Guide on Good Practices in Refrigeration and Air Conditioning Servicing

National Ozone Unit

Ministry of Environment & National Beautification

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Guide on Good Practices in Refrigeration and Air Conditioning Servicing

Prepared in partial fulfilment of the

Capacity Building Component of Barbados' Hydrochlorofluorocarbon (HCFC) Phase-out Management Plan (HPMP)

by

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Nomenclature

A C	Air Conditioning
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
CFC	Chlorofluorocarbon
EEV	Electronic Expansion Valves
EPA	Environmental Protection Agency (United States)
EPD	Environmental Protection Department (Barbados)
GHG	Greenhouse gas
GWP	Global Warming Potential
HBFC	Hydrobromofluorocarbon/Bromodifluoromethane
HC	Hydrocarbon refrigerant
HCFC	Hydrochlorofluorocarbon refrigerant
HFC	Hydrofluorocarbons refrigerant
HFO	Hydrofluoroolefin refrigerant
HVAC&R	Heating, ventilation, air conditioning and refrigeration
ISO	International Organization for Standardization
NEC	National Electric Code
NGO	Non-governmental organisation
NOU	National Ozone Unit
ODP	Ozone Depleting Potential
ODS	Ozone Depleting Substances
ODSS	Ozone Depleting Substance Substitute
OEM	Original Equipment Manufacturer
PMS	Preventative Maintenance Schedule
PPE	Personal Protective Equipment
PPM	Parts per Million
PSIG	Pounds per Square Inch Gauge
R & R	Recovery and Recycling
R-12	Refrigerant (Freon) 12
R-22	Refrigerant (Freon) 22
R-290	Propane
R-600	Butane
R-600a	Iso-Butane
R-1270	Propylene
R-717	Ammonia
R-744	Carbon Dioxide
RAC	Refrigeration and Air Conditioning
SAE	Society of American Engineers
TLV	Threshold Limiting Value
TWA	Time Weighted Average
UNEP	United Nations Environment Programme (UN Environment)
UNDP	United Nations Development Programme

Glossary

- **Alternative refrigerant**: Replacement for a refrigerant which is classified as an Ozone Depleting Substance.

  Table 1 provides an overview of the characteristics of some refrigerants currently used as alternatives to HCFC refrigerants. Research is ongoing to find chemicals that are suitable as refrigerants and benign to the environment, therefore, this list is not exhaustive and will change as more alternative refrigerants are discovered.

Table 1: Characteristics of Alternative Refrigerants (UNEP, 2014)

Properties	Natural Refrigerants			Synthetic Refrigerants	
	HCs	Ammonia	CO_2	Saturated HFCs	Unsaturated HFCs (HFOs)
GWP (100 years)	Very Low	Very Low	Very Low	Very High*	Very Low
Flammability	Very High	High	Very Low	Very Low*	High
Toxicity	Very Low	Very High	Low	Very Low	Very Low
Pressure	Low	Low	Very High	Low	Low
Availability	Low	Low	Low	Very Low*	Very High
Familiarity	Low	Low	High	Very Low	High

*This refers to conventional, widely used HFCs such as R-134a, R-404A, R407A, R-410A, etc. Some saturated HFCs such as R-161 and R-152a have low GWPs, are flammable and may not be as easily available as the common HFCs.

- **Ammonia (NH3):** Ammonia is a gas comprised of nitrogen and hydrogen. Whether found in nature or made by man, ammonia is colourless but has a sharp, pungent odour. Ammonia, frequently used commercially in large freezing and refrigeration plants is also called "anhydrous ammonia" because it contains almost no water (it is 99.98% pure). Ammonia is very toxic but has no ozone depletion potential and no global warming potential.
- **Azeotropic blend:** A mixture made up of two or more refrigerants with similar boiling points that act as a single fluid. The components of azeotropic mixtures will not separate under normal operating conditions and can be charged as a vapour or liquid.
- **Blend:** A mixture of two or more single component refrigerants in a specific ratio. Blends may be Azeotropic or Zeotropic.
- **Chlorofluorocarbons (CFCs):** A family of chemicals that contain chlorine, fluorine and carbon; used as refrigerants, aerosol propellants, cleaning solvents and in the manufacture of foam. Chlorofluorocarbons are hydrocarbon compounds in which the hydrogen atoms are completely or partially replaced by fluorine and chlorine compounds. When they break down, they deplete the ozone layer. These chemicals have high ozone depleting potential and were phased out under the Montreal Protocol in January 2010.

- **Carbon Dioxide (CO_2):** A naturally occurring substance containing one atom of carbon and two atoms of oxygen. It has no ozone depletion potential and insignificant global warming potential. The use of Carbon Dioxide as a refrigerant began in the mid-nineteenth century and steadily increased, reaching a peak in the 1920s. Its use declined with the introduction of CFCs that operated at much lower pressures. Currently, CO_2 is used mainly in cascade systems for industrial and process applications.
- **Contaminant:** Dirt, oil, moisture, acid, particulates or any other substance that is foreign to a refrigerant.
- **Destruction:** The process resulting in a permanent transformation or decomposition of all or a significant portion of disposed refrigerant.
- **Disposal:** The removal and appropriate storage of used refrigerant from a system. This may be necessary if refrigerants become badly contaminated with other products and are no longer of the acceptable specifications for reuse.
- **Flushing (Purging):** The process of removing unwanted air, vapour, dirt or moisture from a refrigeration system. An inert gas like nitrogen is flowed through the system or component forcing the unwanted matter out.
- **Halocarbons:** Chemical compounds made up of the element carbon and one or more of the halogens (bromine, chlorine, fluorine, iodine). Halocarbon refrigerants are chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), Hydrobromofluorocarbons (HBFCs), Hydrofluorocarbons (HFCs) and related compounds. The non-flammability, low chemical reactivity, and low toxicity of many of the halocarbons are their most valuable properties. Halocarbons that release chlorine, bromine or iodine into the stratosphere cause ozone depletion.
- **Hydrobromofluorocarbons (HBFCs):** A family of chemicals related to CFCs which contain hydrogen as well as bromine, fluorine and carbon. The hydrogen reduces their atmosphere lifetime making HBFCs less damaging than CFCs in the longer term.
- **Hydrocarbons (HCs):** A family of naturally occurring, nontoxic substances containing Carbon and Hydrogen. When used as refrigerant that have no ozone depleting properties and insignificant global warming potential.
- **Hydrochlorofluorocarbons (HCFCs):** A family of chemicals related to CFCs which contain hydrogen as well as chlorine, fluorine and carbon. The hydrogen reduces their atmosphere lifetime making HCFCs less damaging than CFCs in the longer term.

- **Hydrofluorocarbons (HFCs):** A family of chemicals related to CFCs, which contain hydrogen, fluorine and carbon, but no chlorine, and therefore, do not deplete the ozone layer. However, HFCs are potent greenhouse gases.
- **Hydrofluoroolefin (HFOs):** A family of unsaturated organic compounds composed of hydrogen, fluorine and carbon. These organofluorine, olefin compounds are categorized as having zero ODP and low GWP and so offer a more environmentally friendly alternative to CFCs, HCFCs and HFCs.
- **Montreal Protocol:** The Protocol to the Vienna Convention, signed in 1987, which commits Parties to take concrete measures to protect the ozone layer by freezing, reducing or ending production and consumption of controlled substances.
- **Ozone-Depleting Potential (ODP)**: A measure of a substance's ability to destroy stratospheric ozone, based on its atmospheric lifetime, stability, reactivity and content of elements that can attack ozone such as chlorine and bromine. The ODP of a substance is calculated relative to the CFC 11 whose ODP is equal to 1.
- **Ozone-depleting substance (ODS)**: Any chemical that can deplete the ozone layer. Most ODS are controlled substances under the Montreal Protocol.
- **Ozone:** A gas whose molecules contain three atoms of oxygen, and whose presence in the stratosphere constitutes the ozone layer. Ozone is toxic to humans, animals and plants at high concentrations, and so is a pollutant when present in the lower atmosphere in smog.
- **Phase out:** The ending of all production and consumption of a substance controlled under the Montreal Protocol over a specified period of time.
- **Phase-down**: The reduction of production and consumption of a substance controlled under the Montreal Protocol to a specified level over a specified period of time.
- **Quota Allocation:** The annual quantity of HCFC refrigerant which an importer is legally allowed to import based on the country's baseline established under the HPMP.
- **Reclamation:** The process of returning used refrigerant to new product specifications. Chemical analysis of the refrigerant is required to determine that appropriate product specifications are met.
- **Recovery:** The removal of refrigerants from equipment and collection in an approved external container for the purpose of storage, recycling, reclamation or transportation. Recovery does not involve processing or analytical testing.

- **Recovery Cylinder:** Certified cylinders used to recover, store and transport used refrigerant from any refrigerant system to a location where it can be recycled and put back in service, or properly disposed of.
- **Recycling:** The process of reducing the contaminants from used refrigerants in order to return refrigerants to acceptable standards for reuse. Recycling is usually conducted in the field with no analytical testing to verify the quality of the recycled refrigerants.
- **Refrigerant:** Substances used in refrigerating mechanisms. It absorbs heat in an evaporator by change of state from liquid to a gas and releases heat in a condenser as the substance returns from the gaseous state back to liquid state.
- **Retrofit:** The process by which changes are made to existing equipment in order for an alternative refrigerant to be used in the system.
- **Zeotropic blend:** A mixture made up of two or more refrigerants with different boiling points. Zeotropic mixtures have a temperature glide greater than 10 °F and should be charged in the liquid state.

1 Background

The term ozone layer describes the zone of the highest concentration of ozone molecules in the stratosphere. The layer, which is 10–20 km thick, envelopes the entire globe like a bubble and acts as a filter for the harmful ultraviolet (UV-B) radiation produced by the sun, thus protecting human health and the environment. In the early 1970's scientists discovered that emissions of human-made chemicals were depleting the ozone Layer.

With increasing scientific evidence of the thinning of the ozone layer, a group of nations concerned with this situation, signed the Vienna Convention for the Protection of the Ozone Layer in 1985 and the Montreal Protocol on Substances that Deplete the Ozone Layer in 1987. The Protocol identified the major ozone depleting substances (ODS), and established legally binding controls for developed and developing nations on production and consumption of ODS guided by an established phase out schedule to realise a reduction and eventual elimination of their production and use.

