NOTICE ON THE DOCUMENT

This ***Code of Practice for Refrigeration and Airconditioning*** was prepared by the Department of Environment and Natural Resources, through its Environmental Management Bureau, specifically the National CFC Phase-out Plan – Project Management Unit of the Philippine Ozone Desk. It is the output of extensive consultation with the Core Group for Code of Practice for RAC and MAC, which was convened by the NCPP-PMU and composed of technical experts from different industry organizations and stakeholders in the field of Refrigeration and Airconditioning. The document was approved and adapted as official document for the RAC and MAC sector last 18 June 2004 in Pasig City, Philippines and had its first revision on 15 April 2013 in Quezon City, Philippines by members of the Core Group as follows:

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This Code will be used by service technicians as reference/guidance document on good practices in handling and working with refrigerants, including regulations and legislations concerning the trade. It is also useful as a handbook for technician's training on retrofitting procedures and recovery/recycling of refrigerants prior to certification from the Technical Education and Skills Development Authority (TESDA).

The Code of Practice is a *living document* and therefore subject to change or revision. It is expected that the concerned stakeholders of the RAC and MAC sector may present additional comments and suggestions for the improvement of the contents of this Code and for inclusion to the next revision and production. Kindly send your comments and suggestions to the National CFC Phase-out Plan- Project Management Unit of the Philippine Ozone Desk.

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TABLE OF CONTENTS

BACKGROUND

A. THE OZONE ISSUE AND THE MONTREAL PROTOCOL

The ozone layer is a thin veil of molecules in the stratosphere, located between troposphere and ionosphere, which is about 11 - 48 kilometers from the earth's surface. It blocks most of the Ultraviolet B or UV-B range from reaching the earth's surface. Harmful effect of the UV-B rays in humans include skin cancer, eye disorders, weakening of body's immune system and damage to plants and aquatic organisms. The stratospheric ozone depletion became a worldwide issue upon the discovery of the Antarctic "ozone hole" in 1985. Scientific evidence confirms that ozone damaged are caused by manmade compounds containing chlorine and bromine-such as chlorofluorocarbons (CFCs) and halons released in the atmosphere. CFCs were considered as "miracle compounds" in the chemical industry, but later were identified as the leading cause of ozone depletion. These are widely used in the industry like refrigeration and air conditioning (household, commercial, stationary and mobile), foam production (building insulation, flexible and rigid) and tobacco expansion. This global problem which alerted the international community led to the adoption of the Montreal Protocol in September 1987 and was entered into force on January 1, 1989 by 73 countries including the Philippines and the EEC. As of 2012, there are197 parties where South Sudan is the newest member

The Montreal Protocol on Substances that Deplete the Ozone Layer was created to restore the ozone layer by implementing programs to reduce production and consumption and eventual phase-out of Ozone Depleting Substances (ODS).

The XXIX Meeting of Parties to the Montreal Protocol in September 2007, through its decision XXIX/6, adopted an accelerated phase out for HCFCs keeping in mind Ozone Depleting Potential and Global Warming Potential. The first control is the freeze on production and consumption of HCFCs on January 2013, at the base level i-,e- average of 2009 and 2010 consumption levels. The second control step is the reduction of 10% from the Baseline Levels on January 1, 2015. Subsequent control steps are 35% reduction by 2020, 67.5% by 2025, 97.5% by 2030 and complete phase out from January 1, 2040. The decision also directed the Executive Committee of the Montreal Fund to assist Article 5 Parties in preparation of HCFC Phase out Management Plans (HPMP).

B. KYOTO PROTOCOL

The Kyoto Protocol is a pact agreed on by governments at the United Nations conference in Kyoto, Japan in 1997 to reduce the amount of greenhouse gases emitted by developed countries by 5.2 percent of 1990 levels during the five-year period 2008-2012. Eighty-four (84) countries have signed the pact and 40 have already ratified it, with Romania as the only country with emissions target who have ratified to date. It is the only legally-binding plan for combating global warming.

Greenhouse gases are gases that trap heat in the earth's atmosphere. The main contributor is Carbon Dioxide (CO_2), most of which comes from burning fuel. The protocol also covers Methane (CH4), much of which comes from agriculture and waste dumps, and Nitrous Oxide, mostly as a result of fertilizer use. Three industrial gases used in various applications, such as refrigerants, heat conductors and insulators, are also included – they are Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulfur Hexafluoride (SF6) as well as Chlorofluorocarbons (CFCs).

In November 2012 during the UN Climate Summit in Doha, Qatar, nearly 200 nations agreed to extend Kyoto Protocol until 2020. The Summit established for the first time that developed nations should move towards compensating developing nations for losses due to climate change. The Conference also cleared the way for the Kyoto protocol to be replaced by a new treaty binding all rich and poor nations together by 2015 to face the challenge in tackling climate change.

C. THE COUNTRY'S SPECIFIC PROGRAM

In the Philippines, the Department of Environment and Natural Resources (DENR) - Environmental Management Bureau (EMB) through its Philippine Ozone Desk (POD) act as the National Ozone Unit (NOU) for the implementation of programs and activities under the Montreal Protocol, through the Refrigeration Management Plan (RMP) that led to the development of wide range of policy and support services.

