Environmental Code of Practice for Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems

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Abstract

This Code of Practice was originally published in 1991 to fulfil the responsibilities of the Minister of Environment for the formulation of environmental codes of practice as required under Section 8 of the Canadian Environmental Protection Act. *The main purpose of this Code was to provide guidelines for the reduction of atmospheric emissions of chlorofluorocarbons (CFCs) used in refrigeration and air conditioning applications.*

The Code of Practice (Code) has been revised, updated, and expanded to cover six trade sectors, and an addendum of pertinent information that can be applied to all trade sectors such as Industrial/Commercial, Residential, Residential Domestic Appliances, Mobile Air Conditioning, Mobile Refrigeration, and Heavy-duty Mobile Air Conditioning. The Code can also now be used as a reference for the reduction of hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs) emissions.

The revised Code reflects the development of new alternative refrigerants, new technologies, revised practices and procedures, and additional regulatory requirements. It has therefore been retitled "Code of Practice for Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems".

Résumé

Ce Code de pratiques a d'abord été publié pour que le ministre de l'Environnement assume les responsabilités que lui impose l'article 8 de la Loi canadienne sur la protection de l'environnement *en ce qui concerne la formulation des codes de pratiques environnementales. Le principal objectif de ce Code était de fournir des directives pour la réduction des rejets dans l'atmosphère de fluorocarbures utilisés pour la réfrigération et le conditionnement de l'air.*

Ce Code de bonnes pratiques a été révisé, mis à jour et élargi, et on y a ajouté des annexes. Il s'applique maintenant à tous les secteurs de la réfrigération et du conditionnement d'air que sont les systèmes commerciaux et industriels, les systèmes résidentiels, les appareils électroménagers, les conditionneurs d'air mobiles, la réfrigération mobile et les systèmes mobiles de climatisation d'air de grande puissance. Ce Code peut également servir d'outil de référence pour la réduction des rejets dans l'atmosphère des hydrofluorocarbures et des hydrochlorofluorocarbures.

Le Code révisé tient compte de la mise au point de nouveaux frigorigènes de remplacement, de nouvelles technologies, de pratiques et de procédures révisées et d'exigences réglementaires additionnelles. C'est pourquoi il est dorénavant intitulé «Code de pratiques environnementales pour l'élimination des rejets dans l'atmosphère de fluorocarbure provenant des systèmes de réfrigération et de conditionnement d'air».

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Glossary

ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers.

Azeotrope - A product resulting from the combination of two or three compounds that have identical vapour and liquid compositions. An azeotrope cannot be separated into its substituent parts by distillation. Azeotropes will fractionate slightly and experience temperature glide outside of the identified azeotropic points, (ASHRAE std. 34 definitions) (See Appendix A).

Blend - A refrigerant mixture of two or more chemical compounds blended in a specific ratio which can be separated by distillation. Regular blends may have up to 10° C or more temperature glide.

Certified Person - A person who has successfully completed the Environment Canada Environmental Awareness Course for the Environmentally Safe Handling of Refrigerants (previously for handling ODSs). This is not the same as a trade certified and qualified person, nor is it intended to imply any trade qualification. The certified person referred to herein will include those persons who are actively involved in the Refrigeration and Air Conditioning Industry, e.g., Service Person, Repair Person, Installation Person, (Refrigerant) Stores Person, Domestic Appliance Technician, Refrigeration and Air Conditioning Mechanic, Automotive Mechanic, Heavy-duty Vehicular Mechanic/Technician, Industrial Mechanic, Technical Representatives, and Power Engineers. This course is mandatory in most provinces.

Chlorofluorocarbon (CFC) - A stable chemical containing only chlorine, fluorine and carbon atoms. Chlorofluorocarbons are ozone-depleting substances (ODSs).

Consumption - Consumption of a controlled substance for a given period is the sum of the quantities produced and imported into the country during the given period of time, less the quantity exported. For the purpose of determining a calculated level of consumption, it excludes any quantity of controlled substance that, when imported or exported, was already used, recovered, recycled, or reclaimed.

Container - A container which is intended to contain only ozone or non-ozone-depleting substances such as chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), or blends, whether the substance contained in the container is under pressure or not. For example, a charging cylinder is a container used to decant small amounts of refrigerant (of various types) into a system, but is not an approved storage or transportation container. Containers may be cylinders or drums made out of metal or glass.

Approved Container - An approved container is a storage drum or cylinder that conforms to the Canadian Transport Commission specification (CTC) which permits its use for the substance it contains. For imported products from the United States, Department of Transportation container specifications (U.S.) are also recognized for storage and transportation.

Approved Cylinder - is a refillable/recyclable CTC approved container that is properly colour-coded for the substance it contains as per the ASHRAE Standard, and it should also be properly labelled in accordance with this Code and CTC regulations.

Designated Ozone-depleting Substance - An ozone-depleting substance that is listed by name in the Montreal Protocol, or substances added to the list as subsequent amendments to the Protocol.

Disposable Container - A container designed to be used only once for the transportation or storage of a virgin substance, such as CFC, HCFC, HFC, blends, designed in accordance with CTC specification 39 (DOT 39 if made in the U.S.A.). This container should not be used for recovery or recycling purposes, or for any other use and should be returned to the supplier when empty. Refillable containers are preferred for replacing existing disposable containers, as they are constructed with better one-way valves and designed for multiple use. There is minimal chances for emissions to take place.

Global-warming Potential (GWP) - A global-warming potential is the time-integrated change in "radiative forcing" due to the instantaneous release of 1 kg of a trace gas expressed relative to the radiative forcing from the release of 1 kg carbon dioxide (CO_2).

Holding Charge - A charge of an inert or a refrigerant gas put into a system or equipment to ensure that there is a positive pressure to prevent leakage of air or moisture into the system or the equipment.

Hydrochlorofluorocarbon (HCFC) - A chemical compound containing only hydrogen, chlorine, fluorine, and carbon. Hydrochlorofluorocarbons are less damaging to the ozone layer than chlorofluorocarbons. These compounds (HCFCs) are considered as an interim replacement for CFCs.

Hydrofluorocarbon (HFC) - A chemical compound containing hydrogen, fluorine, and carbon. With no chlorine or bromine, HFCs do not destroy the ozone layer but have a global- warming potential, as do ozone-depleting substances.

Mixture - A refrigerant that contains oil and contaminants including other refrigerants. The term cocktail mixture describes the inadvertent mixing of two or more refrigerants, usually they are not recyclable or reclaimable.

Near-azeotrope - Sometimes called a NARM, this chemical product is formed by combining two or more compounds. Its vapour and liquid compositions are nearly identical. Near - azeotropes have a temperature glide of less than 2°C (ASHRAE 34 definitions) (see Appendix A).

Ozone-depletion Potential (ODP) - A measure of the relative capability of a particular chemical to destroy ozone. The ODP is measured against CFC-11 which has an assigned ODP of 1.0. Internationally accepted ODP values have been established by UNEP.

Ozone-depleting Substance (ODS) - A chemical compound that is sufficiently stable to reach the stratosphere and is capable of reacting with stratospheric ozone, leading to ozone depletion.

Perfluorocarbon (PFC) - A chemical compound containing only carbon and fluorine.

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.

Reuse - The reuse of previously recovered refrigerant without processing.

Recycling - To improve the quality of recovered refrigerant before re-use. This is to clean refrigerant by oil separation, distillation, and single or multiple passes through replaceable core filter-driers to remove moisture, acidity, and particulate matter. The cleaned refrigerant can then be used at a job site or service shop. Recycling may be done on or off site.

Reclamation - The re-processing and upgrading of refrigerant by filtering, drying, or distillation and chemical treatment of the recovered refrigerant. The re-processed substance will require laboratory analysis to verify that it meets a specific quality standard. This involves processing "off- site" at a re-processing or a refrigerant manufacturing facility.

Refrigerant - A fluid that absorbs heat at a low temperature and pressure, with a change of state, and rejects heat at a higher temperature and pressure.

SAE - Society of Automotive Engineers.

Servicing - Includes installations, maintenance, testing and repair, alteration, conversion, mothballing and decommissioning.

Sweep Charge - Sweep charge is a procedure in which the refrigerant is circulated in a closed-loop system to clean the equipment. The refrigerant is subsequently recovered.

Threshold Limit Value (TLV) - is the measure of toxicity effect. It is the limit of concentration of a substance in the air that an average person can tolerate without any adverse effect for a period of eight hours of continuous exposure. The TLV is assigned by the American Conference of Governmental Industrial Hygienists (ACGIH).

*Tonne of Refrigeration (*tR) - is a unit for refrigeration capacity equal to 3.517 kW (12 000 Btu/h).

Ultraviolet Radiation B (UV-B) - This form of radiant energy is emitted by the sun. It has a wavelength between 280 to 320 nm. Exposure to excess UV-B is harmful to humans, animals, and plants. The ozone layer forms a protective shield that helps to protect the earth from excessive levels of UV-B radiation.

UNEP - United Nations Environmental Program.

White Goods - Household domestic appliances such as freezers or refrigerators, that include a 115/230 volt self-contained plug-in refrigeration or air conditioning system (or gas-operated system for mobile homes).

Zeotropes - Are refrigerant blends consisting of a combination of two or more different chemical compounds, often used individually as refrigerant for other applications. Unlike azeotropes, zeotrophic blends separate more easily into their substituent parts.

B 52-M1995 Mechanical Refrigeration Code - (as amended/updated from time to time) This is a code of practice to ensure that adequate safety standards are consistently applied to refrigeration, air conditioning, and heat pump systems. It applies to the design, construction, installation, operation, and inspection of every type of refrigeration system. This Code is mandatory in all provinces.

B 51 Code for Boilers, Pressure Vessel and Pressure Piping Code (as amended/updated from time to time) - This code of practice ensures adequate safety standards for all types of installations involving high pressure systems [> 103 kPa (>15 psig) design pressure]. This Code is mandatory in all provinces.

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AIA - Automotive Industries Association of Canada
AIAMC - Association of International Automobile Manufacturers of Canada
BOMA - Building Owners and Managers Association
CASE - Coalition of Automotive Safety and the Environment
CEASA - Canadian Electronic and Appliance Service Association
CETAF - Corporation des entreprises de l'air et du froid
CFIG - Canadian Federation of Independent Grocers
CF of L - Canadian Federation of Labour
CMMTQ - Corporation des Maîtres mécaniciens en Tuyauterie de Québec
CTA - Canadian Trucking Association
EC - Environment Canada
FoE - Friends of the Earth
FPWG - Federal/Provincial Working Group (Ozone-depleting Substances)
HRAI - Heating Refrigerating and Air Conditioning Institute of Canada
MVMA - Motor Vehicle Manufacturers Association
NDHQ - National Defence Headquarters
NRC - National Research Council of Canada
PWGSC - Public Works and Government Services Canada
RSES - Refrigeration Service Engineers Society

Introduction

The use of refrigerants contained in a closed loop is both safe and efficient as long as escape to the atmosphere is prevented. The emission of ozone-depleting substances (ODSs), such as chlorofluorocarbons (CFCs), halons, and hydrochlorofluorocarbons (HCFCs), to the atmosphere will continue to adversely affect stratospheric ozone concentrations for many years. Even if all emissions were eliminated, the increased UV_B radiation reaching the earth's surface caused by earlier emissions will affect humans, plants, and animals. In addition, ODSs have a global-warming effect. Hydrofluorocarbons (HFCs) contribute to global warming but have no ozone-depleting potential.

