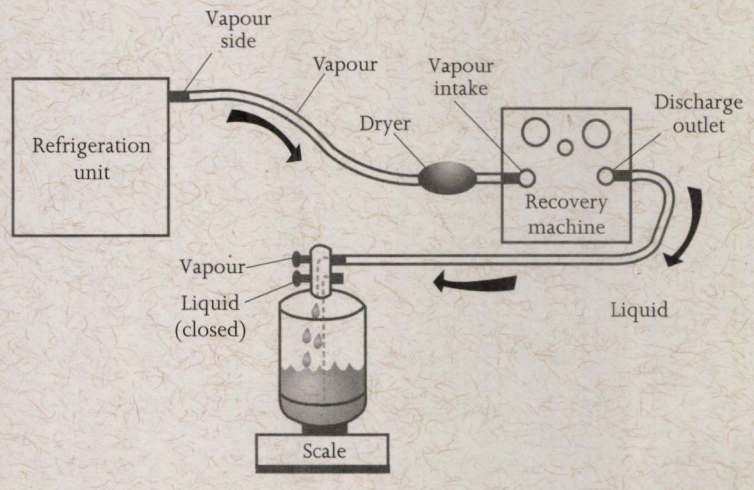
[1] Environment Canada. 1996. *Environmental code of practice for elimination of fluorocarbon emissions from refrigeration and air conditioning systems*. Report ; EPS 1/RA/2E. ISBN 0-660-16448-5.

Recovery under vacuum

Recovery under vacuum is carried out with a portable device (recovery machine) mainly consisting of a compressor, a condenser and a dryer to remove water vapour.

Procedure: The operator connects the recovery unit to the appliance (example: a refrigerator) with the help of a clip. The clip punches a small hole in the tubing and the CFC is pumped out into a closed system where it is converted to a liquid and piped to a secondary unit which separates it from contaminants. The CFC can then be reused (see Figure 2).

Figure 2 *Diagram of CFC Recovery Under Vacuum*



There is a second kind of recovery machine/system which is equipped with a filter that can extract the acid from the refrigerant. The equipment is used when discarded appliances are repaired (usually commercial refrigeration or ventilation systems). CFCs extracted from appliances are purified so that they can be reused in the appliance after it is repaired. This equipment, however, has no additional advantage if CFCs recovered from appliances are to be disposed of.

Recovery by adsorption

This consists of a cylinder containing halozite, a synthetic product capable of absorbing CFCs. Adsorption consists of keeping gas molecules (CFCs) on the surface of a solid (halozite).

Procedure: The cylinder is attached to the appliance by a hose so the refrigerant can be removed. The CFCs, which are gases, are drawn by the difference of pressure levels into a non-pressurized cylinder. The CFCs are then adsorbed by the halozite and captured within the cylinder. When the cylinder is full, it is returned to the manufacturer so that the CFCs can be extracted and reclaimed for use elsewhere (see Figure 3).

At present, in Canada, only the CFC-12 contained in refrigeration systems is recovered. However, in Europe, there are already facilities that recover CFC-11 contained in foam insulation. These facilities, however, are costly (about $2 to $4 million) and handle the recovery of CFC-12 refrigerants, the shredding of appliances, the separation of ferrous and non-ferrous metals and plastics and the recovery of CFCs contained in foam insulation (CFC-11).

Table 3 presents a comparison of the two types of recovery according to different criteria. For more information, technical fact sheets are available from Environment Canada (see Part 3).