Barbados acceded to the Protocol in October 1992 and pursuant to Barbados' obligations thereunder the National ODS Phase out Management Programme was established in 1994. The programme is responsible for the development, coordination and implementation of policies, plans and activities to effect the phase out of ODS at the national level and the transition towards the use of non-ozone depleting, climate friendly and energy efficient alternatives.

Requirements for the Importing and/or Exporting of substances controlled by the Montreal Protocol

Domestic regulation of trade in ODS refrigerants is exercised through the Customs (List of Prohibited and Restricted Imports and Exports) (Amendment) Order 2010 and the Miscellaneous Controls Act. The Order defines (a) the ODS chemicals prohibited and restricted from import or export, and (b) requires all traders to secure an import or export licence for the substances included on the restricted list. These controls apply equally to trade in bulk ODS and any blended derivative thereof. Any individual and/or business planning to import and/or export a restricted refrigerant MUST obtain a licence from the Department of Commerce and Consumer Affairs.

In addition, with the recent adoption of the Kigali Amendment to the Montreal Protocol in October 2016, HFCs will soon be subject to phase-down timetable under the Montreal Protocol and subsequently listed under the Customs Order.

2 Purpose and Scope

This Good Practice Guide has been produced as part of the National Ozone Unit's, continuous effort to enhance the knowledge and capacity of local RAC technicians to respond and contribute to national compliance actions being undertaken as a Party to the Montreal Protocol. It is an important part of the regulatory framework to support Barbados' ODS phase-out activities and was developed taking into consideration recent amendments to the Montreal Protocol.

This Guide applies to Industrial/Commercial, Residential, Domestic, Mobile Refrigeration and Mobile Air-Conditioning sectors, and aims to:

- Enable the reduction of ODS consumption by assisting with a smooth transition from the use of ODS consuming technologies to non-ODS consuming technologies;
- Promote the practice of allowing existing refrigeration systems to run until the end of their useful life, thereby avoiding premature replacement;
- Define minimum standards of good practices for servicing refrigeration systems to help minimise refrigerant discharges to the atmosphere and promote personal safety; and
- Act as a resource document for technicians and to aid with their training and re-training in existing and emerging refrigerant technologies.

This Guide was prepared by Noel Brown Ph.D., P.E. in partial fulfilment of the Capacity Building Component of Barbados' HCFC Phase-out Management Plan. The process involved wide-ranging consultation with key stakeholders in the RAC sector including: the National Ozone Unit, the Refrigeration and Air Conditioning Association (RACA), the Samuel Jackman Prescod Institute of Technology (SJPI) and service technicians.

The complete listing of literatures referred for the compilation of this Guide is provided in the bibliography of this publication.

3 General Recommendations for Good Practice

Technicians

- Only trained RAC technicians should perform service, repair or retrofit works on RAC systems and operate refrigerant recovery and recycling machines, vacuum pumps and other RAC equipment.

Service Workshops

- All service and repair enterprises should be registered with appropriate government agencies.
- Only registered workshops should perform RAC-related services.
- All technicians employed by service entities that are actively involved in the service and repair of RAC systems should be adequately trained and certified.
- Workshops should maintain a record of service activities with information including the quantity of refrigerants recovered and stored or reused.

RAC Servicing

- ODS and HFC refrigerants should **NEVER** be vented to the atmosphere.
- ODS and HFCs should **NEVER** be used as cleaning solvent in systems.
- Different types of refrigerant should not be mixed in one cylinder.
- Refrigerants should **ALWAYS** be recovered before servicing a system. [See recommended practices for refrigerant recovery and recycling in Chapter 9]
- Recovered refrigerants should only be stored in properly labelled, certified recovery cylinders.
- Retrofitted RAC equipment should be properly labelled indicating, among other things, the type and quantity of refrigerant charge, the name of the person who did the retrofit, the date and time.
- Records of servicing should be maintained by the technician and/or servicing company for a period comparable to the remaining service life of the equipment. [See recommended practices for record-keeping and documentation in Chapter 10]

Importers, Distributors, Dealers, Retailers

- Only enterprises that have Quota Allocations administered by the National Ozone Unit are allowed to import refrigerants controlled by the Montreal Protocol.
- Only enterprises that are registered with relevant authorities should purchase, re-sell or distribute refrigerants controlled by the Montreal Protocol.
- Individuals involved in the purchase, re-sale or distribution of refrigerants should employ proper methods for the transportation, handling, storage and labelling of refrigerants. [See recommended practices for transportation, handling and storage refrigerants in Chapter 11]

4 Domestic Refrigeration and Air Conditioning

General Safety

Only qualified, trained, certified or sufficiently experienced technicians should conduct the installation of RAC systems. Technicians should ensure that:

- The main power supply to the unit is switched off while installation is in progress.
- The electrical connection is at the rated current, voltage and phase for the unit.
- The unit is grounded as recommended by the National Electric Code.
- The units are not installed near to any direct heat source.
- The work area is above ground in a well ventilated area, whenever possible.

Installation of Split Air Conditioning Systems

The split air conditioning system consists of an indoor unit (IDU) or evaporator and an outdoor unit (ODU) or condenser. The recommended practices to follow for the installation and pressure testing and vacuuming of these systems are provided below.

Indoor Units (IDU)/ Evaporators

The IDU should be installed such that there is no obstruction to the air flow emanating from the unit. There should be at least 150 mm (6”) between the unit and the walls and ceiling.

Practices to follow

✓ Review installation recommendations thoroughly before commencing installation. Be sure to properly review the:

- selection software report that shows the piping and branching sizes
- floor plan that shows the exact location of each evaporator and confirm evaporator locations with the designing engineer if evaporators are not correctly labelled.

- ✓ Adhere to clearances specified by the Original Equipment Manufacturers (OEM).
- ✓ Check to ensure that supports are securely anchored, including: threaded rods with wall anchors, plates for wall mounted evaporators and brackets fabricated from angled steel or other metals.
- ✓ Fasten evaporators securely to brackets and supports.
- ✓ Check to ensure that the operation of moving parts is unobstructed.
- ✓ Always flare copper tubes with the opening facing down to ensure that shavings do not remain in the pipe causing trouble for the Electronic Expansion Valves or restricting refrigerant flow through the tubes.
- ✓ Connect the flare nut with the recommended torque from the OEM.
- ✓ Insulate liquid lines separately from suction lines.
- ✓ Insulate copper tubes with the recommended thickness from OEM.
- ✓ When conducting welding operations:
    - Use the recommended Personal Protective Equipment (PPE).
    - Have a point person that is responsible for fire suppression in the event of a fire.
    - As illustrated in Figure 1 Schematic of welding operation ensure that a slow stream of nitrogen flows through the pipe/tube to prevent oxides from forming inside the pipe. This may not cause immediate damage but can affect the normal functioning of the EEVs.
    - Push insulation away from the welded joint hold in position with duct tape. Keep the tape in place until joints have been tested during pressurization. After testing the joints, glue the ends of the joining insulation and tape the joints.

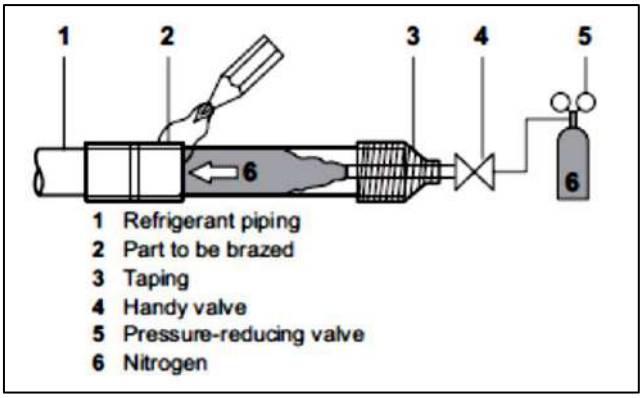

Figure 1 Schematic of welding operation
Source: Daikin's Engineering Data for VRV IV, Heat Pumps, R-410A". Manual number: EDMT341421, page 660.

Practices to eliminate

- ✗ **NEVER** use tube cutters to hold insulation.
- ✗ **AVOID** using tie straps directly on insulation. If tie straps must be used, ALWAYS reinforce the insulation before tightening the tie strap to prevent the tie strap from cutting into the insulation.

Outdoor Units (ODU)/ Condensers

The ODU should be installed on a strong foundation, away from any direct heat source. There should be no obstruction to air circulation. The space around the ODU should not be less than 150 mm (6") in the rear and more than 1500 mm (59") in front of the unit. It should be placed away from any flammable materials. If there is a shade above the ODU, it will improve its performance.

Practices to follow

- ✓ Select a rigid base for the installation of the condenser.
- ✓ Install condensers as per OEM instructions.
- ✓ In the event of multiple condensers being installed, be sure to:
    - Connect each evaporator to the correct condenser.
    - Connect the communication cable for the evaporator to the correct condenser.
    - Connect the outdoor branches in the correct orientation as per OEM instructions.
    - Install oil equalization lines as specified by the OEM.
- ✓ Give consideration for the route of water as the condensers sometimes have heavy condensation.
- ✓ Adhere to the clearances and precautions specified by OEM.

Pressure Testing and Vacuuming

Practices to follow

- ✓ When all lines are closed and the nitrogen is added to the system, ensure that the pressure is brought high enough to test for leakage.
- ✓ Ensure to test all brazed joints and flare nuts for leakage.
- ✓ Increase the system pressure to the maximum working pressure stated on the data plate, record the time of day and ambient temperature at the completion of adding the nitrogen.
- ✓ After 24 hours has elapsed, check to make sure that the pressure in the system remains the same (taking into consideration the ambient temperature).
- ✓ If the pressure is lower than previous readings at the same ambient temperature, try to identify and address leaks. Repeat test in 24 hours until the test is successful.
- ✓ After successfully completing the pressure testing, reduce the pressure in the system to atmospheric pressure and begin the process of vacuuming the system. Ensure that:
    - the vacuum gauge used can read down to 1000 microns
    - a vacuum of 5000 microns can be held for one hour, when the pump is not running.