The strategy is to target the most damaging chemicals first to reduce and eventually eliminate ozone-depleting substances (ODSs) from being emitted to the atmosphere. The *Canadian Environmental Protection Act* (CEPA) *Ozone-depleting Substances Regulation* was amended to eliminate the production and importation of CFCs as of January 1, 1996. Most provinces also have regulatory programs in place for the recovery/recycling/reclamation of refrigerants. Environmental awareness training of service persons in refrigeration and air conditioning fields, is mandatory in most provinces.

The Code has been revised to reflect our national and global commitment to pollution prevention as well as the objectives of the National Action Plan for the Environmental Control of Ozone-depleting Substances and their fluorocarbon alternatives. The Code

has been expanded to include hydrochlorofluorocarbons and hydrofluorocarbons. Although the Code does not address nonfluorocarbon refrigerants, which are used in specific applications, it should be recognized that these may cause other environmental and/or safety concerns. The future development of additional technologies and practices is not discussed in this report. However, technological developments which further improve the ability to eliminate all emissions should be adopted if shown to be feasible.

The Code will require revision as new technology and regulatory advancements are made to address future problem areas. It is a guideline that will be of interest to manufacturers, contractors, service persons, environmental monitors, and regulators. It can also be used as a template for further consistency and harmony of provincial regulations concerning refrigerant emissions into the atmosphere. The Code has been developed in consultation with active and corresponding stakeholders from all trade sectors such as manufacturers, contractors, organized labour, trade associations, service industry representatives, environmental interest groups, federal and provincial representatives, and regulators.

The refrigerants such as HCFCs, HFCs, and blends thereof are fluorocarbons which have been identified as suitable replacement refrigerant alternatives. The HCFCs have a much lower ozone-depletion potential (ODP) than CFCs. Some HFCs have a higher global-warming potential than HCFCs (although much less than CFCs) but have no ozone-depletion potential. No CFC alternative is available today that is totally benign, and thus a proactive approach to pollution prevention continues to be necessary. Recognizing that these alternatives will still have some impact on the environment, the same methodologies used to eliminate emissions of CFCs should be used to recover and recycle HCFCs and HFCs. Canada is committed to the goal of total containment and elimination of the use of ozone-depleting substances, in harmony with other developed countries around the world.

Commercial/Industrial Systems

2.1 Design and General Practices

This section deals with the design of refrigeration and air conditioning systems and their components, and identifies possible sources of refrigerant emissions of CFC/ HCFC/HFCs to the atmosphere.

Application of established technology in both the design, construction, proper operation, and maintenance of refrigeration systems constitutes a good foundation for the prevention of refrigerant leakage to the atmosphere. Improved design of systems and use of new technologies and practices are essential for reduction and elimination of emissions.

2.1.1 General Design Principle

Commercial/Industrial refrigeration and air conditioning sectors are the major source of emissions. Environmentally sound design, therefore, is an important goal in pollution prevention. Equipment manufacturers, distributors, and associated service industries should incorporate product stewardship into their corporate policies, if not already present.

2.1.2 Building Owners, Operators, and Managers

Equipment owners and managers using ODS equipment should be informed of the environmental impact of ODS emissions and use of alternative refrigerants. The immediate need is to communicate that planned preventative maintenance is an essential component of preventing emissions. The second need is to improve maintenance techniques and procedures for maintaining the equipment to reduce or eliminate the potential for refrigerant release.

2.1.3 Relief Devices

Effective on the date of publication of this document, all new units containing over 10 kg (22 lb) of refrigerant should have a self-reseating relief valve vented to the outside atmosphere in accordance with the applicable B-52 code requirements. Also, units with over 50 kg (110 lb) should have a monitoring system in the compressor room, capable of detecting leakage greater than 30 ppm.

2.2 Compressors

To prevent fugitive emissions, compressors or associated equipment fitted to them, e.g., gauge and cut-out connections, oil return, oil drain, oil level sight glass, relief valve and connecting pipe work, need to be inspected regularly according to manufacturer's specifications, or at least twice a year if no specifications exist.

2.2.1 Mechanical Seals

Damaged mechanical seals on open type compressors are a frequent source of refrigerant leakage. Some manufacturers indicate that a small amount of oil leakage is required to keep dirt out of the seal and keep the seal surface lubricated. However, damage to the seals may be caused by oil contamination or lubrication breakdown.

A clean, dry system is essential for prolonged mechanical seal effectiveness to eliminate emissions. Compressor oils used for HCFCs and HFCs will absorb moisture readily and must be kept dry to prevent refrigerant decomposition.

Straining and filtration of refrigerant and compressor oil should be provided on new equipment to minimize mechanical seal wear and thereby reduce the possibility of having leaks. Existing equipment should be modified to include these features.

Gland housing should be designed to prevent oil draining away from the mechanical seal during shutdown, which may cause leakage due to seal face damage on startup.

2.2.2 Seal Lubrication

During shutdown the mechanical seals on large open compressor systems should be lubricated weekly before the compressor is started. A film of oil maintained on the shaft and seal surface, helps to prevent refrigerant from escaping.

2.2.3 Vibration

Compressors should be mounted on a solid foundation and/or with vibration eliminators to prevent leaks due to vibration and failures.

Gauges and Cutouts. Snubber valves should be used to protect gauges and cutouts. They are also required to permit removal of these devices for repair.

Isolating Valves and Access Valves. All commercial and industrial compressors should have isolating and access valves on both the suction and discharge sides. New units/systems immediately or from the date of publication of this document should have "refrigerant recovery access valves" sized to allow 0.64 cm (1/4") of free area for flow of refrigerant on units/systems having up to 4 kg (8.8 lb) of refrigerant charge and 0.95 cm (3/8") I.D. for systems containing over 4 kg (8.8 lb) of refrigerant to permit recovery of refrigerant before the system is opened.

2.3 Condensers and Evaporators

Effective on the date of publication of this document, the refrigerant should not be used as a holding charge for storage or shipping; use dry nitrogen or dry air that meets ASHRAE standards.

2.3.1 Condenser and Evaporator Vibration

Excessive vibration from compressors or other equipment can cause evaporator and condenser tube failure. Antivibration mountings and vibration eliminators should be used where feasible. Piping should have flexible connectors and be solidly anchored. Equipment should be inspected periodically to identify and remediate any excessive vibrations.

2.3.2 Excessive Water Velocity

Excessive water velocity through the tubes of shell and tube units should be avoided. On larger units (e.g., greater than 50 tR), eddy current testing of tubes every three years and water flow measurements will help minimize refrigerant losses due to tube failure. Adequate protection against water hammer is also recommended to reduce failure.

2.3.3 Water Quality

Water treatment and filtration should be used where needed to avoid corrosion or erosion failure. Careful selection of tube materials can also help to minimize corrosion.

For non-ferrous tubes, sacrificial anodes should be used to reduce corrosion pitting.

Reduced or suspended water flow can lead to serious corrosion problems. Flushing and a regular inspections should be done.
Sacrificial anodes are ineffective unless there is water flowing through the tubes. Tube sheets should also have a tube sheet vent valve to avoid trapped gases. These should be purged at least once a month.

2.4 Piping Fittings and Practices

2.4.1 Piping and Fittings

Vibration eliminators should be included in the suction and discharge lines near the compressor to prevent and eliminate leaks and vibration transmission.

Adequate support of pipeline connections to the compressor should be provided to avoid unacceptable stresses that could lead to leakage.

All pipelines should be designed so that the number of joints is minimized. Swedged joints should be used by both manufacturing process and the service person in the field. Welding or brazing is the preferred method of attachment on all refrigerant lines. The use of back seating access valves for attaching control and safety devices or gauges is preferred. Capillary lines on these devices must be positioned to ensure they can absorb vibration without rubbing together or against another object.

Gasket Material Compatibility. Ensure that gaskets are compatible with the refrigerant/refrigerant oil mixture where flanged joints are used, especially when the system is converted to an alternative refrigerant or oil. Equipment manufacturers should always be consulted before any retrofitting to help avoid leakage.
Welded or Brazed Flanges. To eliminate potential leaks in new systems, welding or brazing should be used to join flanges to the pipeline, instead of threaded connections. Where threaded

connections must be used, fluoropolymer film is the preferred pipe lubricant. On existing systems back-weld screwed flanges should be used where possible.

Back Seating Valves. Use valves designed for tightening or replacement of the gland packing/diaphragm under line pressure except when ball valves are involved. Be sure to check valves carefully before servicing. Leak test the gland-packing nut regularly.

Capped Valves. Capped valves which can retain any leakage from the spindle gland should be used for all service stop valves. Regular operating valves in the system should be leak tested regularly.

Welded, Brazed Valves. Valves with welded, brazed, or flanged connections should be used instead of a flared or screwed type, for sizes greater than 19 mm (3/4") outside diameter (O.D.). For small sizes use compression fittings instead of flared fittings.

Bolt-on Valves. Bolt-on valves should not be used on smaller applications. Saddle valves can be used as a tool but must be replaced by weld-in access valves or welded shut before the service person leaves the site. One exception is for recovery of refrigerant when a bolt-on valve can be used during decommissioning of smaller equipment.

Isolation and Access Valves. Valves allowing isolation of all vessels and equipment are required to minimize the risk of refrigerant loss during servicing. Access valves for recovery of residual refrigerant in isolated components are also required. Any piping or segment between two shut-off valves must be protected by a pressure-relief, in accordance with the *B52-M1995 Mechanical Refrigeration Code* (as amended from time to time).

Isolation valves should be added, if not present, when vessels or equipment have to be shut down and evacuated for service.

2.4.2 Piping Practices

Pipelines should always be supported against vibration stresses, which cause leaks, by being adequately clamped to solid fixtures. Use insulated hangers for non-ferrous pipe. Vibration eliminators and expansion bends should be used. Use trombone bends or sprung hangers for lines too large for vibration eliminators. Gauges, high pressure and low pressure shut-off, and oil safety switches should be connected to the main system via flexible connections so that vibrations are absorbed.