Figure 3 ***Diagram of CFC Recovery by Adsorption***

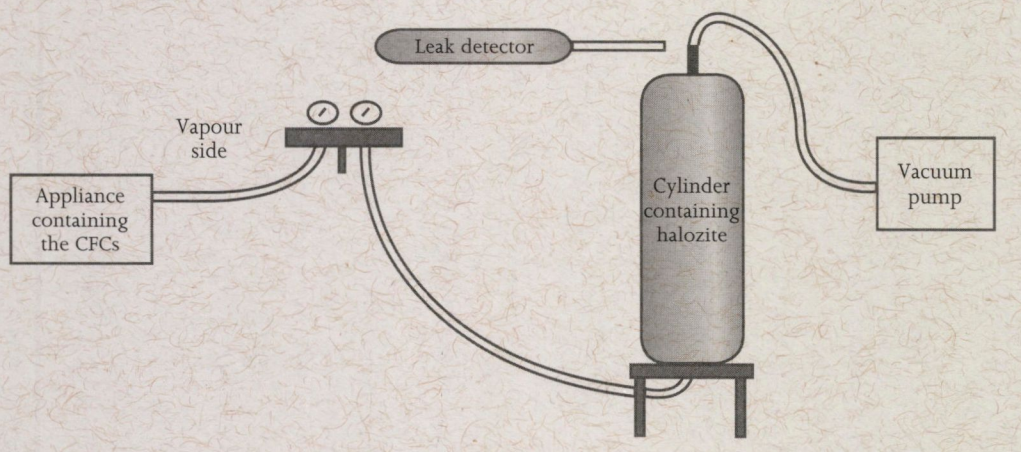


Table 3 *Comparative Analysis of CFC Recovery Techniques*

Determinant Criteria		Recovery Under Vacuum	Recovery by Adsorption
Weight		12 kg - 50 kg[1]	32 kg[2]
Types of refrigerants processed		R-12, R-22, R-500, R-502	all
Cylinder capacity (kg of CFCs)		5 kg - 45 kg	4.5 kg
Appliances treated per hour		6 - 12 temperature should be above 0°C	4 - 5 temperature not important
Effectiveness of Recovery		80 - 90%	90 - 95%
COST	Initial investment costs ■ equipment ■ auxiliary equipment[3] ■ maintenance	 $1500 - $8000 $500 - $2000 change the filters ($13 each)	 nil $1500 —
COST	Deposit per cylinder	$120 - $200[4]	$250[2]
COST	Transportation costs	low	high
COST	Desorption costs	not applicable	$108[2]
Cost of recovery of CFCs ($/refrigerator)		$4 - $10/refrigerator	not available
Transporting the cylinder		In accordance with regulations since contents are under pressure	Not a constraint because the contents are not pressurized.
Temperature of recovery site must be used in a temperate environment (above 4°C)			Can be used in all temperatures, even extreme ones.
Non determinant criteria (Desirable)			
Certification		ARI[5], UL	ARI[5]
Availability in Canada		yes	yes
Credit for recovered CFCs		yes	yes
Summary of advantages and disadvantages		Recovery under vacuum requires a higher initial investment cost ($1500 - $8000 vs $500), while recovery by adsorption has high desorption and transportation costs. Recovery by adsorption can be useful in municipalities that have low volumes of CFCs to recover or that recover CFCs in very cold climates (below 0°C).	

[1] Weight of recovery unit.

[2] For a cylinder with a 4.5 kg capacity.

[3] Auxiliary equipment, including a vacuum pump, hoses, gauges, weigh scale, hand tools, pressurized air or CO_2, leak detectors or monitor equipped with an alarm, a stand to raise and support the cylinder and a gauge.

[4] For a cylinder with a 45 kg capacity.

[5] Air Conditioning and Refrigeration Institute (ARI). Consult specification ARI 740-95 concerning the effectiveness of refrigerant recovery.

Step 4 Choosing the right type of CFC recovery program for your needs

The crucial step when establishing a recovery program is choosing the type of program structure. When you examine the different CFC recovery programs already set up in certain municipalities within Canada, you notice, with a few possible variations, three main categories of programs.

Table 4 gives a description of the three types of programs, followed by a comparative summary. Various criteria regarding costs, program administration, collection of appliances, and CFC recovery are summarized for each of the different programs. In this way, a municipality can easily determine which program suits it best according to its characteristics (size, density, budget, availability of staff and buildings, etc.).

There are different possible variations for the programs described below.

In Program 1, the municipality can charge a minimum amount for transporting the appliance to the transfer centre. In Program 2, appliances can be collected bi-annually (spring-autumn), once a month, or on request. In the case of Programs 2 and 3, appliances can be collected by municipal employees or by a private contractor, at the expense of the municipality or the residents. In any of the programs, the transfer centre can belong to the municipality or be owned by a private contractor. Likewise, CFC recovery can be carried out by municipal employees or a private contractor.

Table 8 in Part 3 contains a non-exhaustive list of various programs which exist throughout Canada. A number of these programs are described in a technical fact sheet available from Environment Canada (see Part 3).