In order to concentrate further in the implementation stages, the Project Management Unit (PMU) was created under DENR Special Order No. 2003-43. Its main tasks are: preparation of detailed planning, conduct of monitoring, coordination and full implementation of specific components of the NCPP project, part of which are the Refrigeration and Air Conditioning (RAC) and Mobile Air Conditioning (MAC) sector, as well as foam, aerosol, Metered-Dose Inhaler (MDI) sectors.

Presently, the following major projects have been approved by the Multilateral Fund Executive Committee to comply with the country's commitments to the Montreal Protocol on Substances that Deplete the Ozone Layer:

Presently, Philippines' Country Programs approved by the Montreal Protocol are the following:

1. The Institutional Strengthening Project (ISP) is the arm of the POD that supports its following functions:

    a. Implement the country programs
    b. Design and implement the law and financial measures to facilitate phase out
    c. Coordinate country activities
    d. Consult with industry and other relevant organizations
    e. Represent the country point of view in the MOP and all working groups and committees
    f. Organize and present awareness and training programs for industry and the public
    g. Implement the licensing system for monitoring and reporting national consumption
    h. Monitoring of past and present investment and non-investment projects
    i. Create a strategy and plan of action for future projects

2. The National CFC Phase out Plan (NCPP) where its main objective is to phase out the remaining uses of CFCs in the country in all sectors particularly in foam, tear gas/aerosol and manufacturing of CFC-based equipment, refrigeration and air conditioning (RAC) and mobile air

conditioning (MAC) servicing and meter-dose inhaler (MDI). Among all sectors, RAC and MAC servicing sector has the highest consumption of CFC where implementation must be focused.

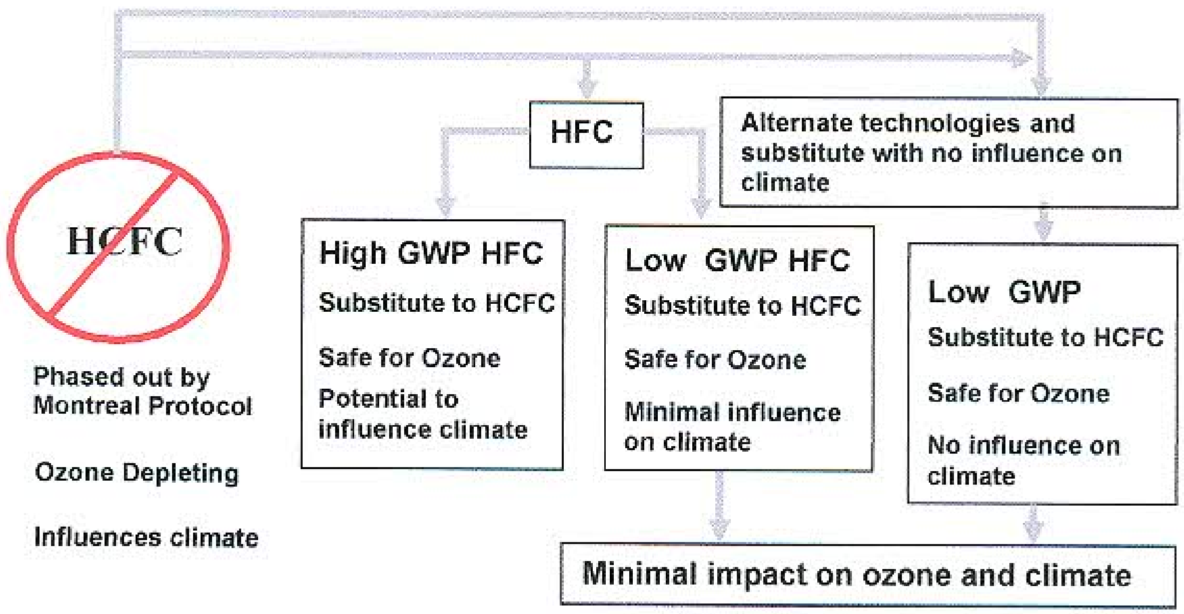
3. As part of the Philippine Hydrochloroflourocarbons Phase out Management Plan (HPMP) strategy, the phase out of HCFC-141b in the foam sector is presently being supervised by the United Nations Industrial Development Organization (UNIDO) as the Implementing Agency and the POD as the NOU. About 364.34MT of HCFC-141b used in the manufacture of PU foams, will be phased out by the end of 2012 to comply with the approved accelerated phase-out schedule of HCFCs for Article 5 countries based from Decision 19/6 of the Meeting of the Parties to the Montreal Protocol. The present HCFC-141b technology utilized for the production of flexible foams will be converted to water technology, while that for rigid foams will be converted to CP or water blown technology, depending of enterprises' size and present level of technology.