System Operation and Maintenance

A service technician's responsibility is to minimise the amount of refrigerant that escapes into the atmosphere during its operation. Any system should be given a thorough visual inspection before starting any service procedures. Examine the entire refrigerant circuit while watching for signs of oil leakage, corroded or damaged lines, hoses, or other components and look out for uncapped valves, dust caps, or missing and/or damaged O-rings.

The condition of a system should be assessed to determine whether it is practical to repair or not. If repairable, perform procedures in accordance with acceptable industry practices. If beyond repair, exert utmost effort to recover the refrigerant content of the unit, if there is any remaining. [See recommended practices for refrigerant recovery and recycling in Chapter 9] The following principles should be observed during the operation and maintenance of RAC systems.

Air Conditioning Units

Practices to follow

- ✓ When leaks exist, shut down systems and make necessary repairs.
- ✓ Always double check the system. Some leaks are very hard to find. Some leaks are vibration, temperature, and or pressure dependent. Therefore, it is important to practice good service procedures and workmanship.
- ✓ Maintain a time delay interval of at least 3 minutes when turning the compressor on after shut-off or during power failures.
- ✓ If evacuation is needed, recover refrigerant before starting the evacuation process. [See recommended practices for refrigerant recovery in Chapter 9]
- ✓ Follow the instruction of the manufacturer for the cleaning and flushing of a contaminated system and for the replacement of filters, driers, accumulators and other components.
- ✓ Always identify refrigerant and oil type prior to any system service procedure to prevent any cross contamination.
- ✓ Raise the oil temperature prior to service work to reduce the amount of refrigerant dissolved in the oil.
- ✓ Use a heat lamp to apply heat to the system if a heater is not installed.
- ✓ If a refrigeration system has been opened to the atmosphere for servicing, evacuate and pressure test the system thoroughly prior to recommissioning.
- ✓ Check the amount of oil or lubricant remaining in the system and add the required amount.
- ✓ To avoid cross contamination, always use the specified oil for a given refrigerant.
- ✓ Keep the oil containers closed and hoses sealed-off when not in use.
- ✓ Always replace the filter-drier when opening-up a system for repair and never reuse lubricant.
- ✓ Adjust the refrigerant charge by using pressure temperature charts until proper operating conditions are realized; the sight glass cannot be used to adjust the charge properly.
- ✓ During system charging, an electronic scale must be used to guarantee that the specified amount of refrigerant is charged into the system.

- ✓ Conduct performance testing after recharging or commissioning.
- ✓ Provide periodic checks on the operating amperages and temperatures.
- ✓ In service practice, if a recovery machine is attached to a cross contaminated system and that crossed refrigerant charge is recovered, the recovery machine must be cleaned and filter-driers replaced.
- ✓ Keep the outlet cap on the valve outlet, and keep the valve hood securely screwed onto the neck of the returnable cylinder when not in use, except when discharging refrigerant.
- ✓ Keep the returnable cylinder secured in an upright position.

Refrigerators

Practices to follow

- ✓ Refer to OEM recommended operation manual.
- ✓ Avoid excessive ice build-up on the evaporator.
- ✓ Observe regular defrosting interval and procedure in accordance with manufacturer's recommendation.
- ✓ Maintain a time delay interval of at least 3 minutes when turning the compressor on after shut-off or during power failures.
- ✓ Minimise frequent opening of the refrigerator door.
- ✓ Provide periodic checks on the operating amperages and temperatures.
- ✓ Maintain minimum distance between wall and condenser section of the refrigerator to provide adequate air flow to cool the condenser.
- ✓ Seal air-tight freezer and refrigerator doors and compartments to avoid migration of humid and warm air that will become additional load to the unit.
- ✓ Maintain a clean condenser, evaporator, blower and other accessories through periodic cleaning.
- ✓ Clean air filters regularly.
- ✓ Use pressurized water or compressed air when cleaning coils.

Practices to eliminate

- ✗ **DO NOT** release the contents of charging lines into the atmosphere.

- **DO NOT** use refrigerants to clean tools, coils, and machinery or as cleaning solvents.
- **DO** NOT attempt to service a system before identifying the type of refrigerant and the oil used in the system.
- **DO NOT** add lubrication oil to a system without establishing the type in use and the acidity level within the system.
- **DO NOT** top up a system short of refrigerant before examination for oil traces and leakages.
- **DO NOT** recharge any refrigeration system if there are doubts about the pressure integrity.
- **DO NOT** open the refrigerant side of a system unless absolutely necessary. Prior to opening, isolate the component to be serviced and recover the refrigerant.
- **DO NOT** use refrigerants as a tracer gas for leak testing.
- **DO NOT** add refrigerant to a system known to have leaks without establishing and rectifying the source of leakage.
- **NEVER** attempt to use a cylinder that is in rusted or deteriorated condition.
- **NEVER** leave an empty refillable or returnable cylinder open to the atmosphere because moisture may enter and result in rapid internal rusting.
- **NEVER** use any flushing fluid other than what is recommended for the system.
- **DO NOT** flush the entire system with the power flushing equipment attached to the service ports.
- **NEVER** mix oil in a system.
- **NEVER** overcharge a system with oil or refrigerants.

5 Commercial and Industrial Refrigeration and Air Conditioning

General Safety

Only qualified, trained, certified or sufficiently experienced technicians should conduct the installation of RAC systems. Technicians should ensure that:

- The main power supply to the unit is switched off while installation is in progress.
- The electrical connection is at the rated current, voltage and phase for the unit.
- The unit is grounded as recommended by the National Electric Code.
- The units are not installed near to any heat source or in hot surroundings.
- The work area is above ground in well ventilated area, whenever possible.

Installation of Equipment

Practices to follow

- ✓ Refer to the manufacturer's recommended installation instruction and procedures.
- ✓ Provide adequate ventilation at refrigeration equipment room or adequate space as per acceptable industry standards (ASHRAE, ARI, and other standard ventilation handbook).
- ✓ Provide sufficient service space to individual equipment, as recommended by the manufacturer.
- ✓ Use a tube or pipe cutter when cutting copper tube or pipes.
- ✓ Clean pipes and fittings to be used before installation.
- ✓ Provide oil trap for refrigerant riser pipelines as per manufacturer's standard.
- ✓ Ensure that refrigerant piping is properly joined, clamped and secured and kept properly insulated with the correct insulation size all throughout its piping length.
- ✓ Provide a rubber pad between unit and its base to prevent transmission of vibration that may cause noise. Do not over-tighten bolt and nuts/fasteners.

- ✓ Secure unit frame to a firm hold to prevent vibration.
- ✓ Whenever possible, avoid installation of condensing unit with its coil directly exposed to sunlight.
- ✓ Install the Fan Coil/Air Handling Unit ensuring positive condensate drain.
- ✓ Ensure that refrigerant piping is done according to acceptable industry or manufacturer's standard.
- ✓ As much as possible, avoid imbedded piping installation.
- ✓ Introduce dry nitrogen into the pipe while brazing or soldering to prevent metal oxidation.
- ✓ Use dry nitrogen or any acceptable non-ODS/HFC agent to flush out debris from brazing or cutting.
- ✓ Always check holding charge content of the condensing unit before connecting to the installed refrigerant piping.
- ✓ Leak test piping installations at 150 psig for low side and 300 psig at high side using dry nitrogen (as per manufacturer's recommendation) to ensure that the system is free from leaks.
- ✓ Evacuate the system to at least 1000 microns (1 mBar, 29.87in Hg) or below.
- ✓ Always provide exclusive power supply and circuit breakers for each unit, as per manufacturer's standards.
- ✓ When using polyethylene tapes on refrigerant piping insulation, do not wrap too tightly to avoid decreasing the insulation property.
- ✓ Check to ensure that safety related components are functioning properly (e.g. high- and low-pressure switches, time delay, solenoid valves, pressure relief valves etc.). The settings and results of tests should be documented for future reference.
- ✓ Label refrigeration system components with type and amount of refrigerant and lubricant used in the system and ensure that equipment specification and technical data (MSDS, technical bulletin, etc.) are readily available. [See recommended practices for record-keeping and documentation in Chapter 10]
- ✓ Complete a Start-Up Data Sheet immediately after installation.

Practices to eliminate

- ✗ **NEVER** use oxygen for flushing.
- ✗ **NEVER** use ODSs or HFCs as cleaning agents or to flush dirt out of the system.

Upgrading of Existing Units

This section covers the improvement of existing system set-up, particularly for larger units with sufficient remaining lifetime. This does not cover system design. Modification of the system including installation of additional parameters mentioned herein shall be done only during major repair, in order not to hamper continuous operation, and should not be put into effect while the unit is under normal operation. The following guidelines should be followed:

Practices to follow

- ✓ **ALWAYS** consult OEM recommendations.
- ✓ Pump down the system and/or recover refrigerant before opening the refrigeration system. [See recommended practices for refrigerant recovery and recycling in Chapter 9]
- ✓ Properly label recovered refrigerant cylinders to avoid used refrigerant being charged to another system unintentionally.
- ✓ Exert all efforts to prevent leaks of refrigerant during recovery operations.
- ✓ Ensure that the existing equipment is set-up to a pump down system. If not, install the necessary refrigerant service valves. Replace valves if found defective.
- ✓ If necessary, modify refrigerant piping installation to standard and acceptable industry practice (refer to applicable ASHRAE/ARI or manufacturer's standard).
- ✓ Whenever possible, convert flared or screwed connections into brazed type refrigerant piping and fittings.
- ✓ Ensure that gauges for monitoring system condition and refrigerant charge are installed and operational.
- ✓ Ensure that vibration eliminators are installed on suction and discharge lines as per manufacturer's standard.
- ✓ Ensure the settings of pressure-limiting devices such as high/low and oil-failure pressure switches are according to the manufacturer's standard.
- ✓ Ensure that the pressure relief valve setting is in accordance with manufacturer's standard.

System Operation and Maintenance

A service technician's responsibility is to minimise the amount of refrigerant that escapes into the atmosphere during its operation. Any system should be given a thorough visual inspection before starting any service procedures. Examine the entire refrigerant circuit while watching for signs of oil leakage, corroded or damaged lines, hoses, or other components and look out for uncapped valves, dust caps, or missing and/or damaged O-rings.