Filter Driers. To prevent leakage, filter driers in the range of 5 to 20 µm should be used to reduce particulate matter and avoid damage to the mechanical seal faces and other working parts of compressors. Similar damage can also be caused to motor windings and compressor parts of hermetic and semi-hermetic compressors. A moisture indicating sight glass is strongly recommended. New systems should have a liquid line filter drier of sufficient size welded into place at the time of manufacture, to protect the equipment. Replaceable filter drier cores are available for larger systems to avoid emissions.

The drier should have isolation and refrigerant recovery connections. A new filter/drier should be installed, complete with required valves in the case of a system that is opened to replace a component that has no filter/drier.

Welding Blanket. Refrigerant should not be used as welding blanket. Dry nitrogen should be used during welding or brazing.

Relief Devices. A nonfragmenting rupture disc in conjunction with a self-reseating type relief valve is recommended for low pressure refrigerant systems. All relief devices must be vented to the outdoors.

Three-way Refrigerant Valves. A three-way refrigerant valve is required to accommodate dual-relief valves on all high pressure refrigerant machines with a charge of over 50 kg (110 lb), to facilitate repair or replacement. To eliminate emissions the relief valve setting shall be in accordance with the *B52-M1995 Mechanical Refrigeration Code*. (As amended from time to time).

2.5 Air Purge and Pump-down Systems

2.5.1 Air Purgers

Air purge systems should vent outdoors. When purge systems operate, some refrigerant is emitted with air and frequent purging indicates a system leak. High-efficiency purgers will help to significantly reduce refrigerant purge emissions. In conjunction with adsorption technology, a 100% capture rate of normal purge emissions is possible. To correct the problem, trained qualified service persons must inspect and repair all leaks in the system. Regular leak testing is essential.

High-efficiency Purgers. Effective on the date of publication of this document, all new low pressure centrifugal units using refrigerants such as CFC-11, CFC-113, or HCFC-123 should be fitted with high-efficiency air purgers or other device that is designed to emit less than 0.1 parts of refrigerant per part of air during usual operation, according to manufacturer's specifications.

It is recommended that by January 1, 1999, existing chillers be retrofitted with a new high-efficiency purge or other device that is designed to reduce emissions below 0.1 kg of refrigerant/kg of air.

After January 1, 2000, all purge systems should have zero refrigerant emissions.

Pre-vacuum systems are available to prevent low pressure systems from going into a vacuum during idle periods. Potential refrigerant loss or leakage will be reduced; however, leaks should still be eliminated through proper leak testing and maintenance.
Residual refrigerant should also be recovered from the purge exhaust port using the best available technology. Systems to be shut down more than four months should have the refrigerant removed and transferred to approved storage vessels or containers.

2.5.2 Pump-down Equipment

Effective on the date of publication of this document, all new high pressure refrigeration and air conditioning units with a refrigeration capacity of 35.2 kW (10 tR) or greater, should incorporate a fully protected and isolatable liquid receiver to facilitate pump down during servicing, repairs, or winter lay ups. A condenser and receiver combination of sufficient capacity to hold the complete refrigerant charge is also acceptable.

Auxiliary Receivers. If manufactured before the date of publication of this document, units containing a refrigerant charge of over 10 kg (22 lb) should be installed with auxiliary receivers, if required, to hold the complete refrigerant charge during winter and summer. Units using capillary expansion control, however, need not necessarily be fitted with an isolatable liquid receiver. For smaller systems approved containers can be used.

Shell and Tube Condenser. The previous paragraph on auxiliary receivers does not necessarily apply to systems containing a shell and tube condenser if the condenser shell is on the refrigerant side; is large enough to contain the entire refrigerant charge; is fully isolatable and is protected by a pressure-relief device.

Evaporator and Accumulator. The paragraph on auxiliary receivers does not necessarily apply when the evaporator and/or liquid accumulator separator can contain the entire refrigerant charge and is fully isolatable and protected by a pressure-relief device.

Pump-down Attachments. Large systems may incorporate a separate pump-down condensing unit and receiver. Compressors and major equipment should be fitted with suitable refrigerant access valves to allow connection of a recovery unit for the removal of refrigerant before service or repair operations or any section of the system.

2.5.3 Oil Draining

Since refrigerants are soluble or miscible in compressor lubricating oils, compressor crankcases should be designed for pumped-down to below atmospheric pressure, before the oil is removed. High pressure systems should have discharge oil separators.

2.5.4 Leak Detection and Alarms

Refrigerant analyzers and warning alarms should be incorporated into the mechanical room design in accordance with the *B52-(latest edition) Mechanical Refrigeration Code*, to detect refrigerant emission.

Refrigerant alarms are not a substitute for actual leak testing on the system itself. Alarms should always give warnings before the TLV level for a particular refrigerant is reached.

A regular leak testing program (minimum twice a year) for all systems is essential. Use industry recognized leak detection equipment and methods. High refrigerant levels, i.e., greater than 10 ppm in the compressor room is an indication that one or more systems are leaking. All compressor rooms should have refrigerant detectors and alarms.

2.6 Manufacturing Operations, Refrigerant, and Equipment

2.6.1 Product Stewardship

Refrigerant manufacturers and suppliers should incorporate product stewardship as a part of the corporate ethic, to ensure that their product is used safely and in an environmentally sound manner.

The Canadian Chemical Producers' Association (CCPA) "Responsible Care®" program states that: "A Total Commitment" signifies commitment to the responsible management of the total life cycle of our products; from the very beginning in the laboratory to the very end at ultimate disposal or destruction". This should be adopted throughout the refrigeration and air conditioning industry.

There are many stakeholders that have a role and responsibility for the disposal or transformation of surplus stock of ODS. Leadership from the chemical industry (i.e., the refrigerant manufacturers) that is consistent with Responsible Care® should be forthcoming to prevent future problems. It should be the same type of leadership that industry initiated for development of new alternatives.

A responsible corporate environmental ethic should not tolerate leaks of ODS and should incorporate and implement the best available design, maintenance, and operational practices to eliminate and prevent leaks.

Components of this program should also include:

- the phaseout of use of CFCs;
- maintaining on-going records of sources and quantities of emissions;
- a preventive leak detection and maintenance repair program;
- routine (such as annual) progress and performance reporting that is readily available to the public; and
- management systems to audit progress and ensure that programs are in place and working.

2.6.2 Refrigerant Manufacturers

Sources of emissions during the refrigerant manufacturing process should be eliminated. The main sources include:

- chemical processing and fugitive emissions;
- bulk loading;
- storage and cylinder filling; and
- laboratory analysis.

The best available technology should be applied in monitoring and processing refrigerant to prevent emissions.

Emissions of chemicals at the plant level are monitored by Federal or Provincial Environment Officers with the goal of pollution prevention.

Chemical Processing. Emissions from chemical processing can be eliminated or minimized by using technologies or
techniques that include, but are not limited to:

- vapour recovery;
- minimum volume fittings;
- continuously welded piping, or if not possible, a minimum number of mechanical joints;
- gaskets specifically designed for the process materials to prevent leaks;
- transfer hoses/tubing of high integrity which are regularly inspected and/or replaced;
- routine inspections and testing for leaks in systems
- online monitors and/or analyzers strategically located in the operations areas and compressor rooms to detect leaks and sound alarms should a leak occur;
- maintenance and repair program to respond rapidly to a detected leak; and
- records maintained and analyzed on leaks and emissions to determine where improvements can be made.

Some specific examples are:

- ensuring that sample valves do not leak (leak test regularly);
- do not vent equipment and piping to atmosphere - recover to low vacuum levels;
- evacuate hoses before disconnecting temporary equipment;
- check relief valves to ensure they are not leaking;
- ensure process refrigeration systems are leak tight; systems should not require regular topping up;
- practice recovery and recycling when recharging dryers and filters; and
- repair the leak before top up.

Storage and Filling Operations. Emissions from storage and filling operations should be eliminated or minimized by:

- checking storage tank relief valves to ensure they are not leaking;

- checking pump seals for leaks regularly;
- not venting overfilled cylinders to the atmosphere;
- ensuring that charging hoses for cylinders are self-sealing when disconnected; and
- totally evacuating cylinders before opening for inspection.

Bulk Loading. Emissions from bulk loading operations should be eliminated or minimized by:

- not venting loading hoses from trailers and railcars to the atmosphere at the plant or customer site; and by using recovery and recycling equipment;
- customers should have recovery equipment available at the loading station;
- when switching trailers from one product to another, all residual refrigerant should be recovered;
- leak checking trailer valves and pumps regularly; and
- all customer bulk installations should be leak tested once a year minimum.

Laboratory Analysis. Emissions due to laboratory and analysis should be eliminated or minimized by:

- ensuring sample hoses are self-sealing;
- recovering all unused portions of samples in the laboratory;
- venting Goetz bulb analysis for volatile compounds to a chilled vacuum container;
- passing vapour from boiling point analysis through resin adsorption;
- sealing and keeping samples of liquid refrigerants sealed; and
- evacuating sample containers and recovering refrigerant after use.

2.6.3 Manufacturers of Equipment

Deep vacuum evacuation, as per the manufacturers' specifications should be the only method used to evacuate and dehydrate refrigerating and air conditioning systems during the manufacturing process. Systems should be evacuated to 75 µm or less.

2.6.4 Holding Charges

Dry nitrogen or dry air (-40 °C dew point) meeting ASHRAE guidelines should be used as a holding charge, when shipping equipment.

2.6.5 Cleanliness of Systems

Irrespective of the type of compressor being used, the system should be absolutely clean to reduce the risk of contamination of refrigerant and the need for subsequent recharging. All key personnel involved should be conversant with refrigerant technology and familiar with the need for zero emission.

2.6.6 Leak Testing

Ozone-depleting substances should not be used as a trace gases and class one substances (CFCs) cannot be used for leak testing without recovering all of the leak test refrigerant using the best available technology. If a leak is found, the system should be evacuated and repaired before top-up.

Leak Testing Methods. Consideration should also be given to bubble testing with soap for larger leaks, or by water immersion. An electronic leak detection device, which will detect very small leaks, can also be used. Some of the major methods of leak detection include:

- bubble testing with soap for larger leaks;
- water immersion;
- electronic leak detection; and
- fluorescent dye.

Various electronic leak detectors are available, most new leak detectors can detect less than 14 g (0.5 oz) per year. Ensure that the detector is sensitive to the refrigerant to be detected.

If the fluorescent dye method is used, make sure there is no equipment warranty problem. Sulphur hexaflouride should not be used for leak testing as it has a high global-warming potential.

2.6.7 Access Valves

Discharge and evacuation valves should be fitted to compressors to assist in servicing and maintaining the installation, with removal of refrigerants to approved recovery containers.

Control Devices. When a low pressure control is used as a cycling control, it should be hooked up to a separate low side access port and not to the normal access suction service port where practicable.

2.7 Installation and Servicing

Installation and servicing is the single largest source of ODS emissions. Principle causes are:

- improper leak testing of new installations;
- venting during installation and servicing;
- failure to repair leaks before recharging; and
- inadequate design and/or improper installation.