The Government of the Philippines through the DENR-Environmental Management Bureau (EMB) will put in place policies to ban the use of HCFC-141b in the foam sector by the end of 2014. The overall HPMP was prepared by the World Bank (WB) wherein the phase out of HCFCs in the domestic air-conditioning manufacturing sector will be implemented by WB and the phase out of HCFCs for the commercial refrigeration and air conditioning manufacturing sector is proposed to be under the United Nations Development Programme (UNDP). In January 2012, a version of the HPMP was submitted to the 66th meeting of the Executive Committee; however, it was later withdrawn upon agreement among the ExCom Secretariat, the Philippines Ozone Desk, and the World Bank that the Philippines' Article 7 HCFC consumption data for 2009 and 2010 needed to be verified. A verification audit was carried out in July-August 2012 and forms the basis for this HPMP. The HPMP has been reviewed by UNEP and UNDP, and incorporates their comments and approved by MLF during the 68th Meeting of the Executive Committee held in Montreal last 3-7 December 2012. To date, the initial phase out of HCFCs in the foam sector project will comply–with the GOP's commitment for an HCFC reduction obligation of 10% by 2015.

INTRODUCTION

A. PURPOSE AND SCOPE

The RAC and MAC sector plays a vital role in the implementation of the Montreal Protocol to phase out the ozone depleting substances and to improve the service level in the refrigeration trade. Refrigeration and air-conditioning systems are large users of electrical energy and represent huge capital investments. To maintain these systems according to this Code of Practice (CoP) ***should ensure low leaks of refrigerants and lowest possible energy consumption resulting to lowest possible impact of the environment from Ozone Depleting Substances and on Global Warming from direct emissions of refrigerants as well as from indirect effects from Carbon Dioxide (CO_2) emissions caused by energy consumption. This CoP will also act as reference document for the training of service technicians, to set minimum standards for good practices in servicing refrigeration and air conditioning systems and initiate communication between relevant stakeholders and other concerned trades***. As a result, upon implementation of this code, it is expected that HCFC consumption will be reduced in a cost effective manner, without requiring major capital investment. It will also help in the smooth transition of technology from HCFC to non-HCFC and will improve quality, safety and the health aspects. The phase out of HCFC and the use of alternatives can be interpreted by the diagram below:



This CoP establishes the minimum acceptable standards of services in refrigeration and air-conditioning systems. If alternative methods are used they should ensure lower environmental impact, higher reliability and better energy performance.

B. REFERENCES

ARI Standards
GIZ Operation of Split Air conditioning systems with Hydrocarbon Refrigerant
Guidebook for Implementation of Codes of Good Practice
HyChill Hydrocarbon Refrigerants

Toyota HFC134a Air conditioning Fundamentals and Repairs
TESDA Training Regulation on HVAC R Sector
UNEP Good Practices in Refrigeration Training Manual
UNEP National Training on Good Practices in Refrigeration
UNEP Manual for Refrigeration Servicing Technicians
Updated Philippine Country Program for Ozone Layer Protection

C. DEFINITION OF TERMS

Accredited Service Shops - service enterprises performing refrigeration and air conditioning related activities that pass qualification requirements and holds a current accreditation certificate by DTI.

Alternative Refrigerant - replacement for ODS with zero ODP such as natural refrigerants and HFCs.

Article 5-country - a developing country that is a party to the Montreal Protocol, and whose annual consumption is less than 0.3 kg per capita and operate under article 5 of the Montreal Protocol.

Azeotrope – a blend consisting of one or more refrigerants of different volatilities that does not appreciably change in composition or temperature as it evaporates (boils) or condenses (liquefies) under constant pressure. Refrigerant blends assigned an R5xx series number designation by ISO 817 are examples of azeotropes.

ARI 700 - standard used as basis for the quality of reclaimed refrigerant.

Back Conversion - an act of going back from non-ODS refrigerant to ODS refrigerant.

Blends - a mixture of two or more pure fluids and are used to achieve properties that fit many refrigeration purposes. It is divided into two categories: azeotrope and zeotrope.

Certified Technician - a technician who has successfully completed and passed the competency assessment given by TESDA (or an accredited institution) and holds a current TESDA-issued certificate.

Chlorofluorocarbon (CFC) - a stable chemical containing only chlorine, fluorine and carbon atoms, known to be ozone-depleting substances (ODS).

Commercial and Industrial Refrigeration and Air Conditioning – similar to the domestic refrigeration and air conditioning but this are commonly found in commercial establishment such as restaurant, flower shops, supermarkets and the like. Some are plug-in type unit like a small reach-in coolers in a local convenience store. These are usually installed and serviced by a certified group of technicians.

Container/Cylinder – a drum or tank that holds refrigerant use for storage or transport.

Contaminants – any substance such as dirt and moisture that is foreign to the refrigerant or the refrigeration system.

Disposable Container/Cylinder - drum or tank designed to be used only once for the transport and storage of a virgin substance, oftentimes termed as "one trip" cylinder; made of common steel that oxidize, therefore weakens when rust occurs on walls, with a single-acting plastic valve that makes it non-refillable.

Disposable Container/Cylinder – non-refillable cylinder (NRC) or DOT 39 drum or tank specified by the U.S. DOT Regulations 39 that cannot be filled or transported more than once. It is termed as "one-trip" cylinder; made of common steel that oxidize, therefore weakens when rust occurs on walls, with a single-acting plastic valve that makes it non-refillable..