The condition of a system should be assessed to determine whether it is practical to repair or not. If repairable, perform procedures in accordance with acceptable industry practices. If beyond repair, exert utmost effort to recover the refrigerant content of the unit, if there is any remaining. [See recommended practices for refrigerant recovery and recycling in Chapter 9] The following principles should be observed during the operation and maintenance of RAC systems.

General Rules

- ✓ Inspect panels (insulated cabinet, control panel, etc.) and schedule repair, if necessary.
- ✓ Inspect unit switches for unusual or abnormal condition.
- ✓ Check bearings for any unusual sound and vibration and apply grease or oil, if necessary.
- ✓ Check tightness of all bolts and screws and tighten, if necessary.
- ✓ Check fan and fan housing for dirt accumulation and clean, if necessary.

Refrigerant/Oil System

Practices to follow

- ✓ Inspect the condition of refrigerant piping insulation, and schedule repair or replacement, if necessary.
- ✓ Inspect sight glass (if present) for refrigerant flow and/or quality.
- ✓ Visually inspect for refrigerant leaks as indicated by oily spots and use appropriate leak detector to accurately locate the leak.
- ✓ Check Schrader/access valves, packing glands, O-rings and service caps for tightness.
- ✓ Check compressor oil level (if applicable). If it is low, report for further analysis.

- ✓ Check oil for discoloration to determine whether it needs to be replaced and the system checked. If it is discoloured, report for further analysis.
- ✓ Check oil pressure (if applicable), it should read higher than the suction pressure or as recommended by the manufacturer. If below the manufacturer's recommended pressure, report for further analysis.
- ✓ Check Oil Failure Pressure Switch (if applicable).
- ✓ Check suction and discharge operating pressures of

Secondary Warm Side

Practices to follow

- ✓ Check condenser coils for dirt accumulation and clean if necessary.
- ✓ Check condenser water supply (if applicable)
- ✓ Check condenser water return (if applicable)
- ✓ Check operating temperatures, where applicable, for:
    - Condenser water supply
    - Condenser water return
    - Condenser supply air
    - Condenser return air
- ✓ Check the operating parameters (suction pressure, discharge pressure) for the condenser water pump, where applicable:
- ✓ Check motor current draw.
- ✓ Check cooling tower's water level, make-up water and other operating parameters and abnormalities.

Secondary Cold Side

Practices to follow

- ✓ Check evaporator coils for dirt accumulation; clean if necessary.
- ✓ Check drain pan for any dirt accumulation; clean if necessary.
- ✓ Check drain line to ensure condensate flow; de-clog if necessary.
- ✓ Check chilled water expansion tank's water level and float valve.
- ✓ Conduct regular bleed-off as per manufacturer's recommendation.
- ✓ Check operating temperatures, where applicable:

- Evaporator water supply
- Evaporator water return
- Evaporator supply air
- Evaporator return air
- Chilled water supply pressure
- Chilled water return pressure

Electrical/Control System

Practices to follow

- ✓ Check and clean all electrical contacts and terminals. Tighten any loose terminals.
- ✓ Check the quality of the power supply. Ensure that power supply is within ±10% of the rated voltage requirement of the equipment.
- ✓ Take reading of compressor motor current draw.
- ✓ Check overload relays.
- ✓ Check belt tensions and alignment of pulley and adjust, if necessary.
- ✓ Check belt for any abnormal wear. Determine causes of wear and make necessary corrections.
- ✓ Take readings of fan and pump motor current draw.
- ✓ Check all electrical controls and calibrate, if necessary:
    - High and low-pressure switch
    - Timers
    - Thermostat
    - All other electrically and electronically controlled devices.

Preventative Maintenance

Regular preventive inspection and maintenance of larger refrigeration systems helps to ensure their reliability and continued efficiency. Preventive inspection by service technicians will be cost-effective for vulnerable applications such as refrigerated transport or larger commercial and industrial applications. For small systems, regular examination of the obvious elements by the user can be very effective in preventing future problems. Early attention to minor matters can be beneficial and cost-effective in the long term. Preventive maintenance procedures are aimed to:

- Promote safety:
  - Avoid accidents to personnel
  - Prevent damage to goods and properties
- Maintain continuous operation of the system.
- Identify system leaks at the earliest possible time.
- Ensure good working condition of all components and parts.
- Minimise energy consumption and peak loads.

Practices to follow

✓ Establish a Preventive Maintenance Schedule (PMS) to ensure efficient equipment performance to avoid breakdown.

✓ All moving parts shall be given extra attention since these are subject to wear and tear.

✓ Signs of abnormal vibration shall be checked and corrected.

✓ Avoid electrical line coming into contact with the discharge line. Hot pipe surface can melt the wire insulation that may result in a short circuit.

✓ Regular bearing lubrication is needed for efficient performance.

✓ Use appropriate leak detector or other leak detection method to accurately locate leak (e.g. refrigerant, air and water).

✓ Use appropriate cleaning agent when cleaning evaporator and condenser coils.

✓ Check evaporator superheat.

✓ Establish the quality (e.g. acidity level) and type of lubricating oil in the system before adding or changing new oil.

Leak Testing, Evacuation and Charging Procedure

✓ Try to locate leaks through visual inspection.

✓ Run the system and check for leaks using appropriate leak detector. (If the system has no charge, proceed with step 4.)

- If leak is located on the low side, pump down the system.
- If the leak is located on the high side, proceed with 3.

✓ Recover refrigerant charge of the system using a recovery machine. [See recommended practices for refrigerant recovery and recycling in Chapter 9]

✓ Charge the system with dry nitrogen (150 psig on low side, 300 psig on high side) for leak testing.

- ✓ Repair leaks found and double check by performing step 4 again until system is sure to be free from leaks.
- ✓ Evacuate the system to at least 1000 microns (1 mBar, 29.87 in Hg) using an appropriate vacuum pump and an electronic/vacuum gauge.
- ✓ Initially charge the system, run the unit and add refrigerant until fully charged.
- ✓ Refrigerant charge should be based on manufacturer's data by weight or pressure temperature chart until proper operating conditions are attained (e.g. proper sub-cooling).

6 RAC Retrofitting Procedure

RAC systems containing substances controlled by the Montreal Protocol may be retrofitted to operate using refrigerants that are more ozone and climate friendly. Before conducting a retrofit, technicians should give consideration to the alternative refrigerant costs; the availability of alternative refrigerant in the present and future; and the expected life of existing equipment.

General Rules

- ✓ Assess existing equipment and examine the system for potential problem areas.
- ✓ Determine the service and operational history of the equipment.
- ✓ Carefully record all information regarding the existing system components, including current operating conditions (pressures, temperatures, amperage, etc.) to determine baseline operations.
- ✓ Cross reference all existing components to the intended alternative refrigerant. Many components are likely to be acceptable but some may need to be changed.
- ✓ Consult the OEM recommendations to ensure components material compatibility with alternative refrigerant and oil.
- ✓ Conduct a thorough leak check as some alternatives require a very tight system for optimal operation.
- ✓ Pay close attention to detail in following the relevant retrofit procedure.
- ✓ Affix a label to the retrofitted system on completion (see sample form in Figure 2).

Retrofit Label

Name of System Owner: .....

Address: .....

Model #: ..... Serial #: .....

Nature of Retrofit: .....

Type of Refrigerant recovered: ..... Quantity:.....kg (lbs)

Type of Lubricant removed: ..... Quantity:.....kg (lbs)

Type of Refrigerant installed: ..... Quantity:.....kg (lbs)

Type of Lubricant installed: ..... Quantity:.....kg (lbs)

Flammability Hazzard: Yes ☐ No ☐

Name of Technician: ..... Licence #: .....

Address: .....

Signature: ..... Date: .....

Figure 2: Sample label to be affixed to equipment after a retrofit

Procedure to Retrofit a RAC System from CFC-12 to HFC-134a; and R-502 to R-404A/R-507

Practices to follow

- ✓ Pump down the system and recover refrigerant before opening the refrigeration system. Recover refrigerant using a recovery machine or a recovery and recycling machine, operated only by a trained and certified technician. Exert all efforts to ensure the prevention of refrigerant emissions during recovery operation. Store recovered refrigerant only in a specified refillable container or cylinder which is properly labelled. [See recommended practices for refrigerant recovery and recycling in Chapter 9]
- ✓ Drain and recover existing mineral oil charge, measure the quantity and compare with the recommended oil charge to determine approximately the quantity of oil left in the system.
- ✓ Replace all equipment components and accessories (e.g. expansion valve, gaskets, filter drier, etc.) that will be affected by the new alternative refrigerant and its alternative refrigerant oil as recommended by the manufacturer.
- ✓ Charge the system with correct amount of alternative refrigerant oil as recommended by compressor/system manufacturer.
- ✓ Run the system while performing oil change procedure as many times as necessary until mineral oil in the system does not exceed the recommended 5 percent acceptable level.
- ✓ Leak test the system with dry nitrogen and observe a 24-hour standing pressure. Make corrections if deemed necessary.
- ✓ Evacuate system to at least 1000 microns (1 mBar, 29.87 in Hg) using appropriate vacuum pump and an electronic vacuum meter.
- ✓ Charge the system with initial amount of alternative refrigerant (50 psig for refrigeration, 70 psig for air conditioning systems).
- ✓ Run the system and charge additional refrigerant, if needed, until fully-charged.
- ✓ Monitor the system operation and performance for at least 48 hours or longer and make necessary adjustment.
- ✓ Check the remaining content of mineral oil with a refractometer or oil test kit.
- ✓ **ALWAYS** Follow system and/or compressor manufacturer recommendations as tolerances are dependent on system and operating conditions.
- ✓ Affix a label to the system (see sample form in Figure 2).

7 Mobile Air Conditioning (MAC)

Engine Driven System

It is important that the mechanic is well informed of the basic Standard Operating Procedure of the MAC system. The mechanic should consider the effect of the air conditioner on the vehicle and vice-versa. The following procedures relate to an engine driven MAC system.