Table 4 *Comparison of Types of CFC Recovery Programs*

	PROGRAM 1 Bringing in appliances and recovering CFCs at the transfer centre	PROGRAM 2 Curbside collection of appliances and CFC recovery at the transfer centre	PROGRAM 3 CFC recovery at curbside or in the home
	■ Residents bring their appliances to the transfer centre themselves. ■ At the transfer centre, the CFCs are recovered from the appliances. ■ The contractor attaches a sticker certifying that the appliance no longer contains CFCs. ■ Once an appliance is emptied of refrigerant, it is sent for metal recovering.	■ The residents leave their appliances on the curbside. ■ A contractor picks up the appliances and carefully takes them to the transfer centre. ■ At the transfer centre, the CFCs are recovered from the appliances. ■ The contractor attaches a sticker certifying that the equipment no longer contains CFCs. ■ Once the equipment is emptied of refrigerant, it is sent for metal recovery.	■ The resident calls the municipality to make an appointment. ■ The resident then puts the appliance at the curbside or leaves it inside the house. ■ A contractor comes to the house and recovers the CFCs. ■ The contractor attaches a sticker certifying that the appliance no longer contains CFCs. ■ The appliance is then taken to the transfer centre and sent for metal recovery.
Costs:			
■ Cost of CFC recovery	$4 - $10	$4 - $10	$22 - $25
■ Cost of transporting the refrigerants	NIL	HIGH (the refrigerator must be moved with care)	MODERATE (since the CFCs have already been recovered, the equipment can be transported without major precautions)
■ Total cost of program	LOW	MODERATE	HIGH
Program administration:			
■ Logistics of accepting calls from residents wanting to make an appointment	NIL	NIL OR HIGH (high if the resident has to call the city to arrange to have the refrigerator picked up)	HIGH
■ Possibility that home appliances left on curbside will be vandalized	NIL	LOW TO MODERATE[1]	LOW TO MODERATE
■ Possibility of illegal discharges in vacant lots	LOW TO MODERATE	NIL[2]	NIL[2]
■ Rate of resident participation in program	LOW	MODERATE	MODERATE
Collecting appliances and CFC recovery:			
■ Risk of CFCs accidently leaking during transport	MODERATE (by the resident)	LOW TO MODERATE (by the resident)	NIL TO LOW (CFC recovery done at the curbside or in the home)
■ Time required for CFC recovery	FAST	FAST	NOT FAST
■ Storage space for appliances	HIGH	HIGH	LOW TO MODERATE
■ Layout of the transfer centre	Must accommodate the CFC recovery process and storage space for appliance.	Must accommodate the CFC recovery process and storage space for appliance.	Must be large enough to store appliances (less space required).
Summary of advantages and disadvantages by municipality	Inexpensive, appropriate for small municipalities.	Appropriate for all municipalities.	Expensive, but could be appropriate for densely populated municipalities.

[1] In big cities, risk of vandalism is considered to be moderate to high.
[2] Assumes that appliance collection and CFC recovery costs are not charged to residents.

Step 5 Planning the physical organization of the recovery operation (Example: the recovery of CFCs is done in a transfer centre belonging to you)

If you have chosen to recover CFCs in a building belonging to you, which will serve as a "transfer centre", you must ensure that the design of this building meets certain standards and is suitable for this type of operation.

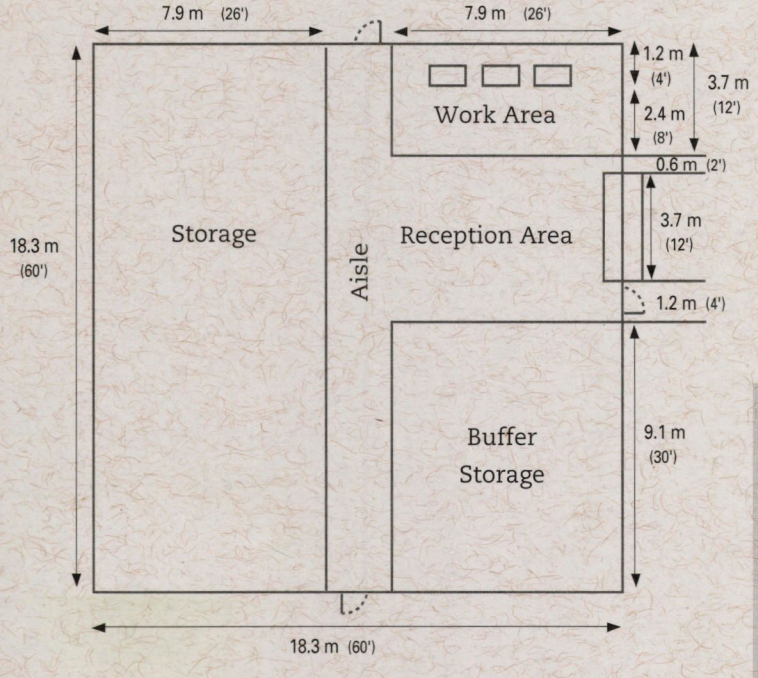
Space requirements

The estimate is based on a transfer centre being capable of accommodating 100 refrigerators (a number that enables the recycler to operate economically).