Domestic Refrigerator – a small refrigeration equipment used for preservation of food and to cool water and beverages.

Drop-in Refrigerant – substance that is claimed to be direct replacement for ODS refrigerant, without changing existing mineral oil in the system.

Dual Pressure Switch - a device with two settings; both high and low, that trips-off compressor's relay when operating pressures go above or below the preset high or low pressure setting.

Elastomers - any of various elastic substances resembling to rubber.

Evacuation - the process of removing air (gas) and moisture from a refrigeration and air conditioning system.

Firestat - a device that controls electric defrost heaters to prevent overheating based on preset temperature setting.

Flushing - an act of cleaning a contaminated refrigeration/air conditioning system or system with burnt compressor by pumping a solvent or pushing it through a system with a gas (Nitrogen) then releasing the compounds to the atmosphere or a system openly exposed or in contact with the atmosphere.

Fractionation - a condition wherein one or more refrigerants in a blend leak at a rate faster than the other refrigerants in that blend (a condition wherein a zeotropic or near-zeotropic refrigerant blends phase changes. This causes different condensation and vaporization rates and temperatures as their phase change.)

Global Warming Potential (GWP) - an index comparing the climate impact of an emission of a greenhouse gas relative to that of emitting the same amount of carbon dioxide. GWP is determined as the ratio of the time integrated radiative forcing arising from a pulse emission of 1 kilogram of a substance relative to that of 1 kilogram of carbon dioxide, over a fixed time horizon.

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 air or moisture from entering into the system or equipment.

Hydrocarbon (HC) - chemical compounds consisting of one or more carbon atoms surrounded only by hydrogen atoms. These are not damaging to the ozone layer and have a minimal global-warming potential. A flammable compound.

Hydrochlorofluorocarbon (HCFC) - halocarbons containing only hydrogen, chlorine, fluorine and carbon atoms. Because HCFCs contains chlorine, they contribute to ozone depletion. They are also greenhouse gases.

Hydrofluorocarbon (HFC) - halocarbons containing only carbon, hydrogen and fluorine atoms. Because HFCs contain no chlorine, bromine or iodine, they do not deplete the ozone layer. Like other halocarbons, they are potent greenhouse gases. Some HFC's are flammable.

Hygroscopic - characteristic of a substance that readily absorbs and retains moisture.

Initial Charge - partial charge of refrigerant to ensure positive pressure in a system prior to final charging.

Installation - refers to any permanent mounting or setting-up of system; or transfer of equipment from one location to another, which involve disconnection and reconnection of refrigerant piping and/or electrical interconnections between indoor and outdoor units.

Lubricant – fluid present in the internal volume of the refrigerating system, present for the main purpose of lubrication of wearing surfaces. In a leak scenario, lubricant may be flammable or increase the flammability of leaking refrigerant.

Mobile Air Conditioning (MAC) - refers to the air conditioning system of motor vehicles. They are usually directly driven by the vehicles' engine while for some bigger units, they are driven by another or separate engine or electric motor.

Mixture - a refrigerant that contains oil and contaminants including other refrigerants.

National Certificate I (NC I) - a technician certification wherein workers in this level perform routine and predictable tasks involving little or no latitude for judgment. Work involves adherence to appropriate standards or specifications while assignments are usually made by a supervisor or a worker at a higher level who gives simple instructions and makes clarifications or suggestions when necessary.

National Certification II (NC II) - a technician certification wherein workers in this level prescribed range of functions involving known routines and procedures, where clearly identified choices and limited complexity applies. Work involves some accountability for the quality of outputs while applications at this level may involve individual responsibility or autonomy or working with others as part of a team or group.

National Certification III (NC III) - a technician certification wherein workers on this level perform a wide range of skilled operations at a high level of competence involving known routines and procedures. The work context involves some complexity in the extent and choice of options available, understanding the work processes, equipment to and material to be used. Applications at this level may involve individual responsibility or autonomy and/or may involve some responsibility for others. Participation in teams including team or group coordination may be involved.

National Certification IV (NC IV) - a technician certification wherein workers in this level perform a wide range of applications in a variety of context most of which are complex and non-routine. Work involves some leadership and guidance when organizing activities of self and others as well as contributing to technical solutions of a non-routine or contingency nature. Work at this level also requires evaluation and analysis of current practices and the development of new criteria and procedures. Application involves responsibility for the organization and performance of others.

Natural Refrigerants- are naturally occurring organic substances that can be used as cooling agents for refrigerators and air conditioners such as water, ammonia, CO2, nitrogen and hydrocarbon.

Non-condensables - gases that do not change to liquid state at operating temperature and pressure of the refrigerant.

Oil Pressure Switch - a device that trips-off compressor when suction and oil pressure difference does not meet manufacturer's recommendation.

Original Equipment Manufacturer (OEM) - manufacturers of complete refrigeration/air-conditioning units.

Ozone-Depletion Potential (ODP) - a measure of the relative capability of a particular chemical to destroy ozone. The ODP is measured against CFC-11 which has an assigned ODP of 1.0.