General Rules for Operation of MAC Systems

- Confirm that the air conditioner switch is off when starting the engine.
- Ensure that the engine is properly warmed-up before starting the MAC system.
- Check that the air vent is set at the re-circulation mode.
- Set the air conditioner blower and thermostat switches to maximum and adjust to the desired setting as the cabin reaches comfortable temperature.
- Turn off the air conditioner/blower switch before shutting off the engine.

Maintenance

Maintenance servicing of the MAC system should be done every two years or at 25,000 km, whichever comes first. The following presents general maintenance procedur.

Practices to follow

- ✓ Check for signs of leak on the systems' fittings and component parts that are readily accessible.
- ✓ Check for any refrigerant lines that are not properly secured.
- ✓ Check for any air conditioner electrical wirings and components that are not properly secured.
- ✓ Check belt tension.
- ✓ Check magnetic clutch gap.
- ✓ Check for unusual sounds e.g. belt noise, bearing noise, vibrations.
- ✓ Check refrigerant content of the system through the sight glass.
- ✓ Attach gauge manifold to check for systems' low and high pressures.

- ✓ Check condition of condenser.
- ✓ Check condition of auxiliary fan.
- ✓ Check function of air conditioner switch.
- ✓ Check function of safety pressure switches.
- ✓ Check function of thermostat.
- ✓ Check systems performance that should run at normal operating pressures:
  - low side - 0.15-0.25MPa (22-36psig)
  - high side - 1.37-1.57MPa (200-228psig)
- ✓ Ensure that the refrigerant charging ports (suction & discharge) are properly capped.
- ✓ Keep the condenser clean as often as possible

Servicing and Repairs

Remove wristwatches, rings, bracelets, necklaces, keys and other personal items that may inflict personal injuries. These may also damage the exterior and interior parts of the vehicle. Before attempting any service or repair, identify first the type of system. The most common means of identification are:

- Vehicle identification through air conditioning labels and fittings.
- Compressor identification through the labels and stickers.
- Line identification through the groove at the connectors and marks on refrigerant lines.

The following represents general servicing and repair procedure:

Practices to follow

- ✓ Select proper and complete set of tools before starting a job.
- ✓ Use lubricating oil compatible to the refrigerant used in the system.
- ✓ **ALWAYS** cover opened or exposed pipes and fittings.
- ✓ Use quick connectors (with check valve) for HFC-134a system.
- ✓ **ALWAYS** tighten all fittings.
- ✓ **ALWAYS** use vacuum pump to evacuate the system.
- ✓ Seal-off containers of excess HFC oils to prevent absorption of moisture.
- ✓ Only remove factory protective caps from the fittings when ready for connection, particularly for the receiver drier or compressor.

- ✓ Observe the following when connecting two pipes with fittings:
  - Apply compressor oil to O-ring surfaces.
  - Check O-ring position if correctly seated on the groove.
  - Insert the pipe with the O-ring parallel to the other pipe and tighten by hand. If unaligned, pipe sealing surface may get damaged.
  - Use two wrenches when tightening/loosening fittings to avoid twisting or bending the pipes. Be aware that excessive tightening torque may cause gas leak.
  - Visually check for cracks on fittings as a result of over-tightening or over-turn.
  - Ensure that the surface of the fitting seat is corrosion free and not deformed.
- ✓ Ensure both the high and low-pressure sides of the system are connected to the vacuum pump when evacuating the system.
- ✓ Observe extra care when replacing O-rings so as not to damage the line.
- ✓ Affix individual labels to oil cans in order not to contaminate a system.
- ✓ Properly clean the evaporator following a standard procedure or as recommended by the manufacturer.
- ✓ Ensure that wire/wire connectors are properly labelled during dismantling/pulling-down of evaporator for repair or cleaning, to avoid misconnections upon re-installation.
- ✓ Make sure all operating parameters like system pressures or temperatures are recorded to serve as reference data for after-service reading.
- ✓ **ALWAYS** use Personal Protective Equipment (PPE).
- ✓ **ALWAYS** add new refrigerant oil to the system after repair.

Practices to eliminate

- ✗ **NEVER** use gauge manifold set used for charging CFC system to charge HFC system. This can cause refrigerant contamination.
- ✗ **NEVER** convert an HFC-134a system to a CFC-12 system.
- ✗ **NEVER** re-use O-rings.
- ✗ **NEVER** use hose clamp in place of crimped connectors.

Sub-Engine Driven (Dedicated Engine) System

Inspection, Operation and Maintenance

It is advisable to follow manufacturer's recommended inspection, operation and maintenance procedure. Otherwise, the following should be considered before and during the operation of a MAC system with a dedicated engine to drive its compressor:

Drive Engine

✓ Check the following and clean, replace or re-charge as necessary:

- Condition and level of engine oil
- Condition of cooling water in the radiator
- Belt tension
- Level of fuel in the tank
- Bolts and nuts for tightness
- Air cleaner element
- Intake air hose
- Radiator hose
- Fuel filter
- Rubber cushion and mounting bolts

Compressor

✓ Check the following and correct, repair, replace or re-charge as necessary:

- Oil level at sight glass
- Installation of mounting brackets, clamps and bolt tightness.
- Abnormal noise and vibration
- Shaft seal for oil leaks
- Other parts of the compressor for possible oil leaks

Condenser

✓ Check:

- Condenser coil, clean if needed
- For leaks, repair if found
- Condition of condenser motor and fan, repair/replace if needed

Cooling Unit

✓ Check the following and clean, repair or replace as necessary:

- Cooling coil
- Air inlet packing for restriction
- Air filter
- Evaporator blower and motor
- System for leaks
- Bearings and lubricate as needed.

Other Accessories

✓ Check the following and correct, repair, replace or re-charge as necessary:

- Refrigerant piping, fittings and hoses for leaks
- Strainers/driers
- Piping clamps
- Flange couplings
- Electrical wirings and connections

8 MAC Retrofitting Procedures

Procedure to Retrofit from CFC-12 MAC System to HFC-134a system

The following are recommended procedures in retrofitting CFC-12 MAC systems to HFC-134a system (refer also to PNS SAE J1661: 2003 and manufacturer retrofit procedures whenever available.):

- ✓ Check for leaks using a hand held leak detector set to detect CFC-12 and/or the soap bubble test. Make repairs if necessary.
- ✓ Run the vehicle to obtain suction/discharge pressures and check again for leaks.
- ✓ Recover all refrigerant from the system following standard procedure for CFC refrigerant recovery and store in a specified refillable container properly labelled. [See recommended practices for refrigerant recovery and recycling in Chapter 9]
- ✓ Remove compressor from its mounting bracket and drain its lubricating oil.
- ✓ Rinse the internal parts by pouring alternative oil for new refrigerant into the compressor and manually rotating the compressor shaft. Amount of oil for rinsing is about 50% of the recommended factory oil charged.
- ✓ Repeat oil rinsing procedure as necessary.
- ✓ Pour proper amount of alternative refrigerant oil into the compressor as per Original Equipment Manufacturer (OEM) and cap suction and discharge lines until the system is ready for re-assembly.
- ✓ Flush the entire system with Nitrogen or any other environmental friendly cleaning agent. **NEVER** use ODSs or HFCs to flush systems.
- ✓ Pressure-test each component for leaks. Repair or replace if necessary.
- ✓ Replace expansion device and filter drier compatible to the alternative refrigerant.
- ✓ Change all flare type to O-ring type fittings. Replace all O-ring seals on pipes and hoses with those approved for HFC-134a and PAG (polyalkylene glycol) oils.
- ✓ Re-install and assemble system components.
- ✓ Modify access valves / fittings to accept only the new alternative refrigerant fittings.

- ✓ Evacuate system to at least 1000 microns (1 mBar, 29.87in Hg) using appropriate vacuum pump and an electronic vacuum meter. Make corrections if necessary.
- ✓ Charge the system with alternative refrigerant (PNS SAE J1657: 2003, Annex 5) as recommended by manufacturer whenever possible. Notice that optimum charge will change when systems are retrofitted.
- ✓ Observe system operation and check again for leaks.
- ✓ Compare new set of data to that obtained when the system was still using CFC.
- ✓ Label system clearly stating, type and quantity of refrigerant, refrigerant oil. [See Figure 2, Chapter 6 for sample label to be affixed to equipment after a retrofit]

Procedure to Retrofit from CFC-12 MAC System to Hydrocarbon (HC) System

- ✓ Check for leaks using a hand held leak detector set to detect CFC-12 and/or the soap bubble test. Make repairs if necessary.
- ✓ Run the vehicle to obtain (suction/discharge pressures) and check for leaks.
- ✓ Recover all refrigerant from the system following standard procedure for CFC refrigerant recovery and store in a specified refillable container properly labelled. [See recommended practices for refrigerant recovery and recycling in Chapter 9]
- ✓ Weigh and record mass of refrigerant recovered.
- ✓ Remove compressor from its mounting bracket and drain its lubricating oil.
- ✓ Rinse the internal parts by pouring alternative oil for new refrigerant into the compressor and manually rotating the compressor shaft. Amount of oil for rinsing is about 50% of the recommended factory oil charged.
- ✓ Pour proper amount of alternative refrigerant oil into the compressor as per Original Equipment Manufacturer (OEM) and cap suction and discharge lines until the system is ready for re-assembly.
- ✓ Flush the entire system with Nitrogen or any other environmental friendly cleaning agent. **NEVER** use ODSs or HFCs to flush systems.
- ✓ Pressure-test each component for leaks. Repair or replace if necessary.