2.7.1 Installation of Equipment

Recommendations on the design of pipework and on the methods of connection can be found in Section 2.1. All facets of the *B52-1995 Mechanical Refrigeration Code* (as amended/updated from time to time) should be followed and any other applicable codes, dealing with design of mechanical rooms and ventilation requirements and space monitoring, adhered to during the siting and installation of the major components. Special attention should be paid to access for recovery and recycling.

Visual Inspections. Before installation all pipework and fittings should be thoroughly examined both for cleanliness and to ensure that they meet approved standards.

Metal Filings. No metal filings are to be left inside the cut pipework since these can cause damage to shaft seals, compressor bearings, and other internal components of compressors, leading to serious leaking and emission.

Flared Tube Connections. Compression type fittings should be used in preference to flared fittings. A suitable lubricant should be used between the back of the flare and the nut to avoid tearing the flare and allowing the flare nut to be tightened more securely. Ensure the correct grade of copper tubing is being used for the pressure and bending requirements of the installation. This will help prevent future leaks.

Flanged Connections. Only the correct type and grade of gasket material compatible for use with CFCs, HCFCs, HFCs and/or other refrigerant products and their lubricants should be used. Flanges should be tightened evenly to avoid leaks.

Nitrogen Welding Blanket. Before welding or brazing pipe joints, dry nitrogen should be allowed to bleed continuously through the system to eliminate oxidation. All mechanical joints should be visually inspected and double checked for tightness before a nitrogen pressure test is performed.

2.7.2 General Items

Refrigerants should not be vented into the atmosphere or used in place of compressed air for any purpose. Valve stem gland caps that cover gauge points and service valve caps must always be replaced and thoroughly leak tested after service. Gland packing nuts should not be tightened unless they are leaking.

Shortage of Refrigerant. A leak test should always be done upon finding a system which appears to be short of refrigerant. Some commons points where leaks appear are:

- flare joints;
- brazed joints;
- compressor gaskets;
- control bellows;
- shaft seals; and
- where there are traces of oil.

The low pressure side of a system should be given a positive pressure before leak testing the evaporator, heat exchanger, thermostatic expansion valve, or solenoid valve. This can be achieved by reversing the cycle if the system is of the hot gas type.

In a normal application, high and low sides of the unit equalize on shut down. The static pressure is more than enough to locate leaks. On sub-atmospheric applications, the evaporator water temperature can be raised a few degrees to facilitate leak testing, taking care not to exceed pressure of the relief devices.

Belt Drives. The belts on open belt driven compressors should be thoroughly checked for wear, damage, and tension. Worn or damaged belts, misalignment, or over-tensioning can cause compressor shaft seal and front end bearing failure, resulting in leaks.

Component Isolation. When a leak has been located, that part of the system must be isolated and pumped down, using recovery/recycling equipment. If isolation is not possible, the charge should be pumped back into the system receiver or into a suitable approved storage container(s).

Purging Manifold Gauge Sets. Hoses with back check or isolation refrigerant valves located within 15 to 30 cm (6 to 12") from their end should be used to minimize emissions. Purge gas must be collected using appropriate technologies. Non-condensables such as air from the lines can be recovered using conventional or adsorption technology.

2.7.3 Cleaning and Flushing

Contaminated systems require cleaning and flushing after a hermetic or semihermetic compressor failure or motor burn out:

- cleaning or flushing fluid should be contained within the confines of the system; and

- procedure must include:
    - recovery of refrigerant,
    - circulation of flushing fluid,
    - recovery of flushing fluid,
    - installation of a new compressor,
    - new suction line filter drier,
    - a leak test, and
    - evacuation and dehydration of the system.

New, recovered, recycled, or reclaimed refrigerant is then charged back into the system for circulation and final cleanup to remove trace contaminants.

Cleaning and Flushing of Large Systems. On large systems, isolate as many sections of the system as possible. Remove contaminated refrigerant to approved recovery containers. Clean each section separately, or when the system is empty, the component parts should be removed, capped off and taken off site for cleaning. The cleaning should be carried out using a non- ODS as a cleaning agent.

Passive Recovery. Passive recovery on small systems using the unit compressor and a bucket of ice is no longer an acceptable practice.

Recovery Equipment Standard. All recovery equipment should, as a minimum, meet the ARI 740-93 standard or other standards or guidelines recommended by federal/provincial agencies, as amended or updated from time to time, for extraction efficiency (see Appendix A).

System Dehydration. After the cleaning operation is complete, the major component parts should be reassembled into the system with the new compressor. The system should be drawn into a deep evacuation of 500 µm or less and the discharge from the vacuum pump recovered using the best available technologies.

2.7.4 Service Records

An up-to-date service record should be kept close to the equipment or with the owner and should be made available for inspection by the proper authorities. This should include details on leak testing and quantities charged or recovered.

2.8 Conversion of Systems to an Alternate Refrigerant

2.8.1 Alternate Refrigerant

System or equipment conversion to a refrigerant with a significantly lower, or zero ODP is one of the best ways to reduce ODS emissions. It is cheaper than equipment replacement. Ultimately all CFC equipment will have to be converted or replaced.

Owners of a large number of systems should develop a long-term strategic plan. This applies to both high pressure and low pressure equipment. Selection of suitable alternative refrigerant should be made by a qualified person. Consult refrigerant manufacturers and/or a consulting engineer.

Alternative refrigerants should be examined for effect on efficiency and capacity as well as effect on motor windings, gaskets, and seals. In addition, for flammable refrigerants or blends, check the Canadian Electrical Code, the B-52 code, CSA, and building code. Highly flammable refrigerants may require systems to be re-wired to meet explosion proof requirements.

2.8.2 Selection of Equipment

Generally, equipment for conversion should be less than 20 years old to avoid early replacement cost.

The equipment and system should first have a thorough leak test and all leaks repaired. A performance test or check should be done on the equipment. A review of the energy efficiency of old versus new may be part of the equation.

2.8.3 Prevention of Emissions and Leaks by Preplanning

Leaks can be prevented by ensuring that the system will be tight after conversion. Existing seals and gaskets should be checked to be sure they are compatible with the new refrigerant and refrigerant oil. If the system is hermetic, motor winding compatibility should also be verified. Any other plastic or elastomeric parts, such as tubing, should be checked for compatibility. The type of oil to be used should be verified so that proper system cleaning can be done before conversion.

Prevention of Emissions and Leaks During Conversion. To prevent leaks during conversion, qualified service persons with experience in equipment conversion should be used. After the system has been shut down and is at room temperature, recover all refrigerant and put it in approved recovery containers. Use approved recovery equipment. Oil in the crankcase should be heated to vaporize residual refrigerant which should be recovered. For low pressure systems the evaporator temperature can be raised using hot water.

Evacuate the system to ≤75 μm by using a vacuum pump and pass the discharge through a resin adsorption system. If necessary, flush the system in accordance with the refrigerant and equipment manufacturers' recommendations.

Dismantle the system and change any gaskets or seals, etc. as necessary. This is best done one section at a time.

It is usually best to replace any removed gaskets with new ones which are compatible with the new alternative refrigerant and oil to prevent leaks.

Install recovery connections and valves where required (one per section) and then do a second low vacuum leak check. If the system is leaking, check all joints, valves, and connections and tighten as required, until the unit is leak free.

Slowly add refrigerant, to pressurize the system, one section at a time. Leak check each section with an electronic leak detector before proceeding to the next. If there is a leak in any section recover all the refrigerant and repair the leak before proceeding.

Once the system has been fully charged with the correct amount of refrigerant and oil, run the system for the recommended time and do another leak check. The weight of the old refrigerant recovered should be logged.

The used refrigerant should be retained for other systems or returned to the supplier for a credit, (see Section 2.9). Re-label the system to indicate the amount and type of both new refrigerant and oil. Recheck for leaks after 24 to 48 hours operating time.

2.8.4 Equipment Replacement

Equipment replacement is available when the previous CFC equipment is no longer serviceable or has outlived its useful life. Suitable long-term alternative replacement refrigerants would be the logical choice for the new equipment.

2.9 Recovery, Reuse, and Disposal of Refrigerants

2.9.1 Venting

Venting of any refrigerant, other than water, to the atmosphere during manufacturing, installation, operating or servicing should be prevented by practicing due diligence and the recovery, recycling and reuse of refrigerant. Owners are responsible for the maintenance, operation, and security of their equipment - as well as ensuring operators are adequately trained.

2.9.2 Performance Testing

When refrigerant is used in performance testing of units or systems in both development and production operations only Transport Canada approved recovery cylinders can be used to capture refrigerant that would otherwise escape to the atmosphere.

2.9.3 Installation and Servicing

Manufacturers may use auxiliary receivers or specially approved "ton tanks" to recover larger quantities of refrigerant from refrigeration and air conditioning equipment to facilitate the reuse of the refrigerant charge following servicing.

Small Self-contained Systems. In smaller capacity equipment it is not always feasible to fit receivers and provide pump-down capability for technical and economic reasons. In such cases only approved recovery cylinders or approved refrigerant drums for low pressure recovered refrigerants may be used for the storage of recovered refrigerants as temporary receivers, for reuse of all or part of the refrigerant charge.

Cylinder Hazards. Hazards may arise in the use of refrigerant containers as storage vessels. A refrigerant container is a pressure vessel if its capacity is greater than 28.32 L (1 ft^3).

All approved containers should be designed to meet the Canadian Transport Commission (CTC) specification. The design maximum working pressure should not be exceeded in any filling operation, however temporary. An approved container should not be filled to more than 80% of its normal refrigerant capacity, when used for recovered refrigerant.

Cylinder Specifications Under the *Transportation of Dangerous Goods Act* (TDGA). All cylinders must meet the appropriate specifications listed in the *Transportation of Dangerous Goods Act*. All cylinders should be properly labelled as to content and weight, as required under TDGA with the appropriate *Workplace and Health Material Information System* (WHMIS) language and labelling. The design specifications and pressure rating should be stamped on the cylinder.

Refrigerant/Oil Mixtures. Refrigerant/oil mixtures have a lower density than refrigerant alone, and so, the weight carrying capacity of refrigerant containers will be reduced for refrigerant/oil mixtures compared to pure refrigerants.

Filling Approved Recovery Cylinders. Never store cylinders near any source of heat or where temperatures could exceed 51.7°C (125°F). Approved cylinders should only be filled to 80% of their fill capacity by weight for normal ambient temperatures of around 21°C (70°F) and should not be filled beyond 60% if the temperatures could reach 48.9°C (120°F).

Corrosion may occur if contaminated refrigerant is decanted into a refrigerant container.

Container Belonging to a Third Party. If a refrigerant container belonging to a third party (e.g., a refrigerant manufacturer), is to be used as a temporary receiver, written permission of the owner of the container must be obtained in advance.

