Environment Canada Environnement Canada

# Draft Environmental Code of Practice

*for*

## Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems

Canada

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## *for*

## Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems

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Environment Canada

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# BACKGROUND

In 1987, Canada signed an international multilateral environmental treaty, the *Montreal Protocol on Substances that Deplete the Ozone Layer* (Montreal Protocol). The Montreal Protocol has universal participation, having been signed and ratified by 196 countries. Under the Montreal Protocol, parties have been phasing out the production and consumption of a wide range of chemicals that are known to contribute to ozone depletion, including chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). The phase-out of these ozone-depleting substances (ODSs) has resulted in an increase in the use of halocarbon alternative substances such as hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), which are now known to be potent greenhouse gases (GHGs).

At the federal level, Canada controls the production, import, export, sale, offer for sale and certain uses of ODSs through the provisions of the *Ozone-depleting Substances Regulations, 1999*. While the production and importation of virgin ODSs are controlled and largely phased out, sizeable volumes continue to exist in equipment such as large commercial building chillers, domestic appliances and mobile air conditioning. The federal government enacted the *Federal Halocarbon Regulations, 2003* to reduce the emissions of refrigerants at federal facilities and on federal and Aboriginal lands. At the provincial and territorial level, there is legislation applicable to all sectors to prevent the release of ODSs, as well as addressing the recovery of refrigerants during servicing and the reuse of refrigerants. Moreover, there are many Standards relating to the design, operation, maintenance and decommissioning of refrigeration equipment.

The *Environmental Code of Practice for Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning* was published in 1991 to provide guidelines for the reduction of atmospheric emissions of CFCs used in air conditioning and refrigeration applications. The Code was later updated in 1996.

This current version of the Code updates the phase-out of CFCs and HCFCs, the technologies and techniques (best practices) to reduce emissions of refrigerants, and alternate means and/or refrigerants to provide cooling.[1] It also considers the global warming implications of refrigerants and their use. GHG emission reductions are not simply the result of reducing emissions in the operation and servicing of refrigerative equipment, but also the indirect result of using equipment that is more efficient and designing facilities to reduce the capacity of refrigerative equipment (and therefore reduce the volumes of refrigerants to spill). To fully appreciate and examine the efficiency of equipment, it is necessary to examine the costs of ownership (both acquisition and over the life cycle). These factors are addressed in this revised Code. In addition, due to the flammability of some newer refrigerants, more attention has been placed on safety. The focus of this Code is the responsible and safe use of refrigerants and refrigerative energy.

Other initiatives are being considered in the near future that will undoubtedly influence the direction provided in this Code. Nonetheless, passages in this Code with respect to existing and proposed non-halocarbon refrigerants such as ammonia, carbon dioxide ($CO_2$) and hydrocarbons (HC) may be useful and provide alternatives to leapfrog over HFCs in transitions from HCFCs directly to more sustainable solutions.

This Code addresses the design, installation, operation, servicing, maintenance[2] and decommissioning of cooling systems. It does not include fire-fighting halocarbons such as Halons and applications other than cooling. This Code does not replace regulations, Codes and Standards. These are to be reviewed and implemented in conjunction with this Code.

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[1] The terms “cooling” and “refrigerative” are used throughout this document to include both air conditioning and refrigeration.

[2] The term “maintenance” in this document includes preventive maintenance, repairs, overhauls and refurbishment.

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# GLOSSARY and ABBREVIATIONS

Disclaimer: This Glossary is provided for ease of reference only. There may be discrepancies with definitions provided in legislation. For a full and accurate statement of the law, refer to the applicable legislation.

## Glossary of Terms

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

Approved Cylinder – A refillable/recyclable cylinder that is Canadian Transport Commission (CTC)-approved for the specific refrigerant and is properly colour-coded for the substance it contains.

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.

Blend – A refrigerant mixture of two or more chemical compounds blended in a specific ratio, which can be separated by distillation.

Certified Person – A person who successfully completed the Environment Canada Environmental Awareness Course for the Environmentally Safe Handling of Refrigerants (previously for handling ozone-depleting substances). This is not the same as a trade certified and qualified person, nor is it intended to imply any trade qualification.

Chiller – An air conditioning system or refrigeration system that has a compressor, an evaporator and secondary refrigerant.

Chlorofluorocarbon – A fully halogenated chlorofluorocarbon, each molecule of which contains one, two or three carbon atoms and at least one atom of chlorine and one atom of fluorine. The production of chlorofluofocarbons has been phased out by the *Montreal Protocol on Substances that Deplete the Ozone Layer*, but they may continue to exist in older equipment.

Class 1 Refrigerant – Refrigerants that cool by phase change (typically boiling as found in vapour-compression systems).

Class 2 Refrigerant – Refrigerants that cool by temperature change (for example, air, brine solutions). They may be cooled by Class 1or 3 refrigerants and become a heat transfer fluid to convey this lower temperature to an area.

Class 3 Refrigerant – Refrigerants that contain absorbed vapours of liquefiable agents/refrigerating media (for example, ammonia absorption refrigeration).

Coefficient of Performance – The ratio of heating/cooling capacity in watts (W), to the power input in watts at set rating conditions. The international community uses Energy Efficiency Rating (EER) as equivalent to cooling coefficient of performance.

Condenser – Central air conditioning systems have essentially two parts: an evaporator that removes unwanted heat from the air and transfers it to a refrigerant; and a condenser that removes unwanted heat from the refrigerant and transfers that heat outdoors. The primary component of a condenser is typically the condenser coil, through which the refrigerant flows. There are essentially three types of condensers: air-cooled, water-cooled and evaporative.

Condensing Unit – The term used for the compressor and condenser assembly.

Container – A container which is intended to contain only ozone or non-ozone-depleting substances such as chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, hydrofluoro-olefins, hydrofluoroethers, natural refrigerants 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 of metal or glass.

Cooling Capacity – The cooling power of a central air conditioner. It is most commonly measured as the kW/hour or BTUs per hour of heat that the air conditioner can remove from the air. Cooling capacity may also be rated in tons (tR).

Disposable Container – A container designed to be used only once for the transportation or storage of a virgin refrigerant, such as a chlorofluorocarbon, hydrochlorofluorocarbon, hydrofluorocarbon or blends, designed in accordance with Canadian Transport Commission (CTC) specification 39 (or Department of Transportation (DOT) 39 if

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made in the USA). 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.

Energy Efficiency Rating – The ratio of the BTU/h cooling capacity (in watts) to the power input (W). The Air Conditioning and Refrigeration Institute standardized this rating, which reports central air conditioning efficiency at 80ºF indoors and 95ºF outdoors. This rating measures steady-state efficiency – that is, the efficiency of the air conditioner once it is up and running. It does not take into consideration the efficiency of the system under partial load.

Fluorocarbons – A series of fluorinated hydrocarbons with fluorine, chlorine or bromine in their molecules. Chlorofluorocarbons and hydrochlorofluorocarbons are fluorocarbons.

Global-Warming Potential – A measurement (usually over a 100-year period) of how much effect a refrigerant will have on global warming in relation to carbon dioxide, which has a GWP of 1. The lower the value of GWP, the better the refrigerant is for the environment.

Ground Loop System – A configuration of equipment that utilizes geothermal temperature gradients (i.e., the differential between ambient surface temperatures and that of deep soil, groundwater or surface water) to provide heating and cooling of a single industrial, commercial, or (multi-)residential building in a manner that significantly reduces the energy requirement for such tasks.

Halocarbons – Human-made chemical compounds including carbon and halogen atoms (fluorine, chlorine, bromine or iodine). The name commonly refers to refrigerant compounds and includes chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons and perfluorocarbons.

Hermetic Compressor – A compressor and motor that are sealed in a metal envelope, where the refrigerant can cool the motor. Overheating of the motor windings can lead to burn-out of the motor and contamination of the refrigerant, thus requiring the replacement of the complete hermetic system (motor and compressor) and refrigerant.

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 – A halogenated hydrocarbon chemical compound in which each molecule contains one, two or three carbon atoms and at least one atom of hydrogen, one atom of chlorine and one atom of fluorine. Hydrochlorofluorocarbons are less damaging to the ozone layer than chlorofluorocarbons and are considered as an interim replacement for them. While hydrochlorofluorocarbon refrigerants generally have lower ozone-depletion potentials than chlorofluorocarbons, they do still affect stratospheric ozone and generally possess significant global warming potentials, as well. Most hydrochlorofluorocarbons have been targeted for eventual phase-out by the *Montreal Protocol on Substances that Deplete the Ozone Layer*.

Hydrofluorocarbon – A hydrofluorocarbon chemical compound containing only hydrogen, fluorine and carbon atoms, used as an alternative refrigerant to replace chlorofluorocarbons and hydrochlorofluorocarbons. While hydrofluorocarbon refrigerants generally have minimal ozone-depletion potentials, they generally possess significant global-warming potentials.

Integrated Energy Efficiency Ratio – A new part-load energy efficiency descriptor. It is calculated according to the method described in 6.2 in the Air Conditioning, Heating and Refrigeration Institute (AHRI) Standard 340/360.

Large Air Conditioning and Refrigeration System – A system with a refrigerative capacity of more than 19 kW that is not a mobile system. They are usually installed systems and may have open compressors.

Mixture – A refrigerant that contains oil and contaminants including other refrigerants.

Near-Azeotrope – A chemical product that is formed by combining two or more compounds, sometimes called a NARM, whose vapour and liquid compositions are nearly identical. Near-azeotropes have a temperature glide of less than 2ºC.

Open Compressor – A compressor with which the motor drive is outside the vapour-compression refrigeration system and drives the compressor by a drive shaft with shaft seals. The motor is often air-cooled.

Ozone-Depletion Potential – A measure of the relative capability of a particular chemical to destroy ozone. The ozone-depletion potential is measured against chlorofluorocarbon CFC-11, which has an assigned potential of 1.0. Internationally accepted ozone-depletion potential values have been established by the United Nations Environment Programme. The less the value of the ozone-depletion potential, the better the refrigerant is for the ozone layer and the environment.

Ozone-Depleting Substance – A chemical compound such as a chlorofluorocarbon or a hydrochlorofluorocarbon that contains chlorine. When they escape refrigeration units, they reach the upper atmosphere (stratosphere) and break up due to ultraviolet radiation and release their chlorine atoms. The chlorine acts as a catalyst to continually break down ozone molecules until the chlorine escapes the atmosphere or binds with another type of molecule to become stable. Loss of ozone permits ultraviolet radiation to reach the earth where it damages humans, animals and plants.

Perfluorocarbon – A chemical compound containing only carbon and fluorine. They do not damage the ozone layer, which means they are not ozone-depleting substances. They do, however, have a high global-warming potential.

Reclamation – The recovery, re-processing and upgrading through processes such as filtering, drying, distilling and treating chemically in order to restore the halocarbon to industry-accepted reuse standards. This involves processing "off-site" at a re-processing or a refrigerant manufacturing facility.

Recovery – The collection of a halocarbon after it has been used, or a collection from machinery, equipment, a system or a container during servicing or before dismantling, decommissioning or destruction of the machinery, equipment, system or container.

Recycling – The recovery and, if needed, cleaning by a process such as filtering or drying, and re-using to charge a system. Cleaning the refrigerant is done through 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.

Refillable Container – A container that is constructed with better one-way valves and designed for multiple uses, and is preferred to a disposable container. Their colour is unique to each type of refrigerant and labelled accordingly so that refrigerants will not be mixed. There are minimal chances for emissions to take place.

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

Reuse – The reuse of previously recovered refrigerant without processing.

Servicing – Includes installation, maintenance, testing, calibration, repair, alteration, conversion, mothballing and decommissioning.

Small Air Conditioning and Refrigeration System – A system with a refrigerative capacity of less than 19 kW that is not a mobile system. They usually have hermetic compressors.

Temperature Glide/Slide – The temperature range of boiling points over which a mixture of refrigerants will have under various operating conditions.

Ton of Refrigeration (tR) – One ton of refrigeration is the rate of heat removal to freeze one short ton (2000 pounds) of water at 0°C (32°F) in 24 hours. One tR = 12 000 Btu/h = 12 660 kJ/h = 3.517 kW. (Most residential air conditioners are between 1 and 5 tR). Caution is required to denote if the metric form is being used, that is, Tonne of Refrigeration. The latter is based on one tonne (1000 kg or 2200 pounds) of water, making it 10% larger than a Ton of Refrigeration.

Unit Power Consumption, $\hat{W}$ – Power consumption per ton of refrigeration.

White Goods – Household domestic appliances such as clothes dryers, washing machines, freezers and refrigerators. They may include a 115/230 volt self-contained plug-in refrigeration or air conditioning system (or gas-operated system for mobile homes).

Zeotropes – 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.

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## Abbreviations and Symbols

| | |
|---|---|
| AHRI | Air Conditioning, Heating and Refrigeration Institute |
| AIAMC | Association of International Automobile Manufacturers of Canada |
| ANSI | American National Standards Institute |
| ASHRAE | American Society of Heating, Refrigerating and Air Conditioning Engineers |
| Atm | Atmosphere, a measure of pressure, equivalent to 760 torr (mmHg) and 14.7 psi |
| BTU | British Thermal Units |
| CFC | Chlorofluorocarbon |
| $CO_2$ | Carbon dioxide |
| COP | Coefficient of Performance |
| CVMA | Canadian Vehicle Manufacturers Association |
| ΄E | Coefficient of Performance |
| EER | Energy Efficiency Ratio |
| GJ | gigajoule (1 GJ ≈ 278 kWh, 1 million BTU) |
| GWP | Global Warming Potential |
| HASP | Health and Safety Plan |
| HCFC | Hydrochlorofluorocarbon |
| HFC | Hydrofluorocarbon |
| HFE | Hydrofluoroether |
| HFO | Hydrofluoro-olefin |
| HSPF | Heating Seasonal Performance Factor |
| HTF | Heat Transfer Fluid |
| IEER | Integrated Energy Efficiency Ratio |
| kJ | Kilojoules |
| kPa | Kilopascals |
| kW | Kilowatt |
| LCC | Life Cycle Cost |
| LEL | Lower Explosive Limit |
| mg/L | milligram per litre |
| NARM | Near Azeotrope Refrigerant Mixture |
| NBP | Normal Boiling Point (or Critical Point) |
| ODP | Ozone-Depletion Potential |
| ODS | Ozone-Depleting Substance |
| OEM | Original Equipment Manufacturer |
| PPE | Personal Protective Equipment |
| PFC | Perfluorocarbon |
| ppm | Parts per million |
| SAE | Society of Automotive Engineers. |
| SCADA | Supervisory Control and Data Acquisition |
| SEER | Seasonal Energy Efficiency Rating |
| $SO_2$ | Sulphur dioxide |

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| TEWI | Total Equivalent Warming Impact (of direct and indirect GHG emissions) |
| TLV | Threshold Limit Value |
| tR, or TR | Ton of Refrigeration |
| UV | Ultraviolet Radiation |
| WHMIS | Workplace Hazardous Materials Information System |

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# 1. SYSTEM DESIGN

## 1.1. General Design Practices

1.1.1. Load Calculations. It is important to have a refrigeration engineer or a heating, ventilation, air conditioning and refrigeration (HVACR) contractor perform a load calculation before a decision is made on which size of air conditioning and refrigeration (AC&R) system to buy. The industry standard for load calculation in residential type buildings is the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) *Cooling and Heating Load Calculation Manual,* and in non-residential buildings the ASHRAE *Load Calculation Applications Manual*. Load calculations can also be made in accordance with CSA-F280-M90, *Determining the Required Capacity of Residential Space Heating and Cooling Appliances*. Load calculations should be made in accordance with *ASHRAE Standard 12*. Where applicable, the above references take into account: the size of the building/cooling requirements, the spatial variation of requirements within the building, the amount of insulation installed, the square footage, contributors to heating and cooling in the building, air changes, and a host of other factors. It is recommended that design managers also access other publications available online to assist in understanding the complex nature of proper selection and sizing of AC&R systems.

1.1.2. Flammable/Toxic Refrigerants. Some of the lower ozone-depleting potential (ODP) alternatives to chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) are more hazardous and/or toxic. Hence, safety considerations should now play an important factor in any design – whether in a new installation or in a conversion from another refrigerant.


1.1.3. Environmental Impacts and Energy Consumption. Good design includes examination of the refrigerant and system type and capacity, environmental impact, energy consumption, siting, and other factors that have direct and indirect beneficial effects. These factors include using more environmentally friendly refrigerants, employing smaller systems (with smaller refrigerant charges), reducing the consumption of electricity and therefore the environmental impact of its generation, and examining alternatives to mechanical AC&R. Environmentally sound design is an important goal in pollution prevention and energy conservation. Some best practices provided herein come from the Leadership in Energy and Environmental Design® (LEED®) program, a program of sustainable construction that is advocated by the federal Treasury Board and other Canadian governments.

a. Designs should take a holistic approach whereby all the disciplines to be involved in a project should be on the design team and have input in the design concepts from the outset rather than using a step-wise approach where the supporting disciplines (electrical, mechanical, refrigeration, landscaping, etc.) only become involved after the basic design is developed.

b. Acquisitions should be subjected to a life cycle cost (LCC) analysis and started as early in the project as possible when there is the best opportunity for having a variety of realistic options. LCC analysis often is directed at large capital projects. However, since the operating and maintenance costs of AC&R equipment often dwarf the initial acquisition cost, the concepts of an LCC analysis still can provide extremely useful insight into different options affecting the total cost of ownership of the system. Such analysis may lead to non-mechanical AC&R options including building siting, landscaping, use of natural ventilation and avoidance of the creation of hot areas in a building. Usually the designers lead the LCC analysis team and present the analysis to senior management for decision on the selection of the best option.

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**Design the building for cooling instead of designing cooling for the building.**

1.1.4. Qualification of Designers. Designers should have current Environmental Awareness certification, and be qualified and knowledgeable about the current technical, environmental, occupational health and safety requirements, and the life cycle options for the equipment they are designing.

## 1.2. Refrigerants

1.2.1. Refrigerant Classes. Although there are many different ways of classifying refrigerants, this Code uses the following:

a. Class 1 – refrigerants that cool by phase change (typically boiling as found in vapour-compression systems).

b. Class 2 – refrigerants that cool by temperature change (for example, air, brine solutions). They may be cooled by Class 1 or 3 refrigerants and become a heat transfer fluid (HTF) to convey this lower temperature to an area.

c. Class 3 – refrigerants that contain absorbed vapours of liquefiable agents or refrigerating media (for example, ammonia absorption refrigeration).

1.2.2. Refrigerant Properties. There are a number of basic properties describing a refrigerant.

a. Critical Temperature. The temperature above which a refrigerant cannot be condensed regardless of pressure. This is the maximum ambient (air/water) temperature to which the refrigerant can discharge its heat on the heat rejection side of the condenser. For example, carbon dioxide ($CO_2$)'s critical temperature is only 31ºC and therefore it cannot function efficiently in high temperature environments, but ammonia's critical temperature is 132ºC, a much more desirable temperature for a variety of AC&R uses.

b. Normal Boiling Point (NBP). The temperature at which a refrigerant changes from a liquid to a gas under 'normal' atmospheric pressure of 1 atm (14.7 psia). The NBP has to be below the desired operating temperature of the application. However, the boiling point of a refrigerant can be increased by increasing its operating pressure. For example, a freezer requires a lower boiling point refrigerant than an air conditioner. The NBP of ammonia is -35.5ºC, HCFC-22 is -41.2ºC, and R-410A (a blend of R-32 and R-125) is -48.5ºC. Some blends may have a range of boiling points based on each of their constituents. This is called glide and is applicable to zeotropic blends.

1.2.3. Compatibility with Components. All system components must be selected to be compatible to the refrigerant and oil used in the system. For example, copper cannot be used in ammonia systems, and mineral oil generally cannot be used with hydrofluorocarbons (HFCs).

1.2.4. Flammability of Refrigerants. **Figure 1** provides a comparison of the flammability of some refrigerants as expressed as the lower explosive limit (LEL) of a vapour in a volume of air. This is a system of measurement that often is used for air monitoring standards established in a Health and Safety Plan (HASP). Note that the LEL of gasoline and diesel are provided as reference points.

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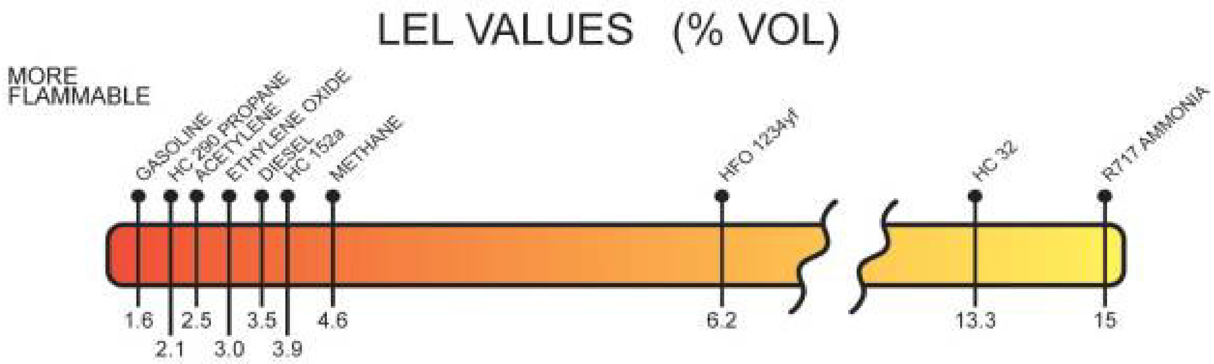
**Figure 1 – Relative Flammability of Some Refrigerants**




1.2.5. Flammable Refrigerant Practices.

a. It is best practice not to use flammable refrigerants in large systems or in banks of small systems (such as for a group of vending machines or display cabinets) since the fire hazard becomes considerable. For larger system requirements, it is best practice to use dispersed smaller units with smaller charges.

b. All systems and tanks, including charging and recovery tanks, should be grounded, and the grounding connections inspected for freedom from corrosion.

c. Flammable refrigerants may require the electrical system to be explosion-proof or separated from the area of the refrigerant. Explosion-proof motors, switches, and other devices, and sealed cabinets and conduit, etc., may be required.

d. AC&R systems, test apparatus, tools and service equipment should not incorporate components or devices that can generate electrical sparks or discharges.

e. Devices that generate sparks should be:
   i. isolated;
   ii. purged with inert gas (to minimize the probability of attaining refrigerant concentrations in air that are within the flammable range); or
   iii. relocated.