- Work area ..... 30 m^2
- Traffic and reception area ..... 90 m^2
- Storage ..... 240 m^2

360 m^2

Figure 4 ***Typical Layout Plan***



Note : Not to scale.

Figure 4 shows a typical layout. This layout requires that storage be in the upright position. Some recyclers prefer to work on refrigerators that are lying flat; if this is the case, extra room will be needed to handle the refrigerators.

Building systems

It is beyond the scope of this manual to consider all the situations that arise from the application of codes and standards. In any case, it is necessary to consult a professional (usually an architect). The municipal insurer must also be contacted.

It is important to check with health and safety officials regarding special measures to take (informing personnel about CFCs, handling of appliances, etc.).

It is also necessary to check with local authorities to find out if it is necessary to present plans and quotations which might include the following information:

- building use;
- ventilation systems;
- maximum number of appliances to be stored;
- the type of refrigerant (example: R-12);
- the existence of an automatic sprinkler system;
- fire alarm system;
- burglar alarm system.

The appliances sometimes harbour insects or vermin, or they may be mouldy. Some municipalities have opted for systematic fumigation, whereas others do not use any treatment. You must think about this in light of the particular situation at each transfer centre, particularly its proximity to housing and the source of appliances.

Mechanical/electrical systems

The following systems should be considered:

- mechanical ventilation, heated in winter, with a rate of 2.54 L/s/m^2;
- sufficient heating to maintain a temperature of at least 17°C (this temperature is required to ensure employee comfort and to maximize the yield of the CFC recovery process). Refrigerators do not need to be stored at any particular temperature. Using direct-fired heating systems (e.g., natural gas unit heater) is not recommended because of constraints imposed by certain codes (exhaust hoods, additional ventilation, etc.);
- garden hose to clean the floor and, when necessary, the refrigerator. Floor drain to drain off water (be careful not to let mineral oil go down this drain);
- automatic sprinkler system when required by local codes;
- portable fire extinguishers that meet local safety regulations;
- 300-lux lighting;
- fire alarm system when required by codes;
- intrusion alarm system: this element is important, given the value of scrap metal on the recycling market;
- 120-volt electrical power supply on a separate circuit (two double plugs minimum) for the use of the recycler.

Architecture

When equipping the transfer centre:

- provide for a sufficiently wide garage door to accommodate loading and unloading equipment;
- designate a space that is separate from other areas of the building;
- consult an architect to determine specific requirements, such as fire exits;
- provide for signs that indicate the storage of appliances containing CFCs;
- sanitary facilities may be required in the vicinity.

Step 6 Preparing the invitation to tender documents for the recovery of CFCs and metals

Once you have become familiar with the principal elements of recovering CFCs from home appliances, you are ready to draw up invitation to tender documents. Table 5 shows the basic elements to consider when drafting these documents.

We emphasize how important it is for municipalities to require the CFC recycler to specify the number of appliances and the quantity of CFCs being recovered, to allow for the proper monitoring of CFC recovery operations by the municipality.

Table 5 *Basic Considerations When Drawing Up the Invitation to Tender*

Information provided by the municipality	Information the contractor should include in the proposal
■ Anticipated number of appliances obtained from the municipality ■ Contractor must pay to eliminate recovered CFCs as required by law ■ Contractor must report to the municipality the number of appliances processed and the amount of CFC recovered ■ General description of the recovery program, including: - who is responsible for pick up; - location of transfer centre; - description of transfer centre; - who handles the appliances at the transfer centre; - who is in charge of the appliances after the CFC recovery stage. ■ Guaranteed minimum number of appliances per year ■ What certifications are required for recovering equipment ■ Hours during which the contractor has access to the transfer centre ■ Contractor's maximum response time after being told that the minimum number of appliances has been reached ■ Cost of liability insurance	■ Price for guaranteed minimum quantity, all taxes and charges included ■ Unit price for each appliance exceeding this specified number ■ Type of recovery technology used, and a technical fact sheet giving the contractor's certifications and demonstrating the effectiveness of recovery ■ List of similar work done by the applicant ■ Copy of necessary permits and certificates ■ Copy of liability insurance certificate
Specific Considerations in Cases Where the Transfer Centre Belongs to the Municipality	
Information provided by the municipality	**Information the contractor should include in the proposal**
■ Dimensions of transfer centre ■ Location of transfer centre ■ Blueprints for the transfer centre ■ Who is responsible for handling the appliances before, during, and after recovery	■ The contractor's specific requirements for the planning and layout of the transfer centre
Specific Considerations in Cases Where the Transfer Centre Belongs to a Contractor	
Information provided by the municipality	**Information the contractor should include in the proposal**
■ Maximum distance to the transfer centre (radius of service area) ■ Who is responsible for the appliances after CFC recovery ■ Minimum storage capacity	■ Location of transfer centre ■ Storage capacity of centre
Specific Considerations in Cases Where the CFC Recovery is Done On Site	
Information provided by the municipality	**Information the contractor should include in the proposal**
■ A detailed map of the area serviced ■ Maximum response time when the contractor receives an order ■ Who is responsible for taking calls from residents	■ Procedures the contractor uses to recover CFCs on site