- ✓ Replace expansion device and filter drier compatible to the HC refrigerant.
- ✓ Replace all O-ring seals on pipes and hoses with those approved for mineral oils.
- ✓ Re-install and assemble system components.
- ✓ Evacuate system to at least 1000 microns (1 mBar, 29.87in Hg) using appropriate vacuum pump and an electronic vacuum meter.
- ✓ Check to make sure the system holds the vacuum when the pump is isolated.
- ✓ Charge the system with HC refrigerant. The charge quantity should be 40% of the mass of the CFC refrigerant recovered if the system had no leak or 40% of the OEM recommended optimum charge.
- ✓ Observe system operation and check again for leaks.
- ✓ Compare new set of data to that obtained when the system was still using CFC.
- ✓ Label system clearly stating, type and quantity of refrigerant, refrigerant oil. [See Figure 2, Chapter 6 for sample label to be affixed to equipment after a retrofit]

Procedure to Retrofit from HFC-134a MAC System to Hydrocarbon (HC) System

- ✓ Check for leaks using a hand held leak detector set to detect HFC and/or the soap bubble test. Make repairs if necessary.
- ✓ Run the vehicle to obtain (suction/discharge pressures) and check for leaks.
- ✓ Recover all refrigerant from the system following standard procedure for HFC refrigerant recovery and store in a specified refillable container properly labelled. [See recommended practices for refrigerant recovery and recycling in Chapter 9]
- ✓ Weigh and record mass of refrigerant recovered.
- ✓ Remove compressor from its mounting bracket and drain its lubricating oil.
- ✓ Rinse the internal parts by pouring alternative oil for new refrigerant into the compressor and manually rotating the compressor shaft. Amount of oil for rinsing is about 50% of the recommended factory oil charged.
- ✓ Pour proper amount of alternative refrigerant oil into the compressor as per Original Equipment Manufacturer (OEM) and

cap suction and discharge lines until the system is ready for re-assembly.

- ✓ Flush the entire system with Nitrogen or any other environmental friendly cleaning agent. **NEVER** use ODSs or HFCs to flush systems.
- ✓ Pressure-test each component for leaks. Repair or replace if necessary.
- ✓ Replace expansion device and filter drier compatible to the HC refrigerant.
- ✓ Replace all O-ring seals on pipes and hoses with those approved for mineral oils.
- ✓ Re-install and assemble system components.
- ✓ Evacuate system to at least 1000 microns (1 mBar, 29.87in Hg) using appropriate vacuum pump and an electronic vacuum meter.
- ✓ Check to make sure the system holds the vacuum when the pump is isolated.
- ✓ Charge the system with HC refrigerant. The charge quantity should be 50% of the mass of the HFC refrigerant recovered if the system had no leak or 50% of the OEM recommended optimum charge.
- ✓ Observe system operation and check again for leaks.
- ✓ Compare new set of data to that obtained when the system was still using HFC.
- ✓ Label system clearly stating, type and quantity of refrigerant, refrigerant oil. [See Figure 2, Chapter 6 for sample label to be affixed to equipment after a retrofit]

9 Refrigerant Recovery and Recycling

Most refrigerants are stable chemical substances and so they always have very long life spans. Apart from environmental impact due to the emission of these gases, it will be of economic interest for the gases to be recovered, reclaimed and re-used as much as is practical. Recovered refrigerant may be reused in the same system from which it was removed or it may be stored or processed as necessary for use in another system.

Practices to follow

- ✓ Only trained refrigeration technicians should use and/or maintain refrigerant recovery and recycling devices. This should be done in accordance with the manufacturer's instructions
- ✓ Recover all refrigerants during service, maintenance or decommissioning for reuse, recycling, reclaim or final disposal and destruction. HFCs, HCFCs and CFCs **MUST** be recovered.
- ✓ Use certified recovery and recycling (R&R) equipment which meets relevant specifications. Recycling equipment **MUST** be able to separate lubricant from recovered refrigerant.
- ✓ Make certain that R&R equipment have an 80% full shut-off device and a mechanical pressure relief valve.
- ✓ Ensure that all cylinders are appropriately labelled to record the type, quantity and quality of refrigerant recovered from a system. Figure 3 provides an example of a label that could be affixed to a cylinder containing recovered refrigerant gas.

Cylinder Label

Type of Refrigerant: .....

Quantity of Refrigerant Recovered: .....kg (lbs)

Quantity of Refrigerant stored in cylinder: .....kg (lbs)

Condition of Refrigerant: **Good** ☐ **Fair** ☐ **Contaminated** ☐

Date of Recovery: .....

Name of Technician: .....**Signature:** .....

Figure 3: Sample refrigerant storage cylinder label

- ✓ Ensure that all contaminated recovered refrigerant is labelled as contaminated refrigerant and stored for destruction at an approved destruction site
- ✓ Use refrigerant containers or recovery bags as temporary receivers for very small systems where permanent liquid receivers are not installed.
- ✓ Use purge compressors and portable evacuation devices to recover refrigerant liquid and vapour from refrigerant drums and cylinders.
- ✓ Determine the amount of lubricant removed during the refrigerant removal process and add new lubricant.
- ✓ Store used lubricant for proper disposal. **NEVER REUSE LUBRICANT**.
- ✓ High-, low- and centre-service hoses should have shut-off valves within 12 inches (30 cm) of their service ends. These valves must be closed prior to hose removal from the air conditioning system. This will reduce the volume of refrigerant that would otherwise be vented to the atmosphere.
- ✓ During all service operations, close valves until connected to the system or the charging source to avoid introduction of air and to contain the refrigerant.
- ✓ When the service manifold gauge set is disconnected from the system or when the centre hose is moved to another device that cannot accept refrigerant pressure, first attach the gauge set hoses to the R&R equipment to recover the refrigerant from the hoses.

Practices to eliminate

- ✗ **NEVER** trap liquid refrigerant in a hose. Liquid refrigerant can heat up during the day increasing the pressure in the hose resulting in damage to the hose.
- ✗ **DO NOT** use the R&R unit if the is no pressure in the system.
- ✗ **NEVER** heat with an open flame.
- ✗ **NEVER** reuse lubricant.

10 Record-Keeping and Documentation

A good way to properly diagnose a system's fault is by reviewing its recorded service history. The type of information which should be recorded depends on the size, type and application of the refrigeration system. For domestic refrigerators, operational parameters and performance indicators may not be available, but basic data concerning the equipment and the equipment supplier, type and charge of refrigerant, repair and servicing operations should be included. Figure 4 presents a sample form which may be used by technicians to record service activity.

Service Record

Contractor / Service Company: .....

Name of Technician: ..... **Phone #:** .....

Licence/ Certificate #: ..... **Expire Date:** .....

Date of Service: ..... **Time of Service:** .....

Service Carried Out: **Inspection** ☐ **Maintenance** ☐ **Repair** ☐

Observations: .....

.....

Type of Repair: .....

Observations: .....

.....

Method of Leak Testing: .....

Observations: .....

Type of Maintenance: .....

Observations: .....

Initial Refrigerant: ..... **Initial Refrigerant Charge:** .....kg (lbs)

Quantity of Refrigerant:

Recovered: .....kg (lbs) **Recycled:** .....kg (lbs) **Reuse:**..... kg (lbs)

Type of Refrigerant Recharged: ..... **Quantity of Refrigerant Charge**: .....kg (lbs)

Type and Quantity of Lubricant: ..... **Quantity of Lubricant**: **Added** .....kg (lbs)

Recommendations: .....

Date of Next Service/ Inspection: .....

Signature of Technician: ..... **Date:** .....

Figure 4: Sample form to capture service record data

Practices to follow

- ✓ Locate and maintain a service log book and a plant manual in a place accessible for service technicians and near to the refrigeration system.
- ✓ Record the loss, recovery and consumption of refrigerant for each type of refrigerant at the company level if the company operates more than one refrigeration system. Figure 5 and Figure 6 are samples of forms which may be completed by technicians to be kept by owners/operators of the equipment and service companies, respectively.
- ✓ If the company is a service or disposal business, record the loss, recovery and consumption of each type of refrigerant and each customer, as well as purchase and recycling data.
- ✓ Advise the owner of a company to maintain a refrigerant use log book for all refrigeration system, specifying the overall consumption of refrigerants.
- ✓ Keep a copy of all records in a safe place and store them for an appropriate time period. A minimum of five (5) years is recommended.
- ✓ Maintain records of the name and address of any facility to which refrigerant is sent having been recovered and/or recycled using approved refrigerant recycling equipment.
- ✓ Retain records demonstrating that all persons authorized to operate approved refrigerant recycling equipment are certified by relevant training institutions.
- ✓ Ensure that records are readily available for access by relevant authorities, if requested.
- ✓ Maintain records for at least five (5) years. Where applicable, the following should be recorded:
    - User specific data (see sample form in Figure 7)
    - Retrofitting data
    - Type, amount and quality of recovered refrigerant
    - Amount and type of refrigerant charged into the system
    - Technical and design data
    - Manufacturers' instructions for safe service and maintenance

Refrigerant Inventory Form (owner / operator)

YEAR	EQUIPMENT 1			EQUIPMENT 2			EQUIPMENT 3			EQUIPMENT 4			EQUIPMENT 5		
TYPE															
LOCATION															
REFRIGERANT															
CHARGE															
	Lost	Rec.	New	Lost	Rec.	New	Lost	Rec.	New	Lost	Rec.	New	Lost	Rec.	New
JANUARY															
FEBRUARY															
MARCH															
...															
OCTOBER															
NOVEMBER															
DECEMBER															
YEARS TOTAL															

Figure 5: Sample refrigerant inventory form for owners and operators of RAC Equipment

Refrigerant Inventory Form (service companies)

SERVICING COMPANY REFRIGERANT PERIOD

Name: _____ Phone: _____ Type: _____ Year: _____

Address: _____ Fax _____ Month: _____ Email: _____

COMPANY	EQUIPMENT	LOCATION	REFRIGERANT LOST	RECOVERED FOR RECYCLING	NEW REFRIGERANT RECHARGED	DATE / TIME	TECHNICIAN
TOTAL REFRIGERANT (1) LOST, (2) RECOVERED, (3) RECHARGED			(1)	(2)	(3)		
TOTAL REFRIGERANT (4) RECYCLED, (5) PURCHASED				(4)	(5)		
REFRIGERANT STORED: (6) CONTAMINATED, (7) RECYCLED				(6)	(7)		

Figure 6: Sample Refrigerant Inventory Form for Service Companies

User Specific Data

Owner's/ Company's Name: .....

Owner's/ Company's Address: .....

Phone #: ..... **Fax #:** ..... **Email:** .....

POLICY STATEMENT

The company's / owner's commitment to protect the ozone layer and to require all personnel to take all steps to achieve these goals has been documented in the separate policy statement.

EQUIPMENT / SYSTEM

Type: ..... **Year Manufactured:** .....

Model #: ..... **Serial #:** .....

Type and Quantity of Refrigerant: ..... kg (lbs)

Type and Quantity of Lubricant: ..... kg (lbs)

LOCATION

Building Address: .....