Recovery Cylinders. Recovery cylinders (have a broad yellow band and ASHRAE designated colour) must be inspected and hydrostatically retested every five years by the owner. Virgin cylinders usually only have a one-way valve and cannot be used to store recovered refrigerant, because they should not be contaminated.

2.9.4 Recovered Refrigerant, Reuse, and Disposal

Refrigerant removed from working equipment must be recovered, reused, and recycled by the service person or sent to the supplier for reclaim or disposal. Alternatively, it may be sent to an independent reclaimer or to a licensed disposal facility.

A recovery unit does not bring refrigerant to a new level of purity. The refrigerant should only be returned to the same refrigerant system or a similar system of the same owner. If the refrigerant is to be used elsewhere, only recycling equipment meeting the ARI 740-93 and ARI 700 standard, latest edition or other standards or guidelines recommended by federal/ provincial agencies, is acceptable to ensure that Original Equipment Manufacturer (OEM) equipment warranties within the industry are valid (see Appendix A).

A service person or equipment owner/operator who recycles a refrigerant using his/her own equipment should ensure that the equipment is intended for the type of refrigerant being processed, and that it will clean the refrigerant to meet the industry recognized standards. Recycling machines must meet the ARI 740-93 and ARI 700, latest edition, Purity Standard; or other standards or guidelines recommended by federal/provincial agencies, if OEM equipment warranties are to be valid.

An external agency that recycles or reclaims used refrigerants should ensure that the equipment it uses is functioning properly and the recycled or reclaimed refrigerant meets at least the recognized industry standards (ARI 700; should be verified by laboratory analysis) (see Appendix A). If facilities are available, refrigerant that cannot be reused should be returned to the refrigerant manufacturer to be destroyed or reclaimed by an approved facility.

2.10 Handling and Storage of Refrigerants

Refrigerant can be lost to the atmosphere during the handling and storage of refrigerant containers. Some sources of emissions are faulty valves, pin-hole leaks, and improper closing of bungs and valves on drums.

Refrigerant Storage. Refrigerant containers should be stored in a cool dry place, away from risk of fire, and sources of direct heat. Areas where large quantities of refrigerant containers are stored should be monitored.

Refillable Refrigerant Containers. Effective on the date of publication of this document, only refillable refrigerant containers should be filled in Canada or imported into Canada by those who are registered to import refrigerants under the *Canadian Environmental Protection Act* (CEPA).

Pressure Testing of Hoses and Equipment. Hoses and gauges should be pressure tested to prevent refrigerant emissions to the atmosphere. Dry nitrogen should be used to pressure test the hoses and gauge manifold for leaks at regular intervals before they are attached to a system.

Charging Lines. Charging lines should be as short as possible and fitted with either back check valves or an isolation valve within 15 to 30 cm (6 to 12") of the end of the charging lines.

Refrigerant Transferred. Refrigerant transferred to a sealed system should be metered by either weight or volume using approved weigh scales or a volumetric charging device. The use of quick disconnect fittings having one-way valves is strongly recommended.

Charging Cylinders. Charging cylinders may be used to charge or recharge air conditioning or refrigeration systems and should not be used as storage vessels to transport new, used, recycled, or reclaimed refrigerant from the shop to the job site.

Refrigerant Container Handling. Containers should be handled carefully and not dropped to prevent mechanical damage to the container and its valve. When not in use, container valves should be closed, and the valve outlet cover nut or cap screwed on.

Refrigerant containers should not be manifolded together if there is a possibility of temperature differences existing between them, since this will result in refrigerant transfer and the danger of overfilling the coldest container. Where containers are manifolded together, care should be taken that all containers are the same height to avoid gravity transfer between containers. These items constitute safety hazards as well as sources of leaks.

Refrigerant Transfer Between Containers. Refrigerant should be carried out in a way that is safe and will prevent any chances of release or over-filling when refrigerant is transferred from one container to another.

A pump and weight scale should always be used. Establish a pressure differential between the containers using a pump or by heating of discharging container under controlled conditions. Heating of the discharge container must be of an indirect method (warm water or forced warm air) to a maximum 49°C (120°F). Under no circumstances should direct heating of any type be used, with the exception of plug-in charging cylinders (dial-a-charge).

The maximum carrying capacity, when filling refrigerant containers, is a function of the internal volume of the container and the liquid density of the refrigerant at a reference temperature.

Service personnel removing refrigerant for recovery have no practical way of determining the density of a given refrigerant charge. (Under ideal room conditions (21°C or 72°F).) A good rule of thumb is to not exceed 80% of the maximum net weight capacity as stamped on the upper portion of the cylinder. The receiving container should be on a portable scale to ensure over-filling does not occur.

2.11 Records

Up-to-date records should be kept detailing the transfer refrigerants by type and quantity, between various containers and refrigeration systems.

Accurate records of the contents of refrigerant storage containers (type, quantity, transfer in, transfer out) should also be kept. Be sure cylinders are properly labelled as to the content and weight.

It is prudent to practice due diligence by keeping proper records and getting the best information available in handling refrigerants. Some provinces require that annual records be maintained and consumptions reported. Some provinces also require that emissions or spills over a certain weight, usually 10 kg (22 lb) be reported to the local authorities.

Recommendation: It is recommended that annual consumption records of all refrigerants [including spillage of 10 kg (22 lb) or more] be maintained for a minimum of three years. Corrective actions taken as a result of spills should be documented. All releases or spills of 10 kg (22 lb) or more should be reported to the authority having jurisdiction.

2.12 Disposal of Equipment

As soon as the decision to retire equipment containing a refrigerant has been taken, the owner should arrange for full pump down of both refrigerant and oil. The equipment should then be labelled as containing no refrigerant, by a certified service technician.

2.12.1 Decommissioning

Decommissioning of working equipment or mothballing of equipment that may be required for future use should include:

- removal of all refrigerant into approved recovery approved containers for retention, or returned to the supplier or manufacturer for reclaiming;
- charging of the closed loop with dry nitrogen to help prevent contamination of the system; and
- inspection of the equipment at regular intervals to ensure that adequate pressures are maintained, to prevent contamination.

2.12.2 Decommissioning of Smaller Equipment

Equipment or systems should be properly labelled to indicate they are empty. In some provinces, a 5-cm green or yellow label is attached to decommissioned equipment with the service person's certification number on it. This policy should be adopted across Canada by January 1, 1997. Smaller air conditioning and refrigeration equipment should be stored inside heated building, be certified leak free and inspected annually by a properly trained certified person. The equipment owner should have the refrigerant removed and stored in approved cylinders if the owner intends to keep the unit in a decommissioned state for more than four months.

2.12.3 Receiver Condenser

The refrigerant charge on larger equipment should be pumped down and isolated in the receiver or receiver condenser storage, providing valves are holding and there is a pressure relief device to protect the vessel in accordance with the appropriate code requirements.

2.12.4 Equipment Disposal

Refrigerant and oil must be recovered from equipment before disposal. The owner or a representative should be able to show proof that the guideline or provincial regulation has been satisfied by presenting a copy of the completed work order to the metal shredder or the land fill operator before the equipment is removed for disposal . Appendix B shows a sample of a label that can be used to identify equipment that is refrigerant free. Oil must also be recovered and properly disposed of.

Building Demolition. The owner (or representative) of a building containing equipment which used refrigerants for its operation should show proof that the appropriate guideline or provincial regulation has been followed before demolition. In some cases, the local "permit for destruction" or demolition may already ask if the building contains refrigeration or air conditioning equipment. Only those persons who have been properly trained in the safe handling of refrigerants may recover the refrigerant. Residual oil must also be recovered for disposal or recycling.

2.13 Environmental Awareness Training

Environment Canada, provincial, and territorial authorities have recognized two environmental awareness training courses. The Environment Canada course was developed to provide consistent understanding of the environmental issues of ozone depletion and pollution prevention as it pertains to the Air Conditioning and Refrigeration Industry.

2.13.1 Training of Individuals Handling CFCs, HCFCs and HFCs

There is a general need for continuing the delivery of environmental awareness training programs. To provide consistent training nationally, large companies, trade associations, labour organizations, community colleges, and other provincially recognized learning institutions across Canada have developed curricula which include environmental awareness training programs.

2.13.2 Environmental Awareness Card and Certification

The Provincial Ministers of Labour and Ministers of Education are responsible for TRADE QUALIFICATIONS. The Ministers of the Environment are concerned about pollution prevention and refrigerant emissions to the atmosphere.

The Environmental Awareness Card is issued on behalf of Provincial Ministers of the Environment to all service persons who have taken an environmental awareness course in accordance with the applicable provincial regulations. This card should be carried at all times and is required to purchase refrigerant in most provinces.

The card is not a Trade Qualification Certificate (or permit) and does not allow those persons not permitted by other regulations, to work in the refrigeration or air conditioning trade.

2.13.3 Standardized Training of (Apprentice) Service and Repair Persons

A number of provinces have adopted the environmental awareness training program as a course component of their provincial trade school training programs.

Residential Systems and Domestic Appliances

3.1 Types of Systems

Residential systems include central air conditioning or split systems under 17.6 kW (5 tR) of capacity, window air conditioners, heat pumps, and central dehumidifiers.

The general principles which underlie Section 2, Commercial/Industrial Systems, are also applicable to residential systems.

Appliances includes plug-in residential refrigerators, freezers, window air conditioners, and dehumidifiers. Appliances are generally very reliable systems but proper procedures in manufacturing and refrigerant recovery are essential.

3.2 Equipment and Systems Design

3.2.1 Compressor

To prevent leaks and emissions, the compressor should be mounted on the unit's frame in such a way as to prevent vibration and stress on connecting tubing. The compressor should be accessible and removable for leak testing and repairs.

3.2.2 Isolating Valves

Isolating valves should be provided to permit compressor removal and replacement without losing the refrigerant charge. A suitable permanent valve for a recovery connection should be provided on all appliances.

3.2.3 Condensers and Evaporators

Condensers and evaporator coils should be designed and mounted in a way that will prevent vibration. Only welded non pre-charged line sets should be used to attach the evaporator and the condensing unit together. Quick connects are not a dependable leak-free permanent connection and as such their use (except for temporary use) should be discontinued by January 1, 1996.

3.3 Equipment Manufacturing

The equipment manufacturing process should verify that systems are leak-free before charging with refrigerant. The reuse of trace gas mixtures used for leak testing systems should be implemented.

Fugitive emissions should be captured using the best available technologies from the evacuation and dehydration process.

Isolation valves should be used to isolate the compressor, condenser, and evaporator on larger residential systems. All systems should have access valves for the recovery of refrigerants.

3.3.1 Elimination of Emissions in Manufacturing

Elimination of emissions should be established by:

- verifying the system is leak-free before charging with refrigerant;
- leak testing after run-in;
- checking the carton for damage before shipment; and
- checking the carton for refrigerant leakage.