Step 7 Estimating the total costs and revenues and choosing a method to finance your CFC recovery program

The information gathered during the preceding steps (1-6) will enable you to estimate the total costs and revenues of a CFC recovery program for your municipality or region.

Total costs of a CFC recovery program

The main costs to consider are the following.

Planning and organizing the program. The planning of the CFC recovery program can be entrusted to the environment department or public works department of a municipality. The person in charge of the program carries out and/or co-ordinates the following procedures:

- estimating the number of home appliances and the quantities of CFCs and metals;
- drawing up invitation to tender documents and evaluating proposals;
- organizing the collection of home appliances (if necessary);
- preparing a training program for municipal employees, if they will recover the CFCs themselves;
- designing a promotional and educational campaign for the CFC recovery program.

Depending on the size of the municipality and the type of CFC recovery program implemented (see Table 4), these activities may represent several weeks to several months of work for the person in charge of the program and for the various people who are helping with its preparation.

Setting up a transfer centre. In a number of municipalities, it will be possible to use an existing building (often the municipal garage) as a transfer centre. However, this new function usually calls for additional modifications, the costs of which may vary considerably according to the design of the existing building. The municipality could also choose to use facilities owned by the recyclers.

Collecting home appliances. For a number of municipalities, the program for recovering CFCs from home appliances will not entail additional collection costs as this service is already being offered. For municipalities that do not already offer collection of appliances, it is possible to organize a CFC recovery program in which all residents are responsible for transporting their home appliances to the transfer centre (see types of programs, Step 4). If a municipality decides to offer a new home appliance collection service, it is important to stress that the costs of this collection service should be attributed only in part to the CFC recovery program.

Program promotion. The costs of promoting the CFC recovery program will vary widely according to the size of the municipality and the scope of the promotion program's activity. If the municipality makes use of methods of communication that are already at its disposal (municipal newsletters and press releases, community newspapers, etc.), the costs of promotion and public education may be very modest. If, on the other hand, the municipality chooses custom-designed communications to promote the program, for

example through flyers sent to all residents, the costs will be higher. Whatever methods are chosen, however, the promotional costs of a CFC recovery program are usually quite low, given the relative simplicity of this kind of program for the residents (compared, for instance, to the selective collection of domestic garbage).

Recovery of CFCs. Recyclers usually charge a fixed price per appliance, around $4 to $10 per appliance if the recovery is done at a transfer centre. The variables that influence the recovery price are the size of the municipality, the building design, and the type of facilities made available to the entrepreneur at the transfer centre, the number of appliances handled on each collection trip made by the recycler, and so on. If one assumes that the price for processing an appliance is $6, the cost for a municipality may be calculated in the following way:

Example for a municipality with 100 000 residents:

600 appliances/year

X

$6/appliance

=

$3600
(cost of CFC recovery)

Revenues from the recovery of scrap metal

Recovering scrap metal currently generates revenues that almost cover the costs of recovering CFCs. In fact, the recovered metal corresponds to about $6 per home appliance:

Example for a municipality with 100 000 residents:

600 appliances/year

X

$6/appliance

=

$3600
(revenues from the recovery of scrap metal)

Financing methods

The municipality may choose to assume the entire cost of a CFC recovery program, or it may charge its residents a part of the costs. These costs may be borne by the residents through a general property tax or through a special tax for the CFC recovery program. It is also possible to only charge the users of the CFCs collected when they are deposited at the transfer centre. The latter method, however, has the disadvantage of discouraging residents from participating in the program, and is not recommended.