   Note that DC motors that use brushes will have the potential for continuous spark generation. A fan that uses such a DC motor may have to be isolated, replaced with a non-sparking one, or purged with an inert gas such as nitrogen or with adequate air flow to minimize the quantity of refrigerant within the flammable range. If nitrogen inerting is used, route the exiting nitrogen gas to a local exhaust if practical. Otherwise, the adjacent work environment may also have to be monitored for oxygen concentrations so that an acceptable breathing atmosphere is maintained.

f. As spark energy data may not readily be available, electrical contactors, refrigerator door and system switches, relays, and other electrical or electronic devices capable of generating a spark that are located in proximity to probable leak sites should be subject to risk evaluation.

g. Electrical equipment in and adjacent to the refrigerant charging and storage locations should be electrically classified according to applicable codes and regulations.

h. HFC systems should not be retrofitted with hydrocarbon (HC) refrigerants without changing the key components.

i. Selection of flammable refrigerants should include considerations of non-static clothing requirements for service technicians, non-sparking tools, leak-test equipment suitable for the

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refrigerant, appropriate hazard warning signage (including the prohibition of smoking and communication devices); requirements that are common when working around petroleum fuels.

j. The design process should include the determination of the requirement for and provision of:
   i. A Health and Safety Plan (HASP);
   ii. A hot work permit system;
   iii. Fire alarms, smoke detectors, suppression systems, fire extinguishers; and
   iv. A Fire Plan that includes egress, fire separation, emergency response and emergency lighting.

## 1.3. Compressors

1.3.1. Component Mounting. 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.

1.3.2. Inspection. To prevent fugitive emissions, compressors and associated equipment fitted to them (e.g., gauge and cut-out connections, oil returns, oil drains, oil level sight glasses, relief valves, and connecting pipe work) should be inspected regularly according to manufacturer's specifications, or at least twice a year if no specifications exist.

1.3.3. Mechanical Seals.

a. Damaged mechanical seals on open type compressors are a frequent source of refrigerant leakage. Damage to the seals may be caused by improper installation of the seal in the compressor or the shaft in the seal, oil contamination, or lubrication breakdown. A clean, dry system is essential for prolonged mechanical seal effectiveness to minimize emissions.

b. 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 start-up.

1.3.4. Lubricant Cooling. Some large open compressor systems should have compressor lubricating oil chillers to prolong the life of shaft seals and avoid leakage of refrigerants.

1.3.5. Oil Contaminants. Compressor oils used for refrigerants will absorb moisture readily and must be kept dry to prevent refrigerant decomposition.

a. To prevent leakage and avoid damage to the mechanical seal faces and other working parts of compressors, filter-dryers should have a desiccant to remove moisture and a filter in the range of 5 to 20 μm to remove particulate matter. Particulate matter can also cause damage to motor windings and compressor parts of hermetic and semi-hermetic compressors.

b. New systems should have a liquid line filter-dryer of sufficient size welded into place at the time of manufacture. The dryer should have isolation valves and refrigerant recovery connections.

c. In the case of an older system that has no filter-dryer, when opening a system to replace a part or component, a filter-dryer should be installed, complete with required valves.

d. A moisture-indicating sight glass is strongly recommended.

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

1.3.7. Relief Devices. All new units containing over 10 kg (22 lb) of refrigerant should have a self-reseating relief valve.

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a. All relief vent lines should be provided with the ability to carry out leak testing near the relief valve.

b. Self-reseating type relief valves are recommended for large low-pressure refrigerant systems.

c. All relief devices should be vented to the outdoors.

## 1.4. Condensers and Evaporators

1.4.1. Holding Charges. Other than for plug-in domestic units, the refrigerant should not be used as a holding charge for storage or shipping. Dry nitrogen or dry air that meets ASHRAE standards should be used.

1.4.2. Vibration and Thermal Expansion. Excessive vibration from compressors or other equipment can cause evaporator and condenser tube failure. Anti-vibration mountings and vibration eliminators should be used where feasible. Piping to condensers and evaporators should be welded, have flexible connectors, be solidly anchored, and have allowances for expansion and contraction, especially at anchors and bends. Equipment should be inspected periodically to identify and remediate any excessive vibrations.

1.4.3. Water Velocity. Excessive water velocity through the tubes of shell and tube units should be avoided to prevent erosion and water hammer.

a. Eddy current testing of tubes every three years and water flow measurements on larger units (for example, greater than 175 kW [50 tR]) will help minimize refrigerant losses due to tube failure.

b. Adequate protection against water hammer is also recommended to reduce failure.

1.4.4. Water Quality and Corrosion. Water treatment and filtration should be used where needed to avoid scaling, corrosion or erosion failure.

a. Scaling may be a concern where there are dissolved solids in the cooling water, common when the source is groundwater. Water softeners should be installed to remove dissolved solids. If the water is being used in a closed system (for example, a ground loop system), then softened water should be used.

b. Catalytic Corrosion. Careful selection of tube, valve and condenser materials can also help to minimize catalytic corrosion. When non-ferrous materials are used in the system, sacrificial anodes should be used to reduce corrosion pitting. Sacrificial anodes are effective only when the water is flowing through the system.

## 1.5. Piping and Fittings

1.5.1. Piping.

a. To ensure maximum efficiency of AC&R systems, pipe diameters, lengths and bend radii should be in accordance with manufacturer's instructions, and workmanship should be of a very high quality.

b. High and low pressure piping should be labelled and be well insulated to prevent heat gain and condensation issues.

c. Vibration eliminators should be included in the suction and discharge lines near the compressor to prevent and eliminate leaks and vibration transmission. Trombone bends or sprung hangers should be used for lines too large for vibration eliminators. Gauges, oil safety switches, and high and low pressure shut-offs should be connected to the main system via flexible connections so that vibrations are absorbed.

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d. Adequate support of pipeline connections to the components should be provided to avoid unacceptable stresses that could lead to leakage, and allowances should be made for expansion and contraction, especially at anchors and bends. Insulated hangers should be used for non-ferrous pipe.

e. Piping layouts should be designed so that the pipes will be protected against physical damage and impacts.

f. If flammable refrigerants are involved, piping and other components should be grounded in accordance with applicable regulations and standards.

g. All pipelines should be designed so that the number of joints is minimized.

h. Welded, brazed or flanged connections are the preferred method of attachment instead of flared, threaded or quick connect joints. For smaller sizes, compression fittings or single flare connections are preferred as allowed by applicable regulation. Flare fittings should be made carefully on a square cut, soft copper tube without any burrs and for the appropriate flare angle. The connection should be tightened with two wrenches, and Teflon tape or pipe dope should not be used. Test for leaks.

i. Line taps are available with cast metal bodies and split packing that seal the line tap to the pipe. They come in fixed tube outside diameter sizes of 1/4", 5/16" and 3/8". These line taps can be installed and left in place on the equipment. Schrader valves can be connected to the line taps for the recovery and charging of refrigerant.

j. Swaged joints of pipes should be used both during the manufacturing process and by the service technician in the field.

k. Capillary lines should be positioned to ensure they can absorb vibration without rubbing together or against another object.

l. Quick connects are not dependable leak-free connectors and therefore should not be used for permanent connections.

m. Piping should be labelled in accordance with good engineering practice.

1.5.2. Gasket Material Compatibility. Flanged joint gaskets should be compatible with the refrigerant and refrigerant oil, especially when the system is converted to an alternative refrigerant or oil. Equipment manufacturers should always be consulted before any retrofitting to help avoid flange leakage.

1.5.3. Welded or Brazed Flanges. To eliminate potential leaks in new systems, instead of threaded connections, welding or brazing should be used to join flanges to the pipeline. Where threaded connections must be used, fluoropolymer tape (also called Teflon, or PTFE) is the preferred pipe thread lubricant. On existing systems with threaded joints, back-welded screwed flanges should be used where possible.

1.5.4. Valves.

a. Isolation Valves.
   i. Valves allowing isolation of all components on the system (other than plug-in domestic units) should be used to minimize the risk of refrigerant loss during servicing.
   ii. Isolation valves should be added, if not present, when components have to be evacuated for service or replacement.
   iii. Any piping or segment between two shut-off valves should be protected by a pressure-relief, in accordance with the CSA B52 Mechanical Refrigeration Code.

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iv. All open compressors should have isolating and access valves on both the suction and discharge sides.
v. Valves and piping should be designed to avoid the trapping of liquid between valves.

b. Recovery Access Valves.
i. Permanent access valves are required for recovery of residual refrigerant in isolated components.
ii. Discharge and evacuation valves should be fitted to compressors to assist in servicing and maintaining the system for removal of refrigerants to approved recovery containers.
iii. Recovery access valves should have adequate internal cross-sectional area. For systems having up to 4 kg (8.8 lb) of refrigerant, there should be 6.4 mm (1/4") of free cross-sectional area for the flow of refrigerant. For systems containing over 4 kg (8.8 lb) of refrigerant, there should be 9.5 mm (3/8") inside diameter of free cross-sectional area.

c. Schrader Valves. These valves come ready for brazing or connection to a saddle valve or line tap for bolting on to piping systems. With time, the neoprene gland may deteriorate and leak, but the valve stem can be replaced without evacuating the system. Schrader valves should always be capped to prevent dirt entering from the outside and damaging the sealing surface, thus causing a leak. These valves should be used to attach gauge manifold test sets.

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

e. Back Seating Valves. The use of back seating access valves is preferred for attaching control and safety devices or gauges.

f. Snubber Valves. Snubber valves should be used to protect gauges and cutouts from pressure surges. They should also be used to permit removal of these devices for repair or calibration of the gauges.

g. 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.

h. Welded and Flanged Valves. Valves with welded, brazed or flanged connections should be used instead of a flared or screwed type, for pipe sizes greater than 19 mm (3/4") outside diameter. Use compression or single flare fittings for small pipe sizes.

i. Three-way Refrigerant Valves. A three-way refrigerant valve should be used 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.

j. Tube Sheet Vent Valve. Tube sheets should have a tube sheet vent valve to avoid trapped gases.

k. Valve Servicing. Valves designed for tightening or replacement of the gland packing or diaphragm under line pressure should be used (except when ball valves are involved).

1.5.5. Welding Blanket. Dry nitrogen should be used during welding or brazing. Avoid overheating the tubing/piping since that may cause scaling on the inside, which can contaminate the refrigerant with particulate matter. Refrigerant should not be used as welding blanket.

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## 1.6. Air Purge and Pump-down Systems

1.6.1. Air Purgers

a. Air purge systems should vent outdoors.

b. When purge systems operate, some refrigerant is emitted with air and frequent purging indicates a system leak. To correct the problem, trained, qualified and certified service technicians should inspect and repair all leaks in the system.

c. Purge systems should be high efficiency systems that meet ANSI/AHRI Standard 580*, Non-Condensable Gas Purge Equipment*.

1.6.2. Pump-down

a. In-System Liquid Receivers. All new high-pressure AC&R systems with a refrigeration capacity of 35 kW (10 tR) or greater should incorporate a pressure-relief 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 acceptable.

b. Auxiliary Receivers. 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. This 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. Units using capillary expansion control, however, need not necessarily be fitted with an isolatable liquid receiver. For smaller systems, approved containers can be used.

c. 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.

d. 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 on any section of the system.

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

## 1.7. Mobile Systems

1.7.1. Mobile systems include AC&R systems in:

a. Refrigerated transport trucks and transport trailers ("reefers");
b. Refrigeration systems on rail cars, intermodal containers, ships, aircraft and other large mobile systems;
c. Air conditioners in automotive vehicles; and
d. Air conditioning systems in trains, buses, trucks, agricultural equipment, mines, cranes, ships, aircraft and other large mobile systems.

1.7.2. Leakage from Vehicle Air Conditioners. In recent years, automotive air conditioner systems have become tighter, more reliable and more efficient. Nonetheless, mobile AC&R is still a large percentage of the AC&R market, and this sector still uses and leaks significant amounts of refrigerants.

1.7.3. Reliability and Ease of Repairs. Mobile systems are subject to greater and more frequent external vibration forces than installed systems. As a result, there is a higher probability of damage to pipelines and refrigerant leakage at connections. Mobile systems also normally operate in a more aggressive environment due to rain, dust, debris, road/marine salt, etc. Even one breakdown of such equipment may cause the loss of tens of thousands of dollars or more in spoiled goods that are being shipped. Equipment selection and purchase decisions may therefore determine whether the new AC&R systems:

a. Include HFCs or newer, environmentally friendly refrigerants;
b. Are designed with more reliability not to leak;
c. Have a proven long service life;
d. Are easily inspected and repaired with readily available parts and technology wherever the systems are destined to travel to; and
e. Have a good and practical preventive maintenance program.

1.7.4. Use of Flammable Refrigerants. Due to the regulatory requirements for personnel safety, toxic and/or flammable refrigerants may be excluded from certain applications. For example, the Canadian Vehicle Manufacturers Association (CVMA) and Association of International Automotive Manufacturers in Canada (AIAMC) do not support the use of HC blends as refrigerants in automotive air conditioners.

1.7.5. Recommendations for Manufacturers. Manufacturers should ensure that the design of AC&R systems includes a series of proven features that will minimize refrigerant loss into the atmosphere and premature failure of equipment, such as:

a. Anti-vibration mounts with the equipment strongly supported to prevent misalignment;
b. Metal braided vibration eliminators between fixed piping and components;
c. Pipe lines that are not subject to abrasion and stresses;
d. High-pressure screwed, compression or single flare fittings;
e. Rust-free clamps, fittings and equipment;
f. Clamps, fittings and equipment that minimize catalytic corrosion by using similar metals in a system;
g. Near-zero permeability and high temperature-resistance hoses with heavy-duty clamps;
h. Heavy-duty rotary shaft seals designed to survive extreme temperature environments, maintain seal lubrication while the equipment is idle for extended periods, and have external protection against rusting shafts, dust and grit;
i. Hermetic compressors;
j. Self-reseating pressure-relief valves;
k. Isolation valves to facilitate maintenance and repair;
l. Access connections for recovery and service;
m. Easy access for inspection, cleaning and changing out of all system components while providing a high degree of physical protection to the system and components; and
n. System status that can be easily monitored by operator control panels with "alerts" built in so that corrective action can be taken before system failure.

1.7.6. Energy Conservation. In addition, consideration should be given to reducing overall energy consumption by refrigerated trucks and tractor-trailer rigs. For example, whereas only one third of the energy in motive fuel goes to motive effort, the other two thirds of the energy goes to waste heat (radiator and exhaust). High-grade exhaust energy could especially be used by an ammonia absorption refrigeration system and an HTF to provide cooling to the load. Coupled with condenser fans that only run when needed when on the road, the energy cost of refrigerating the load would be virtually zero. When parked the absorption system could run on electricity.

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## 1.8. <u>Ships</u>

1.8.1. <u>Condensers</u>. 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, which uses seawater for heat rejection and cooling the refrigerant condenser, should be used. Sacrificial anodes should be placed in the seawater side of the heat exchanger to help prevent corrosion. Use of resistance alloys is also recommended. The placement of both the condenser and the heat exchanger should incorporate layouts to allow easy access, cleaning and maintenance.

1.8.2. <u>Pipelines</u>. All pipelines should be designed so that the number of joints is minimal. Welded or flanged piping and fittings are preferred over threaded connections.

1.8.3. <u>Absorption Refrigeration</u>. In line with refrigerated trucks, refrigerated holds in ships could be refrigerated by waste heat from the stack instead of operating vapour-compression systems with onboard generated electricity.

## 1.9. <u>Instrumentation and Control Systems</u>

1.9.1. <u>Energy Savings</u>. The control of ventilation and air conditioning has a great effect on energy conservation. Digital controls can accurately control the building AC&R systems and be very cost-effective. Ventilation control can save 30%, and night setback can save 10 to 30%.

1.9.2. <u>Direct Digital Control</u>. Direct digital controls, known as Programmable Logic Controllers (PLC) and Supervisory Control and Data Acquisition (SCADA) systems, are replacing manual and electromechanical controls in retrofits and are being widely used in new systems. With occupancy sensors, $CO_2$ sensors and distributed space temperature sensors, they can:

a. Control the ratio of make-up air in ventilation based on $CO_2$ concentrations and occupancies. (ASHRAE recommends that return air duct $CO_2$ settings be programmed for 800 to 900 mg/L [800-900 ppm].) The need for energy for ventilation and conditioned air can be reduced further by establishing periods of setback, or by having ventilation turned off completely aside from monitoring only temperature, as is done for gymnasiums, kitchens and bathrooms.

b. Vary the amount of air conditioning with respect to outside temperatures. When the outside air is cool enough, these systems can bring the outside air in and avoid mechanical cooling. Sensors would be required in various zones, as well as one to measure the outdoor ambient temperature.

c. Automatically institute setbacks for evenings and weekends. Different zones can be set for different night setback temperatures and start periods. While the building is still occupied, the night setback routines can commence in accordance with the thermal lag of each zone and its occupancy. When the zone temperatures are to be brought back up for occupancy, the system can start the recovery according to the thermal inertia of each zone, and with respect to the outside temperature (that affects the heat loss/gain).

d. Sequence start-up routines for maximum efficiency. Optimized start/stop can increase the night setback by one to two hours per day without occupants noticing due to the thermal lag of the building and heat generation of occupants, lighting and electrical consumption during the occupancy.

1.9.3. <u>Potential for Inefficiencies</u>. This automation of electromechanical processes offers the potential for greater data acquisition (for trend analysis), reliability, control and efficiency. However, it is a waste of the cost of the data acquisition equipment if sufficient personnel resources will not be allocated to analyze and act on the data. Moreover, it must be remembered that central electronic systems are complex and have a useful life of perhaps less than 10 years, at which point the manufacturer may have upgraded their product line and no longer support the older systems with technical training,

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service and parts. Moreover, malfunctioning controls and sensors (for example, system not balanced, controls/sensors non-serviceable or out of calibration) can waste more energy than the system saves.

1.9.4. Good News – Bad News. The reliability and complexity of these systems is a good news – bad news story. Good News – they don't break down often. Bad News – due to their high reliability, the numbers and availability of highly trained and skilled technicians for a particular system are few and far between due to the cost of training and maintaining their skill level. In addition, technicians skilled in one manufacturer's system do not know other manufacturers' systems. Hence, routine servicing and maintenance contracts are virtually monopolized by one manufacturer and there is little opportunity for competitive price bidding. When a central control system does break down, often there is a delay in the time to bring in appropriately trained technicians from other locations, and costs are high due to their specialist fees, travel and living costs. Hence, a careful decision has to be made in the LCC analysis and cost benefit analysis as to whether it is better to have direct digital – SCADA control systems or the simpler traditional individual controls.

1.9.5. Shortened Service Life. As mentioned earlier, one manufacturer usually will not know or be willing to service or trouble-shoot a system that has another manufacturer's components. If the service contract is switched to a service organization not familiar with that system, the owner could be facing a change-out of the system components to another manufacturer's before the end of their predicted service life, thus incurring unplanned life cycle costs.

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

1.9.7. Access for Servicing. The location of controls and sensors should be well marked, provide easy access for testing and servicing without the use of lifting equipment or scaffolding, and be well protected from dust, moisture and physical damage.

1.9.8. Commissioning. A thorough commissioning of the control system should be carried out by a knowledgeable, and preferably independent, third party. The installation contract or specification should have detailed requirements for commissioning. Refer to **Chapter 2** on Commissioning.

1.9.9. Documentation. All installations should be provided with complete control system operating manuals, wiring and/or operating schematics, and labelling of all components, pipe runs and wire runs.

## 1.10. Mechanical Rooms

Poor design of the compressor room can lead to servicing personnel taking shortcuts and/or not following proper servicing routines (for example, if electrical outlets are not in convenient reach for use of test or servicing equipment, physical access to the system components are crowded or awkward, lighting is poor, or electrical circuits cannot be located easily by contractors who are not familiar with the installation).

1.10.1. Leak Detection Alarms. Systems with a refrigerant charge of over 50 kg (110 lb) should have a refrigerant monitoring system in the compressor room capable of detecting leakage greater than 30 mg/L (30 ppm). Refrigerant alarms are not a substitute for actual leak testing on the system itself. Alarms should always give warnings before reaching the threshold limit value (TLV) or 25% of the LEL for a particular refrigerant.

1.10.2. Ventilation. High refrigerant concentrations (greater than 10 mg/L [10 ppm]) in the compressor room are an indication that one or more systems are leaking. If a large refrigerant leak occurs, the air in the mechanical room may be so polluted that an electronic leak detector cannot distinguish a leak from the contaminated air in the room. The room should have ventilation to clear the air of refrigerant so that leak detection or refrigerant recovery and repair can proceed quickly.

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1.10.3. Emergency Cut-Off. If flammable refrigerants are in use or stored, and if not already required by the Fire Code, consider the installation of an emergency switch outside the room to cut off all electrical power to the room. The switch should be labelled, and the room should be labelled for flammable content.

1.10.4. Service Outlets. An electrical outlet should be within 10 m of the compressor and mounted on the wall at approximately 110 to 120 cm (44 to 46 inches) off the floor in accordance with the Electrical Code, and possibly combined with a switch for ceiling mounted work light(s) above the equipment. This will facilitate the routine servicing and maintenance of the equipment.

1.10.5. Labelling of Circuits. Due to a variety of service technician and contractors visiting the mechanical rooms, the location of the power distribution panel and identification of the circuits should be clearly identified.

1.10.6. Breathing Protection. Ammonia systems should have self-contained breathing apparatus (SCBA), or "air packs," readily available to access the mechanical room. Such air packs should be tested and personnel instructed on their use on a regular basis.

1.10.7. Access to Equipment. Proper physical access to equipment and work areas is essential to service and maintain equipment. All AC&R equipment, including outdoor units, should be located such that access is easy for servicing and maintenance/repairs, including refrigerant charging and compressor replacement. Awkward and poor servicing conditions lead to maintenance being skipped and logs being "pencil whipped" (logs being filled in as though the work was done).

## 1.11. Hydrocarbon Refrigerants

Generally, HC and alternate refrigerants have been in use for many years. They are cheaper than manufactured refrigerants and their emissions do not pose the same environmental impacts as those of many of the halocarbon and other manufactured refrigerants. HC refrigerants are flammable and/or toxic, as can been seen in **Figure 1** in the range of gasoline and diesel fuel. Due to competition with manufactured refrigerants, one should take care to ensure that warnings of this hazard are not exaggerated by market forces.

1.11.1. Propane (HCR-290). Thermodynamically, propane is a good refrigerant that has been used for many years, but its flammability limits its use in buildings to systems not much larger than a refrigerator. Propane (or liquefied petroleum gas) can cause damage to the nervous and other bodily systems and is a heavier-than-air flammable gas whose vapours may pool and cause a flash fire. Handling of propane containers should be by hand truck, and containers should not be dragged, rolled, slid or dropped. The use of propane may require adequate and explosion-proof ventilation. Due to its high flammability, propane should be used in smaller systems and not when there will be a number of such appliances grouped in the same room. Electrical devices should be located in separate compartments from the refrigerants, or the electrical devices should be explosion-proof if leakage of refrigerant is possible in their proximity. In some jurisdictions, propane and other HCs may be prohibited in domestic refrigerators and other small packaged AC&R equipment.