The unit may be repaired and recharged using the original name plate sticker. If a depot or retail store finds a refrigerant shortage, they should leak test the unit and apply a repair sticker indicating the sealed system has been opened.

3.3.2 Cleanliness of Systems

Systems should be absolutely clean to reduce the risk of refrigerant contamination. Key personnel should be conversant with refrigerant technology and familiar with all aspects of the manufacturing process, especially those related to emission prevention.

3.3.3 Labels

Labels on equipment are essential to prevent accidental addition of improper oils or refrigerants during servicing. Labels should be permanent and displayed prominently. Information should include:

- equipment manufacturer,
- refrigerant type CFC, HCFC, HFC, or blend,
- ASHRAE Refrigerant Number,
- ASHRAE Safety Designation,
- refrigerant quantity,
- refrigerant oil type, quantity, and viscosity,
- ozone-depleting potential, and
- global warming potential.

See Appendix B for examples.

3.4 Installation and Servicing

3.4.1 General Servicing

All service persons should have an environmental awareness course card. Installation and Servicing personnel should be qualified and knowledgeable about the equipment they are servicing or installing. Proper location and installation procedures are important.

Equipment should be located so that leak testing and maintenance are not impeded.

3.4.2 Bolt-on Access Valves

Bolt-on access valves cannot be used other than as a tool that must be removed before the service person leaves the job site, or the repair shop. These valves may be used to evacuate systems before disposal.

3.4.3 Leak Testing and Repair

The following procedures are recommended and approved before repairing leaks and replacing components in systems.

- Verification that the unit is genuinely short of charge, before opening the closed loop.

- The system should be thoroughly leak checked before and after servicing, using the best available technology, e.g., an electronic leak detector, capable of detecting leakage rates of less than 14 g (0.5 oz) per year. If a leak is found, the unit should be evacuated and repaired.

- Leak testing using ODS and releasing them to the atmosphere is an unacceptable practice and is illegal in most provinces.

- In the case of an non-repairable leak, the refrigerant should be recovered and the owner should dispose of the equipment in accordance with the appropriate Municipal By-laws or provincial regulations. All refrigerant and oil should be recovered.

NOTE: Charging cylinders are tools and not approved storage vessels and cannot be used to store or transport refrigerant.

If there is a repairable leak, the following procedures are recommended:

- The service person will attach an access entry valve if necessary, and evacuate the system.

NOTE: Do not use ODS for the leak test.

- A permanent access entry valve is brazed onto the refrigeration system before the closed loop is punctured. This should be done in accordance with CEASA procedures.

- Small systems will then be sweep charged using the appropriate CEASA procedure.

- After a leak testing and repair, the sweep charge is recovered.

- The unit is recharged to the proper operating level.

The following alternate methods are recommended for larger equipments:

1. Standing Vacuum test 75 μm for 15 minutes. The system is then repaired and recharged.
2. Standing pressure test at 1034 kPag (150 psig) of dry nitrogen for 24 hours. The system is then repaired and recharged.

The unit should be isolated to contain the refrigerant or have the refrigerant recovered until the service is completed when repairing leaks and replacing components on residential systems. Leak repair of a residential split system, usually entails removing a maximum of four to five pounds of refrigerant which should be recovered for reuse. Epoxy should not be used to repair leaks, as it may fail or loosen after several months service. Brazing or welding is preferred.

3.4.4 Recovery, Reuse, Recycling, and Reclamation

Recovery, reuse, recycling, reclamation of refrigerant is the only acceptable practice today. Venting of refrigerant into the atmosphere during manufacturing, installation, or servicing is unacceptable. Typical and nontraditional recovery systems such as resin adsorption technology are now available to recover refrigerant.

Refrigerant Recovery. There are three acceptable methods of recovering refrigerants from residential systems and appliances.

1) The Active Recovery Method (recovery machine and an approved recovery cylinder). Typical active recovery equipment consists of two basic types. Type one is capable of refrigerant recovery only. The quality of the refrigerant removed for reuse or storage is exactly the same as was in the system being emptied.

   The second type of equipment (recovery/recycle) not only recovers refrigerants similar to type one, but also improves the refrigerant quality by removing particulate matter, moisture, and refrigerant oil. The material stored or returned to the system is of superior quality to that removed by type 1.

2) The Passive Recovery Method uses a specially designed approved plastic recovery bag (for domestic refrigerators and freezers only). The bag has been approved to recover 672 g (24 oz) of R-12 or R-500, or 560 g (20 oz) of R-22 or R-134a and is reusable and recyclable.

   The recovered refrigerant is then transferred to an approved recovery cylinder for reclaiming back at the shop.

3) The Adsorption Recovery Method uses resin in a cylinder. The cylinder is then sent back to the supplier to have the refrigerant reclaimed. Because this cylinder is not under pressure it can be transported without special labelling under the *Transportation of Dangerous Goods Act*.

Standards for Recycled Refrigerants. Service organizations should ensure that the recycled refrigerant quality meets the appropriate industry standard of purity, unless the refrigerant is being returned to the same system.

Recycling Equipment Maintenance. Follow the recovery/recycling equipment manufacturers' maintenance instructions using the prescribed filter and cleanup procedures. This equipment service includes such things as emptying oil containers, changing compressor oil, changing filters and dryers, checking equipment and hoses for leaks. This will ensure that the level of quality of final recycled refrigerant is in accordance with the equipment manufacturers' certified claim.

3.5 Refrigerant Cylinders

3.5.1 Approved Refrigerant Container

The designed maximum working pressure and carrying capacity of the refrigerant recovery container should not be exceeded. The working pressure is stamped on the cylinder.
A nonpressurized refrigerant recovery container such as the molecular sieve or resin adsorption container are approved by Transport Canada. These containers are not pressure cylinders. Disposable cylinders should not be used. Low pressure refrigerants are normally shipped in drums which may be returnable or nonreturnable.

3.5.2 Refrigerant/Oil Mixtures

Refrigerant/oil mixtures have a lower density than refrigerant alone. Fill refrigerant recovery containers with mixture only to 80% by weight of the allowable pure refrigerant weight.

3.5.3 Contaminated Refrigerant

If contaminated refrigerant is decanted into a refrigerant container, corrosion may occur. This container should be sent to the reclaimer or disposed of as hazardous waste as soon as possible.

3.5.4 Refrigerant Container Belonging to a Third Party

Refer to Section 2.9.3 of this report.

3.5.5 Cross-contamination of Refrigerant

Mixing of different refrigerants should be avoided. The receiving container should have been used previously only for the refrigerant that is being transferred into it.

3.6 Conversion of Systems to Alternate Refrigerants

In future it will become necessary to convert some CFC systems to alternate refrigerants. This is environmentally desirable as the alternates have very low, or zero ODP values.

3.6.1 Basics of Conversion

The basic principles for conversion are the same as those for commercial equipment described in Section 2.8.1.

Ensure the new refrigerant has a zero or very low ODP and is thermodynamically efficient. It is also important that it is compatible with all system components and parts, including the lubricant oil. Parts that are not compatible must be replaced.

3.6.2 Recommended Procedure

Remove all refrigerant using recovery/recycling equipment and put recovered refrigerant in an approved recovery container.

Warm the system with indirect heat to recover refrigerant from oil, then remove oil. Flush system if necessary using procedures recommended by the manufacturer. Change components as necessary. Reassemble the system and evacuate to 75 µm. If there are any leaks use an approved tracer gas and an electronic leak detector.

After the system is leak free, recharge with the new refrigerant and recommended oil. Recheck for leaks. Operate systems for 4 to 8 hours and recheck for leaks.

3.6.3 Surplus Used Refrigerant

Used refrigerant should be returned to the supplier or manufacturer for credit, reclamation, or disposal or it should be sent to an independent reclamation centre. Reclaimed material should meet or exceed ARI-700 purity standards for refrigerant to be reused (see Appendix A).

3.7 Handling of Used Refrigerant

Refrigerant removed from working equipment may be:

- reused,
- recycled,
- reclaimed and returned to the supplier, or
- disposed of as hazardous waste.

Ensure that recycling equipment is intended for the type of refrigerant being processed and will clean the refrigerant to meet prescribed specifications, i.e., ARI 700 latest edition. Refrigerant that cannot meet the prescribed purity specifications must be returned to the supplier for reclamation or disposal using environmentally acceptable methods of destruction.

3.7.1 External Agencies

An external agency that reclaims used refrigerants should ensure that the equipment it uses is functioning properly and the reclaimed refrigerant meets the prescribed purity specifications as defined in ARI 700 latest edition (verified by laboratory analysis).

3.7.2 Destruction Facilities

Facilities are presently available with limited capability to destroy mixtures of refrigerant that cannot be reused, recycled, or reclaimed. These mixtures should be returned to the manufacturer.

Refrigerant that has been contaminated by foreign or toxic materials (excluding oil) must be sent to a hazardous waste disposal centre.

3.8 Disposal of Appliances Containing Refrigerants

The disposal of appliances that contain refrigerant should be handled with care and brought to a pre-assigned site for the recovery of the refrigerant and oil.

Alternatively, have the refrigerant removed first, depending on the Provincial regulations. Equipment should be labelled indicating that all CFC/HCFC/HFC has been removed.

Mobile Air Conditioners (Automobiles)

The basic principles which underlie Sections 2 and 3 of this report can also be applied to mobile air conditioning.

The operation, service, and repair of mobile air conditioning systems is one of the major sources of ODS emissions.

With the new focus of pollution prevention and elimination of refrigerant emissions into the atmosphere, the automobile industry should address these concerns. Systems should be designed in such a way that they do not leak. New improved technologies such as hermetic compressors attached with leak-proof tubing or hoses, leak-proof seals, and access fittings should be assessed.

Automobile manufacturing, distribution, and service industries should incorporate product stewardship into their corporate policies, if not already present.

4.1 Design

Manufacturers should ensure that the design of mobile air conditioners includes a series of proven features, such as the following, that will eliminate refrigerant loss into the atmosphere.

- anti-vibration mountings;
- heavy-duty clamps;
- near zero permeability, temperature resistance hoses;
- high pressure screwed or compression fittings; and
- access connection for recovery/service.

With the use of alternate refrigerants or interim refrigerants, it is essential that zero permeability hoses be used.

4.2 Manufacture

4.2.1 Cleanliness

The system should be absolutely clean to reduce the risk of contamination of refrigerant or compressor damage, thus eliminating the need for subsequent recharging. Supervisory personnel should be conversant with refrigerant technology and familiar with all aspects of the manufacturing process, especially emission elimination procedures and refrigerant recovery.

4.2.2 Discharge Evacuation

Discharge evacuation valves should be fitted to the suction and discharge sides of the air conditioning system to assist in the servicing and maintenance of the installation.