Floor: ..... **Room:** .....

RESPONSIBILITY

Department: .....

Plant Manager: ..... **Phone #:** .....

PREVENTIVE INSPECTION

Responsible Technician: ..... **Phone # of Technician:** .....

Inspection interval: ..... **Date of last inspection:** .....

SERVICE CONTRACT

Name of Service Contractor: .....

Address: .....

Phone: ..... **Fax:** ..... **Email:** .....

Figure 7: Sample form to capture user-specific data

11 Handling, Transportation and Storage of Refrigerants

Refrigerants and their blends are gases that serve their useful purpose in a refrigeration system and are extremely dangerous outside the system; therefore, they require careful transportation, handling and storage. All refrigerants pose a number of safety implications including asphyxiation; acute and chronic toxicity effects; flammability and explosion; and pressure. The risk imposed in handling refrigerants can be considered with regards to primary and secondary consequences depending on the type of substance and the conditions and environment within which it was released. All person handling, transporting and storing refrigerants should be adequately trained and the following practices implemented.

General Rules

Practices to follow

- ✓ Review Material Safety Data Sheet (MSDS) for the refrigerants, lubricants and other substances in use in order to determine the adequate level of protection required.
- ✓ **ALWAYS** wear suitable personal protective equipment including gloves and goggles at all times.
- ✓ **DO NOT** eat, drink or smoke while handling refrigerants.
- ✓ Follow industry recommended procedures and use approved equipment for transporting, handling and storing refrigerants.
- ✓ Use closed-loop refrigerant equipment when recovering, charging and storing refrigerants.
- ✓ Ensure that any portable container used for transfer of reclaimed or recycled refrigerant meets certification standards.
- ✓ Control cylinder safe filling levels by measuring the mass of the refrigerant. Liquid net mass must not exceed 80% of the cylinder's internal volume.
- ✓ Transfer refrigerant to another container by using a pump or by establishing a pressure difference between the containers.
- ✓ Cool refrigerant cylinders to the ambient temperature prior to use.
- ✓ Store refrigerants in a manner conducive to refrigerant conservation during periods of system shutdown.
- ✓ Store refrigerant cylinders vertically upright in a secure ventilated area away from fire risk and direct heating. Maximum exposure temperature is 50°C

- ✓ Inspect stored cylinders containing refrigerant for leaking glands and defective gaskets on the cap.
- ✓ Inspect refrigerant containers for corrosion after use for recovered refrigerant. Third-party containers should be inspected by the owners.
- ✓ Observe local regulations on handling, transport and storage of virgin, recovered, contaminated or recycled refrigerants.
- ✓ Always utilize a recovery tank marked 'CLEAN' for recycled refrigerant and a recovery tank marked 'DIRTY' for recovered but not recycled refrigerant.
- ✓ Check refrigerant cylinders for non-condensables prior to use. The cylinder must stand for approximately six (6) hours.

Practices to eliminate

- ✗ **DO NOT** vent refrigerant into the atmosphere knowingly.
- ✗ **DO NOT** dispose of any refrigerant by using methods other than recovery and recycling, reclamation, reuse, adequate storage or destruction.
- ✗ **DO NOT** exceed the designed maximum working pressure or the designed capacity shown on the refrigerant cylinder.
- ✗ **DO NOT** mix refrigerants. In many cases, if refrigerants are mixed reclamation by specialists will not be possible and destruction is the only alternative.
- ✗ **DO NOT** connect refrigerant containers to systems or other containers at a higher pressure, temperature or height because back flow of the refrigerant may result in overfilled or liquid-filled containers with a possible danger of bursting.
- ✗ **DO NOT** heat refrigerant cylinders with flames or direct contact heaters in order to drive refrigerant into another vessel.
- ✗ **DO NOT** cool down receiving refrigerant cylinders by venting refrigerant into the atmosphere to transfer the refrigerant.
- ✗ **DO NOT** drop cylinders as this may lead to valve or valve thread damage; warnings should be clearly shown in storage areas.
- ✗ **DO NOT** fill refrigerant cylinders with mixtures of refrigerant and oil.

Handling Halocarbon Refrigerants

Halocarbon refrigerants are chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), Hydrofluorocarbons (HFCs) and related compounds. They are the colourless, odourless, non-flammable, non-corrosive gases or liquids of low toxicity that were introduced as refrigerants in the 1930s. They also proved useful as propellants for aerosols and in numerous technical applications. Most halocarbons and derived compounds are classified by ASHRAE in Group A1 (Lower Toxicity & No Flammability) or Group A2 (Lower Toxicity & Flammable).

Practices to follow

- ✓ Handle all refrigerants accordance with good industrial hygiene and safety practices.
- ✓ **DO NOT** eat, drink or smoke while handling refrigerants.
- ✓ **ALWAYS** wear personal protective equipment to protect against contact with skin, eye and clothing. This should include synthetic rubber gloves (0.7 mm thick) and eye protection with side shields.
- ✓ Take care not to breathe vapours or spray mist and avoid all contact with skin, eye and clothing.
- ✓ Make showers and eyewash fountains of the deluge type readily available in case of refrigerant contact with skin or eyes.
- ✓ Ensure sufficient air exchange when used indoors or use a local exhaust in the work room.
- ✓ Wear respirator protection (with organic vapour cartridges) when performing an operation during which exposure in excess of 50 ppm for an entire 8- or 12-hour work day is expected.
- ✓ Store auxiliary breathing apparatus in a readily accessible area in case of abnormally high concentrations of refrigerant vapour in storage or handling areas.
- ✓ **DO NOT** handle refrigerants or blends below ground level or in an enclosed space alone.
- ✓ **DO NOT** use refrigerants as an uncontained flushing fluid or as solvent for general cleaning.
- ✓ Follow all precautions handling and use of compressed gas cylinders to prevent rupture of cylinders.
- ✓ Ensure adequate earthing as liquid refrigerants transferred between containers and from systems can generate static charge, leading to an explosion.
- ✓ Evacuate the area immediately in the case of a spill and obtain the required breathing apparatus before returning

Handling Carbon Dioxide Refrigerant Gas (R-744)

Carbon Dioxide (CO_2) is a relatively safe refrigerant compared to other natural and artificial working fluids. It is classified in Group A1, which are the refrigerants with low toxicity and are non-flammable (ASHRAE Handbook-Fundamentals and ISO 817: 2005). Group A1 is the group that contains the refrigerants that are least hazardous and without an identified toxicity at concentrations below 400 ppm.

Naturally, CO_2 exists in the atmosphere at concentrations around 350 ppm and for concentrations between 300 and 600 ppm people do not usually notice the difference. A CO_2 concentration of 1000 ppm is the recommended limit to satisfy comfort for the occupants, for a CO_2 controlled ventilation system fresh air should be supplied so that the CO_2 concentration level will not exceed this value. High levels of CO_2 concentration can cause serious health hazards, such as suffocation resulting in death (see Table 2).

Table 2: Expected health consequences of different concentrations of Carbon Dioxide

Concentration (PPM)	Effects on Health
350	Normal value in the atmosphere
1,000	Recommended not to be exceeded for human comfort
5,000	TLV-TWA
20,000	Can affect the respiratory functions and cause excitation followed by depression of the central nervous system. 50% increase in breathing rate
30,000	100% increase in breathing rate after short time exposure
50,000	IDLH value
100,000	Lowest lethal concentration. Few minutes of exposure produces unconsciousness
200,000	Death accidents have been reported
300,000	Quickly results in an unconsciousness and convulsions

Source: Manual for Refrigeration Servicing Technicians, UNEP, 2010.

Practices to follow

- ✓ Refer to 'Practices to follow' for Halocarbon Refrigerants
- ✓ Always install sensors in facilities where CO_2 may leak to trigger alarm when the concentration level exceeds 5,000 ppm. This is always required because CO_2 lacks a distinctive odour or colour.
- ✓ CO_2 sensors and ventilators should be located close to the floor to take advantage of the fact that CO_2 is heavier than air, and therefore will collect closer to the floor when it leaks;
- ✓ Always locate high pressure components such as the accumulation tank in isolated areas away from the consumers.

Handling Ammonia Refrigerant Gas (R-717)

Ammonia is classified as having lower flammability and higher toxicity. In general, it is fairly difficult to ignite, and even then, it does not easily sustain a flame. Ammonia (R-717) is also a higher toxicity refrigerant, and for this reason, extra caution should be taken when handling. Due to its affinity for water, R-717 will attack any moist body parts such as armpits, eyes, throat and groin at relatively low concentrations. Its strong odour is detectable by most people at 2 to 5 ppm. Low temperatures increase the sensitivity to the presence of ammonia. High humidity reduces the level at which ammonia is perceived. Table 3 presents the physiological effects of exposure to different concentrations of Ammonia.

Table 3: Physiological effects of different concentrations of Ammonia

Concentration	Effects on Unprotected Human Body	Exposure Limits
20 ppm	Smell readily detected by most people	Unlimited
25 ppm	HSE long term exposure limit	8 hr per day 5 days per week
35 ppm	HSE short term exposure limit	15 minutes per day not more than 1 hour per week
50 ppm	Smell is distinctive and may be irritating	Do not stay longer than necessary
70 ppm	No dangerous effects on healthy people	Leave the area
400 – 700 ppm	Immediate irritation to eye, nose, throat and respiratory system	Under normal circumstances no serious injury in 1 hour
1,700 ppm	Severe coughing, cramps, serious irritation to nose, eyes, throat and respiratory system	30 minutes exposure can lead to serious injury
2,000 – 5,000 ppm	Severe coughing, cramps, serious irritation to nose, eyes, throat and respiratory system	30 minutes exposure can lead to serious injury
Above 5, 000 ppm	Respiratory spasm, rapid asphyxia	Lethal within a few minutes

Source: Manual for Refrigeration Servicing Technicians, UNEP, 2010.

When handling R-717 the following procedures should be adhered to in addition to the practices recommended for the handling of halocarbon refrigerants in order to be able to respond to leakage or release of R-717 into the atmosphere.

Practices to follow

- ✓ Ensure that escape routes are known, clearly marked and free from obstacles.
- ✓ Ensure that only suitably qualified and/or experienced personnel work on ammonia systems.