1.11.2. Isobutane (HCR-600a). Thermodynamically, isobutane is a good refrigerant, but its flammability limits its use in buildings to systems not much larger than a refrigerator. Isobutane is a heavier-than-air, naturally occurring natural gas with zero ODP, negligible global warming potential (GWP) and good energy efficiency. It was used in refrigerators up to the 1940s. It again is being used as the refrigerant in many new European and Japanese domestic refrigerators and freezers, and being pursued for acceptance in North America. Performance is dependent on a tight design window of charge amount and any deviation causes efficiency to drop off significantly, especially in undercharge situations. There are no quality standards for the purity of isobutane. Safety regulations in many international


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jurisdictions limit the maximum charge to 150 g for household appliances. Due to its flammability, very careful handling and safety precautions are required. Explosion-proof or separate compartments for switching elements (thermostat, door light switch, compressor relay, etc.) from refrigerant compartments are necessary. Only small numbers of these refrigerators/freezers should be located in the same room/dwelling since a leak from many may exceed the LEL for the air space. There have been reports that there have been some explosions due to a leak (possibly due to poor manufacture or handling) coming in contact with a spark (for example from a loose wire, switch or thermostat).

1.11.3. Isopentane (HCR-601a). Isopentane is a naturally occurring compound. Thermodynamically, isopentane is a good refrigerant, but its flammability limits its use in buildings to systems not much larger than a refrigerator. It is also used in lower temperature geothermal electrical generation plants where the isopentane is heated by geothermal water to become a dry vapour to be sent through a turbine to generate electricity. On exiting the turbine, it is condensed and resumes its cycle of being passed back through the heat exchanger.

## 1.12. Alternate Refrigerants and Refrigerative Systems

1.12.1. Ammonia (R-717). Anhydrous ammonia has been used in industrial plants for over 130 years. It is still widely used as a refrigerant in arenas, in industrial facilities (meat, poultry and fish processing plants; dairy and ice plants; wineries and breweries; fruit/vegetable juice and soft drink processing plants; seafood processing plants aboard ships; petrochemical facilities; etc.) and in refrigerators that use heat instead of electricity (or a choice of either) such as in recreational vehicles (RVs). Ammonia can be used as a refrigerant in vapour compression systems or can be used in absorption systems. Because of its high electrical conductivity, it is difficult to use in hermetic systems. Absorption systems can be powered by any heat source. The current solar refrigerators use solar energy as the heat source. One reason ammonia is used in arenas is that the HTF that is circulated under the arena floor can be heated to quickly remove the ice for other events in the facility. Copper should not be used in ammonia systems. Ammonia is environmentally friendly, economical and energy efficient. It has a high health hazard due to its corrosiveness to the skin, eyes and lungs, and its flammability, especially when mixed with lubricating oils. Building, fire and hazardous material codes apply limitations. Highly purified ammonia, with trace amounts of an odorant such as mercaptan, is gaining favour, especially in systems designed for R-22.

1.12.2. A variation on the standard ammonia-water absorption refrigeration cycle also uses butane. It was patented in the 1930 by Albert Einstein, and research is now underway to increase its efficiency. It is used in small, mobile refrigeration systems such as in RVs. When idle for long periods, the three components separate. To get the system working again, the fluid/system has to be shaken, like driving the RV over a rough road.

1.12.3. Air (R-729). Air is a Class 2 refrigerant and is used in residential, automobile and turbine-powered aircraft for air conditioning and/or cooling. With compression and expansion, it is a practical yet not very efficient refrigerant. It has no ODP, GWP, toxicity or flammability. It is being considered for railway air conditioning in Europe.

1.12.4. Carbon Dioxide (R-744). $CO_2$ operates at a high pressure (100 atm) and is rather inefficient as ambient air temperatures rise (hot climates). However, due to its high volumetric capacity, small components and piping can be used. It is very safe for critical environments, and the refrigerant does not need to be recovered, reclaimed or recycled. $CO_2$ is now being used in Germany for automobile air conditioning. It is inherently inefficient for building applications. The high pressure indicates a higher safety risk to personnel who are working on the system, and may also result in higher maintenance requirements.

1.12.5. Sulphur Dioxide (R-764). Since sulphur dioxide ($SO_2$) is condensed easily and has a high heat of evaporation, it was used as a refrigerant in domestic and walk-in refrigerators before the introduction

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of Freon. Piping should be steel, since copper is dissolved and deposited in the compressor and elsewhere. It is very corrosive when exposed to moisture and hazardous to humans.

1.12.6. Water systems.

a. Misting Fans. Misting fans inject a fine spray of water into the fan's exhaust or have wet canvas flaps whereby the water quickly evaporates, drawing heat in from and cooling the air stream. These simple and inexpensive systems can reduce the ambient air temperature in a chill zone by up to 22ºC (40ºF) and without any ODP, GWP or fire hazard. If pressurized water is used, the water supply should be soft water (low total dissolved solids [TDS]) so that the small nozzles do not become clogged with calcium deposits. Misting fan applications include factories, loading docks, produce stores, football game sidelines, outdoor restaurants and greenhouses.

b. Swamp Coolers. In dry climates, installed evaporative coolers are popular for comfort cooling. These units draw outside air in through a wet sponge pad, thus cooling the air. The building should allow for discharge of the (upper) interior air to balance the output with the input air.

c. Passive Ground Source-Based Cooling. These systems are probably the most energy-efficient means to chill air, using only 20% of the energy that a heat pump would use. Such systems bring cool groundwater up to the surface to chill the indoor air. The water then is discharged to a surface water body or back into the ground. A variation on this basic system uses a closed loop with an HTF (for example, water with glycol) to be cooled at depths and then the chilled HTF is cycled to the surface for cooling the facility.

d. Water (R-718). Water is a "natural refrigerant," and is cheap, safe, energy-efficient and ozone-friendly. Although it is the main gas responsible for absorption of infrared radiation in the atmosphere, with a life of only nine days, its anthropogenic impacts are negligible. Skilled operators and high-purity water are not required. Leaks are not of a serious concern and therefore maintenance requirements and costs are lower. Water is flash-evaporated in a vacuum and is then removed from the vessel by compressors and condensed. Large volumes of water are required. In fact, the swept volume of a water vapour compressor ($m^3$/h) is about 500 times that for conventional refrigerants because water yields only about 340 kW (100 tR) of refrigeration for a swept volume of 100 000 $m^3$/h. These large flows necessitate large equipment, possibly doubling the installation cost in comparison to conventional refrigerative systems. Water is being used as a refrigerant in two compression stage simple vacuum-water chillers, and is being viewed as a potential common future refrigerant.

1.12.7. Peltier Thermoelectric Cooler. Thermoelectric cooling uses the Peltier solid-state effect to create a heat flux between the electrical junctions of two different types of materials. A Peltier cooler has no refrigerant. When DC current runs through it, heat is moved from one side to the other. Therefore, it can be used either for heating or for refrigeration, although in practice the main application is the latter. Such an instrument is also called a Peltier heat pump, solid-state refrigerator or thermoelectric cooler (TEC). Peltier coolers use more electricity than a vapour compression system because they are not as thermodynamically efficient. As a refrigeration technology, it is far less common than vapour-compression refrigeration. The main advantages of a Peltier cooler are its lack of moving parts or circulating liquid, its small size and its flexible shape. Its main disadvantage is that it cannot simultaneously have low cost and high-power efficiency. Many researchers and companies are trying to develop Peltier coolers that are both cheap and efficient.

1.12.8. Thermal Acoustic. Acoustic refrigeration uses high-intensity sound waves in an acoustically isolated tube with pressurized inert gas to pump heat from one end to the other by acoustic pressure waves. The sound waves take the place of pistons and crank shafts that otherwise would be in a compressor. The inert gases, like helium and xenon, are nontoxic and environmentally benign. The heat is discarded and the cold is routed to the refrigerator. The principle has been known for years, but recent

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research is developing what promises to be a very efficient means of cooling. Presently, efficiencies are in the range of internal combustion engines. Prototypes are now being developed and tested. The evolution of thermal acoustic refrigeration may be likened to the efficiency of fluorescent and LED lamps versus the incandescent light bulb.

## 1.13. Labels and Service Records

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

a. Equipment manufacturer;
b. Refrigerant type (HCFC, HFC, HC, etc.) ;
c. ASHRAE Refrigerant Number;
d. ASHRAE/Workplace Hazardous Material Information System (WHMIS) Safety Designation;
e. Refrigerant quantity; and
f. Refrigerant oil type, quantity and viscosity.

1.13.2. Service Logs. Owners should maintain a document to record the installation, servicing, leak-testing, charging or other work on an AC&R system that could result in the release of a halocarbon. The equipment logbook should be updated with data each time the equipment is inspected, serviced or otherwise maintained. **Appendix 6** provides a copy of various forms and a link to the Environment Canada website where these forms can be requested for printing and use.

## 1.14. Life Cycle Costing/Analysis

1.14.1. A Decision Tool. LCC is a decision aid that looks at the total costs of constructing, operating and maintaining a system – a cradle-to-grave financial analysis tool. It recognizes the fact that the cost of operation and maintenance can be substantial. It is a widely recognized method for examining the cost effectiveness of maintaining, versus replacing or rehabilitating, aging equipment and systems. It can also facilitate a more intelligent selection among choices of such matters as pollution prevention and energy conservation. As such, it:

a. forces a conscious determination of alternatives;
b. promotes a design that supports maintainability; and
c. is useful in revealing hidden assumptions and biases.

1.14.2. Overarching Cost of Ownership. LCC not only considers the initial or capital costs for each alternative, but also all the significant personnel, operating, maintenance and disposal costs in terms of effective payback. It also reduces the chances of under/over design and lessens the likelihood of extreme unplanned maintenance and support costs in future years.

1.14.3. Early Analysis. It is estimated that by the time the design concept has been established and the Preplan phase has commenced, approximately 70% of the project construction and operating costs have been locked in and therefore there are few options remaining to reduce the LCC (refer to **Figure 2**). Therefore, the earlier the LCC analysis is started, the better the opportunities for large cost savings. The best option is to develop the LCC model very early in the conceptual stages of a project, even though much of the information is sketchy. Then as more information becomes available, intermittently refine the accuracy of inputs.

1.14.4. LCC Process.

a. **Appendix 4** provides key factors for the scope of an LCC process. It is written in accordance with the federal Treasury Board Guide on benefit-cost analysis and accepted practices in the public and private sectors. The technique is very simple and straightforward.

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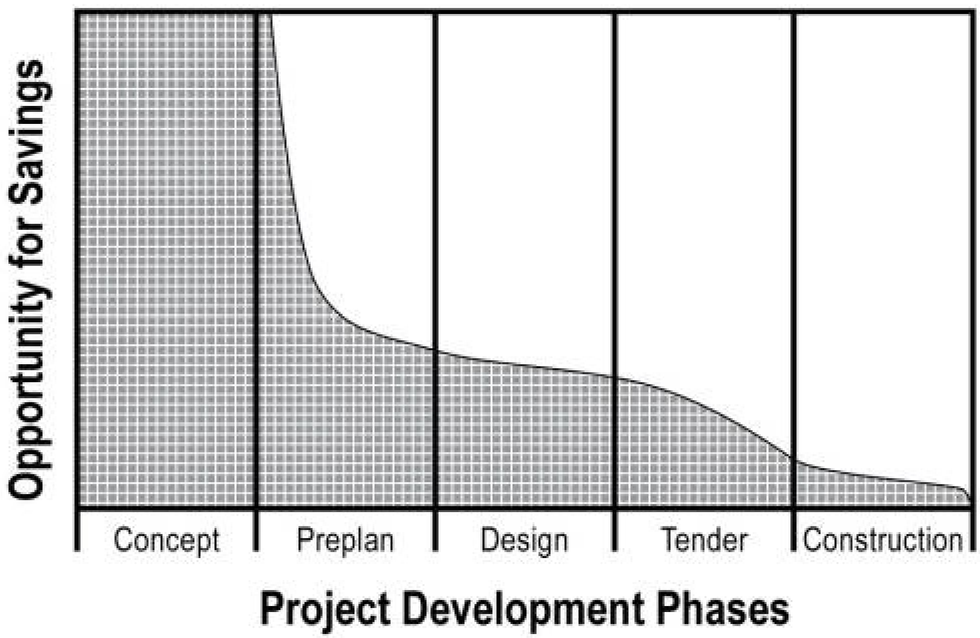
b. The analysis usually is carried out very early in the conceptual stages of a design while there is the greatest opportunity for realizing significant numbers of options (refer to **Figure 2**).

**Figure 2 – Opportunity for Savings during a Project**




c. The LCC team is usually headed by a senior designer and has participation from all disciplines such as architectural, mechanical, plumbing, HVACR, electrical, roofing and landscaping.

d. Once the LCC analysis has been completed, then the team briefs senior management and an option is selected by senior management.

e. Although there are a number of variations in the application of the technique, sometimes this variety of applications clouds the acceptance and use of the results. However, the criteria in **Appendix 4** can be useful for senior management to validate the LCC analysis done by others.

f. After the project is completed, an analysis of the actual acquisition and construction costs versus the predicted costs as used in the LCC analysis should be made so that future LCC analyses can use better data. Moreover, the operating and maintenance costs should be tracked and compared to the predicted costs in the LCC analysis so that, again, other LCC analyses can use better data. If there are significant deviations in the actual from predicted costs, the LCC analysis of options can be revisited to see if the project should be modified.

1.14.5. <u>Recommendations for LCC</u>. The Treasury Board of Canada, Public Works and Government Services Canada (PWGSC), the Department of National Defence (DND), Defence Canada Construction (DCC), and governments in a number of jurisdictions have enacted policies and legislation making LCC effectiveness studies mandatory for the planning, design and construction of government buildings and large capital projects. LCC is an approach used by all responsible project managers for evaluating large construction and maintenance projects. Due to the variety of options open to choosing and replacing AC&R equipments and the considerable operating and maintenance costs these systems will incur over their lifetime, LCC is a useful process to assist in the selection of options.

1.14.6. LCC analysis will help make sure that AC&R equipment choices result in high-quality systems that are less prone to leaking and have a lower operating and maintenance cost over their lifetime. Even if a full LCC analysis will not be carried out for smaller projects, the thought process, and to varying degrees, the application of the procedures, should be applied to smaller projects – if only to identify and recognize all the inputs.

## 1.15. Energy Efficiency

1.15.1. Load Calculation. If an AC&R system is oversized, it will cycle on and off too often, substantially reducing the efficiency of the system, and not adequately removing humidity. If too small, the system may not be able to meet the demands at peak periods. Cooling loads and sizing should be determined by a qualified refrigeration engineer or qualified air conditioning contractor using a recognized sizing method, such as that specified in CSA-F280-M90, Determining the Required Capacity of Residential Space Heating and Cooling Appliances. Simple rules of thumb for sizing should not be relied upon, but a thorough analysis should be undertaken. An AC&R system size or capacity should be selected to just meet the design cooling-load calculated. Also, the air flow into and out of rooms and zones should be carefully "balanced" to ensure efficient operation of an air conditioning system.

1.15.2. Energy Efficiency Ratings. The most common measure of the efficiency of domestic central and split air conditioners is the Seasonal Energy Efficiency Ratio (SEER). The federal *Energy Efficiency Regulations SOR 94-651* stipulate the minimum energy efficiency standards that energy-using products (including various home appliances) must comply with to be imported into Canada or shipped interprovincially for the purpose of sale or lease. Beginning in February 2005, a package central air conditioner must have a SEER of at least 13. Higher-efficiency models have a SEER between 14 and 22. A more common rating method for the larger commercial air conditioners is the Energy Efficiency Ratio (EER). The EER is a measure of the ratio of the amount of cooling (measured in kW) to the amount of electricity it consumes (measured in watt-hours). For example, the regulations stipulate that the EER for a large air conditioner (between 19 and 40 kW) must be 11.3. The EER is a steady state measure – that is, the efficiency is only measured once the unit has started up and is running at a steady capacity. SEER takes into account the start-up and shutdown operation as well as the steady state operation of a unit, making it a more accurate measurement for determining the actual energy costs for the end user.

1.15.3. ENERGY STAR®. In Canada, Natural Resources Canada (NRCan) administers the international ENERGY STAR program. These criteria typically indicate that the product is among the top 25% of all makes and models on the market, and are higher than the minimum regulated efficiency requirements where such exist. Sample US/Canada minimum ENERGY STAR® efficiency ratings are illustrated in **Table 1**. If whole systems are not certified, then select components and assemblies that are certified.

**Table 1 – Sample Regulated ENERGY STAR® Minimum Efficiency Ratings**

| | SEER | EER | HSPF |
|---|---|---|---|
| Indoor air conditioners | 14 | 11 | |
| Split air conditioners | 14.5 | 11 | |
| Heat pumps | 14 | 11 | 8 |
| Split heat pumps | 14.5 | 12 | 8.2 |

1.15.4. Large air conditioners, heat pumps and condensing units 19 kW (65,000 BTU/h) to 220 kW (760,000 BTU/h) should meet the new federal energy efficiency requirements for both full load and part load performance.



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1.15.5. Other Efficiency Measures.

a. Variable speed drives (VSDs) can reduce motor speeds and thereby reduce energy consumption. For example, a speed reduction of 10% can cut power consumption by 27%, and reduction of 20% cuts consumption by 49%. Moreover, with reduced speed, noise is reduced. VSDs have a payback of two to eight years and can be used as motors for ventilation and condenser fans and for AC&R compressors.

b. Premium efficiency motors (NEMA Premium) can reduce full load energy consumption by up to approximately 4%. The cost of a motor probably only represents 1 to 2% of the full cost of ownership. Hence payback of the incremental cost for the premium motor is rapid. Premium motors tend to run faster at load than standard motors, so replacement premium motors should be carefully selected to ensure they are of the same full load speed. A motor replacement policy should be instituted whereby motors of a certain size range and minimum operating schedule are designated for replacement when they fail, or others, especially older motors, for immediate replacement with premium motors. Note that when an older motor fails, it cannot be rewound to exceed its original efficiency.

c. Infiltration of air and small exhaust fans can represent up to 40% of the loss of conditioned air in a building. Programs to reduce infiltration and unneeded operation of small fans will reduce the load on air conditioning systems.

d. Green roofs and shade trees are a means of avoiding the solar load on the building, and therefore reducing the required capacity of air conditioning equipment.

e. The LEED® program has a number of excellent solutions to reduce the energy consumption and environmental footprint of a building. Many of these will have a direct or indirect effect on reducing the cooling requirements for the building.

1.15.6. Maximize Performance Rating. To achieve the stated performance rating of AC&R equipment:

a. Install equipment in accordance with the manufacturer’s instructions (including tubing diameters, bend radii and lengths).

b. Keep refrigerant lines as short as possible between indoor and the outdoor unit since there is always some loss of cooling effect to the atmosphere from these tubes. The tubing should be well insulated. This could affect where mechanical rooms, chillers and other equipment are located in a facility.

c. Keep the outdoor unit at the height above the indoor unit. If the outdoor unit is below the indoor unit, some of the compressor power is lost in pumping the refrigerant against gravity, thus reducing the effective performance of the system.

d. Locate indoor (evaporative) split units inside the room at a location from where the air can be distributed evenly throughout the room, and make use of the natural air flow patterns in the room. In bedrooms, the indoor unit should be installed above the bed so that the maximum cooling effect can be obtained there. The flow of chilled air can always be changed by directing the louvres.

e. Locate the indoor unit so that it is easily accessible for convenient and frequent cleaning of the filter and the whole unit, and so that the position of the louvres can be easily adjusted.

## 1.16. Siting

Siting can have a major impact on the performance of an AC&R system. Designs should utilize natural ventilation, shade and other concepts to reduce AC&R requirements. For example, windows should open to let fresh air in, and should open at the top to let hot air out, and attics should be well ventilated to avoid the build-up of hot air.

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1.16.1. Hot Micro-Climates. As the cooling air for a condenser approaches the critical temperature of the system's refrigerant, the system operates less efficiently. Outdoor air-cooled AC&R units require 10% or 20% extra energy just to provide the same cooling effect if they are located in a hot microclimate (for example, on roofs in the direct sun, in hot attics, in alcoves where there is little air movement). Therefore, compressors and condensers should be located where cool ambient air can flow freely over these components and exhaust the rejected heat away from the area so it will not accumulate near the unit. Packaged air conditioners (particularly rooftop units) can have evaporative pre-coolers added to pre-cool the air to their condensers. Condensing units can be hung on the north side of buildings, installed on the prevailing windward side of building roofs with shade built over the unit, installed on the ground on the north side of buildings, etc. If condensers are located in basements (for example, for walk-in refrigerators) they should not be located where there will be a build-up of heat (for example, in small alcoves).


1.16.2. Freedom of Air Movement. Hindrances of air movement to and from the cooling fan on condensers can seriously reduce the energy efficiency of AC&R units and lead to burning out the hermetically sealed compressor. Condensers should be kept free from a build-up of dust and be located where there is no blockage of fan air from moving away into the open space, be susceptible to leaves and grass clippings accumulating on the condenser, where storage of goods or poor housekeeping can impede the free movement of cooling air, etc.

1.16.3. Noise. Outdoor units should be located where noise will not be a problem, for example, near bedroom windows and patios. Systems can also be selected that have a low noise rating and variable speed drives to further reduce noise. All components of AC&R systems should be installed on rigid surfaces to prevent vibration that will cause noise in the building and also lead to the breaking of the copper tubing and leakage of the refrigerant.

1.16.4. Avoidance of Ignition Sources. Due to the flammability of many newer refrigerants, ignition sources and apparatus that produce ignition sources (including AC&R system test rigs and equipment) should not be located in proximity to AC&R systems or storage vessels that contains even "mildly flammable" refrigerants.

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# 2. SYSTEM INSTALLATION, OPERATION, SERVICING, MAINTENANCE

## 2.1. General

2.1.1. Equipment Replacement. When replacing equipment, the planned replacement components as well as repair parts should be the best available technology. A leak repair requirement also may be an opportunity for using improved parts and components, such as high-efficiency motors or more efficient condensers.

2.1.2. Visual Inspection.

a. Before installation or reassembly of systems, all pipe work and fittings should be thoroughly examined for cleanliness and for freedom from corrosion, and that they meet approved standards.

b. All mechanical joints should be visually inspected and double-checked for tightness before a nitrogen pressure test is performed.