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

Philippine National Standard (PNS) - standards developed by the Department of Trade and Industry-Bureau of Product Standards (DTI-BPS) that will be used as basis for the certification of certain products or practices.

Polyalkylene Glycols (PAGs) - a very hygroscopic refrigeration lubricant that is used for HFC refrigerants for automotive air conditioning systems and have very high molecular weights.

Polyolester - a popular synthetic lubricant for use with HFC refrigerants.

Pump-down system - a term used wherein the refrigerant content of a refrigeration system is isolated and temporarily stored in the condenser/liquid receiver.

RAC - Refrigeration and Air Conditioning

Large RAC System – capacity of more than 300kg refrigerant charge

Medium RAC System – capacity of 30kg up to 300kg refrigerant charge

Small RAC System – capacity of less than 30kg refrigerant charge

Reclamation - means re-processing of recovered/used refrigerant to a quality/degree or specification the same as that of new refrigerant. Reclaimed material should meet the specification defined by ARI 700.

Recovery – the removal of a refrigerant at any condition (vapor, liquid or mixed with other substance) from a system and to store it in an external container.

Recovery Machine – an equipment that removes or extract refrigerant at any condition from a system and store it to an external cylinder.

Recovery & Recycling Machine – an equipment that removes or extract refrigerant in any condition from a system and clean it by oil separation in a single or multiple passes through a replaceable core filter drier which reduces moisture acidity and particulate matter.

Recycling –a process wherein a contaminated refrigerant, is made to pass to a core filter drier several times and clean it through oil separation method to reduce moisture acidity and particulate matter.

Refillable Container/Cylinder – a re-usable drum or tank intended to contain refrigerant for storage and transport.

Refractometer - an instrument used to measure the percentage of residual mineral oil during retrofit or conversion. Recommended range is between 1-5%.

Refrigerant Identifier – an instrument used to identify refrigerant percentage composition of CFCs, HCFCs, HFCs, Hydrocarbons and air content.

Relief Valve - a safety calibrated spring-operated device that is designed to relieve system over pressure.

Retrofit - process by which the equipment currently using an ODS refrigerant is made to run on a non-ODS refrigerant.

Rupture Disk - a circular (round and dished) device used on some refrigeration equipment to provide pressure release for safety purposes. This disc suddenly breaks when a certain pressure is reached.

R-value – is a measure of resistance to heat flow through a given thickness of a material.

Servicing - means any act of repair, maintenance, testing and trouble shooting of parts, including mechanical and electrical components of an existing refrigeration and air conditioning equipment.

Specified Refillable Container/Cylinder - a re-usable container that is color-coded or tagged for a specific refrigerant intended for storage or transport.

System - refers to refrigeration and air conditioning components assembled/installed into a closed circuit structure isolated from outside air or surroundings.

Gauge manifold – gauge manifold with at least high and low pressure gauge and valves to allow control and service on RAC system.

Temperature Glide – the range of temperature between the dew point (condensing) and bubble point (evaporating) at a single given pressure.

Thermistor – a semi-conductor electronic device that changes resistance with a change in temperature.

Venting - means intentional release and/or purging of refrigerant to the atmosphere.

Window Type Air Conditioner – the smallest packaged air conditioning unit used to cool a space.

Zeotrope – a refrigerant blend consisting of two or more substances of different volatilities that appreciably changes in composition or temperature as it evaporates (boils) or condenses (liquefies) at a given pressure. A zeotropic refrigerant blend assigned an R4xx series number designation in ISO 817.

D. ABBREVIATIONS/ACCRONYMS

AHU	-	Air Handling Unit
ARI	-	Air conditioning and Refrigeration Institute
ASHRAE	-	American Society of Heating, Refrigerating and Air Conditioning Engineers
CCO	-	Chemical Control Order
CTS	-	Collection, Transport and Storage Facility
DENR	-	Department of Environment and Natural Resources
DTI	-	Department of Trade and Industry
GWP	-	Global Warming Potential
LTO	-	Land Transportation Office
MAC	-	Mobile Air Conditioning
MAPHIL	-	Maintenance Association of the Philippines
MSDS	-	Material Safety and Data Sheet
NCPP	-	National CFC Phase-out Plan
ODP	-	Ozone-Depletion Potential
ODS	-	Ozone Depleting Substances
OEM	-	Original Equipment Manufacturer
PEC	-	Philippine Electrical Code
PMU	-	Project Management Unit
PNS	-	Philippine National Standard
POD	-	Philippine Ozone Desk
PSME	-	Philippine Society of Mechanical Engineers
PSVARE	-	Philippine Society of Ventilating and Refrigerating Engineers
PPE	-	Personal Protective Equipment
SAE	-	Society of Automotive Engineers
TESDA	-	Technical Education and Skills Development Authority
UNEP	-	United Nations Environment Programme
UNDP	-	United Nations Development Programme
UNIDO	-	United Nations Industrial Development Organization
WB	-	World Bank

PART 1: GENERAL REQUIREMENTS

PART 1.1 - TESDA Certification on Technicians

1.1.1 Only service technicians who have passed the competency assessment by TESDA will be given certification.

1.1.2 Each Certified Technician shall be assigned with a certification number and their list will be maintained in a database at TESDA.