- ✓ Wear suitable personal protective equipment including gloves and goggles at all times.
- ✓ Ensure that breathing apparatus and/or respirator masks are available and close to hand. It is good practice for technicians to wear their respirator mask loosely around the neck when carrying out any works other than visual inspections.
- ✓ Ensure that fire-fighting equipment is accessible within the machinery room.
- ✓ Only commence work on equipment after carrying out a full and approved risk assessment plus a method statement so that all relevant persons are aware of what work is being undertaken and by whom.
- ✓ Work in pairs if carrying out works other than routine checks.
- ✓ Check national regulations governing the use and handling of ammonia in industry operations.
- ✓ Immediately alert the Environmental Protection Department (535-4600) and/or the Barbados Fire Service (311) whenever there is a leak resulting in the release of 100 lb or more of ammonia.

If you do come into physical contact with ammonia, you should administer the following first aid, and seek immediate medical attention:

- In case of skin contact, remove contaminated clothing. Drench with large quantities of water and continue to wash affected skin areas for at least 20 – 30 minutes, and use safety shower if available.
- In the case of freeze burns, clothing may adhere to the skin in which case, immerse the affected area in comfortably warm water to defrost.
- In case of eye contact, flood eyes with clean tap water for at least 20 – 30 minutes followed by immediate medical attention.
- In case of ingestion, rinse mouth with water and give plenty to drink. Do not induce vomiting but seek medical attention immediately.
- In case of inhalation, remove the patient to fresh air immediately. Remove contaminated clothing and keep the patient warm and rested. Seek medical assistance immediately. The patient must be kept under observation for at least 48 hours after exposure as delayed pulmonary oedema may develop.

Handling Hydrocarbon Refrigerants (R-290, R-600a, R-1270)

Common hydrocarbon refrigerants include Propane (R-290), iso-butane (R-600a) and Propylene (R-1270). Hydrocarbon refrigerants are classified as having high flammability and low toxicity. As such, special attention should be given to the correct handling of flammable refrigerants and associated equipment, refrigerant detection, charging, equipment decommissioning, removal, recovery and storage of the refrigerant, and aspects related to ensuring the integrity of the protection for electrical components. Any equipment used in the process of repair must be suitable for use with flammable refrigerants.

Before handling hydrocarbon refrigerants, service personnel must inform themselves about the safety requirements regarding the use of flammable gases. OEM Manuals should be consulted to get all the relevant information about the equipment to be serviced, such as the maximum refrigerant charge, the minimum rated airflow if required, the minimum floor area of the room or any other special requirements, as well as all the corresponding warnings.

Only competent professionals trained in the use of flammable refrigerants should be allowed to open equipment housing or to break into the refrigerant circuit. Any maintenance and repair requiring the assistance of another skilled person should be carried out under the supervision of the competent individual.

Practices to follow

- ✓ Check all tools and equipment (including measuring equipment) for suitability for working on the equipment. Pay attention to the selection of:
  - Refrigerant recovery units
  - Refrigerant leak testing units
  - Electrical test meters
  - Refrigerant recovery cylinders
  - Portable lighting.
- ✓ If the installation permits, wherever possible, move the equipment to a controlled workshop environment suitable for the type of repair where work can be conducted safely.
- ✓ Perform the necessary safety checks prior to beginning work on systems containing hydrocarbon refrigerants, to ensure that the risk of ignition is minimised.
- ✓ Conduct work under controlled conditions to minimise the risk of a flammable gas or vapour being present while the work is being performed.

- ✓ Inform all maintenance staff and others working in the local area of the nature of work being carried out.
- ✓ Avoid working in confined spaces and cordon off a sectioned area around the workspace.
- ✓ Ensure that the conditions within the work area have been made safe by the control of flammable material.
- ✓ Check the area with an appropriate refrigerant detector prior to and during work to ensure that the technician is aware of potentially flammable atmospheres.
- ✓ Ensure that the leak detection equipment being used is suitable for use with flammable refrigerants, i.e. non-sparking, adequately sealed or intrinsically safe.
- ✓ Ensure that appropriate fire extinguishing equipment is available to hand if any hot work is to be conducted on the refrigeration equipment or any associated parts. Have a dry powder or carbon dioxide fire extinguisher adjacent to the charging area.
- ✓ **DO NOT** use any sources of ignition in such a manner that it may lead to the risk of fire or explosion when carrying out work on a refrigeration system which involves exposing any pipe work which contains or has contained flammable refrigerant.
- ✓ Keep all possible ignition sources, including lighted cigarettes, sufficiently far away from the sites where flammable refrigerant can possibly be released to surrounding space; including sites of installation, repair, removal and disposal.
- ✓ Prior to work taking place, survey the area around the equipment to establish any flammable hazards or ignition risks and display "No Smoking" signs.
- ✓ Ensure that the area is in the open or that it is adequately ventilated before breaking into the system or conducting any hot work. A degree of ventilation should continue during the period that the work is carried out. The ventilation should safely disperse any released refrigerant and preferably expel it externally to the atmosphere.

Requirements for Transportation

Persons transporting refrigerant cylinders in a vehicle should always follow basic safety requirements. The driver of such vehicle transporting the refrigerant should be trained and knowledgeable on the associated hazards and dangers of the goods they are transporting, and in emergency procedures and the use of fire-fighting equipment.

Practices to follow

- ✓ Vehicles used for transporting cylinders should have an open compartment where the cylinders are placed. The use of cars, vans, or any other enclosed vehicle is extremely dangerous, and should be avoided. If this cannot be achieved the vehicle should be properly ventilated.
- ✓ At minimum, a 2kg fire extinguisher should be on all vehicles carrying gas cylinders to fight engine and cab fires.
- ✓ The protective cap should always be placed on the cylinders when they are being transported. If the cylinders were not designed to hold a protective cap over the valve, special care should be taken to prevent the valve from damage or opening during transportation.
- ✓ All compressed gas cylinders should be secured from movement during transportation and should not project beyond the sides or ends of the vehicle. Cylinders that can move freely may open accidentally, or roll off the vehicle into the path of oncoming traffic.
- ✓ When moving cylinders (50 lbs or heavier) within the work site, they should be firmly strapped onto an appropriate wheeled device. A cylinder should never be rolled on its base or laid down to roll on its side.
- ✓ A lift truck should be used to move large containers of refrigerant on pallets.
- ✓ Cylinders should not be strapped or lifted by the valve or valve cover.

Storage of New and Used Refrigerants

The following guidelines are intended for use by persons in the domestic and commercial/industrial refrigeration sectors to provide guidance on the storage of new and used refrigerants:

Practices to follow

- ✓ Store refrigerants in cylinders upright, in their original cylinders or other approved cylinder (Figure 8) with a combined liquid/vapour valve located at the top.

Figure 8 Approved Refrigerant Storage Cylinders

- ✓ Store cylinders at or below a temperature of 50°C. If stored at or below 50°C they shall never be more than 80% filled.
- ✓ Never apply steam or direct heat to cylinders.
- ✓ Store cylinders above ground level in well ventilated areas. If stored outdoors, store cylinders out of direct sunlight and rain. If stored indoors, ensure that the area is dry and properly ventilated. As refrigerants vapours are heavier than air, place the ventilation near to ground level. Install a refrigerant leak detector to monitor indoor air quality.
- ✓ Cylinders shall be protected from salt and other corrosive chemicals.
- ✓ Store refrigerants in separate areas from alkali and alkali earth metals such as sodium, potassium and barium in their free state as interaction could result in a violent reaction. The reaction might be explosive if the metals are in the fine-grained or powered state.
- ✓ Store recovered refrigerants in ASHRAE approved recovery cylinders only. **NEVER** store refrigerants in recovery bags. Label recovery cylinders in accordance with local standards.

- ✓ Carefully weigh and inspect cylinders to be used as storage cylinders before filling. **DO NOT** use cylinders that are dented, rusted, gouged or damaged in any way for storing refrigerants.
- ✓ Inspect stored cylinders periodically for damage or deterioration of condition during storage. During inspection, examine the valve for leakage, damage or tampering. Carry out inspections at least once every six months.
- ✓ Carefully handle cylinders used for refrigerants as most are steel cylinders and are under pressure. Observe all guidelines for handling compressed gas cylinders. Whether full or empty, **DO NOT** drop cylinders or hit with a hammer or any other sharp or blunt objects.
- ✓ Where possible, only store refrigerants in reasonable quantity as it relates to the nature of the operation. Also store empty containers outside, and away from full containers.

Storage of Hydrocarbon Refrigerants

The following guidelines should be adhered to specifically for storage of hydrocarbon refrigerants:

Practices to follow

- ✓ Store cylinders with HC refrigerant outside and never in residential premises.
- ✓ Store cylinders with HC refrigerant in commercial and industrial premises according to the following guidelines for storage:
    - Restrict quantities stored to no more than 70 kg and store in specific dedicated areas or cages.
    - Restrict access to storage areas to 'authorised persons only', and mark such places with notices prohibiting smoking and the use of naked flames.
    - Store cylinders at ground level, never in cellars or basements.
    - Ensure that cylinders are readily accessible, and stored upright.

12 Disposal of Used Refrigerant Oils

Due to the miscibility of oil and refrigerant, used refrigerant oil often becomes contaminated with dissolved chlorine and fluorine (halogens) at concentrations greater than 4,000 ppm. As a result, used refrigerant oil is categorized by the EPA as off-specification and must be treated as hazardous waste. If the oils are stored in sealed containers at elevated temperature, they will slowly release the dissolved refrigerants.

Practices to follow

- ✓ **ALWAYS** collect used refrigerant oil and store in sealed containers with valves installed to recover the refrigerant.
- ✓ Connect the container to a recycle unit and periodically recover the refrigerant that was released from the oil. The oil can then be burned as fuel.
- ✓ Evacuate the area immediately in the case of a spill and obtain the required breathing apparatus before returning.

Practices to eliminate

- ✗ **NEVER** dump used refrigerant oils in gullies or water ways.
- ✗ **NEVER** pour used oil on the bare soil or on the roots of plants to control pests.
- ✗ **DO NOT** handle used refrigerant oil with your bare hands.
- ✗ **NEVER** heat used refrigerant oils.

13 Bibliography

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