2.1.3. Compression and Flare Fittings. Compression type fittings should be used in preference to flared fittings. Where flared tube connections are to be used (for example, when connecting factory-prepared pre-charged lines), they should be made carefully on a square cut, soft copper tube without any burrs and for the appropriate flare angle. The connection should be tightened with two wrenches, and Teflon tape or pipe dope should not be used. Test for leaks.

2.1.4. Flanged Connections**.** The correct type and grade of gasket material that is compatible with the refrigerant and oil should be used. Flanges should be tightened evenly to avoid leaks.

2.1.5. Welded Connections.

a. Welded, brazed or swaged connections are the preferred method of attachment on all refrigerant lines instead of flared, threaded or quick connect types. If this is not possible for smaller sizes, compression or flare fittings should be used as approved for your jurisdiction.

b. Before welding or brazing pipe joints, dry nitrogen should be allowed to bleed continuously through the system to eliminate oxidation. Take care not to overheat the pipes and material since overheating may cause scaling inside the pipe and introduce particulates into the refrigerant.

c. Internal Cleanliness of Pipe. Metal filings should not be left inside the cut pipe work since these can cause damage to shaft seals, compressor bearings and other internal components of compressors, leading to serious leaking and emissions.

2.1.6. Air and Moisture Contamination. The presence of air and moisture particularly in replacement refrigerants and oils can cause acid generation and oil breakdown leading to premature equipment failure and refrigerant leakage.

2.1.7. Grade of Copper Tubing. The correct grade of copper tubing should be used for the pressure and bending requirements of the installation. This will help prevent future leaks. Copper should not be used in ammonia and in sulphur dioxide ($SO_2$) systems.

2.1.8. Valve Gland Caps. Valve stem gland caps that cover gauge points and service valve caps should always be replaced and thoroughly leak-tested after service. Gland packing nuts on valves should not be tightened unless they are leaking.

2.1.9. Handling Hydrocarbons (HCs). Handling procedures for HC refrigerants are similar to those for other flammable substances such as gasoline.

a. Ensure handling is conducted in a well-ventilated area.

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b. Ensure no ignition sources are within 3 m, including the dropping or dragging of refrigerant containers.

c. Ground all components, including charging rigs and containers.

d. Wear required personal protective equipment (PPE), such as gloves, glasses and non-static clothing.

e. Use a leak detector suitable for hydrocarbons – not halocarbons.

f. When recovering and charging HCs, ensure that the equipment is suitable for HCs, that there is no residual HC left in the test equipment, and that the electronics are sealed.

g. Ensure that the area is signed for flammables in accordance with the applicable Fire Code for the quantities of refrigerant in the location.

h. Remember that no one will smell a leaking refrigerant, and that refrigerants will pond and possibly concentrate above the lower explosive level (LEL) in low areas or in compartments because they are heavier than air. Therefore, when leaking refrigerants are suspected:
    i. Evacuate area.
    ii. Be aware of the asphyxia hazard.
    iii. Ventilate to disperse HC refrigerants.
    iv. Eliminate sources of ignition.
    v. Prevent the heavier-than-air refrigerants from entering basements, floor drains and other low-lying areas.
    vi. In case of doubt call the fire department in accordance with local procedures.
    vii. DO NOT UNPLUG any electrical equipment (possible ignition source).

i. Use hot work permits around systems with flammable refrigerants.

j. The facility should:
    i. Perform fire and safety reviews and inspections;
    ii. Review the Fire and Safety Codes;
    iii. Examine the need for fire alarms, smoke detectors, suppression systems, fire extinguishers; and
    iv. Maintain and exercise a Fire Plan that includes egress, fire separation, emergency response and emergency lighting.

k. Note that many accidents in the past have been due to human error.

**IMPORTANT!**

**Managers and supervisors should ensure their employees are trained in handling, using and disposing of flammable refrigerants.**

2.1.10. Common Sources of Emissions. Installation and servicing are the single largest sources of refrigerant emissions. Service technicians should look for:

a. Inadequate design and/or improper installation of systems;

b. Poor quality control of the manufacture of components and/or construction;

c. Shipping damage to the shipping cartons and the equipment;

d. Poor workmanship and supervision during installation;

e. Improper leak-testing of new installations;

f. Venting of refrigerants during installation and servicing;

g. Leaks from rotating shaft seals, o-rings, mechanical connections, broken lines and rusting equipment;

h. Failure to repair leaks before recharging;

i. Residual refrigerant left in the AC&R equipment after recovery; and

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j. Poor design of the compressor room where electrical outlets are not in convenient reach for use of test or servicing equipment, physical access to the system components are crowded or awkward, lighting is poor, etc., leading to service technicians taking shortcuts to avoid troublesome or unpleasant work.

## 2.2. Commissioning

2.2.1. When new installed-type air conditioning and refrigeration (AC&R) systems, equipment, and component upgrades are being installed and a commissioning of the equipment is specified, the Team Leader should be well trained, qualified, certified and experienced in these systems, and the team should inter-disciplinary. It may be useful to include members of the designated operation and maintenance personnel in the commissioning team for familiarizing them with the system. The duties of the General Contractor, Mechanical Contractor, Electrical Contractor and various sub-contractors should be specified in the contract specifications. Commissioning is not intended to replace the contractor's normal and accepted procedures for installing and pre-testing the equipment and carrying out the standard check-out and start-up responsibilities.

2.2.2. Preparation. In preparation for commissioning, the commissioning team should:

a. Be fully familiar with the manufacturer's installation instructions, the system operating and maintenance manual, and the purchase and installation specifications;

b. Confirm that all applicable regulations, Standards and this Code have been adhered to;

c. Ensure that the facility or designated function will have a cooling load available of approximately 60 to 80% of the design load;

d. Ensure that all electrical and control systems are complete and certified;

e. Inspect and verify the quality of all piping systems (including connections, support, insulation and bend radii), ductwork, electrical systems and installation;

f. Check all specification requirements, including: vibration insulators, water piping, mechanical room safety features, ventilation and labelling; and

g. Verify that the system has been filled with refrigerant in accordance with the manufacturer's instructions.

2.2.3. Initial Startup and Shut-down. This portion of the commissioning will verify all components and controls through functional performance testing. The initial startup and shut-down should:

a. Follow the manufacturer's Commissioning Checklist (including the functioning of all valves and switches, and that all gauges are reading in accordance with manufacturer's instructions).

b. Confirm the refrigerant charge with sight glass readings. This may be specified in manufacturer's instructions as:
   i. liquid at 1/3 without load;
   ii. at minimum partial load, some gas in liquid; and
   iii. at full load, no gas in liquid.

c. Check and exercise all the systems controls, detectors and actuators, measure balancing, etc. throughout the facility.

d. If operating on 3-phase power, confirm unit shuts down if any one of the phases are opened.

e. Confirm that the unit and controls properly reset after an emergency shut down or power failure.

f. Ensure that the operating manuals are complete for all components and cover all operating and maintenance activities.

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2.2.4. Follow-up. Upon completion of the on-site testing, the test results should be compiled and documented and a final commissioning report prepared.

## 2.3. Qualifications of Technicians

2.3.1. Service technicians should have a current Environmental Awareness certification, or approved equivalent, and be qualified and knowledgeable about the technical, environmental and energy-efficiency options for the equipment they are operating, servicing and maintaining.

## 2.4. Servicing and Maintenance

2.4.1. Visual Inspections. A frequent walk-around is a simple, cost-effective manner to reduce and avoid AC&R failures and emissions and to look for energy inefficiencies. The following checks on the installed AC&R systems are recommended, as applicable to each particular system:


a. Check the sight glasses for the proper and consistent levels of fluids over time. Bubbles in the refrigerant can be an indication of low refrigerant levels or leaks in the system.

b. Listen to the sound of the compressor and condenser fan for changes from the norm.

c. Note any unusual vibrations.

d. Ensure that the readings on gauges and settings on thermostats and other sensors and controls are within acceptable ranges.

e. Examine the system for indications of oil leakage.

f. Check the piping and couplings for indications of damage and corrosion.

g. Ensure the condenser is clean and the air flow to and from it are unimpeded.

h. Ensure that the air around the condensing unit is not hotter than the ambient temperature of the larger area.

i. Check the belts on open belt driven compressors 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.)

j. Ensure that the evaporator coil is not iced up and that the condensate pan drain is functioning well. A build-up of ice may indicate problems with the electric or hot gas defrost cycle, or that the compartment is open too long or too often without a vinyl curtain to isolate the compartment from the occupied space.

k. Ensure that the equipment guards are not loose, area signs are in place and housekeeping in the area is good.

l. Confirm that the air quality monitor in the mechanical room is functioning.

m. Check the refrigerator/freezer door for proper seal.

n. Look for indications in the occupied areas that zones are being over- or under-cooled (for example, louvres sealed shut or improvised deflectors).

2.4.2. Leak Testing Program

a. A regular leak testing program (minimum once a year, or more in accordance with local regulations, policies or manufacturer's specifications) for all installed systems is essential. If the system has a history of leakage, then leak tests should be carried out more frequently.

b. Small sealed packaged units like window air conditioners, water coolers, vending machines and domestic refrigerators, do not need a regular leak testing program. Apart from cleaning the condenser, normally their maintenance is on a breakdown basis.

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c. Due to the higher probability of refrigerant leakage at pipe connections and a higher probability of damage to pipelines in mobile systems, more frequent inspections and leak checks are advisable. Refer to the section on Mobile Systems for the leak testing program as applicable to mobile systems.

d. Regular leak testing of an air purge system is essential.

2.4.3. Instrumentation and Control Systems. A good system of receiving and logging complaints and maintenance calls is important to monitor the performance of the AC&R instrumentation and control systems. The log should be reviewed periodically and in relation to the past work orders to detect trends and to take appropriate action. If the system has a standing contract for preventive maintenance and servicing, then this evaluation should be brought to the attention of the contractor.

2.4.4. Filter-Dryer. Replacement filter-dryer cores are available for larger installed systems and should be replaced when it is deemed that the filter and/or desiccant are no longer viable. Clogged filters will cause the system to run inefficiently.

2.4.5. Corrosion Protection. Reduced or suspended water flow in evaporators can lead to serious corrosion problems. Flushing and a regular inspection should be carried out.

2.4.6. Bleeding Air. Trapped gases in the tube sheets should be purged periodically.

2.4.7. V Belts. V belts should be checked to confirm that they are not too tight. Overly tight belts can cause undue strain on bearings and seals causing premature failure and leaks.

2.4.8. Instrument Calibration. Test equipment (such as test gauges, manifold gauge sets, weigh scales, and combustible gas or multi-gas detectors) should be calibrated annually or in accordance with the local policy or manufacturer’s recommendations.

2.4.9. Indoor Air Quality. Air flowing over evaporators will cause humidity to condense on the surfaces. This wet environment can become a breeding ground for bacteria, mould and algae that could affect indoor air quality and cause Legionella. Drainage and cleaning of the evaporator air-side surfaces and condensate pans are important to prevent the build-up of microbial growth. Condensate pans could also have biocide pucks placed in them to prevent the growth of bacteria and slime in the pans and drain lines. Biocide pucks should be reviewed to ensure that they will not affect any warranty or react with any materials the amended water will contact.

2.4.10. Gasket Material Compatibility. Flanged joint gaskets should be compatible with the refrigerant and the refrigerant oil.

2.4.11. Valve Servicing. Except when ball valves are involved, valves designed for tightening or replacement of the gland packing/diaphragm under line pressure should be used. Valves should be carefully checked before servicing and the spindle gland-packing nut should be leak-tested regularly.

2.4.12. Seal Lubrication. During shutdown and while the refrigerant has been isolated or recovered, the rotating shaft at the seals on large open compressor systems should be lubricated. This will prevent rusting of the shaft, rust that could migrate into the seal and cause a refrigerant leak later. Prior to system start-up, oil can be placed on the seal to penetrate the seal-shaft seam to prevent the seal from sticking to the shaft and tearing when the motor is started.

2.4.13. Bolt-on Valves. Saddle valves can be used as a tool but should be either replaced by welded-in access valves or the tube puncture welded shut before the service technician leaves the site.

2.4.14. Welding Blanket**.** Refrigerant should not be used as welding blanket. Dry nitrogen should be used during welding or brazing. Do not overheat the tubing because that may cause scale on the inside.

2.4.15. System Shutdown/Winter Layup. Open systems, greater than 19 kW (5.6 tR), that are to be shut down for more than six months should have the refrigerant isolated in receivers or removed to approved storage vessels or containers.

2.4.16. Motors. Premium efficiency motors use about 4% less electricity and cost 15 to 30% more than a standard electric motor. When a motor fails, rather than repairing it, if the motor operates most of the time it may be an opportunity to install a more efficient motor with the same full load speed. The savings in electricity usually offer a payback in the order of four to six years.

2.4.17. Safety. Safe working practices and PPE are important when working around cooling systems. The following hazards can cause injuries:

a. Missing or loose machine guards;
b. Discharge of high pressure refrigerant from burst hoses;
c. Hot parts of automotive engine compartments;
d. Generation of phosgene by exposing refrigerant to an open flame;
e. Opening valves too quickly;
f. Leaving refrigerant recovery equipment on and unsupervised;
g. Overfilling cylinders;
h. Poor housekeeping including slip-trip-fall hazards.

2.4.18. Documentation. Upon completion of any inspection, servicing or other work on an AC&R system, ensure that the equipment log book is updated with the additional information.

## 2.5. Leak Testing

2.5.1. Leak tests should be carried out:

a. Before charging a new installation with refrigerant;
b. After initial run-in;
c. When a leak is suspected;
d. When refilling existing equipment that has been laid up;
e. When replacement parts are to be installed;
f. Annually for installed systems (or more frequently in accordance with local policy or manufacturer's specifications).

2.5.2. Some common points where leaks appear are:

a. Flared, compression and brazed joints;
b. Schrader valves;
c. Compressor gaskets;
d. Rotating shaft seals;
e. Control bellows; and
f. Locations with traces of oil.

2.5.3. Whenever a system is leaking or is to be repaired, the history of breakdowns and leaks from that system should be examined for trends that indicate more serious actions are warranted than a simple leak test, leak repair and system recharge.

2.5.4. In a normal situation, the high and low sides of the unit equalize on shut down. The static pressure normally is more than enough to locate leaks. On larger systems, the low pressure side of a system could be given a positive pressure before leak-testing the evaporator, heat exchanger, thermostatic expansion valve or solenoid valve by short circuiting hot gas to the low pressure side on hot gas type systems. 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.

2.5.5. Organizations may want to consider hiring a separate contractor to conduct the annual leak testing so that the technicians are not diverted by other concerns and possibly not do the thorough test as required.

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2.5.6. Leak Testing Sequence. The following leak testing procedures are recommended:

a. Visual Check. Verify that the unit is genuinely short of charge before opening the closed loop. Initially, check the sight glasses for indications of a shortage of refrigerant. Also look for staining.

b. Leak Check. Thoroughly leak check the system before servicing, using the best available technology. The following leak detection methods can be used:

  i. Electronic leak detector. Detectors capable of detecting halocarbon leakage rates of less than 14 g (0.5 oz) per year should be used for chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs). Single combustible or multi-gas detectors are available to test for HCs, carbon dioxide ($CO_2$), $SO_2$, etc.
  - Ensure that the detector is sensitive to the refrigerant in use.
  - Because refrigerants are heavier than air, when testing a connector, make sure to test under the connector.
  - If leak testing out-of-doors (in the wind), a temporary plastic tarp should be used to shield the area before leak testing.
  - If the mechanical room is contaminated with refrigerant and the background contamination will not permit location of the leak, proceed immediately to recovering the refrigerant.

  ii. Fluorescent dye. If the fluorescent dye method is used, make sure the dye is compatible with the refrigerant and oil, and there is no equipment warranty problem with its use.

  iii. Bubble test. Bubble test with soap solution for larger leaks.

  iv. Water immersion. Water immersion can be used for parts that have been removed, such as small finned oil heat exchangers.

c. Pressure Check. When a leak has been located, hook up the gauge manifold set and confirm pressures are within an acceptable range and consistent with earlier readings.

## 2.6. Leak Repair

2.6.1. Leak Repair.

a. If the leak is due to a mechanical connection, the connection should be tightened and retested to confirm that the connector is no longer leaking.

b. If the leak is due to a leaking Schrader valve, tools are available to replace the valve core while the system is charged.

c. If the leak is from another cause, that part of the system should be isolated and pumped down using approved recovery or recycling equipment. If isolation is not possible, the charge should be pumped back into the system receiver or into a suitable approved storage container.

2.6.2. Procedure. If there is a repairable leak, and the repair is not simply tightening a mechanical connection or replacing a leaking Schrader valve, the following procedures are recommended:

a. Identify the location of the leak.

b. Pump the refrigerant into the receiver, or, if not possible, prepare to remove the refrigerant.

c. If necessary, attach a line tap with a Schrader valve, or temporary bolt-on valve with Schrader valve.

d. Evacuate the system. The refrigerant should be recovered for reuse. (If the system has been contaminated by a hermetic compressor failure, flushing all refrigerant and oil are necessary. Refer to **paragraph 2.9**.)

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e. Once the refrigerant has been recovered, if a temporary bolt-on valve was used, braze a permanent access entry valve onto the refrigeration system.

f. Repair leak. Brazing or welding is preferred for leak repair of piping. Replace components with rusted or leaking casings. Follow the recommendations for work on AC&R systems in **paragraph 2.1**.

g. Conduct a standing vacuum or pressure test. On larger systems, use a standing vacuum test to 75 mmHg (3 inHg) for 15 minutes, or a standing pressure test at 1034 kPag (150 psig) of dry nitrogen for 24 hours.

h. Recharge the unit to the proper operating level and cap the Schrader valve.

i. Run the unit in accordance with the manufacturer's instructions (4 to 48 hours) and carry out another leak check.

j. Update the Service Log, Leak Test Notice and equipment labels to record the details on the work performed.

2.6.3. Non-Repairable Leaks. If the refrigerant leak cannot be repaired, the refrigerant should be recovered. 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 (refer to the "Out of Service Equipment" chapter, **Chapter 4**).

## 2.7. Refrigerant Removal

2.7.1. Storage of Small Units. Out-of-service small packaged AC&R equipment should be stored inside a heated building.

2.7.2. Nitrogen Charge. Where systems have had their refrigerant removed and it is intended to use the equipment again in the future, the system should be charged with dry nitrogen to help prevent contamination of the system. Note that some supplies of nitrogen may not have all the moisture removed and should not be used.

2.7.3. The 4 R's. Recovery, reuse, recycling and reclamation of refrigerant are the only acceptable practice today of removing refrigerants. It is prohibited to vent halocarbon refrigerants to the atmosphere in Canada. As a minimum, all recovery equipment should meet local regulations, Codes and Standards for extraction efficiency and not be cross-contaminated with other refrigerants.

2.7.4. Methods of Refrigerant Recovery. There are two acceptable methods of recovering refrigerants from AC&R systems:

a. The Active Recovery Method (recovery apparatus and an approved recovery cylinder). Typical active recovery equipment consists of two basic types.

   i. Type 1 is capable of only refrigerant recovery. The quality of the refrigerant removed is exactly the same as was in the system being emptied.

   ii. Type 2 (recovery/recycle) not only recovers refrigerants similar to Type 1, 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. This process usually will not remove UV dyes and refrigerant sealants from the recovered refrigerant. Ensure that recycling equipment is intended for the type of refrigerant being processed and will clean the refrigerant to meet prescribed specifications (AHRI 700). Internal filters in the equipment should be replaced with a clean filter for each service job. Refrigerant that cannot meet the prescribed purity specifications must be returned to the supplier for reclamation or disposal using environmentally acceptable methods of destruction. External agencies may have only limited capability to deal with the destruction of blends. Therefore, blends should be returned to the supplier.

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b. 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 labeling under the federal *Transportation of Dangerous Goods Act.*

c. Note that while not permitted in Canada, other jurisdictions outside Canada may reference a passive recovery method, especially for refrigerant conversion kits for domestic refrigerators and freezers. With passive recovery, the old refrigerant is discharged into a specially designed approved plastic recovery bag. The recovered refrigerant is then transferred back at the shop to an approved recovery cylinder for reclaiming.

2.7.5. Filling Approved Recovery Cylinders.

a. Service technicians removing refrigerant for recovery have no practical way to determine the density of a given refrigerant charge. Therefore, a good rule of thumb is:

i. not to exceed 80% of the maximum net weight capacity as stamped on the upper portion of the cylinder for normal ambient temperatures of around 21°C (70°F); or

ii. not to exceed 60% if the temperatures could reach 49°C (120°F).

b. The receiving container should be on a portable weigh scale to ensure overfilling does not occur.

c. The design maximum working pressure that is stamped on the container should not be exceeded in any filling operation, however temporary.

d. Valves should be opened slowly, and the operation should be supervised at all times.

e. When dealing with flammable refrigerants, recovery cylinders should be grounded to the equipment with an approved grounding strap before any transfer of fluids is commenced.

f. Cylinders should be colour coded and labelled to indicate the type of refrigerant. Some jurisdictions may require additional label information.

2.7.6. If the equipment is not to be reused or will be disposed of, it is to be labelled to indicate that the refrigerants have been removed (refer to the "Out of Service Equipment" chapter, **Chapter 4**).

## 2.8. Holding Charges

2.8.1. Unless the equipment is shipped with a pre-charge, equipment should be shipped and stored with dry nitrogen or dry air (-40°C dew point) as a holding charge that meets American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) guidelines.