Step 8 Carrying out a cost-benefit analysis of your CFC recovery program

The costs and revenues of your program for recovering CFCs from home appliances were discussed in the preceding Part. A number of additional aspects, however, deserve to be examined in order to take into account all the benefits and costs of such a program for society.

Benefits

Reducing landfill costs for home appliances. Over the last few years, the landfill costs for domestic garbage have continued to increase. Current landfill costs for municipalities vary from $15 to $50 per tonne dumped. In the case of new landfill sites that fully meet new environmental requirements, landfill costs often reach $80 to $100 per tonne. The savings achieved by reducing the volume of home appliances that are buried in landfill sites will therefore be increasingly important as time goes by. In the short term, if one assumes the landfill costs to be $30/tonne, the potential savings can be estimated as follows:

Example for a municipality with 100 000 residents:

600 appliances/year

X

89 kg/appliance

=

53.4 tonnes

X

$30/tonne

=

$1602
(in reduced landfill costs)

In the medium and long terms, these savings may be two or three times higher. Furthermore, the cost of transporting the home appliances could also be reduced, as the transfer centres are generally located closer to the municipalities than the landfill sites. As it can often cost $15 a tonne to transport waste to landfill sites, additional savings can be achieved in this area.

Increasing the lifespan of landfill sites through reducing the volume of home appliances disposed there.

Reducing the effect on the ozone layer caused by the release of CFCs into the atmosphere when recovering the metal but not the CFCs, or during burial of the appliances.

In addition, setting up a CFC recovery program can facilitate the organization of a recovery program for all unserviceable home appliances, whether they contain CFCs or not, thereby permitting further reductions in landfill costs.

Costs

Total net costs of a CFC recovery program. In general, under the current conditions of the recovery market, the recovery costs specific to CFCs and the revenues from the sales of scrap metal cancel each other out. The total net costs of a program corresponds to the costs of planning and organizing the program, promoting it, and making any required modifications to the transfer centre (if necessary).

Net benefits of a CFC recovery program

The councillors and the inhabitants of each municipality or region must decide if all the advantages offered by a CFC recovery program, for society as well as for the environment, more than outweigh the costs of the program (see Table 6).

Table 6 *Summary of the Benefits and Costs of a CFC Recovery Program*

Benefits for a municipality with a population of 100 000	
■ Reducing the landfill costs for home appliances 600 appliances/year x 89 kg/appliance = 53.4 tonnes x $30/tonne	$1602
■ Increasing the lifespan of landfill sites	n/a
■ Reducing the impact on the ozone layer	n/a
■ Revenues from the recovery of metal 600 appliances/year x $6 per appliance =	$3600
Subtotal of benefits :	**$5202**
Costs for a municipality with a population of 100 000	
■ Planning and organizing the program	n/a
■ Upgrading and organizing the program	n/a
■ Collecting home appliances (part of the costs are attributable to the program)	n/a
■ Promoting the program	n/a
■ Cost of CFC recovery 600 appliances/year x $6/appliance =	$3600
Subtotal of costs :	**$3600**
Net benefits for a municipality with a population of 100 000	
■ The net benefit is equal to the sum of the advantages minus the sum of the costs	n/a

n/a: not available

Step 9 Developing a promotion campaign for your CFC recovery program

A program for recovering CFCs from home appliances can only be successfully implemented if residents participate. To ensure that all the residents co-operate in the project, a public education campaign should stress the beneficial effect the recovery of CFCs has on the ozone layer. Other information gathered during the long process of planning the program may also be used in the promotional campaign (amount of CFCs recovered from each home appliance, method of collecting the home appliances, site for recovering CFCs, benefits and costs of the program for the municipality or the region, how the program is financed, etc.).

Promotional means that can be used include:

- an information kit for the spokespersons of various community/environmental organizations and media representatives;
- information included in tax bills sent to residents;
- news conferences and news releases;
- general information on the program and in-depth articles in community newspapers and municipal newsletters;
- increasing the awareness of primary and secondary school students through activities in school settings;
- promoting the program through those who sell new appliances within the municipal territory;
- local radio announcements;
- other.

The nine steps are provided in the worksheet in Part 4 (Planning).