1.1.3 Only Certified Technicians will be allowed to perform service/repair works on RAC equipment/system (refer to Section 9. Item 9.1 of the revised Chemical Control Order for ODS).

1.1.4 Only Certified Technicians will be allowed to purchase refrigerants listed under the Montreal Protocol Controlled Substances (refer to Section 8 Item 8.5 of the revised Chemical Control Order for ODS).

1.1.5 Only Certified Technicians will be allowed to operate a Recovery and Recycling Machine.

PART 1.2 - DTI Accreditation on Service Shops

1.2.1 All service and repair enterprise must be registered with appropriate government agencies and accredited by DTI.

1.2.2 Only Accredited Service Shops will be allowed to perform RAC-related services.

1.2.3 Only Accredited Service Shops will be allowed to purchase refrigerants listed under the Montreal Protocol Controlled Substances (refer to Section 8 Item 8.5 Annex II of the revised Chemical Control Order for ODS).

1.2.4 All technicians of service shops actively involved in the service of RAC system shall be TESDA certified.

PART 1.3 - DENR Registration on ODS Importers, Distributors, Dealers, Retailers and Service Providers

1.3.1 Only DENR-registered enterprises shall be allowed to import ODS refrigerants.

1.3.2 Only enterprises (dealers, retailers, re-sellers) registered by DENR shall be allowed to purchase, re-sell or distribute ODS refrigerants.

1.3.3 All service providers must be registered with DENR-EMB.

PART 1.4 - Practices

1.4.1 Never use ODS and petroleum products as cleaning/flushing agent for the system.

1.4.2 Never mix different types of refrigerant.

1.4.3 Always recover refrigerant before servicing a system.

1.4.4 Never vent ODS/ HFCs in the atmosphere.

1.4.5 Never re-charge (tap up) the system without repairing leaks.

1.4.6 Never use refrigerants for leak testing.

1.4.7 Never use halide torch for leak testing of flammable refrigerants.

1.4.8 Use only appropriate leak testing instrument for flammable refrigerants.

1.4.9 Never use oxygen for leak and pressure testing.

1.4.10 Never use nitrogen for pressure testing without the use of nitrogen regulator.

1.4.11 Never use compressed air for leak and pressure testing.

1.4.12 Never use compressed air in flushing refrigeration system.

PART 2: REFRIGERATION AND AIR CONDITIONING SECTOR

PART 2.1 – WINDOW TYPE AIR CONDITIONER AND DOMESTIC REFRIGERATION

SECTION 1 – INSTALLATION

1.1 Window Type Air Conditioner

1.1.1 Refer to the manufacturer's recommended installation instruction when installing window type air conditioning unit;

1.1.2 As much as possible, avoid installation wherein the condenser coil is exposed to direct sunlight;

1.1.3 Seal-off all possible air leakages within the conditioned area to prevent infiltration of outside air;

1.1.4 Seal-off air gap between unit's housing and wall;

1.1.5 Install unit in such a way that the water condensate is prevented from dripping back inside the room;

1.1.6 Make sure that available electrical power supply is in accordance with Philippine Electrical Code (PEC) and with manufacturer's specification;

1.1.7 Secure unit using approved brackets or acceptable fabricated frames;

1.1.8 Install unit with its own disconnect switch (circuit breaker, manual disconnect switch) in accordance with PEC; and

1.1.9 Ensure that the condenser airflow is not blocked.

1.2 Refrigerators

1.2.1 Provide adequate flow of air on the condenser section of the refrigerator; and

1.2.2 Do not place refrigerator unit near a heat source.

SECTION 2 – MAINTAIN, SERVICE AND REPAIR

2.1 Window Type Air Conditioners

2.1.1 Assess condition of unit to determine whether it is practical to repair or not;

2.1.2 If beyond repair, the technician shall exert utmost effort to recover the refrigerant content of the unit, if there is any;

2.1.3 If repairable, perform procedures in accordance with acceptable industry practices;

2.1.4 Refer to manufacturer's recommended service manual;

2.1.5 Clean air filter regularly;

2.1.6 Perform regular cleaning of condenser, evaporator, blower and other accessories;

2.1.7 Check for traces of oil on refrigerant lines as signs of possible leaks;

2.1.8 Ensure that the unit's operating current and voltage is within the acceptable range;

2.1.9 **DO NOT USE LYE**. Use appropriate and environmentally acceptable cleaning agents to the evaporator and condenser coils;

2.1.10 Use pressurized water or compressed air when cleaning coils;

2.1.11 Use fin comb in straightening fins; and

2.1.12 Use appropriate PPE.

2.2 Refrigerators

2.2.1 Assess condition of unit to determine whether it is practical to repair or not;

2.2.2 If beyond repair, the technician shall exert utmost effort to recover the refrigerant content of the unit, if there is any;