## 2.9. Cleaning and Flushing

2.9.1. General. Repairing a system after it has been contaminated by a hermetic compressor failure or conversion of systems from HCFC/mineral oil to HFC/polyolester (POE) oil should include a thorough cleaning by flushing (for the latter, refer also to the "Refrigerant Conversion in Existing Systems" chapter, **Chapter 3**). Any residual moisture, acid and/or mineral oil can react with the POE to form system-failing sludge, and therefore systems should be thoroughly cleaned by flushing. Note that old servicing equipment is not compatible with new refrigerants. New hoses, coupler/valve seals and O-rings are necessary. Generally, the procedure is:

a. Leak Test. The equipment and system should have a thorough leak test and all leaks should be repaired.

b. Remove Refrigerant. After the system is at room temperature, all refrigerant should be removed using approved recovery or recycling equipment, and the recovered refrigerant should be put in an approved recovery container. If not contaminated, used refrigerant should be retained for servicing other in-service equipment. Otherwise, it should be returned to the

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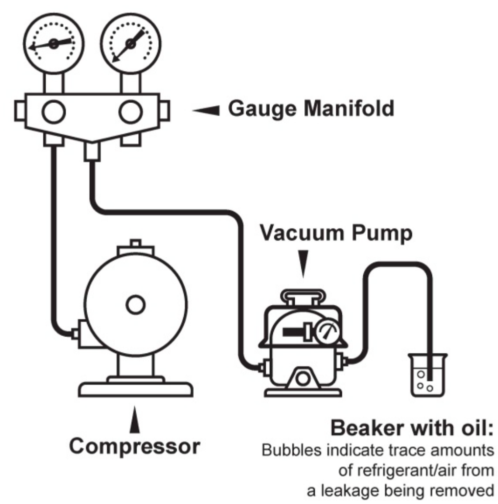
supplier or manufacturer for credit, reclamation or disposal. The weight of the old refrigerant recovered should be logged.

c. Remove Oil. The system should be warmed with indirect heat to recover refrigerant from oil, then the oil should be removed (open flame should not be used since flame reacting with any escaping halocarbon refrigerant may generate phosgene, and reactions with flammable refrigerants could cause a fire or explosion). 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.

d. Flush System. The system should be flushed if necessary using procedures recommended by the manufacturer. A liquid flushing agent should be used from a pressurized container (flushing agents in open jugs can be contaminated with atmospheric moisture). Biodegradable flushing agents with boiling points in the order of 85 to 90ºC (185 to 195ºF) seem to work very efficiently and thoroughly. The system should be flushed until the flushing agent is clear. Note that flushing will remove both the refrigerant and oil.

**Figure 3 – Removing Flushing Agent**




e. Vacuum. A vacuum to 500 mmHg (20 inHg) should be drawn to ensure all the flushing agent has been removed (see **Figure 3**).

f. Change Components. Components should be changed as necessary. Conversion kits may be available, particularly for domestic units. The system should be dismantled, which is best done one section at a time. Shaft seals damaged during installation are a common cause of subsequent leaks. Therefore seals and insert shafts should be replaced with extreme care. The filter dryer should also always be replaced. Recovery connections and valves should be installed where required (one per section).

g. Reassemble System. It is best practice to replace any removed gaskets with new ones. In a conversion, new gaskets should be compatible with the new alternative refrigerant and oil.

h. Leak Test. A standing vacuum test to 75 mm (3 inHg) for 15 minutes, or a standing pressure test at 1034 kPag (150 psig) of dry nitrogen for 24 hours should be used to confirm there are no leaks.

i. Charge System. The system should be charged immediately with refrigerant and oil using the approved procedures, or sealed to prevent atmospheric contamination. Refrigerant should be added slowly to pressurize the system one section at a time. Each section should be leak checked with an electronic leak detector before proceeding to the next. If there is a leak in any section, the entire refrigerant charge should be recovered and the leak repaired before proceeding.

j. Leak Test. The system should be run in accordance with the manufacturer's instructions (4 to 48 hours) and a final leak test should be carried out to confirm all connections are tight.

k. Documentation. The equipment should be labelled with weatherproof, permanent labels indicating the date, refrigerant type and charge, and oil type and quantity. If UV dye has been added to the charge, include this information on the label too. One label should be placed on the compressor above the weld line, one to the back of the cabinet just above the compressor

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compartment, and, if applicable, another just inside the refrigerator door by the model/serial number. The equipment logbook should be updated.

2.9.2. Small Packaged Systems. Contaminated systems require cleaning and flushing after a hermetic or semi-hermetic compressor failure or motor burn-out. 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) should be used for the storage of recovered refrigerants for reuse of the refrigerant charge.

2.9.3. Large Systems. On large installed systems, as many sections of the system as possible should be isolated and cleaned as follows:

a. Remove the contaminated refrigerant and oil to approved recovery containers. Manufacturers may use auxiliary receivers or specially approved “ton tanks” to recover larger quantities of refrigerant from AC&R equipment to facilitate the reuse of the refrigerant charge following servicing.

b. Clean each section separately, or when the system is empty, remove, cap off, and take the component parts off-site for cleaning. The cleaning must be carried out using non-ozone-depleting flushing agents approved for the refrigerant and oil being cleaned.

c. After the cleaning operation is complete, reassemble the system and include a new filter-dryer, and other modifications as required if a different refrigerant is to be used.

d. Draw the system into a deep vacuum of 500 mmHg (0.02 inHg) or less and recover the discharge from the vacuum pump using the best available technologies.

e. Recharge the system.

f. Run the system and leak test to confirm that all connections are tight.

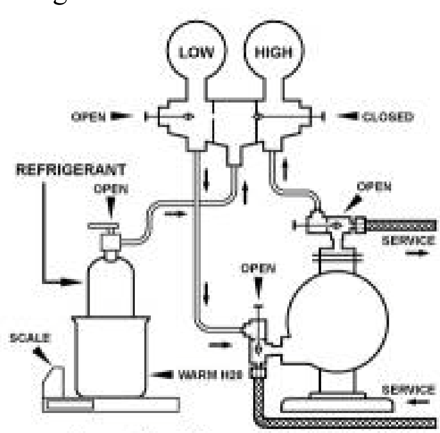
g. Affix weatherproof labels to identify the work done and update equipment records.

## 2.10. Charging

2.10.1. Preparation. After the system has been prepared, the charging rig 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 manifolds for leaks at regular intervals before they are attached to a system.

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

2.10.3. Purging. Purge gas should be collected using appropriate technologies. Non-condensable fluids such as air from the lines can be recovered using conventional or adsorption technology.



Connection for Low-Side Charging

2.10.4. Venting. Do not vent off any refrigerant, other than water, to the atmosphere.

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

2.10.6. Confirmation of Charge. If pre-charged equipment and tubing has been used, do not assume that the assembled

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system will have the correct amount of charge. It is always recommended to confirm the amount of the refrigerant charge by adjusting the charge to the correct pressure settings.

2.10.7. Charging Sealed Systems. 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. Weighing of containers is also useful for monitoring whether the cylinder was leaking in storage.

## 2.11. Refrigerant Sealants

2.11.1. Sealants now exist on the market that, when added to the refrigerant, will seep out of any small holes or cracks with the refrigerant and, on contact with air, will solidify and seal the hole/crack. They only work when the system is operating. However, since only a small amount of the sealant is used initially, it will continue to do its job on subsequent small holes and cracks. Hence, these symptoms of a deteriorating AC&R system will conceal a deteriorating component, pipe or connection, leading to a catastrophic failure later.

2.11.2. Applications. Refrigerant sealants are not a replacement for good preventive maintenance and servicing. Sealants should not be used on installed systems. Therefore it is recommended that they be considered only for:

a. use in emergencies on mobile systems to prevent the loss of a refrigerated load in transit;
b. in small package units (vending machines, ice cream display cases, water coolers, etc. – that is, units that will not have any preventative maintenance or inspections); or
c. in remote, unattended locations.

2.11.3. The leak sealant works best when the leak is on the low-pressure side, particularly if there is a small leak from an O-ring. If the leak is on the high-pressure side, the sealant likely will not work. Refrigerant leak sealant often will slow the leak, but it will not completely fix it. The most common scenario for using a leak sealant is during an emergency to prevent loss of a cargo long enough to get the cargo unloaded and the system to a repair shop so that the leak can be repaired properly.

2.11.4. UV Dye. Sealants with UV dye could be considered since this combination may reveal locations where formerly sealed leaks are located.

2.11.5. Warranty. Before any sealant is used, the manufacturer of the equipment and the supplier of the refrigerant should be consulted to confirm any effects it will have on warranty.

2.11.6. Labelling. If a sealant has been placed in the refrigerant of a system, this information should be written on a weatherproof label for the benefit of other service technicians. The labels should be attached to the compressor and above the compressor.

## 2.12. Refrigerant Containers, Handling and Storage

2.12.1. Refrigerant removed from working equipment may be:

a. reused;
b. recycled;
c. reclaimed and returned to the supplier; or
d. disposed of as hazardous waste.

2.12.2. Recovery Cylinders. Recovery cylinders have a broad yellow band and an ASHRAE designated refrigerant colour. The cylinder owner must have them inspected and hydrostatically retested every five years. The container's pressure rating should be suitable for the refrigerant to be stored in it.

2.12.3. Refillable Containers. Only refillable refrigerant containers (as illustrated on the cover of the Code) should be filled in Canada or imported into Canada by those who are allowed to import refrigerants under the federal *Ozone-depleting Substances Regulations 1998*.

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2.12.4. Disposable Cylinders. Disposable cylinders are not permitted in most Canadian jurisdictions. They usually only have a one-way valve and should not be used to store (contaminated) recovered refrigerant.

2.12.5. Charging Cylinders. Glass charging cylinders may be used to charge or recharge AC&R systems and should not be used as storage vessels to transport new, used, recycled or reclaimed refrigerants.

2.12.6. Drums and Ton Tanks. To facilitate the reuse of a refrigerant following servicing, manufacturers may use auxiliary receivers or specially approved "ton tanks" to recover larger quantities of refrigerant from AC&R systems to facilitate the reuse of the refrigerant charge following servicing. Low-pressure refrigerants are normally shipped in drums, which may be returnable or nonreturnable.

2.12.7. Containers Belonging to a Third Party. If a refrigerant container belonging to a third party (for example, a refrigerant manufacturer) is to be used as a temporary receiver, written permission of the owner of the container should be obtained in advance.

2.12.8. Pressure Vessel. A refrigerant container is a pressure vessel if its capacity is more than 28 L (1 cu ft). The designed maximum working pressure and carrying capacity of the refrigerant recovery container should not be exceeded. The working pressure and expiry of the pressure certification is stamped on the cylinder. All approved containers should be designed to meet the Canadian Transport Commission specifications. Non-pressurized refrigerant recovery containers, such as molecular sieve or resin adsorption containers, are approved by Transport Canada and are not pressure cylinders.

2.12.9. Cylinder Specifications. Under the federal *Transportation of Dangerous Goods Act* (TDGA), all cylinders must meet the appropriate listed specifications. All cylinders should be properly labelled as to content and weight, with the appropriate Workplace and Hazardous Material Information System (WHMIS) language and labelling (refer to **Appendix 5**). The design specifications and pressure rating should be stamped on the cylinder.

2.12.10. Transfer of Refrigerant Between Containers.

a. Refrigerant should be transferred in a manner that is safe and will prevent any chances of release or over-filling during the refrigerant transfer. A pump and weigh scale should always be used.

b. A pressure differential should be established between the containers using a pump or by heating the discharge container under controlled conditions. The discharge container should be indirectly heated by 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).

c. If dealing with a flammable refrigerant, both cylinders should be connected with an approved grounding strap before any transfer of fluids is commenced.

2.12.11. Contaminated Refrigerant. If a 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.

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

2.12.13. Cross-contamination of Refrigerant. Mixing of different refrigerants should be avoided. The receiving container should have been used only for the refrigerant that is being transferred into it. The container should be colour-coded and labelled accordingly.

2.12.14. Refrigerant Container Handling. For safety and leak prevention:

a. Cylinders should be properly strapped into place.

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b. Containers should be handled carefully, and dragging, dropping, denting or mechanically abusing containers should be avoided, to prevent mechanical damage to the container and its valve.

c. When not in use, container valves should be closed and the valve outlet cover nut or cap should be screwed on.

d. Refrigerant containers should not be manifolded together if there is a possibility of temperature differences existing between them. 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.

2.12.15. Container Storage.

a. Smoking should not be allowed in storage, handling and servicing areas.

b. Refrigerant containers should be stored in a cool, well-ventilated, dry place, away from risk of fire, sources of direct heat and direct sunlight. Cylinders should never be stored near any source of heat or where temperatures could exceed 51°C (125°F).

c. Cylinders should be protected from rusting.

d. Cylinders should be stored upright and securely.

e. Containers should be in good condition and not leaking, and all valves and bungs should be closed.

f. Areas should be fenced, labelled and protected from vandalism and weather.

g. Areas where large quantities of refrigerant containers are stored should be monitored.

2.12.16. Storage of Flammable Refrigerants. In addition to general handling and storage practices, storage of flammable products should be in accordance with the Fire Code, including:

a. Cylinders should be stored at least 3 m (10 ft) from other buildings;

b. Cylinders should be electrically grounded, and the grounding should be checked periodically for corrosion;

c. All electrical equipment should be appropriately rated; and

d. The area should be labelled properly.

## 2.13. Recovered Refrigerant, Reuse and Disposal

2.13.1. Refrigerant removed from working equipment should be recovered, reused and recycled by a service technician or sent to the supplier or an independent reclaimer or licensed disposal facility for reclamation or disposal in accordance with applicable regulations.

2.13.2. Recovered Refrigerants. A Type 1 recovery unit does not improve the 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 latest editions of AHRI 740 and AHRI 700, or other standards or guidelines recommended by the relevant jurisdictions, is acceptable to ensure that Original Equipment Manufacturer (OEM) equipment warranties are valid. If the refrigerant has an additive (for example, UV dye or refrigerant sealant), this information should follow the refrigerant wherever it is stored or reused.

2.13.3. Recycling Equipment Maintenance. A service technician or equipment owner or 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. Servicing of recycling equipment includes: emptying oil containers, changing compressor oil, changing filters and dryers, and 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. If OEM equipment warranties are to be valid, recycling units must meet the AHRI 740 and AHRI 700 Purity Standard or other standards or guidelines recommended by federal/provincial agencies.

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2.13.4. Third Party Recycling. 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 (AHRI 700 and AHRI 740) as verified by laboratory analysis.

2.13.5. Return of Refrigerants. When used refrigerants cannot be reused, they should be returned to the refrigerant wholesaler/supplier to be destroyed or reclaimed by an approved facility. Refrigerants that have been contaminated by foreign or toxic substances (other than oil), should be sent to a hazardous waste disposal centre.

## 2.14. Mobile Systems

2.14.1. A Significant Source of Emissions. Automotive air conditioning systems have become tighter, more reliable and more efficient in recent years. Nonetheless, mobile AC&R is still a large percentage of the AC&R market, and continues to use and lose significant amounts of refrigerants.

2.14.2. Pre-Inspection of Equipment. Due to the circuitous routing of intermodal refrigerated containers, maintenance routines are usually sporadic and often result in "breakdown maintenance." Nonetheless, shippers should have these units inspected by qualified certified refrigeration technicians before loading goods in them. Container owners should be notified of the results of the inspection and maintenance carried out.

2.14.3. Shore Power. When a vehicle or intermodal container is parked for long periods with an operating vapour-compression refrigeration system:

a. the system should be connected to "shore power" as a more efficient source of electricity; and

b. the unit should be parked in the shade and/or should be provided with overhead protection to reduce the heat load on the installed refrigeration system.

2.14.4. Vehicle/System Operators. The vehicle or system operator should understand the basic principles of how the refrigeration system works and the normal operating parameters of the unit. Operators should know how to:

a. Visually inspect the system for temperature, pressure, sight glass inspections for refrigerant and oil levels, and the moisture indicator;

b. Watch for oil leaks on the bottom of fittings and connections as a sign of refrigerant leaks;

c. Start and stop the system;

d. Understand the functions and alerts set on the monitoring control; and

e. The location of inspection logs.

2.14.5. Preventive Maintenance Program. Regularly planned and implemented preventive maintenance programs are essential to the reliability of mobile AC&R systems. The preventive maintenance program should be integrated into the vehicle maintenance program. Service logs should travel with the unit. PM programs should include:

a. Visual inspection for catalytic corrosion around clamps, dissimilar metal connections, etc., and rusting of metal shells, due to the more chemically aggressive, dusty and damp environments that mobile systems operate in;

b. Visual inspection for signs of oil deposits from a large leak or any other obvious physical damage;

c. Verification of operating pressures, in that higher than normal operating pressure can cause leaks, emissions and premature equipment failure. High head pressure is caused by high (37°C [99°F]) outside ambient air temperatures, air in the system, and/or condenser coils blocked with bugs, fluff, dirt and debris;

d. Pressure washing the system to remove any accumulation of dust, debris, bugs and road salt residues on components;

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e. Inspections carried out by trained and certified technicians using the manufacturer's service check sheets and service procedures.

2.14.6. Mobile System Leak Testing. Leak testing using the refrigerant as the test gas is acceptable in accordance with SAE J1627 and SAE J1628, provided that:

a. Leak testing is conducted using an electronic leak detector, fluorescent dye or bubble test;

b. If a leak is found, all refrigerant from the test and system is recovered immediately following the test;

c. Note that since 1 Jan. 1998, OEMs should use fluorescent dyes or other proven technology in new vehicles.

2.14.7. Flammable Refrigerants. Due to the flammability of many newer refrigerants, care should be taken to avoid and prevent them from coming into contact with flame or spark-producing equipment and tools during charging, leaks, recovery and failure of mobile AC&R systems. This is particularly important for hybrid vehicles, which have large energy capacity and circuitry. Remember too that refrigerants are heavier than air and can travel great distances to a low-lying ignition point. For the same reason, there is a potential for asphyxiation in floor pits or confined spaces. Refrigerant leak detection at 25% of LEL is acceptable. Ventilation can be one means to assist in preventing a disaster. In the case of a refrigerant leak, all energy should be shut off at a removed location, not locally.

2.14.8. Records.

a. Service organizations should maintain up-to-date records of receipts, shipments and inventory levels of new, used and recycled refrigerants.

b. Some jurisdictions require that accidental and intentional releases of refrigerants be reported to the specified authorities.

c. All refrigerants should be removed before vehicles, shipping containers, etc. are shredded or salvaged (refer to the "Out-of-Service Equipment" chapter, **Chapter 4**).

d. It is unlawful in some jurisdictions to sell new or used components from the closed loop side of a mobile AC&R system to people who are not certified in the safe handling of refrigerants. To ensure that only trained certified service technicians are purchasing new or used components for or from the closed loop side of the system, the service/repair technician's certification number should be on the bill of sale. Some jurisdictions recognize businesses as corporate persons and issue Secondary Distribution Certificates for larger companies that assume the same responsibilities as service technicians for the care and safekeeping of refrigerant and components.

## 2.15. Halocarbon Release Reports

2.15.1. AC&R system owners should check the halocarbon release reporting, or equivalent, requirements in their applicable Canadian jurisdiction. For the federal jurisdiction:

a. The FHR 2003 requires that for federal properties and operations, owners report halocarbon releases of 100 kg or more within 24 hours of the detection of the release. This is to be followed up by a written report within 14 days. Refer to **Appendix 6** for sample forms.

b. The FHR 2003 requires that for federal properties and operations, owners report halocarbon releases between 10 and 100 kg twice annually by 31 Jan. and 31 Jul. Refer to **Appendix 6** for sample form.

c. Some provinces and territories require that emissions or spills over a certain weight, usually 10 kg (22 lb), be reported to the local authorities. All releases or spills of 10 kg (22 lb) or more should be reported to the authority having jurisdiction. Owners should check the halocarbon release reporting requirements in their applicable Canadian jurisdictions.



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## 2.16. Service Records

2.16.1. Equipment Records. Some jurisdictions require that owners keep all logs, notices, records and reports on site of the AC&R systems (or other suitable location if the site is unoccupied), for a specified period of time.

a. Refer to **Appendix 6** for sample Service Log and Leak Test Notice forms.
b. All inspection, servicing and maintenance should be documented in the service log, including details on leak testing and quantities or refrigerants charged or recovered. The date and name of the lead service technician should be included, and entry initialled by him/her.
c. Labels and records should be weatherproofed and written in permanent ink for longevity (such records could be affixed to the equipment in a strong resealable plastic bag that is duct taped to the equipment).

2.16.2. Facility Records. Records should be kept up-to-date. They should detail the transfer of refrigerants by type and quantity between various containers and AC&R systems. Accurate records should also be kept of the contents of refrigerant storage containers (type, quantity, transfer in and transfer out). It is prudent to practice due diligence by keeping proper records and implementing the best procedures available for handling refrigerants.

2.16.3. Location of Records. An up-to-date service record should be kept close to the system. Such records could be affixed to the system in a resealable plastic bag that is duct taped to the equipment. Records for mobile systems should be kept in a central location. If the service record is kept with the owner, a notice should be at the affixed to the system to identify where the record is located. The record should be made available for inspection by the proper authorities and service technicians, and copies attached to service contracts for background information on the history of servicing and maintenance.

2.16.4. Consumption Reports. Some jurisdictions require annual reports of refrigerant consumptions.

2.16.5. Record Retention and Content. It is recommended that annual refrigerant consumption records (including spills of 10 kg [22 lb] or more) be maintained for a minimum of five years. Corrective actions taken as a result of spills should be documented and retained.

2.16.6. Contract Inspection Records. Inspection records prepared under contract should be separate from the invoice and indicated on the record that it is to be filed in the equipment logbook.

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# 3. REFRIGERANT CONVERSION IN EXISTING SYSTEMS

## 3.1. Conversion of Systems to an Alternate Refrigerant

3.1.1. Change Out of Chlorofluorocarbon (CFC) and Hydrochlorofluorocarbon (HCFC) Refrigerants. One of the best ways to reduce the environmental impact of ozone-depleting substance (ODS) emissions is to convert the system or equipment to a refrigerant with a significantly lower ozone-depleting potential (ODP). Some alternate refrigerants are listed in **Appendix 3**.

3.1.2. Air conditioning and Refrigeration (AC&R) Asset Upgrade Plan. Ultimately, all CFC and HCFC equipment will have to be converted or replaced. Owners of many AC&R systems should develop a long-term strategic plan to upgrade their inventory.

3.1.3. Conversion Kits. When planning a refrigerant conversion, a conversion kit may be available for that specific model and application.

3.1.4. Properties of Alternate Refrigerants. Alternative refrigerants should be examined for their ODP, global warming potential (GWP), fire hazard, toxicity, and their effect on efficiency, capacity, motor windings, piping, gaskets and seals. It is important that the new refrigerant, including its lubricant oil, are compatible with all system materials and components, including plastic or elastomeric parts, such as tubing, seals and gaskets. If the system is hermetic, the compatibility of the motor winding should be verified. Parts that are not compatible should be replaced.

3.1.5. Flammability of Refrigerants. For flammable refrigerants or blends, the *Canadian Electrical Code*, B-52 Code, CSA Standards, local Fire Code, Building Code, and any other applicable Regulations, Codes, and Standards should be checked for factors that affect their storage, use and disposal. Highly flammable refrigerants may require that AC&R systems and associated facilities, including storage facilities, meet explosion-proof requirements. There may be limitations on the number of small units (e.g., vending machines) that can be installed in any one location. Selection of a suitable alternative refrigerant should be made by a qualified person.