3 Identifying Available Resources

Table 7 *List of Resource Persons*

Environment Canada	Contact	Telephone
To obtain technical fact sheets describing CFC recovery technologies and existing CFC recovery programs in Canada	John Ayres, Project Manager Air Issues and Toxics	(514) 496-6858 (819) 953-2268
If you have questions regarding regulations governing ozone-depleting substances (ODS), call:	Bernard Madé, Chief Ozone Protection Program Sector	(819) 994-3249
Provincial Ministries of the Environment	**Contact**	**Telephone**
Newfoundland	Philip Blagden Industrial Environmental Engineering Division Department of Environment and Land	(709) 729-2110
Prince Edward Island	Todd Fraser Air Quality & Hazardous Materials Section Department of Environmental Resources	(902) 368-5037
Nova Scotia	David Blair Air Quality Branch Department of the Environment	(902) 424-2566
New Brunswick	Denis L. Marquis Air Quality Section Department of Environment	(506) 457-4848
Québec	Daniel Champagne Service de la qualité de l'atmosphère Ministère de l'Environnement et de la Faune	(418) 643-7880
Ontario	Alex Salewski Program Development Branch Ontario Ministry of Environment and Energy	(416) 314-7935
Manitoba	Karen Warren Pollution Prevention Branch Manitoba Environment	(204) 945-3554
Saskatchewan	Earl Craig Air Quality , Saskatchewan Environment and Resource Management	(306) 787-6197
Alberta	Larry Begoray Air Quality Branch Alberta Environment	(403) 422-2540
British Columbia	Doug Brian Environmental Protection Division Ministry of the Environment	(604) 953-3351
Northwest Territories	Chris Wolnik Environmental Protection Division Department of Renewable Resources	(403) 873-7654
Yukon Territories	Bengt Peterson Department of Renewable Resources	(403) 667-5634

As of spring, 1996

Table 8 *Examples of CFC Recovery Programs in Canada*

Municipality or region	Studies	Program	Population	Contact	Telephone
Newfoundland					
None					
Prince Edward Island					
Department of Environmental Resources		1	130 000	Debbie Johnston	(902) 368-5059
Nova Scotia					
Metropolitan Authority (Halifax County, Halifax, Dartmouth, Bedford)		3	320 000	Christa Rafuse	(902) 421-8577
New Brunswick					
Saint John		1	74 969	Claude MacKinnon	(506) 658-2876
Moncton and surrounding area		1	200 000	Pierre Landry	(506) 858-8478
Québec					
Lévis		3	42 676	Pierre Sévigny	(418) 838-4171
Montréal		2	1 017 666	Alain Leduc	(514) 872-2210
Ontario					
Oshawa	●		129 344	Mike Simms	(905) 725-7351
Region of Peel (Mississauga, Brampton)		2	699 445	Robert Rivers	(905) 791-9400
Regional Municipality of Hamilton-Wentworth	●		450 000	Phil Jensen	(905) 546-4436
Manitoba					
Winnipeg		?	616 790	Dwight Gibson	(204) 986-3685
Saskatchewan					
Prince Albert		1	38 000	Robert Burns	(306) 953-4926
Alberta					
Calgary		?	710 677	Klaus Ohman	(403) 230-6617
Edmonton		?	616 741	Roy Neehall	(403) 496-5656
British Columbia					
BC Hydro		3	1 200 000	Steve B. Hobson	(604) 528-1467
Greater Vancouver Regional District (GVRD)		1	1 478 000	Kevin Lorette	(604) 436-6822

1 Type 1 Program: appliances brought to the transfer centre and CFCs recovered there
2 Type 2 Program: appliances picked up from the curbside and CFCs recovered at the transfer centre
3 Type 3 Program: CFCs recovered at the curbside or in the home

As of November, 1995

Note: See also Part 2, Step 4, for a complete explanation of the types of programs.

Table 9 *List of CFC Reclaimers (not exhaustive)*

Reclaimers	Contact	Telephone/Fax
Refrigerant Services Dartmouth, Nova Scotia	James V. Thomas	Tel.: (902) 468-4997 Fax: (902) 468-5102
Anachemia Solvents Mississauga, Ontario	William Feng	Tel.: (905) 279-5122 Fax: (905) 279-4130
Cryo-Line Supplies Inc. Mississauga, Ontario	John McIsaac	Tel.: (905) 608-2919 Fax: (905) 608-2926
Protocol Resources Management Inc. Toronto, Ontario	Jim Flowers	Tel.: (416) 233-8677 Fax: (416) 233-4482

As of spring, 1996.