4.2.3 Leak Testing

Leak Testing for mobile use, using the refrigerant as the test gas in accordance with SAE J1627 and J1628 (see Appendix A) is acceptable provided that:

- visual inspection indicates no signs of oil deposits from a large leak or any other obvious physical damage;
- all refrigerant from the test must be recovered immediately following the test, if there is a leak.

4.2.4 Fluorescent Dyes

Original Equipment Manufacturers (OEMs) should use fluorescent dyes or other proven technology in new manufactured or imported vehicles commencing on or before January 1, 1998.

4.3 Servicing

4.3.1 Venting

Venting refrigerants to the atmosphere during servicing operations must be eliminated by the use of recovery equipment and the subsequent reuse, recycling, and reclamation of the refrigerant.

4.3.2 Container Size

Federal regulation requires that "No refrigerant will be sold in containers of 10 kg (22 lb) or less". The disposable containers should not be used. Only refillable approved containers should be used.

4.3.3 Equipment Conversion

After January 1, 2000, automotive air conditioning systems should not be recharged with CFC-12. Equipment conversion of mobile air conditioning systems will become necessary after this date.

Alternative Refrigerant. HFC-134a is the choice supported by the OEMs at present for the alternatives to CFC-12.

Manufacturers should have conversion kits for most late models cars or vehicles under warranty.

Use of HFC-134a. Avoid leaks and emissions by following the manufacturers instructions EXACTLY. Do not omit any steps. In addition:

- recover all the existing CFC-12 and store it in an approved recovery container. Refer to the manufacturers' instructions for your specific make and model;
- change all required parts using the correct kit; leak test the system to ensure there are no leaks using an electronic leak detector; repair any leaks as necessary;
- charge the correct amount of HFC-134a refrigerant and the recommended oil;
- the system should be operated and leak checked again; and

- recycle or reclaim the used CFC-12 and retain for servicing other older vehicles or for reclamation. **Relabel** under the hood, stating the type of refrigerant and quantity charged as well as type of oil and quantity charged and the date. (see Appendix B).

Automotive Blends. There are several automotive blends available. Use caution in selecting the one to be used. Blends are not recommended or supported by the automotive manufacturer. These blends should not contain a CFC ozone-depleting substance and should have service fittings unique from R-12 or R-134a, to avoid contamination in the vehicle system or in the recovered material. In the United States, some states have banned the use of highly flammable blends.

- The use of all blends should be consistent with requirements and standards of the SAE or EPA.

- Some blends may contain hydrocarbons which may attack hoses or gaskets designed for fluorocarbons. This should be confirmed, before retrofitting.

- The density of the blend may be different than CFC-12 so the quantity may have to be adjusted to ensure proper operation.

- The label, which should be applied under the hood, should give the ASHRAE number of the blend and clearly identify if it is flammable.

- Confirm if the oil needs to be changed or not.

- Information on performance of blends including safety and compatibility should be verified by the manufacturer or supplier and be available in a published format.

- Recovery/Recycle equipment should be suitable for the specific refrigerant or blend being recovered. Recovery equipment fittings should be different from those used for R-12 or R-134a and consistent with of the vehicle.

- Relabel under the hood.

4.4 Handling of Refrigerant in Automobiles Slated for Wrecking

It is essential that all refrigerant in the air conditioning system be removed, and oil collected according to local regulations before the car is wrecked or scrapped. The dealer or wrecker should use a certified service person trained in the safe handling of refrigerants, to remove the refrigerant. The refrigerant should be recovered for recycling, reclaiming or disposal of as a hazardous waste. Oil should be sent to the reclaim facilities or disposed of in accordance with the local regulation. Containers should be properly labelled, including ASHRAE refrigerant number.

4.5Training of Personnel

Service personnel should be fully trained in leak test procedures for mobile air conditioning refrigeration equipment and possess an environmental awareness course certificate.

4.6 Records

Active service organizations must maintain up-to-date records of receipts, shipments, inventory levels of new, used, and recycled refrigerant (e.g., CFC, HCFC, HFC, other and ASHRAE designated blends).

Some provinces require that accidental and intentional releases of refrigerants be reported to the provincial authority.

All refrigerants must be removed before parts are shredded or salvaged.

It is unlawful in some provinces to sell new or used components from the closed loop side of the mobile air conditioning system to people who are not certified in the safe handling of refrigerants. To ensure that only trained certified service/repair persons are purchasing new or used components for or from the closed loop side of the system, the service/repair person's certification number should be on the bill of sale.

Some provinces recognize businesses as corporate persons and issue Secondary Distribution Certificates for larger companies that assume the same responsibilities as service persons for the care and safe keeping of refrigerant and components.

Mobile Refrigeration

The general principles found in Sections 2, 3, and 4 Commercial/Industrial, Residential Systems and Domestic Appliance and Mobile Air Conditioners (Automobiles) are also applicable to the Mobile Refrigeration section.

The scope of this section includes refrigerated transport trucks, trailers, refrigerated rail cars, intermodal containers, ships, and air transport.

5.1 Design

The equipment manufacturer should ensure that the design of mobile refrigeration units incorporates a series of proven features that will eliminate emissions to the atmosphere and minimize servicing.

5.1.1 Compressors

Compressors generally do not leak from design faults, but rather due to installation, vibration, and contamination.

Mobile refrigeration design should incorporate a high degree of physical protection of associated equipment attached to the compressor, e.g., gauge and cutout connections, oil return, oil drain, oil level sight glass, relief valve, condensing coils, and connecting pipe work. The physical environment that mobile refrigeration equipment must operate in is much more severe than for fixed systems like those found in buildings. It is essential that there is good access for cleaning.

Mechanical Seals (Open Drive). The unique environmental, geographic, and extreme hot and cold temperature conditions that mobile refrigeration equipment is subjected to can damage mechanical seals and compressors. Adequate protection should be provided to prevent leaks and emissions.

Mechanical Shaft Seals. There are several factors that can lead to the premature failure of mechanical seals and result in leakage, such as the exposure of refrigerant and oil mixtures to various contaminants, and physical factors as previously mentioned.

High Head Pressure. High head pressure is caused by high [37 °C (98.6°F)] outside ambient air temperatures, air in the system and/or condenser coils blocked with bugs, fluff, dirt, and debris. Higher than normal operating pressure can cause leaks, emissions, and premature equipment failure. In addition, the presence of air and moisture can cause acid generation and oil breakdown that can lead to premature equipment failure and refrigerant leakage.

Design features should include a method to alert the operator of potential problems before they occur, so that corrective actions can be taken before failure.
Seal Design. New replacement refrigerants and their oils have little or no ability to tolerate

moisture.

Double-faced mechanical seals and single-carbon seals with improved features that keep the carbon in a oil-coated state help prevent leakage.

The mechanical shaft seal design should minimize oil seepage and work towards eliminating external refrigerant loss.

On larger systems, separate oil pumps are recommended to lubricate the seal before startup. On smaller open compressor refrigerant systems without an auxiliary oil pump, the lack of lubrication on shutdown can cause the faces of the seal to stick together. Subsequent damage on the next startup can be prevented by rotating the shaft by hand and lubricating the seal.

Vibration. Vibration stress leaks can be minimized by using:

- antivibration mountings,
- heavy-duty insulated clamps,
- proper maintenance to eliminate vibration,
- metal braided vibration eliminators between fixed piping and components that are subjected to movement, and
- a minimum number of soldered joints to reduce potential leaks.

Mobile Refrigeration Design Features. Design features should include:

- operator-friendly control panels with self-diagnostic abilities;
- self-reseating pressure-relief valves vented to the outside;
- the use of adequate isolation valves and access fittings to facilitate maintenance, repair, recovery, and recycling of refrigerant.

5.1.2 Condensers on Ships

The condensers found on ships are the same as those found in commercial and industrial applications. To prevent fouling and scaling of the primary refrigeration condenser, a secondary heat exchanger is used which uses sea water to absorb the heat being rejected and to cool the refrigerant condenser cooling water. Sacrificial anodes should be placed in the sea water heat exchanger to help prevent corrosion. Use of resistance alloys is also recommended. Both the condenser and the heat exchanger should incorporate designs to allow easy cleaning and maintenance.

Water Velocity. Excessive water velocity through the tubes of shell-and-tube units can cause vibration or erosion failures, and should be avoided.

Water Conditions. Proper water treatment and filtration will help minimize effects of corrosion or erosion that can cause failures too.

5.1.3 Pipelines and Connections

All pipelines should be designed so that the number of joints are minimal. Welded or flanged piping and fittings are preferred over screw connections.

5.2 Servicing

5.2.1 Planned Preventative Maintenance

Particulate matter and other types of soiled materials (contaminants) can damage the refrigeration system and lead to leaks by allowing moisture into the system, resulting in contamination of refrigerant and oils.

Planned preventative maintenance is the key to minimizing breakdowns, down time, and increasing overall dependability. This is very important when at sea or on the road. System cleaning is a very important part of planned maintenance.

5.2.2 Regular Planned Preventative Inspections

Refrigerated transport should incorporate regularly planned preventative maintenance inspections into its vehicle maintenance safety inspection program.

As the production and importation of CFC is phased out, it is essential to have a leak-free system to avoid shut down due to lack of refrigerant, expenditure for retrofitting existing equipment, and possible premature capital for new equipment using alternative refrigerant.

Only trained qualified certified service persons using the manufacturers service check sheets and service procedures can ensure that the unit is leak-free and is operating at peak efficiency.

An annual inspection check sheet should be developed by systems owners, that can travel with the unit. This annual inspection sheet will also verify that the equipment was leak-free as of a certain day and by whom it was serviced. Any repairs that were required to bring the system up to leak-free standards should be noted.

5.3 Equipment Conversions

The principles and procedures outlined in previous sections should be followed. See Sections 2.8 and 3.6 and the following sections.

5.4 Operator Education

The vehicle or system operator should understand the basic principles of how the refrigeration system works and the normal operating parameters of the unit. Parameters may include temperatures, pressures, oil levels, sight glass inspection, and/or visual inspection of the moisture indicator.

The operator should know the basic components that make up the unit, how to start and stop the unit, and how to pump it down and isolate the refrigerant charge if necessary.

Logs of inspections should be kept with each unit. These can be invaluable in helping the service person diagnose some types of problems.

A good operator knows his/her equipment and watches for oil leaks (a sign of refrigerant leaks) on the bottom of fittings and connections.

Heavy-duty Mobile Air Conditioning Systems

Heavy-duty air conditioning applies to equipment on: subway trains, buses, trucks, rail cars, airplanes, agricultural equipment, underground mining equipment, large overhead cranes, centrifugal chillers on ocean-going ships, and any large mobile air conditioning equipment that does not fall into the categories discussed in the previous sections.

6.1 Design

The equipment manufacturer should ensure that the design of mobile air conditioning units incorporates a series of proven features that will eliminate emissions to the atmosphere. The same principles in Sections 2 to 5 apply here.