3.1.6. Convert or Replace. Equipment replacement should be considered when previous CFC and HCFC systems are no longer serviceable or have outlived their useful life. A performance test or check should be carried out on existing systems. A review of the energy efficiency of old versus new equipment should be part of the decision-making equation. Although generally the initial cost of conversion may be cheaper than equipment replacement, nonetheless a life cycle cost (LCC) analysis may indicate that replacement with more efficient equipment will result in a reduced cost of ownership over the life of the system. On the other hand, a short life extension of a system by converting to a newer refrigerant may permit the ultimate conversion or replacement to another system destined to be on the market in a few years with a higher efficiency and low ODP, GWP and hazards. Therefore, an LCC analysis should be carried out (refer to **Appendix 4**).

3.1.7. Poor and incomplete information has led to a number of less than successful retrofit projects in the past. It is important to consider that R-22 and blends containing R-22 will be available until 2020. A rush to retrofit without considering all aspects, including the energy consumption, of the refrigeration equipment throughout its remaining life can be more harmful to the environment when GWP is added into the equation. Sound service practices and a low refrigerant leak rate using existing HCFC refrigerant is a viable option.

3.1.8. While new blends may match or come close in capacity to existing refrigerants, the efficiency of the system may decline considerably. Many systems running on interim blends may be approaching 20+ years in age, and it may not be economically feasible to invest in this type of retrofit. Any retrofit to a hydrofluorocarbon (HFC) will require seal and gasket changes, control adjustments, and possibly the addition or complete change to synthetic lubricants.

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## 3.2. Recommended Conversion Procedure

3.2.1. To prevent leaks during conversion, certified service technicians with experience in equipment conversion should be used.

3.2.2. For packaged and installed systems, the Cleaning and Flushing procedure as described in **paragraph 2.9** should be followed.

## 3.3. Mobile System Refrigerant Conversions

3.3.1. Vehicles should not be recharged with CFC-12. HFC-134a is commonly used as the alternative to CFC-12 and conversion kits may be available for most late model cars and light trucks and for standard packaged refrigeration systems. Note that:

a. Service fittings for R-12 and R-134a are not the same.
b. Highly flammable refrigerants may be banned in certain jurisdictions.
c. The oil may need to be changed.
d. The recovery/recycle equipment should be suitable for the specific refrigerant or blend being recovered.
e. If blends are to be used:
   i. Although there are several automotive blends available, not all are CFC- or HCFC-free, nor are they supported by the vehicle manufacturers.
   ii. All blends should be consistent with the Society of Automotive Engineers (SAE) or US Environmental Protection Agency (US EPA) requirements and Standards.
   iii. Some blends may contain hydrocarbons (HCs) which may attack hoses or gaskets designed for fluorocarbons. This should be confirmed before retrofitting.
   iv. The density of the blend may be different than CFC-12 so the quantity may have to be adjusted to ensure proper operation.
   v. Information on performance of blends including safety and compatibility should be supplied by the manufacturer/supplier and be available in a published format.
f. The hood should be relabelled. The label should give the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) number of the refrigerant and clearly identify if it is flammable and whether the refrigerant contains a UV dye.

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# 4. OUT OF SERVICE EQUIPMENT

## 4.1. Decommissioning

4.1.1. Equipment Disposal. Refrigerant and oil should be recovered from equipment before disposal. Before the equipment is disposed of, the owner or a representative should be able to show proof that the refrigerant and oil have been recovered by presenting a copy of the completed Work Order to the metal shredder or, if allowed in the jurisdiction, to the landfill operator. Oil should be properly disposed of in accordance with local requirements. 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, the refrigerant should be removed first, in accordance with the local requirements.

4.1.2. Recovery of Refrigerant and Oil.

a. The refrigerant charge in air conditioning and refrigeration (AC&R) equipment should be pumped down by a properly trained and certified service technician and stored in approved cylinders for retention or reuse.

b. The refrigerant recovery requirements may be regulated by local authorities. Otherwise, as much refrigerant and oil as possible should be removed. If the compressor is operational, at least 90% of the refrigerant should be recovered. If the compressor is not operational, at least 80% of the refrigerant should be recovered. Since refrigerant may be trapped in or below the oil, the oil should be removed when warm or, in cold weather, by drilling a hole in the base of the hermetic unit.

4.1.3. Labelling. Equipment should be properly labelled with a decommissioning notice by a certified service technician to indicate it is empty. Labels should conform to the requirements of the applicable jurisdiction.

4.1.4. Further guidance is provided in *Generation and Diversion of White Goods from Residential Sources in Canada*, Canadian Appliance Manufacturers Association.

## 4.2. Vehicles Destined for Wrecking

4.2.1. It is essential that all refrigerant in a vehicle air conditioning system be removed and oil collected according to applicable requirements before a vehicle is wrecked or scrapped. The refrigerant should be recovered for recycling and reclaiming, or disposed of as a hazardous waste. Oil should be sent to a reclamation facility or disposed of in accordance with the local requirements. Refrigerant containers should be properly labelled, including the ASHRAE refrigerant number.

4.2.2. The dealer or wrecker should use a certified service technician trained in the safe handling of refrigerants to remove the refrigerant.

4.2.3. Refer to the *National Code of Practice for Automotive Recyclers*, Environment Canada.

## 4.3. Building Demolition

4.3.1. The owner or representative of a building containing AC&R systems should retain proof that the appropriate requirements have been met before demolition. In some cases, the local “permit for destruction” or demolition may identify that the building’s AC&R systems have already had the refrigerants and oils recovered.

4.3.2. Only certified technicians should recover the refrigerant. Residual oil in systems should also be recovered for disposal or recycling.

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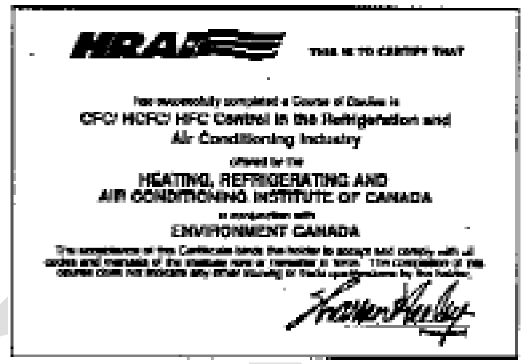
# 5. TRAINING AND CERTIFICATION

## 5.1. Environmental Awareness Course

5.1.1. Most jurisdictions require that all service technicians, including contractors, who perform work on air conditioning and refrigeration (AC&R) systems should have a current Environmental Awareness Course card or approved equivalent. Installation and servicing technicians should be qualified and knowledgeable about the equipment they are installing or servicing.


THIS IS TO CERTIFY THAT

has successfully completed a Course of Studies in
CFC/ HCFC/ HFC Control in the Refrigeration and
Air Conditioning Industry
offered by the
HEATING, REFRIGERATING AND
AIR CONDITIONING INSTITUTE OF CANADA
in conjunction with
ENVIRONMENT CANADA

5.1.2. In addition, managers, designers and purchasing agents who are involved with AC&R may benefit from the Environmental Awareness certification.

5.1.3. Due to the rapidly changing technology and techniques, it is recommended that personnel take a refresher course after a specified period.

## 5.2. Other Qualifications

5.2.1. Personnel who work on AC&R systems must be trade-qualified and licensed in accordance with the requirements for the jurisdiction in which they work. The job titles associated with this field include:

a. Refrigeration Engineer;
b. Mechanical Engineer;
c. Facilities Maintenance Supervisor;
d. Heating, Ventilation and Air Conditioning (HVAC) Technician;
e. Refrigeration and Air Conditioning Systems Technician/Mechanic;
f. Automotive Mechanic;
g. HVAC Mechanic;
h. Controls Technician;
i. Duct System Installer;
j. Refrigeration Specialist; and
k. Domestic Appliance Technician.

5.2.2. Personnel should also be trained in:

a. Workplace Hazardous Materials Information System (WHMIS);
b. Transportation of Dangerous Goods (TDG);
c. Handling flammables, and hot work permits;
d. Confined space entry;
e. Emergency plans, and health and safety plans (HASP); and
f. Care and use of personal protective equipment (PPE).

## 5.3. Apprentice Training

5.3.1. Apprentices in formal training plans should work under the direct supervision of a licensed AC&R tradesman. It is important to note, however, that in accordance with local jurisdiction requirements, each apprentice should have his/her own environmental awareness certification or equivalent.

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# APPENDIX 1 – REFRIGERANTS

## Evolution of Refrigerants

Evaporation Refrigeration. Although there are references to cooling in Egyptian times, refrigeration for the general population probably had its general start in the 1700s with the cutting of lake ice in the winter and storing it in moss or sawdust in icehouses to use in iceboxes during the rest of the year. Small coolers were used in pioneer days to keep food like dairy products from spoiling. These coolers often consisted of wrapping a cloth around a small box and keeping the cloth wet by immersing the ends in basins of water below and above the box, wherein the evaporation of water would cool the box. Drinking water was kept cool by putting it in a thick canvas bag, and again the evaporation of water from the outside of the canvas would cool the bag and water inside. These evaporative coolers are examples of the simple evaporation of water to cool the air/material around it. (Iceboxes are still used in remote regions, and modern versions of evaporative cooling, such as the misting fan, are still widely used as an inexpensive means to cool air.)

Absorption Refrigeration. Mechanical refrigeration was experimented with for many years. However, it was not until the early 1850s when breweries, meat packing plants, railcars, ships and ice-making plants used commercially viable mechanical systems. These systems generally used ammonia, propane or methyl chloride as the refrigerant using the absorption principle. The absorption process basically has ammonia gas being dissolved in water and hydrogen after it leaves the evaporator. The solution is then heated to drive off the ammonia at a higher pressure, and cooled to return the ammonia to a liquid state for expansion again in the evaporator. Therefore, a compressor is not required. Smaller, domestic refrigerators working on ammonia absorption and using natural gas, propane or kerosene for energy were introduced in the early 1900s. Absorption refrigeration is very quiet since only a small fan or circulating pump is often used (but not necessary). Absorption refrigeration is still in use. It is commonly used with solar or inexpensive waste heat and where electricity is not available. Frequently it is used for very large cooling capacities such as in arenas and industrial applications. AHRI Standard ANSI/AHRI 560[3] covers ammonia absorption cooling.

Vapour-Compression Refrigeration. In the 1930s, DuPont introduced the chlorofluorocarbons (CFC-11, CFC-12, CFC 502, etc.) commonly called Freon. CFCs were heralded as a major breakthrough because these refrigerants were efficient with low boiling point, and were non-flammable and non-toxic. The energy efficiency of vapour-compression is better than absorption refrigeration. The age of vapour-compression refrigeration had begun. Refrigeration of all sizes and applications became common throughout industrialized societies.

Air Conditioning. Air conditioning was slower to become commonplace. Houses previously were built to rapidly cool down at night. During the day, houses were kept cool through the use of high ceilings, shade trees, orientations to minimize solar gain in the summer, large eaves, and window blinds to shield from direct sun. Doors inside the buildings had transom windows above them and windows were double hung so that the warmer air in the building could migrate along the ceilings and exit the building through the top of the windows. Inside, comfort cooling was provided by fans that assisted people in cooling themselves. Sometimes to cool the air stream the fans would blow through or by a wet cloth that had its base in a pan of water. More recently, large sealed buildings were constructed creating the need for conditioned air. Smaller buildings were constructed with unnecessarily flat roofs that could not be ventilated to keep the solar gain from radiating into the building. Builders started using chillers and central air conditioning to provide cool air throughout the building. Smaller residential self-contained/window and central air conditioners and heat pumps also became more common. Most air conditioning is generally done using unitary (air-to-air) equipment or liquid chillers.

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3 This Code references current regulation, Standards, and Codes, which may be amended from time to time. Always refer to the most current version of these documents.

Phase-out of CFCs. The scientific community realized that the chlorine molecule in the chemically stable CFCs were destroying the protective ozone layer in the stratosphere. The *Montreal Protocol on Subtances that Deplete the Ozone Layer* (Montreal Protocol), a global treaty, was adopted to phase out ozone-depleting substances (ODS) including CFCs. The federal and most provincial/territorial jurisdictions currently prohibit most new uses and recharging of CFCs in equipment. Note that regulatory requirements are subject to change and therefore individuals must be aware of regulatory requirements for each jurisdiction to ensure compliance.

Phase-out of hydrochlorofluorocarbons (HCFCs). HCFCs were developed to replace CFCs and have lower ozone-depleting potentials (ODPs). However, they still have chlorine content, and many have high global warming potential (GWP). Their phase-out has been scheduled under the Montreal Protocol. One of the most commonly used HCFCs is HCFC-22, which has been in wide use since the 1940s. Because it still contains chlorine and has a high GWP, Canada prohibited the sale or use of HCFC-22 in new applications on 1 Jan. 2010. As of 1 Jan. 2020, the remaining HCFCs (such as HCFC-123, HCFC-124, etc.) will be prohibited from import and manufacture. Nonetheless, equipment with HCFCs can continue to be used until their recharge becomes prohibited. HCFCs have less chlorine and are less stable than CFCs; hence, they break down faster, often before reaching the ozone layer. However, with the growing concern for aggregate ODP and GWP, and the potential impact of the increasing quantities of HCFCs being used globally to replace CFCs, efforts are being made to find more environmentally friendly alternatives.

Introduction of hydrofluorocarbons (HFCs). HFC refrigerants do not contain chlorine and therefore are non-ODS. However, they do have GWP. With the conversion of CFC and HCFC equipment to HFCs and new equipments being manufactured to contain HFCs, the total effect of emissions from all HFC-containing systems on global warming will be considerable.

The Next Generation of Refrigerants. Refrigerants are continuing to evolve and many manufacturers are exploring the use of alternative chemical and natural refrigerants, including propane, isobutane, water and carbon dioxide ($CO_2$). There are over 400 million refrigerators containing the hydrocarbon (HC)-based refrigerant HCR-600a (isobutane) in Europe, Japan, Canada and elsewhere. However, many of the HC refrigerants have a flammability hazard – something that was not common with the halocarbon refrigerants. Apparently, there have been a few cases of explosions in refrigerators due to refrigerant leaks and non-explosion-proof electrical systems in the refrigerators. Nonetheless, it is deemed that the safety considerations of using HCs is in line with the safety practices already used in dealing with gasoline and other flammable substances. Past problems or accidents seem to be mainly due to human error in design, construction, handling and use.

The use of ammonia, with its negligible ODP and GWP, is expanding as the leading refrigerant for cold storage and food processing, especially in the European Union where HCFCs are banned in new facilities. Efforts are underway to improve the efficiency of ammonia refrigeration systems for medium-capacity facilities, such as the use of better welding procedures, high efficiency plate-type heat exchangers (to reduce the size of charge), and direct-expansion tube and shell evaporators instead of flooded evaporators. Moreover, other means of cooling are gaining popularity, including ventilation with fresh air and the use of misting fans (in factories, open-air restaurants, residential properties, on loading docks, etc.). Conversion of existing HCFC equipment may bypass the high GWP HFCs and instead use the natural refrigerants and the newer low ODP-GWP chemical refrigerants. Research is underway to find refrigerants that have good efficiency, no ODP, low GWP and low flammability, such as the hydrofluoro-olefin (HFO) and hydrofluoro-ether (HFE). One such chemical refrigerant that is coming on the market is HFO-1234yf. **Figure 4** shows the refrigerants discussed above by type. **Table 2** is a brief selection of different refrigerants to illustrate the differing properties of the groups of refrigerants. A more complete list of common refrigerants can be found in **Appendix 3**.

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**Figure 4 – Types of Refrigerants**

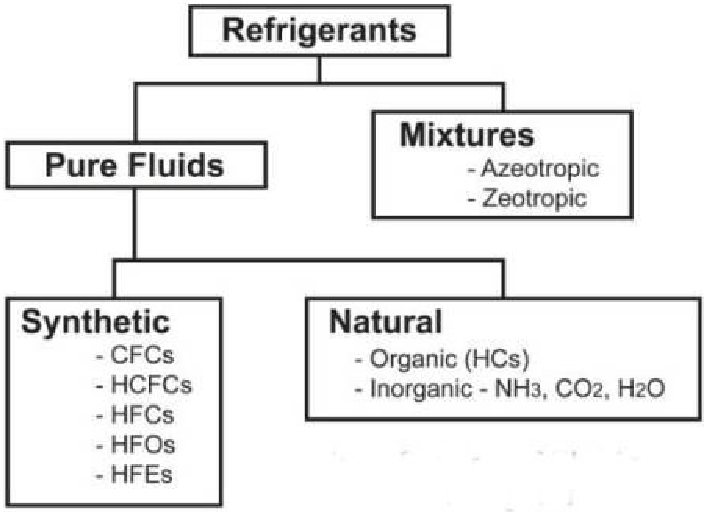


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**Table 2 - Properties of Some Common Refrigerants**

| Refrigerant | Name | ODP | GWP | Flammable | Remarks |
|---|---|---|---|---|---|
| CFC-12 | Freon 12 | 0.82 | 10900 | No | Phased out. Creates phosgene in flame |
| R-502 (Note) | Blend | 0.25 | 4700 | No | Phased-out |
| HCFC-22 | | 0.06 | 1780 | No | Federal phasing out existing equipment 2020 |
| HFC-23 | | 0 | 12000 | No | Very low temperature applications |
| HFC-32 | Blend | 0 | 720 | High | |
| HFC-125 | Blend | 0 | 3450 | No | |
| HFC-134a | Blend | 0 | 1430 | No | Common replacement for CFC-12 |
| HFC-143a | | 0 | 4300 | High | |
| HFC-404A | Blend | 0 | 3900 | Low | Common use for frozen food and ice cream |
| HFC-407C | Blend | 0 | 1800 | Low | HCFC-22 replacement |
| HFC-410A | Blend, Puron | 0 | 2100 | Low | New residential AC & heat pumps |
| HFC-422B | Blend | 0 | 2500 | Low | Drop in replacement for R-502A |
| HFO-1234yf | | 0 | 4 | Mild | Possible adoption for automotive AC in 2013 |
| HFE-347 | | 0 | N/A | N/A | Possible replacement for CFC-11 |
| HC-290 | Propane | 0 | 20 | High | Non-toxic |
| HC-600a | Isobutane | 0 | 4 | High | Common replacement for CFC-12 |
| HC-601 | Isopentane | 0 | n/a | High | |
| HC-1270 | Propylene | 0 | 2 | High | |
| R-717 | Ammonia | 0 | 0 | Mild | Toxic, economical, efficient |
| R-718 | Water | n/a | 0.2 | No | |
| R-744 | $CO_2$ | 0 | 1 | No | Toxic, poor efficiency at high ambient temps |

Note. ASHRAE uses R, but with recent regulatory differences for groups of refrigerants, current practice is to use the type of refrigerant, for example, HCFC-22 versus R-22. Nonetheless, both forms are acceptable.

Mobile Air Conditioning. Since 1939, mobile air conditioners used HCFC-22. It was reliable, stable, safe and worked well in a wide range of ambient temperatures. When CFCs were banned, manufacturers of mobile air conditioners switched over to HFC-134a. Although it has a low ODP, it has a high GWP. In 2008, the European Common Market began a phase-out of refrigerants with a GWP of 150 and higher, with the transition to alternative substances to be completed by 2017. For automotive air conditioners, German manufacturers switched to the $CO_2$ refrigerant R-744 with zero ODP and a GWP of one. Unfortunately, $CO_2$ systems operate at a high pressure, which have a higher risk potential for equipment breakdown and for injury to service technicians. $CO_2$ systems reportedly require more servicing, and are not very efficient in high ambient temperatures. Manufacturers in North America, Japan and the rest of the EU are looking into the use of HFO-1234yf., which has been approved by the US Environmental Protection Agency. It has an efficiency similar to HFC-134a, even in higher ambient temperatures (which means low fuel consumption in these conditions), has low toxicity, zero ODP, a GWP of 4 to 6 and can be used in HFC-134a systems. It is, however, mildly flammable. Many countries are examining opportunities for its commercialization. Other manufacturers continue research to find other suitable replacements for CFCs, HCFCs and HFCs. Some of these will make it to market within the next few years.

## Refrigeration Equipment Considerations

Efficiency. Greenhouse gas (GHG) emissions from air conditioning and refrigeration (AC&R) systems come from both releases of the refrigerant to the atmosphere (direct effect) and energy emissions from generating electricity to power the refrigerative processes (indirect emissions). The total impact of the direct and indirect effects is termed the Total Equivalent Warming Impact (TEWI). To reduce the use of electricity and the global warming effect of its generation, refrigerative processes should be efficient. Some refrigerants as well as some refrigerative processes are more efficient than others. For example, the efficiency of heat pumps depends more on the design and construction than the efficiency of the refrigerant. In addition, new system designs are developing more efficient means of cooling. For example, in supermarkets, rather than having a number of individual refrigerated display cabinets, one "indirect system" is installed in a mechanical room to provide cooling to the cabinets by means of a heat transfer fluid (HTF). The HTF may be monopropylene glycol (MPG) for medium temperature applications, potassium acetate or other brines for low temperature applications, or $CO_2$ ice slurries for phase change cooling. These indirect systems can improve efficiency and reduce the amount of the refrigerant charge by 50 to 75%, and isolate the possibly flammable or toxic refrigerants in a mechanical room. For example, a major Canadian grocery chain is starting to use an indirect system with a $CO_2$ HTF to reduce its display cabinet refrigeration requirements by 15%, and use only 10% of the original amount of R-507.[4]

High efficiency split air conditioners are making significant inroads on the residential and small commercial-institutional air conditioning market. One condensing unit can serve up to three in-room evaporators, and cool only the rooms needed instead of central air conditioners that cool the whole building – whether the rooms are in use or not. They do not need the installation of air ducts throughout since pipes distribute the refrigerant to the evaporators. Moreover, just changing a refrigerant in a system may increase efficiency. For example, a large multinational company has over 400 000 ice cream coolers around the world each with 100 g of HC refrigerant. They are 9% more energy efficient than their HFC counterparts.

Unfortunately, with the ease of mechanical air conditioning, many of the old techniques to keep buildings cool are no longer practiced. Buildings are no longer designed to cool themselves, for example, through proper orientation, design and landscaping to protect them from direct sun. Huge plate glass windows on the sunny side of buildings act as greenhouses. Buildings are sealed, so the only way to remove the hot air is through air conditioning. However, as energy costs escalate and concerns for the environment increase, there has been increasing interest in sustainable buildings. To avoid "greenwashing" (the use of unsupported environmental claims), a few sustainable building standards have evolved. One such standard is the Leadership in Energy and Environmental Design (LEED®) Standard. Application of this and other such standards are reducing and reusing the heat gain in buildings with the benefit that air conditioning requirements are being downsized. More use is made of pitched roofs in lieu of flat roofs so that the solar heat gain can be evacuated from the attic instead of going into the building. Similarly, flat roofs are being turned into green roofs with vegetation to absorb and deflect solar heat from entering the building. As for the effect on emissions, smaller and fewer air conditioning systems mean smaller and fewer sources of potential refrigerant emissions.