Table 10 *List of Manufacturers of CFC Recovery Equipment (not exhaustive)*

Reclaimers	Contact	Telephone/Fax
Enspeco Inc.	Cocagne, New Brunswick Canada	Tel.: (506) 576-7301 Fax: (506) 576-9838
National Refrigeration Products	Bensalem, PA United States	Tel.: (215) 639-5885 Fax: (215) 639-5765
P & F Technologies Ltd.	Mississauga, Ontario Canada	Tel.: (905) 615-9393 Fax: (905) 615-1614
Robinair	Mississauga, Ontario Canada	Tel.: (905) 612-8588 Fax: (905) 612-8594
Therma Flo	Springfield, MA United States	Tel.: (413) 733-4433
Cryo-Line Supplies Inc.	Mississauga, Ontario Canada	Tel.: (905) 608-2919 Fax: (905) 608-2916

As of spring, 1996.

4 Planning

Example: Municipality with 100 000 residents	Case study data	Your municipality
Step 1 Estimate the Amount of CFCs and Metal to be Recovered		
■ Estimate the number of appliances discarded per year 100,000 residents x 6 home appliances/year / 1,000 residents =	600 home appliances containing CFCs	
■ Estimate the amount of CFCs and metal to be recovered 600 home appliances/year x 0.25 kg of CFCs/appliance =	150 kg of CFCs recovered/year	
600 home appliances/year x 65 kg of metal/appliance =	39 000 kg of metal/year	
Step 2 Get to Know the Recovery Market		
■ CFC market ■ Scrap metal market		
Step 3 Learn About the Different CFC Recovery Technologies		
■ Recovery under vacuum ■ Recovery by adsorption		
Step 4 Choose the Type of CFC Recovery Program That Suits Your Needs		
■ Appliances brought to the transfer centre; CFCs recovered at transfer centre or ■ Appliances collected at curbside; CFCs recovered at transfer centre or ■ CFCs recovered at curbside or in the home		
Step 5 Plan How to Physically Organize CFC Recovery Operations (if you own the transfer centre where the CFC recovery will take place)		
■ Space requirements ■ Building systems ■ Mechanical and electrical requirements ■ Architecture		
Step 6 Prepare the Invitation to Tender Documents for the Recovery of CFCs and Metal		
■ Considerations when drafting invitation to tender		
Step 7 Estimate Total Costs and Revenues and Choose a Way to Finance Your CFC Recovery Program		
■ Costs for CFC recovery 600 appliances/year x $6/appliance =	$3600	
■ Revenue from metal recovery 600 appliances x $6/appliance =	$3600	
Step 8 Analyze the Cost-Benefits of Your Recovery Program		
■ Lower landfill costs of home appliances 600 appliances/year x 89 kg/appliance = 53.4 tonnes x $30/tonne =	$1602	
Step 9 Develop a Promotional Campaign for Your CFC Recovery Program		

Glossary

Adsorption: retention of gas molecules on the surface of a solid.

Home appliance: in this document, refers to any residential appliance containing CFCs (refrigerators, freezers, air conditioners, de-humidifiers, etc.).

Transfer centre: area converted, retained and intended for the temporary accommodation of home appliances that could contain CFCs. Generally, CFC recovery is also done at this site.

Ozone layer (stratospheric ozone): layer of ozone molecules located in the stratosphere at an altitude of 15 to 40 kilometres.

CFC(s): chlorofluorocarbon(s); synthetic gas containing chlorine, fluorine and carbon.

De-humidifier: appliance that lowers the moisture content of air or other substances.

Elimination: final disposal of contaminated CFCs, usually by incineration.

Ozone: gas composed of three oxygen (O_3) atoms. Ozone partially filters certain types of ultraviolet rays from the sun and prevents them from reaching the surface of the Earth.

Recovery machine: device used for CFC recovery.

Reclaiming: the re-processing and upgrading of refrigerant by filtering, drying, or distillation and chemical treatment of the recovered refrigerant. This involves processing off-site at a re-processing or a refrigerant manufacturing facility.

Recovery: the collection and storage of refrigerant from any system or equipment, containment vessels, etc., in approved external recovery storage cylinders, or in drums for low pressure refrigerants during servicing, repair, or before equipment disposal.

Recycling: to improve the quality of recovered refrigerant before re-use. The cleaned refrigerant can then be used at a job site or service shop. Recycling may be done on or off site.

Refrigerant: coolant used in refrigeration.

ODS: ozone-depleting substance (includes CFCs, halons, HCFCs, etc.).

Stratosphere: atmospheric layer 15 to 40 kilometres above the surface of the Earth; contains 90% of the ozone in the atmosphere.

Canada