Compressors for some of the equipment using heavy-duty air conditioning such as underground scoop trams and agricultural equipment are essentially the same as large automotive compressors with longer hose runs, and in some cases, external condensing units. Some underground compressors are driven by hydraulic motors. Trains and subways tend to use large commercial semi-hermetic or belt-driven open compressors for air conditioning. Buses on the other hand, use belt-driven compressors with a mixture of copper and elastomeric hose connections.

Compressors are subject to the same problems listed in Sections 2, 3, 4, and 5.

Mechanical Seals (Open Drive). The unique environmental, geographic, and extreme hot and cold temperature conditions that mobile refrigeration equipment may be subjected to, can be damaging to the mechanical seals of compressors for large trucks, trains, agricultural equipment, etc.

Mechanical Shaft Seals. There are several factors that can lead to the premature failure of mechanical seals. Exposure of refrigerant and oil mixtures to various contaminants, the presence of rust or particulate matter, and shaft misalignment are some of the factors that cause seal failure and the resulted leaks.

High Head Pressure. High head pressure is caused by high outside ambient air temperatures, air in the system, and/or condenser coils blocked with bugs, fluff, dirt, and debris. Higher than normal operating pressure can cause leaks, emissions, and premature equipment failure. In addition, the presence of air and moisture can cause acid generation and oil breakdown that can lead to premature equipment failure and refrigerant leakage.

Design features should include a method to alert the operator of potential problems before they occur, so that corrective action can be taken.

Refrigerant Moisture Tolerance. Virtually all of the new replacement refrigerants and their respective oils have little or no ability to tolerate moisture. Every precaution should be taken to prevent moisture from entering the system.

Vibration . Vibration stress leaks should be minimized by using:

- antivibration mountings;
- heavy-duty insulated clamps;
- metal braided vibration eliminators between fixed piping and components that are subjected to movement; and
- a minimum number of soldered joints.

Protection of System. Design should provide for as much physical protection as possible without compromising accessibility**.**

6.2 Mobile Air Conditioning Design Features

6.2.1 Design Features

Desirable design features should include:

- self-reseating pressure relief valves vented to the outside of any enclosed space; and
- the use of adequate isolation valves and access fittings to facilitate maintenance, repair, recovery, and recycling of refrigerant; this will reduce service time and allow the component to be replaced or serviced without compromising the entire refrigerant charge.

6.2.2 Mobile Centrifugal Chillers

The chillers used on ocean-going ships are the same as those on land with a few exceptions. The condensers used on ships are the same as those found in commercial and industrial applications. To prevent fouling and scaling of the primary refrigeration condenser, the use of a secondary heat exchanger, which uses sea water to absorb the heat being rejected and to cool the refrigerant condenser cooling water down, should be used.

Sacrificial anodes should be placed in the salt water heat exchanger to help prevent corrosion, using the same technology as the semihermetic and reciprocating refrigeration compressors found aboard ships. Both the condenser and the heat exchanger should be designed for easy maintenance and cleaning.

6.2.3 Excessive Water Velocity

Excessive water velocity through the tubes of the shell and tube units can cause vibration or erosion failures and should be avoided. Follow manufacturers' recommendations and guidelines.

6.2.4 Condenser Water Treatment

Condenser water conditions vary widely. Proper water treatment and filtration will help minimize the effects of corrosion or erosion that can cause failures and leaks.

6.3 Pipelines and Connections

All pipelines should be designed so that the number of joints are kept to a minimum. Flared fitting joints should not be used. Welded, brazed, or flanged fittings are preferred. Use of elastomeric hoses should be minimized to eliminate diffusional leaking. Other options such as flexible metal tubing should be considered.

6.4 Planned Preventative Maintenance

Particulate matter and certain types of soils can damage the air conditioning system by allowing moisture into the system resulting in contamination of refrigerant and oils and leading to leaks.

Planned preventative maintenance is the key to minimizing breakdowns, down time, and refrigerant loss. The same information found in the previous sections apply here.

Fluorescent dye leak detection methods have been proven valuable particularly for underground scoop trams and rail coach applications.

This equipment is subjected to the most adverse physical and environmental conditions; therefore, it is imperative that units be kept clean.

Refrigerant should be removed from rail coaches and other equipment that are out of service for extended periods of time. A dry nitrogen charge should be used to keep a positive pressure in the system. The pressure is monitored during the shutdown period. When the system is reactivated, it should be evacuated and the oil changed. A vacuum pulled down to less than 500 μm is recommended before the system is recharged.

6.5 Systems Conversion to Alternate Refrigerants

Follow the principles and guidelines detailed in Sections 2.8 and 3.6, and the subsequent sections.

Strategic Planning

Those who have facilities containing CFCs should develop a strategic plan to control, and in the long run eliminate their use. A good plan should also contain the elements necessary to assess, define short- and long-term action, and to ensure financial resources are available.

7.1 Strategic Planning for Existing Facilities Containing Chlorofluorocarbons

Those who have larger or multiple facilities containing CFCs should develop containment, phaseout, conversion, and replacement strategies. A good plan should have:

- a policy statement giving direction and commitment;
- a total inventory assessment;
- an action plan;
- a financial plan; and
- an assessment and monitoring plan.

Eventually all end users will have to plan for their future needs when existing stocks of CFC refrigerants are no longer available or use is prohibited.

7.2 Goal

Elimination of all refrigerant emissions to the atmosphere and phaseout of all CFCs and other ODSs will ultimately lead to minimizing future operating disruptions.

7.3 Refrigerant Inventory and Audit

Refrigerant inventory and auditing should include the following information:

- refrigerant type - ozone-depleting potential (ODP);

- refrigerant audit:

    - refrigerant presently in use,

    - refrigerant presently in storage,

    - consumption over the past five years, estimated consumption for next five years;

- refrigeration air conditioning equipment evaluation (equipment life cycle) retrofit versus new options; and

- equipment inventory and audit:
  - model, age, type, manufacturer, and capacity.

7.4 Conservation Objective

Both short- and long-term containment is essential. Maintain equipment using the best available planned preventative technology to eliminate refrigerant emissions to the atmosphere. This will allow industry and end users time to manage the phaseout of CFC and other ODS refrigerants in an environmentally sensitive way, using sustainable development concepts and values.

7.5 Development of a Corporate Stewardship Policy

Development of a corporate ethic that is committed to sustainable pollution prevention is essential for the future. A strategic plan for orderly transition from CFC and other ODS dependence to interim and alternative refrigerants should be based on the ethic.

7.6 Establishing Priorities

Priorities should be established for the order of phaseout, retrofit, or replacement of existing CFC and other ODS refrigerant systems using the following criteria.

- First and most important, implement a containment program to ensure that all equipment leaks have been repaired.

  Base your priority to retrofit or replace your equipment by selecting from the equipment with the highest to the lowest (ODP) that has historically leaked the most over the past five years first.

  These systems should be retrofitted or replaced with systems that either use an interim or an alternative refrigerant that has the minimum possible effect on ozone layer depletion and global warming potential.

- Generally, equipment more than 15 to 20 years old should not be converted but operated until obsolete.

- Refrigerant must be recovered from equipment before its disposal. This refrigerant can be reclaimed by a third party for future use or recycled for use in the original owner's other equipment, as part of their phaseout strategy.

List of Recognized Industry Standards

1. ANSI/ASHRAE - Standard 34-1992, Number Designation and Safety Classification of Refrigerants.
2. ARI Standard 700 - Standard for Specification for Fluorocarbon Refrigerants.
3. ARI Standard 740 - 1995 Standard for Refrigeration Recovery/Recycling Equipment.
4. ARI Standard 793 - Specification for Fluorocarbon and Other Refrigerants.
5. CSA - “Boiler, Pressure Vessel, and Pressure Piping Code B51-M19xx, Public Safety”, Canadian Standard Association.
6. CSA- “Mechanical Refrigeration Code B57-M19xx Public Safety”, Canadian Standard Association.
7. SAE j 1627 - Rating Criteria for Electronic Refrigerant Leak Detectors.
8. SAE j 1628 - Technician Procedure for Using Electronic Refrigerant Leak Detector for Service of Mobile Air Conditioning Systems.
9. SAE j 1657 - Selection Criteria for Retrofit Refrigerant to Replace R-12 in Mobile Air Conditioning Systems.
10. SAE j 1658 - Alternate Refrigerant Consistency Criteria for use in Mobile Air Conditioning Systems.
11. SAE j 1661 - Procedure for Retrofitting CFC-12 (R-12) Mobile Air Conditioning Systems to HFC-134a (R-134a).
12. SAE j 1991 - Standard of Purity for use in Mobile Air Conditioning Systems.
13. SAE j 2209 - CFC-12 (R-12) Extraction Equipment for Mobile Air Conditioning Systems.
14. SAE j 2211 - Recommended Service Procedure for the Containment of HFC-134a.
15. UL Standard for Safety - Refrigerant Recovery, Recycling Equipment, 2nd Edition, 1995.

Examples of Labels

Example of a Manufacturer's Label

COMPANY
ADDRESS/PHONE
Refrigerant:
Type (CFC-HCFC-HFC)
No. (R-134a)
Quantity (113 grams 4 oz)
Oil Type Polyester
Oil Quantity (34.43 grams 1.25 oz)
ROil Viscosity (SUS)
ODP No.
GWP (100 years) -- 1300

Example of a Service Label for Conversion

COMPANY (CONTRACTOR)

ADDRESS/PHONE

Technician
Certificate No.
Expiry Date
Date of Service
Leak Test Pass ☐ Failed ☐

Type
No. (ASHRAE)
Quantity (g)
Oil (POE, POG, Mineral Oil)
Oil Quantity (g)
Oil Viscosity (SUS)
ODP No.

Technician

Example of a Service/Leak Testing Label

COMPANY

ADDRESS/PHONE

Technician
Certificate No.
Expiry Date
Date of Service
Leak Test Pass ☐ Failed ☐

Technician

Example of a Label for Refrigerant-free Units/Systems/Containers

Technician Certificate No. Refrigerant Type Expiry Date Oil Type Date of Service This equipment is certified to be refrigerant and oil free. ______________________________ Technician

Example of an Automobile Retrofit Label

NOTICE: RETROFITTED TO R-134a RETROFIT PROCEDURE PERFORMED TO SAE J1661 USE ONLY R-134a REFRIGERANT AND SYNTHETIC OIL TYPE: ____________________ PN: ____________________ OR EQUIVALENT, OR A/C SYSTEM WILL BE DAMAGED. REFRIGERANT CHARGE/AMOUNT : _______________________ LUBRICANT AMOUNT: _______________ PAG ☐ ESTER ☐ Retrofitter Name: ______________________ Date: _____________ Address: ____ City: ____________________ Province: ____________ Postal Code: _______ Part Number: 21030867 DO NOT REMOVE