Effect of Fossil Fuels. The combustion of fossil fuels, whether to operate equipment (vehicles, furnaces, etc.) or to produce electricity, generates GHG emissions that are a leading cause of climate change. Although

[4] Refer to **Appendix 3** for information on this refrigerant.



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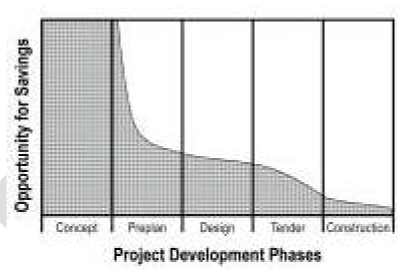
generating electricity by hydro and nuclear means does not produce as much GHG as the burning of fossil fuels, electricity generated by these means produces the baseline power and therefore is not affected by efforts to save the generation of electricity. On the other hand, most peaking power is generated by burning natural gas, fuel oil and coal since these systems can be started and stopped relatively quickly. So reducing energy consumption has a significant effect on Canada's air pollution with its attendant health effects.




Life Cycle Costing (LCC). The LCC of purchasing and operating a refrigerative process in the intended environmental setting has to be examined carefully to make sure that the selection of refrigerant and refrigerative processes includes the evaluation of ozone-depletion, global warming, energy efficiency, pollution prevention, safety and the ambient conditions in which the system will be operating. Equipment that is more efficient may cost more, but the operating costs over its lifetime will usually dwarf the initial purchase cost and provide a payback of the incremental purchase cost in a short time. Therefore, the selection of a refrigeration system is more than simply opening a catalogue and choosing the cheapest one that will satisfy the requirements of cooling capacity for the intended use. The requirement to condition air is more than just to get a machine to do it after the building has been designed. Sustainable design requires that a holistic approach be taken at the outset of the project when there are the best opportunities to save costs over the life cycle. A design team, consisting of all the architectural, engineering and landscaping disciplines, needs to work on an integrated design rather than a step-wise design where the electrical, mechanical and landscaping systems are designed afterward to make the architectural design work.

Flammability. Many of the HC and natural refrigerants are flammable. Recognition of this hazard is particularly important since the ODS halocarbon refrigerants were non-flammable. Designers and service technicians may not be familiar with working amid this danger. Some installations using these refrigerants may need explosion-proof electrical systems or have the refrigerant in a different compartment from the electrical system. Hot work permits, grounding, anti-static clothing and tool selection are important to prevent generation of ignition sources and sparks.

## The Future of Air Conditioning and Refrigeration

The impact of AC&R on the environment is considerable, considering the increased demand for AC&R in Canada. More Canadian homes, more businesses, more cars, a change in diet to more prepared and semi-prepared foods, and global sourcing of foods all indicate an increased demand. The average automobile's air conditioner has about the same capacity as the central air conditioner for a small home and can use up to 20% of the fuel being used by the car.

For packaged, installed and mobile AC&R equipment, much effort is underway around the world to improve their efficiency, to minimize the loss of refrigerants, and to reduce the environmental impact of the refrigerants and their consumption of energy. In addition, regulations affecting AC&R and how these equipment are being used are undergoing many changes. These improvements will reveal themselves in the next decade and will affect the choice of AC&R equipment and refrigerants, and the thermal/energy efficiency of buildings, cold storage and mobile uses, as these new and better ideas make it to market.

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# APPENDIX 2 – ROLES AND RESPONSIBILITIES

The Challenge. While the need to change refrigerants is pressing, air conditioning and refrigeration (AC&R) equipment, facilities and vehicles are failing, are coming to the end of their service life, or must be changed due to unavailability of halocarbon refrigerants. Moreover, all this necessary change is happening at a time when budgets and personnel resources are being constrained and are under considerable pressure from other demands. Decisions may be being made not only on what is necessary by regulation, but also on what has the best cost versus benefit to one's organization, primarily. Therefore, it is extremely important that the personnel who are now making the decisions and carrying out the work are current in their knowledge and have the appropriate updated skills. Clear lines of responsibility and readily available ongoing professional development and training are important.

Professional Development. With the rapid change of technology and regulation, the half life[5] of one's knowledge gained in university or in trades training can now be as little as six years. Personnel must understand how to validate manufacturer's claims, and determine which technologies are best suited for their objectives. Hence, professional organizations are requiring their members to demonstrate ongoing professional development to stay current in their fields. In this vein, the upgrading of knowledge of architects, engineers, designers, purchasers and service technicians should be encouraged and monitored. As a result, it is recommended that the trade certification of personnel in the refrigeration field expire after a specific period unless they have completed a refresher suitable for another period. In line with this, it also is suggested that any regulatory or other Environmental Awareness certification expire after a specified period of time unless the individual has had a refresher course.

## Managers

Managers are responsible for integrating sound and cost-effective environmental practices and concerns into corporate and/or departmental activities, policies and procedures affecting the operational, administrative, safety, health and other relevant requirements. With respect to AC&R systems, managers should:

a. Apply environmentally responsible management practices to hazardous substances and their systems used in refrigerative operations, specifically with regard to the design, acquisition, handling, storage, safety in use, transportation and disposal of such substances, respecting all applicable laws, codes and regulations.

b. Develop and maintain a cooling systems plan for the phase-out, conversion, replacement, ongoing maintenance and disposal of AC&R assets. The plan should include a policy statement, inventory (refrigerants, refrigerative systems and equipment), action plan, financial plan, monitoring plan and third party assessment/audit plan.

c. Ensure compliance with applicable federal, provincial/territorial and municipal regulatory requirements, and conformance with other requirements formally adopted as best practices.

d. Develop, maintain and implement a Health and Safety Plan (HASP) to ensure that workers are trained, practiced and equipped to work safely and in a safe environment.

e. Ensure that financial, equipment, training and personnel resources are available to carry out the planned preventive maintenance programs, including scheduled inspections and servicing, and to implement repairs and decommissioning.

f. Ensure that designers, purchasers and technicians are knowledgeable, qualified and current in their certifications.

g. Be responsible for the maintenance, operation and physical security of their equipment, including cylinders, and ensuring that designers, purchasers, operators, and service technicians are adequately trained.

5 The half life of one's knowledge is when half of what one learned in university or technical school is now outdated.



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h. Provide clear direction to designers, procurement officials and servicing personnel to integrate energy and resource efficiency and conservation in their decision making that will affect the whole life cycle of the equipment they are purchasing, installing and maintaining (for example, stipulate the purchase of ENERGY STAR® products), and monitor the implementation of this direction thereafter. If the organization has an active ISO 14001 Environmental Management System, use this management system to implement, monitor and assess the direction provided.

i. Seek cost-effective ways over the life cycle of reducing pollution, and consumption of energy, water, and other resources and materials associated with AC&R systems and operations.

j. Ensure that life cycle cost (LCC) analyses for the operation, maintenance, upgrade, conversion and replacement of cooling systems have examined the environmental impact and cost of ownership for a life span of 20 years of at least three practical options with each, including:
   i. Design concepts (equipment service life, system efficiency, control systems, associated safety requirements and systems, sustainable building and siting opportunities, etc.);
   ii. Acquisition;
   iii. Operation (energy consumption, hazardous material and waste handling, ongoing personnel training, personal protective equipments (PPE) requirements);
   iv. Maintenance (manufacturers' requirements and projected costs for preventive maintenance inspections, servicing, maintenance, repairs); and
   v. Decommissioning.

k. Control the quality of the services provided by monitoring actual performances against planned performances and taking or recommending appropriate corrective actions to support or coach individuals.

l. Coordinate activities with other managers to ensure the maximum service as efficiently as possible.

m. Through ongoing professional development, stay abreast of regulatory and best practice developments in the AC&R industry and taking a holistic and informed view to solving problems regarding leak prevention, refrigerants and other associated hazardous materials and waste, resource conservation including energy, and system designs and applications.

n. Ensure that the personnel and financial resources are provided to collect, compile, and analyze the necessary data and other information to monitor system performance and environmental impacts. This data can be used to confirm predicted performance data (refrigerant, energy, and water consumption, servicing and repair parts for refrigerative equipment and for control systems, etc.) used in previous decisions and to detect unfavourable trends in equipment performance and maintenance, including the loss of refrigerants.

## Designers

When designing building systems to include AC&R systems and/or being involved in the operation and maintenance of AC&R systems, designers should:

a. Ensure that systems and components, including control systems, have a proven history of performance and that manufacturer's performance data has been verified by independent third parties.

b. Through ongoing professional development, stay abreast of regulatory and best practice developments in the AC&R industry and taking a holistic and informed view to solving problems regarding leak prevention, hazardous material and waste, resource conservation including energy, and system designs and applications.

c. Be knowledgeable about the different energy efficiency ratings and programs, such as ENERGY STAR®, and the types of products that are included in each.

d. Examine system designs for the future ease of servicing and maintenance of the equipment, including adequate personnel access space to inspect and service the equipment.

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e. Conduct LCC analysis of options for new installations, retrofits, major overhauls, etc., for all options over at least the full life cycle of the option with the longest life cycle.

f. Use the most current (and even proposed) information in tender documents and contracts to ensure that the products specified meet the ENERGY STAR® and other designated criteria. (Sample generic procurement language to specify ENERGY STAR® products can be found at www.oee.nrcan.gc.ca/energystar.) Keep their applicable professional knowledge and Environmental Awareness certification current.

## Purchasers

Whether purchasing for governments, institutions, businesses or property management groups, purchasing agents can have a considerable effect on buying and promoting the use of good quality and energy efficient products and services. Purchasers should:

a. Confirm that options were examined when replacing parts as to whether newer, more efficient, more reliable parts are now available (e.g., high efficiency electric motors) than simply replacing with the original equipment.

b. Become familiar with what is available in the marketplace and influencing the decision on procuring or selecting those products manufactured to high quality standards. Select products with optimum energy performance ratings, especially ratings that have been confirmed by independent third parties.

c. Take every opportunity to specify the international ENERGY STAR® certification for components and assemblies.

   i. Products not certified under the ENERGY STAR® program may be certified or qualified for certification under Environment Canada's Environmental Choice program (a program that evaluates energy efficiency, harmful emissions, recycled content and water use).

   ii. In addition, ensure equipment has the mandatory Canadian EnerGuide labels for specified products (e.g., household refrigerators and air conditioners). Although equipment may have a label, it may not be one of the most efficient in its class. The label guides in the selection of equipment at or near the top of its class.

   iii. Other products may have individual energy performance ratings, for example, energy efficiency rating (EER), seasonal energy efficiency rating (SEER), integrated energy efficiency rating (IEER), coefficient of performance (COP).

   iv. The Natural Resources Canada (NRCan) ecoENERGY Retrofit Incentive program may also provide financial assistance for energy saving projects.

d. Ensure that purchases comply with the federal *Energy Efficiency Regulations*.

e. Due to a number of cheap, poor quality systems coming on the market, ensure that systems being supplied have a proven history of performance and a good chain of supply for spare parts in Canada.

f. Consider offering contracts for the annual leak testing of AC&R equipment separate from other work so that the contractor will focus on that sole requirement and not be diverted by other concerns.

g. Ensure that contracts for inspections, servicing or other work have a photocopy of the current equipment Service Log(s) attached to the quotations to provide tombstone and historical performance data to the technician.

h. Ensure contracts require that:

   i. Work will respect all applicable federal, provincial, territorial, and municipal regulations and guidelines.

   ii. Quotations attach lists of personnel to be employed, their qualifications, and proofs of trade and Environmental Awareness certification.

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iii. Quotations include an option for premium-efficiency motors and components if system specifications do not require them.

iv. Suppliers accept returned refrigerants.

v. Suppliers provide Material Safety Data Sheets (MSDS) for all hazardous materials, including refrigerants and servicing supplies, and that MSDS are distributed when received. (Note that an MSDS expires after five years.)

vi. Personnel working on site each day are qualified in accordance with current regulations and are certified.

vii. As-built and wiring diagrams are updated and filed in the equipment logbook.

viii. Servicing reports, including the performance test results, are submitted separate from the invoice and identified specifically for filing with the applicable equipment logbook.

i. Keep their Environmental Awareness certification current.

## Supervisors

Supervisors should:

a. Plan the implementation of the organization’s operating plan in the short term, including the coordination of the day-to-day use of resources, and encouragement of resource conservation.

b. Coordinate activities with other supervisors to ensure efficiency and adherence to schedules.

c. Ensure that all personnel (employees and contractors) who will be employed on a work site have been properly trained on the use and maintenance of their PPE and instructed on the relevant portions of the Spill Response Plan, and HASP as applicable.

d. Ensure that service technicians and contractors are qualified and show proof of current trade and Environmental Awareness certification.

e. Control access to the work site and ensure that immediate steps are taken to make certain of the safety of all personnel including visitors.

f. Ensure that all fire prevention procedures are followed immediately, including taking immediate action to prevent the ignition or the spread of a fire.

g. Ensure that immediate steps are taken to stop or minimize refrigerant emissions.

h. Ensure the safe storage, handling and use of hazardous materials.

i. Ensure that test equipment is calibrated in accordance with the organization’s policies.

j. Supervise personnel, and approve and oversee contractors, to ensure work is done in accordance with specifications, regulations, adopted best practices/requirements and high quality to prevent emissions and damage to the equipment, especially the installation of rotating shaft seals – a major source of subsequent leaks.

k. Issue Hot Work Permits and Confined Space Entry Permits as necessary and ensure that all requirements are adhered to including pre and post work requirements.

l. In the case of a spill or emission, once all required information has been gathered, report the spill immediately (and within the prescribed timeframe) to all concerned personnel, agencies and organizations in accordance with the organization’s policy and procedures and applicable regulations.

m. Ensure that equipment and devices are appropriately labelled and as-built plans are updated as required.

n. Ensure that AC&R equipment records (inventories, preventive maintenance, servicing, maintenance) and hazardous material inventories including refrigerants are maintained up-to-date and accessible.

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o. Track servicing and repairs to detect trends in equipment poor performance to institute equipment modifications where appropriate.

p. Provide training and coaching to junior employees.

q. Provide current information to management relating to workplace activities.

r. Ensure all employees keep their trade and Environmental Awareness certifications current.

s. Keep their trade and Environmental Awareness certification current.

## Technicians

Technicians should:

a. Comply with applicable policies, procedures, legislation and directives.

b. Immediately report any refrigerant leaks, suspected leaks and AC&R equipment problems to their supervisor.

c. Report out-of-date or missing MSDSs to their supervisor.

d. Be sensitive to customers' needs and assist with solving problems.

e. Work harmoniously and in cooperation with all other employees.

f. Perform efficiently and to the best of their ability.

g. Cooperate in maintaining a safe and healthy work environment.

h. Use and maintain their PPE.

i. Recommend changes within their areas of expertise that will reduce emissions, make their jobs safer and easier, and improve the effectiveness and/or efficiency of a process.

j. Keep their trade and Environmental Awareness certification current.

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# APPENDIX 3 – REFRIGERANT OZONE-DEPLETION POTENTIAL (ODP), GLOBAL WARMING POTENTIAL (GWP) AND CONTAINER COLOURS

| Controlled Substance | | ODP | GWP | Container | Properties | Typical Uses, Remarks |
|---|---|---|---|---|---|---|
| **Chlorofluorocarbons (CFC)** | | | | | | |
| Trichlorofluoromethane | R-11 | 1 | 4000 | Orange | NT, NF | Centrifugal compressors. Lge commercial plants. No mftr/import after-1996-01-01 |
| Dichlorodifluoromethane | R-12 | 1 | 2400 | White | NT, NF | Reciprocating compressors. Small units (e.g., refrigerators). No mftr/import after-1996-01-01 |
| Chlorotrifluoromethane | R-13 | | | Light blue | | No manufacture/import after-1996-01-01 |
| Bromotrifluoromethane | R-13B1 | | | Pinkish-Red | | |
| Trichlorotrifluoroethane | R-113 | 0.8 | 4800 | Dark purple | NF | Centrifugal compressors for-AC. No manufacture/import after-1996-01-01 |
| Dichlorotetrafluoroethane | R-114 | 1 | 3.9 | Navy blue | | For-rotary compressors. No manufacture/import after-1996-01-01 |
| Chloropentafluoroethane | R-115 | 0.6 | | | NF | Heat pumps, frozen food cabinets. No manufacture/import after-1996-01-01 |
| Methyl chloride | R-40 | | | | | |
| **Hydrochlorofluorocarbons (HCFC)** | | | | | | |
| Dichlorofluoromethane | R-21 | 0.04 | | | | No manufacture/import after-2020-01-01 |
| Chlorodifluoromethane | R-22 | 0.05 | 1700 | Light green | NT, NF | Widely used AC&R, heat pumps. Banned except cooling. No mftr/import. |
| Chlorofluoromethane | R-31 | 0.02 | | | | No manufacture/import after-2020-01-01 |
| Tetrachlorofluoroethane | R-121 | 0.04 | | | | No manufacture/import after-2020-01-01 |
| Trichlorodifluoroethane | R-122 | 0.08 | | | | No manufacture/import after-2020-01-01 |
| Dichlorotrifluoroethane | R-123 | 0.02 | 0.02 | Light blue grey | NF | No manufacture/import after-2020-01-01 |
| Dichlorotrifluoroethane | R-123a | 0.06 | | | | No manufacture/import after-2020-01-01 |
| Dichlorotrifluoroethane | R-123b | 0.06 | | | | No manufacture/import after-2020-01-01 |
| Chlorotetrafluoroethane | R-124 | 0.02 | 620 | DOT green | | No manufacture/import after-2020-01-01 |
| Chlorotetrafluoroethane | R-124a | 0.04 | | | | No manufacture/import after-2020-01-01 |
| Trichlorofluoroethane | R-131 | 0.05 | | | | No manufacture/import after-2020-01-01 |
| Dichlorodifluoroethane | R-132 | 0.05 | | | | No manufacture/import after-2020-01-01 |
| Chlorotrifluoroethane | R-133 | 0.06 | | | | No manufacture/import after-2020-01-01 |
| Dichlorofluoroethane | R-141b | 0.11 | | | SF | Banned as of 2010-01-01 except for-cooling. No manufacture//import. |
| Chlorodifluoroethane | R-142 | 0.07 | | | | No manufacture/import after-2020-01-01 |
| Chlorodifluoroethane | R-142b | 0.06 | | | | For-heat pumps, high condensing temp apps, Banned 2010-01-01 except cooling. |
| Trifluoroethane | R-143a | 0 | 1000 | | | |
| Chlorofluoroethane | R-151 | 0.00 | | | | No manufacture/import after-2020-01-01 |
| Hexachlorofluoropropane | R-221 | 0.07 | | | | No manufacture/import after-2020-01-01 |
| Pentachlorodifluoropropane | R-222 | 0.09 | | | | No manufacture/import after-2020-01-01 |
| Tetrachlorotrifluoropropane | R-223 | 0.08 | | | | No manufacture/import after-2020-01-01 |
| Trichlorotetrafluoropropane | R-224 | 0.09 | | | | No manufacture/import after-2020-01-01 |
| Dichloropentafluoropropane | R-225 | 0.07 | | | | No manufacture/import after-2020-01-01 |
| Dichloropentafluoropropane | R-225ca | 0.02 | | | | No manufacture/import after-2020-01-01 |
| Dichloropentafluoropropane | R-225cb | 0.03 | | | | No manufacture/import after-2020-01-01 |
| Chlorohexafluoropropane | R-226 | 0.1 | | | | No manufacture/import after-2020-01-01 |
| Pentachlorofluoropropane | R-231 | 0.09 | | | | No manufacture/import after-2020-01-01 |
| Tetrachlorodifluoropropane | R-232 | 0.1 | | | | No manufacture/import after-2020-01-01 |
| Trichlorotrifluoropropane | R-233 | 0.23 | | | | No manufacture/import after-2020-01-01 |
| Dichlorotetrafluoropropane | R-234 | 0.28 | | | | No manufacture/import after-2020-01-01 |
| Chloropentafluoropropane | R-235 | 0.52 | | | | No manufacture/import after-2020-01-01 |
| Tetrachlorofluoropropane | R-241 | 0.09 | | | | No manufacture/import after-2020-01-01 |
| Trichlorodifluoropropane | R-242 | 0.13 | | | | No manufacture/import after-2020-01-01 |
| Dichlorotrifluoropropane | R-243 | 0.12 | | | | No manufacture/import after-2020-01-01 |
| Chlorotetrafluoropropane | R-244 | 0.14 | | | | No manufacture/import after-2020-01-01 |
| Trichlorofluoropropane | R-251 | 0.01 | | | | No manufacture/import after-2020-01-01 |
| Dichlorodifluoropropane | R-252 | 0.04 | | | | No manufacture/import after-2020-01-01 |
| Chlorotrifluoropropane | R-253 | 0.03 | | | | No manufacture/import after-2020-01-01 |
| Dichlorofluoropropane | R-261 | 0.02 | | | | No manufacture/import after-2020-01-01 |
| Chlorodifluoropropane | R-262 | 0.02 | | | | No manufacture/import after-2020-01-01 |
| Chlorofluoropropane | R-271 | 0.03 | | | | No manufacture/import after-2020-01-01 |
| **Hydrofluorocarbons (HFC)** | | | | | | |
| Trifluoromethane | R-23 | | | Light blue grey | | Ultra low temperature refrigeration |
| Difluoromethane | R-32 | 0 | 650 | | SF | |

| Controlled Substance | | ODP | GWP | Container | Properties | Typical Uses, Remarks |
|---|---|---|---|---|---|---|
| Pentafluoroethane | R-125 | 0 | 3400 | | NF | |
| Tetrafluoroethane | R-134a | 0 | 1300 | Light blue | NF | Automobiles, domestic appliances, heat pumps. Popular recreational drug |
| Trifluoroethane | R-143 | 0 | 4300 | | F | |
| Difluoroethane | R-152a | 0 | 120 | | F | |
| Octafluoropropane | R-218 | | | | | |
| Pentafluoropropane | R-245a | 0 | | | | Centrifugal chillers |
| Tetrafluoroprop | R-1234yf | | | | | Potential replacement for HFC-134a |
| **Refrigerant Azeotropic Mixtures** | | | | | | |
| R12+R114 | R-12/114 | | | White | | No manufacture/import after-1996-01-01 |
| R22+R124+R152a | R-401A | 0.37 | 1100 | Pinkish-Red | | No manufacture/import after-2020-01-01 |
| R22+R124+R152a | R-401B | 0.04 | 1200 | Yellow brown | | No manufacture/import after-2020-01-01 |
| R22+R125+R290 | R-402A | 0.02 | 2600 | Light brown | | No manufacture/import after-2020-01-01 |
| R22+R125+R290 | R-402B | | | Green brown | | No manufacture/import after-2020-01-01 |
| R22+R218+R290 | R-403B | | | Light grey | | No manufacture/import after-2020-01-01 |
| R125+R143a+R134a | R-404A | 0.04 | 3300 | Orange | | Low temperature refrigeration |
| R32+R125+R134a | R-407C | 0 | 1610 | Brown | | Popular blend with higher critical temperature than R-410A |
| R22+R143+R125 | R-408A | | | Medium purple | | No manufacture/import after-2020-01-01 |
| R22+R125+R142 | R-409A | | | Medium brown | | No manufacture/import after-2020-01-01 |
| R32+R125 | R-410A | 0 | 1725 | Rose | | Popular blend being used in new AC equipments instead of R-22 |
| R22+R142b+R218. | R-412A | | | | | No manufacture/import after-2020-01-01 |
| R22+R125+R142+R600a | R-414B | | | Medium blue | | No manufacture/import after-2020-01-01 |
| R134a+R124a+butane | R-416A | | | Yellow green | | |
| R125+R134a+R600a | R-417A | 0 | | Green | | For-new equipment and drop in replacement for-R22 |
| R12+R152a. | R-500 | | | Yellow | | Like R22 but 20% > refrigeration with same eqpt. No mftr/import after-1996-01-01 |
| R12+R22. | R-501 | | | | | No manufacture/import after-1996-01-01 |
| R115+R22. | R-502 | 0.28 | 4.1 | Light purple | NT, SF | Supermarket frozen food cabinets with high pressure apps. |
| R134a+R125 | R-507 | 0 | 3300 | Agua blue | | Low temperature refrigeration. Potential replacement for-R502 |
| R143+hexafluoroethane | R-508B | | | Dark Blue | | |
| R22+R218. | R-509A | | | | | No manufacture/import after-2020-01-01 |
| **Hydrocarbon (HC)** | | | | | | |
| Propane | R-290 | 0 | 20 | | NT, F | |
| Isobutane | R-600a | 0 | 4 | | F | Domestic refrigerators |
| Isopentane | R-601 | 0 | | | F | |
| **Other** | | | | | | |
| Ammonia, NH3 | R-717 | 0 | 0 | | T, NF | Explosive, efficient. For-cold storages, ice plants, food refrigeration, etc. |
| Water-vapour | R-718 | 0 | 0 | | NF | Used in water-lithium bromide absorption and steam-ejector-systems for-air |
| Nitrogen | R-728 | 0 | 0 | | NF | |
| Air | R-729 | 0 | 0 | | NF | |
| Carbon dioxide, CO2 | R-744 | 0 | 1 | | NF, NT | Used as solid carbon dioxide or-dry ice in transport refrigeration |
| Perfluorocarbons (PFC) | | nil | high | | | CFC and HCFC substitute |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| **Legend** | | | | | | |
| NT = nontoxic | | | | | | |
| T = toxic | | | | | | |
| NF = non-flammable | | | | | | |
| SF = slightly flammable | | | | | | |
| F = flammable | | | | | | |
| Note: The designation of a refrigerant may uses the class or-"R" in front of its numeral, e.g., CFC-11, or-R-11, or-both, e.g., HCFC R-22 | | | | | | |

A more complete list of refrigerants and their designations can be found on the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) site: [www.ashrae.org/technology/page/1933](http://www.ashrae.org/technology/page/1933)

# APPENDIX 4 – LIFE CYCLE COST ANALYSIS

## Overview of the Process

This Appendix does not detail how to conduct a life cycle cost (LCC) analysis, however, key factors are listed below so that senior management can determine if the LCC analysis was probably conducted adequately.

- The choice of the method of cooling and ventilation is more important than the choice of the actual air-conditioning and refrigeration (AC&R) equipment or manufacturer.
- Increased long term maintenance costs are self evident for controls with poor access, or using technology that is beyond the ability of local personnel and contractors to maintain it.
- To equate various alternatives, each with different timings of expenditures, the time value of money is considered. Future expenses are translated into current dollars (Present Worth) by the effects of interest on theoretically borrowed money to pay for these future expenses. The interest rate is the Discount Rate.
- Results of the LCC analysis should be subjected to a sensitivity analysis. The sensitivity analysis examines the vulnerability of the results to different service lives, increased or decreased levels of maintenance, increased or decreased energy costs, various discount rates, etc.

## LCC Checklist

- Options should include: Option 1 – Status Quo, and Option 2 – Improvements to status quo.
- Period of evaluation: the system with at least the longest service life (20 years?).
- Initial costs include: contract and contributed costs, design and engineering costs, construction administration, commissioning, outfitting, initial personnel training, tools, personal protective equipment (PPE) and contingencies.
- Personnel, operating and maintenance costs include: total personnel and energy-water operating costs, servicing and maintenance (supplies, parts, contracts), ongoing training for staff turnover, overhauls, refitting/replacement costs, and disposal costs within the whole period of evaluation.
- Residual value for items at the end of the evaluation period, for items that have significant residual value.
- Inputs are in constant dollars, without inflation. (Escalation only if estimated to be significant and not balanced among options). No depreciation or subsidies are to be included.
- Discount rate – Normally 10%.
- Discounted payback should be determined at the Discount Rate.
- Final report to include background, briefing notes, requirements statement, option descriptions and sensitivity analyses.
- Set a file budget forecast for the project completion date plus two years for validation of final versus the estimated LCC input costs used in the presentation to the decision maker and analysts.

## Points to Consider

Ask supplier, manufacturers and experienced service technicians for:

- Data and history on energy and water consumption, supplies and parts cost and consumption, electronic control systems, and is the data based on historical values from similar equipment?
- Hazmat content and consumption (including servicing and maintenance products).
- Refrigerant, greenhouse gas (GHG) emissions.
- Hazardous waste generation.
- Initial cost.
- Equipment, installation including modifications to building systems and the building.
- Training.
- Tools and servicing equipment.
- Safety equipment.
- Power consumption (kWh).
- If existing personnel will be responsible for the new equipment, who will do the jobs they are doing now?
- Will the personnel designated to operate, service and maintain/repair the equipment have the necessary knowledge and skills for all components, including the electronic control systems?
- The service life of the equipment and controls is highly variable and should be agreed upon before detailed analysis of the options commence.

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# APPENDIX 5 – LEGISLATION and STANDARDS

This appendix provides an overview of certain Acts and regulations from Canadian federal, provincial and territorial jurisdictions setting out norms applicable to air conditioning and refrigeration (AC&R) and activities in relation thereto.

There also are a number of recognized Codes and Standards that may be applicable to work on AC&R systems. This appendix also lists the organizations and some of the Codes and Standards that they promulgate. Note that these organizations provide a wide variety of Codes and Standards. In addition, this appendix lists some organizations that publish guides to assist in the selection, operation and maintenance of AC&R equipment.


**Anyone involved in the management, design, installation, operation, servicing, maintenance or decommissioning of AC&R systems is responsible to ensure that the work is done in accordance with applicable and current legislation, Codes and Standards. These lists are not to be considered complete, and are mainly concerned with the use of refrigerants for cooling, not their manufacture, import or export.**

## List of Selected Legislation for Canadian Jurisdictions

Since Acts and Regulations are being updated and revised from time to time, users should ensure that they are accessing the most current versions of the instrument before use.

1. **Federal/Federal House (may be referenced in provincial/territorial legislation)**

    a. *Canadian Environmental Protection Act, 1999*

    b. *Controlled Products Regulation* (SOR/88-66)

    c. *Federal Halocarbon Regulations* (SOR/2003-289)

    d. *Ozone-depleting Substances Regulations* (SOR/99-7)

    e. *Transportation of Dangerous Goods Act, 1992*

    f. *Transportation of Dangerous Goods Regulations* (SOR/2001-286)

    g. *Energy Efficiency Regulations* (SOR/94-651)

    h. *Canada Occupational Health and Safety Regulations* (SOR/86-304)

    i. National Fire Code of Canada 2010

    j. National Building Code of Canada 2010

    k. National Energy Code for Buildings 2011

2. **Provincial/Territorial**

Newfoundland and Labrador

a. *Halocarbon Regulations* (NLR 41/05)

b. *Boiler, Pressure Vessel and Compressed Gas Regulations* (NLR 119/96)

Prince Edward Island

a. *Ozone Layer Protection Regulations* (EC619/94)

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Nova Scotia

a. *Ozone Layer Protection Regulations* (NS Reg 54/95 OC 95-293)

b. *Greenhouse Gas Emissions* (NS Reg 260/2009)

c. *Emergency Spill Regulations* (NS Reg 26/95)

d. *Dangerous Goods Management Regulations* (NS Reg 56/95)

New Brunswick

a. *Ozone Depleting Substances and Other Halocarbon Regulation* (NB Reg 97-132)

Quebec

a. *Regulation Respecting Halocarbons* (c.Q-2, r.15.01)

Ontario

a. *Meat Regulation* (OReg 31/05)

b. *Building Code* (OReg 350/06)

c. *Milk and Milk Products*, RRO 1990 (OReg 761)

d. *Boilers and Pressure Vessels* (OReg 220/01)

e. *General – Waste Management*, RRO 1990 (OReg 347, amended to OReg 337/09)

f. *Ozone Depleting Substances and Other Halocarbons* (OReg 463/10)

g. *Licensing of Electrical Contractors and Master Electricians* (OReg 565/99)

h. *Operating Engineers Regulation* (OReg 219/01)

i. *Trades Qualification and Apprenticeship Act*, RSO 1990 (Chap T.17)

j. *WHMIS Regulation* (OReg 644/88)

Manitoba

a. *Ozone Depleting Substances and Other Halocarbons Regulation* (MR 103/94)

b. *Steam and Pressure Plants Regulation* (MR 108/87)

c. *Power Engineers Regulation* (MR 40/92)

d. *Guarded Status Requirements Refrigeration Book*, MB Labour and Immigration, April 2003

e. *Trade of Refrigeration and Air Conditioning Mechanic Regulation* (MR 229/97)

f. *Workplace Safety and Health Regulation*, Part 35 (MR 217/2006)

g. *Electricians License Act* (186/87 R)

Saskatchewan

a. *Halocarbon Control Regulations* (Chap E-10.21 Reg 2)

b. *The Boiler and Pressure Vessel Regulations* (Chap B-5.1 Reg 1)

c. *The Apprenticeship and Trade Certification Regulations*, 2003 (Chap A-22.2 Reg 3)

d. *The Occupational Health and Safety Regulations*, 1996, amended to 2009

Alberta

a. *Ozone-Depleting Substances and Halocarbons Regulation* (Alberta Reg 181/2000, with amendments to Alberta Reg 132/2004)

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b. *Release Reporting Regulations* (Alberta Reg 117/93)
c. *Occupational Health and Safety Code 2009* Part 29 29-1 Part 29 (WHMIS)
d. *Refrigeration and Air Conditioning Mechanic Trade Regulation* (Alberta Reg 300/2000)

British Columbia

a. *Ozone Depleting Substances and Other Halocarbons Regulation* (BC Reg 387/99)
b. *Occupational Health And Safety Regulation* (BC Reg 296/97 (Part 6), amended to 2009)
c. British Columbia Safety Authority: Boiler, Pressure Vessel and Refrigeration Program

Yukon

a. *Boiler and Pressure Vessels Act, 1999*
b. Motor Vehicle Air Conditioning Systems and Ozone Depletion
c. *New Rules for Ozone Protection: Ozone Depleting Substances and Other Halocarbon Regulations*, Information for Technicians
d. *Ozone Depleting Substances and Other Halocarbons Regulation* (O.I.C. 2000/127)
e. *Occupational Health and Safety Act* (O.I.C. 1988/107)

Northwest Territories

a. *Environmental Protection Act* (RSNWT 1998, c.E-7 amended)
b. Guideline for Ozone Depleting Substances
c. Good Building Practice
d. Boilers, Pressure Vessels, Pressure Piping and Plants
e. *Work Site Hazard Materials Information System Regulations* (RRNWT (Nu) 1990 c.S-2)

Nunavut

a. Environmental Guideline Ozone Depleting Substances Jan 2002
b. *Boiler and Pressure Vessel Act* (to be replaced by the *Technical Standards and Safety Act*)
c. *Technical Standards Act*
d. *Apprenticeship Trade and Occupations Act*
e. *Work Site Hazardous Materials Information System Regulations* (RRNWT (Nu) 1990 c.S-2)

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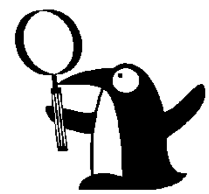
## Organizations for Industry Standards and Guides Related to AC&R



Note: This list of organizations is not inclusive, and the Standards listed are only a short indication of a few of the Standards available. Personnel responsible for designing, purchasing, installing, commissioning, operating, servicing, maintaining, repairing, rehabilitating, converting and decommissioning AC&R equipment are responsible for determining which Standards are applicable to their work and ensuring that they consult the most current versions.

1. **Air Conditioning, Heating and Refrigeration Institute**, (AHRI), www.ahrinet.org

   Note: AHRI Standards are available for free download
   a. AHRI 320-1998: *Water-Source Heat Pumps*
   b. AHRI 740-1998: *Refrigerant Recovery/Recycling Equipment*
   c. ANSI/AHRI 760-2007: *Performance Rating of Solenoid Valves for Use with Volatile Refrigerants*
   d. AHRI Guideline B: *Roof Mounted Outdoor Air Conditioner Installations* (1997)
   e. AHRI Guideline N: *Assignment of Refrigerant Container Colors* (2008)

2. American National Standards Institute (ANSI), www.ansi.org
   a. ANSI standard B.31.5 -2010, *Refrigeration Piping and Heat Transfer Components*
   b. ANSI/ASHRAE 15-2010 and 34-2010 package, *Safety Standard for Refrigeration Systems*
   c. SAE AIR 1811A-1997, *Liquid Cooling Systems* (Oct 2003) [including corrosion control]
   d. A-A-59442 NOT 1, *Elbows, Tube, 90 And 45 Degree, Solder-Joint, Refrigeration* (USA Gov't)

3. **American Society of Mechanical Engineers** (ASME), www.asme.org
   a. B16-5 - 2009 *Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard*
   b. B31.5 - 2006 *Refrigeration Piping and Heat Transfer Components*
   c. B16.22 - 2001 *Wrought Copper and Copper Alloy Solder Joint Pressure Fittings*
   d. B16.50 - 2001 *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*
   e. *Practical Guide to Energy Management*

4. **Canadian Standards Association** (CSA), www.csa.ca
   a. CSA Standard B52-05 *Mechanical Refrigeration Code*
   b. ANSI Z21.74-1992 (R1999) *Portable Refrigerators for Use with HD-5 Propane Gas* [Absorption]
   c. CSA-C657-04 Energy Performance Standard for Refrigerated Display Cabinets (Merchandisers)
   d. CSA Standard C22.2 No. 236 *Heating and Cooling Equipment* (Bi-National Standard with UL 1995)
   e. CAN/CSA-C22.2 No. 120-M91 (R2008) *Refrigeration Equipment*
   f. CSA-F280-M90, *Determining the Required Capacity of Residential Space Heating and Cooling Appliances*

5. **National Research Council of Canada** (NRC), www.nrc-cnrc.gc.ca
   a. *National Building Code of Canada*, 2005
   b. *National Fire Code of Canada*, 2010
   c. *National Plumbing Code of Canada*, 2010

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# APPENDIX 6 – FORMS AND DOWNLOAD LINKS

The **following** forms are provided for meeting the requirements of the *Federal Halocarbon Regulations, 2003*.

1. 24-Hour Halocarbon Release Report
2. 14-Day/SemiAnnual Halocarbon Release Report
3. Service Log (To be used for Installations, Leak tests, Servicing, Maintenance, Repairs)
4. Halocarbon Leak-Test Notice
5. Dismantling, Decommissioning, or Destruction Notice

   Electronic templates are available from Environment Canada on request by contacting OzoneProtectionPrograms@ec.gc.ca.

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# 24-Hour Halocarbon Release Report

Report of releases of halocarbons estimated to be equal or greater than 100 kg

Report releases to the applicable Environment Canada location:
www.ec.gc.ca/ozone/default.asp?lang=En&n=E06A6B0D-1#contacts

| | |
|---|---|
| Date and time of release (if known): | |
| Date and approximation time of detection: | |
| Date and time of call/fax/email: | |
| Report was ___ called _____ faxed: | |
| Recipient's name of the call: | |
| | |
| Owner / Company name: | |
| Owner / Representative name, phone number | |
| Owner address: | |
| | |
| | |
| Operator of system (name and phone number) | |
| Location of equipment: | |
| Asset number: | |
| Type of Halocarbon system: | |
| Type of Halocarbon released: | |
| Estimated quantity (kg) of release (if known): | |

* Verbal or written reports must be sent to Environment Canada **within 24 hours** after the leak is detected.

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# HALOCARBON RELEASE REPORT

Report to Environment Canada for:

1) Releases of Halocarbons more than 100 kg within 14 days of detection, and

2) Releases of Halocarbons estimated between 10 and 100 kg semi-annually by 31 July and 31 January

Report releases to the applicable Environment Canada location: www.ec.gc.ca/ozone/default.asp?lang=En&n=E06A6B0D-1#contacts

| **OWNER (Legal name and facility mailing address):** | **OPERATOR of system (Name and phone number):** |
|---|---|
| | |

| **Release Number** | **Date of Release/Leak (or detection)** | **Type of Halocarbon Released/ Leaked** | **Quantity Released/ Leaked (measured or estimated) (kg, or kg(e))** | **Equipment Location** | **Description of System/Equipment** | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | **Equipment Type** | **Make** | **Model** | **Serial #** |
| | | | | | | | | |
| | | | | | | | | |
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| **Release Number** | **Circumstances Leading to Release/Leak** | **Corrective Actions and Actions to Prevent Subsequent Releases/Leaks** |
|---|---|---|
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# Service Log for AC&R Systems

(For: installation, leak tests, servicing, charging, maintenance, repairs and modifications)
(File in the equipment's logbook)

| OWNER (Legal name and facility mailing address): | OPERATOR of system (Name and phone number): |
|---|---|
| | |

| Description of system | | | | | System location | Installation date | Refrigerant type | System charge (kg) |
|---|---|---|---|---|---|---|---|---|
| Asset ID # | System type | Make | Model | Serial # | | | | |
| | | | | | | | | |

| Date (YY-MM-DD) | Activity | Leak test Y/N/n/a | Leak(s) detected Y/N/n/a | Leak(s) repaired Y/N/n/a | Refrigerant charged (if applicable) | | Refrigerant recovered (if applicable) | | Certified person's employer (if applicable) | Certified person's name, Environmental Awareness certificate #, Trade Qualification certificate # (as applicable) Sign/initial entry | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Type | kg | Type | kg | | | |
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# Leak Test Notice for AC&R Systems

(Use permanent ink and affix to the system in a weatherproof plastic bag)

| OWNER (Legal name and facility mailing address): | OPERATOR of system (Name and phone number): |
|---|---|
| | |

| Description of system | | | | | System location | Installation date | Refrigerant type | System charge (kg) |
|---|---|---|---|---|---|---|---|---|
| Asset ID # | System type | Make | Model | Serial # | | | | |
| | | | | | | | | |

| Date (YY-MM-DD) | Activity | Leak test Y/N/n/a | Leak(s) detected Y/N/n/a | Leak(s) repaired Y/N/n/a | Refrigerant charged (if applicable) | | Refrigerant recovered (if applicable) | | Certified person's employer (if applicable) | Certified person's name, Environmental Awareness certificate #, Trade Qualification certificate # (as applicable) Sign/initial entry | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Type | kg | Type | kg | | | |
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# Dismantling, Decommissioning or Destruction Notice

A copy of this notice must be affixed to the equipment in a weatherproof plastic bag

**and**

the owner must keep a copy of this record in the equipment's logbook.

| OWNER (Legal name and facility mailing address): | OPERATOR of system (Name and phone number): |
|---|---|
| | |

| Description of system | | | | | Location of system before its dismantling, decommissioning or destruction | Refrigerant type | Charging capacity of system (kg) | Final destination of system |
|---|---|---|---|---|---|---|---|---|
| Asset ID# | System type | Make | Model | Serial # | | | | |
| | | | | | | | | |

| Date (YY-MM-DD) | Activity | Refrigerant recovered | | Oil recovered | | Certified technician's employer (if applicable) | Certified technician's name, Environmental Awareness certificate #, Trade Qualification certificate # (if applicable) Sign/initial entry | Comments |
|---|---|---|---|---|---|---|---|---|
| | | Type | kg | Type | kg | | | |
| | | | | | | | | |
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* Please note that all Halocarbons must be removed before dismantling, decommissioning or destruction.

**Do not remove this notice from unit.**

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# APPENDIX 7 – SOURCES OF INFORMATION

There are a multitude of sources of information on air conditioning and refrigeration (AC&R) systems, refrigerants, conversions, life cycle analysis, energy efficiency, sustainable construction, etc. on the Internet. Listed below are just a few such sources:

1. Office of Energy Efficiency (OEE), Natural Resources Canada, http://oee.nrcan.gc.ca/english/index.cfm?attr=4
2. The Office of Greening Government Operations (OGGO), http://www.tpsgc-pwgsc.gc.ca/ecologisation-greening/index-eng.html
3. The Office of Greening Government Operations (OGGO) provision of advice and guide on green procurement.
4. Canadian Council of the Ministers of the Environment, *National Action Plan*, CCME, PN1316, http://www.ccme.ca/assets/pdf/nap_update_e.pdf
5. CampusDirect, Canada School of Public Service [free online green procurement course for federal government], www.csps-efpc.gc.ca/cdirect/index-eng.asp
6. *National Code of Practice for Automotive Recyclers*, Environment Canada, http://www.certifiedautorecycler.ca/Downloads/RYR_AB%20Code%20v2%20eng.pdf
7. *Generation and Diversion of White Goods from Residential Sources in Canada*, Canadian Appliance Manufacturers Association, http://www.nrcan.gc.ca/mms-smm/busi-indu/rad-rad/pdf/can-whit-goo-rec-05-eng.pdf
8. US Environmental Protection Agency (US EPA), Ten Questions to Ask Before You Purchase an Alternative Refrigerant, www.epa.gov/ozone/snap/refrigerants/buying.html

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www.ec.gc.ca

Additional information can be obtained at:

Environment Canada
Inquiry Centre
10 Wellington Street, 23rd Floor
Gatineau QC K1A 0H3
Telephone: 1-800-668-6767 (in Canada only) or 819-997-2800
Fax: 819-994-1412
TTY: 819-994-0736
Email: enviroinfo@ec.gc.ca

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