2.2.3 If repairable, perform procedures in accordance with acceptable industry practices; and

2.2.4 Refer to manufacturer's recommended service manual

PART 2.2 – COMMERCIAL AND INDUSTRIAL REFRIGERATION AND AIR CONDITIONING

SECTION 1 – UPGRADING/MODIFICATION OF EXISTING UNIT

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 its continuous operation, and should not be affected while the unit is normally operating. The following guidelines should be followed as well as those given by the manufacturer, if available:

1.1 Pump down system and/or recover refrigerant before opening the refrigeration system;

1.2 Weigh and label recovered refrigerants properly. Exert all efforts to prevent/ minimize loss of refrigerant during recovery operation;

1.3 Ensure that the existing equipment is set-up to a pump down system. If not, install the necessary refrigerant service valves, replace if found defective;

1.4 Modify refrigerant piping installation to the standard and acceptable industry practice (refer to applicable ASHRAE/ARI or manufacturer's standard), if necessary;

1.5 Convert flared connections into brazed type refrigerant piping and fittings, whenever possible;

1.6 Ensure that gauges for monitoring system condition and refrigerant charge are installed and operational;

1.7 Ensure that vibration eliminators installed on suction and discharge lines are in accordance with manufacturer's standard; and

1.8 Ensure setting of pressure-limiting devices such as pressure relief valve, high/low and oil-failure pressure switches are in accordance with manufacturer's standard.

SECTION 2 - INSTALLATION OF EQUIPMENT

The following should be observed for all refrigeration and air conditioning installations:

2.1 Refer to the manufacturer's recommended installation instruction and procedure;

2.2 Seal-off exposed pipe ends to prevent it from being exposed to moisture and foreign materials;

2.3 Install all units free from hazards to person, property and the environment;

2.4 Monitor and supervise all installation works by a competent and responsible person;

2.5 Observe safety procedures during installations at all times;

2.6 Provide adequate ventilation at refrigeration equipment room or adequate space as per acceptable industry standards (ASHRAE, ARI, and other standard ventilation handbook);

2.7 Provide sufficient service space to individual equipment, as recommended by its manufacturer;

2.8 Use tube or pipe cutter when cutting copper tube or pipes;

2.9 Ensure that pipes and fittings to be used are clean before installation;

2.10 Provide U-trap for refrigerant riser pipelines as per manufacturer's standard;

2.11 Install appropriate auxiliary components such as sight glass, filter drier, liquid receiver, vibration isolator/eliminator, crank case heater, etc;

2.12 Clamp and secure properly refrigerant piping;

2.13 Insulate refrigerant piping properly with the correct insulation r value all throughout its piping length;

2.14 Ensure that insulations are properly joined;

2.15 Provide proper rubber isolation pad between unit and its base to prevent transmission of vibration that may cause noise;

2.16 Secure unit frame by tightening bolts & nuts/fasteners properly to prevent vibration;

2.17 Avoid installation of condensing unit with its coil directly exposed to sunlight;

2.18 Ensure positive condensate drain when installing Fan Coil Unit (FCU) / Air Handling Unit (AHU);

2.19 As much as possible, imbedded pipe should be installed in a trench;

2.20 Introduce dry nitrogen into the pipe while brazing or soldering to prevent metal oxidation;

2.21 Use dry nitrogen to flush out debris or any foreign particles from brazing or cutting. ***Never use oxygen for flushing;***

2.22 Use approved cleaning agent for flushing dirt out of the system;

2.23 Check holding charge content of the condensing unit whether it is a refrigerant or nitrogen;

2.24 Ensure that the system is leak tested at 150 psig for low side and 300 psig at high side using dry nitrogen. For R-410A and CO_2 refer to manufacturer's recommendation. Evacuate system to *1000 microns (29.87in Hg)*;

2.25 Provide exclusive power supply and circuit breakers for each unit as per manufacturer's standards;

2.26 Do not wrap too tightly when using polyethylene tapes on refrigerant piping insulation to avoid decreasing the insulation R value;

2.27 Check properly safety related component's functionality (e.g. high and low pressure switches, time delay, solenoid valves, pressure relief valves and the like). The settings and results of tests should be documented for future reference;

2.28 Ensure crankcase heater is energize for a minimum of 24 hours prior to start-up;

2.29 Label properly components of the refrigeration system. Equipment specification and technical data (MSDS, technical bulletin, etc.) shall readily be available, to include type and amount of refrigerant and lubricant used in the system;

2.30 Accomplish Start-Up Data Sheet right after installation; and

2.31 Cut pipe in accordance to accepted industry practices.

SECTION 3 - OPERATION AND MAINTENANCE

This section includes activities performed on a regular basis:

3.1 General

3.1.1 Inspect panels (insulated cabinet, control panel, etc.); schedule repair, if necessary;

3.1.2 Inspect unit switches for unusual or abnormal condition;

3.1.3 Check bearings for any unusual sound and vibration. Apply grease or oil, if necessary;

3.1.4 Check tightness of all bolts and screws; tighten, if necessary;

3.1.5 Check fan and fan housing for dirt accumulation; clean, if necessary;

3.1.6 Check belt tensions and alignment of pulley; adjust, if necessary; and

3.1.7 Check belt for any abnormal wear. Determine its cause and make necessary correction.

3.2 Refrigerant/oil system

3.2.1 Inspect condition of refrigerant piping insulation, and schedule repair or replacement, if necessary;

3.2.2 Inspect sight glass (if present) for refrigerant flow/quality;

3.2.3 Inspect for refrigerant leaks as indicated by oily spots and use appropriate leak detector to locate the leak;

3.2.4 Check schrader/access valves, packing glands, O-rings, service caps and fittings for tightness;

3.2.5 Check compressor oil level (if applicable). If it is low, report for further analysis;

3.2.6 Check oil for discoloration; and

3.2.7 Check operating pressures:

3.2.7.1 Suction

3.2.7.2 Discharge

3.2.7.3 Oil Pressure (if applicable)

3.3 Central System (Condenser)

3.3.1 Air-cooled

3.3.1.1 Check and clean condenser coils for dirt accumulation;

3.3.1.2 Check condenser operating pressure; and

3.3.1.3 Check condenser supply air.

3.3.2 Water-cooled

3.3.2.1 Check condenser water supply and return temperature;

3.3.2.2 Check operating pressure and temperature of condenser;

3.3.2.3 Check water temperature in and out of the cooling tower;

3.3.2.4 Check cooling tower's water level, make-up water and other operating parameters and abnormalities;

3.3.2.5 Conduct regular blow-down of cooling tower;

3.3.2.6 Check cooling tower fan motor current draw;

3.3.2.7 Check condenser water pump suction and discharge pressure; and

3.3.2.8 Check current draw of condenser water pump's motor.

3.4 Central System (Evaporator)

3.4.1 Check chilled water supply and return temperature;

3.4.2 Check operating pressure and temperature;

3.4.3 Check and clean AHU and FCU for dirt accumulation;

3.4.4 Check and clean drain pan for any dirt and slime accumulation;

3.4.5 Check and clean drain line to ensure continuous condensate flow;

3.4.6 Check chilled water expansion tank's water level and float valve;

3.4.7 Check air vent for good working condition;

3.4.8 Check operating pressure and temperature of AHU and FCU:

3.4.8.1 Check AHU and FCU supply and return air and dry and wet bulb temperature.(if necessary);

3.4.8.2 Check evaporator water supply (if applicable);

3.4.8.3 Check evaporator water return (if applicable);

3.4.8.4 Check pressure and temperature of chilled water supply and return;

3.4.8.5 Check chilled water pump suction and discharge pressure; and

3.4.8.6 Check current draw of chilled water pump's motor.

3.5 Electrical/control system

3.5.1 Check and clean all electrical contacts and terminals;

3.5.2 Check quality of power supply. Ensure that power supply is within ±10% of the rated voltage requirement of the equipment;

3.5.3 Take motor compressor current draw;

3.5.4 Check overload relays;

3.5.5 Take the reading of fan and motor pump current draw; and

3.5.6 Check all electrical controls; calibrate or adjust, if necessary:

3.5.6.1 High and Low Pressure switch

3.5.6.2 Oil Failure Pressure Switch

3.5.6.3 Timers

3.5.6.4 Thermostat

3.5.6.5 All other electrically and electronically controlled devices.

SECTION 4 - PREVENTIVE MAINTENANCE

This section includes planned activities that must be done on specific intervals.

4.1 Preventive maintenance procedures shall be aimed to:

4.1.1 Promote safety:

4.1.1.1 Avoid accidents to personnel; and

4.1.1.2 Prevent damage to goods, equipment and properties.

4.1.2 Maintain continuous operation of the system;

4.1.3 Identify system leaks at the earliest possible time;

4.1.4 Ensure good working condition of all components and parts; and

4.1.5 Minimize energy consumption at peak loads.

4.2 Establish a Preventive Maintenance Schedule (PMS) to ensure efficient equipment performance to avoid breakdown;

4.3 Give *extra attention* to all moving parts since these are subject to wear and tear;

4.4 Check and correct signs of abnormal vibration;

4.5 Avoid electrical wires to come in contact with the refrigerant discharge line;

4.6 Regularly lubricate bearing for efficient performance;

4.7 Use appropriate leak detector or other leak detection method to accurately locate refrigerant leak;

4.8 Use appropriate cleaning agent when cleaning evaporator and condenser coils;

4.9 Check expansion valve's sensing bulb mounting and location;

4.10 Check evaporator superheat;

4.11 Establish refrigeration oil quality (e.g. acidity level, etc.); and

4.12 Ensure the type of refrigeration oil in the system before adding or changing new oil.

SECTION 5 - LEAK TESTING, EVACUATION, CHARGING AND REFRIGERANT COVERSION PROCEDURES

5.1 LEAK TESTING

5.1.1 Charge system with dry nitrogen (150 psig on low side, 300 psig on high side) for leak testing;

5.1.2 Locate the leak through visual inspection, appropriate leak detector and other leak detection method;

5.1.3 Release nitrogen pressure if leak is detected in the system do proper repair procedure in accordance to accepted industry practice; and

5.1.4 Recover the refrigerant in accordance with the accepted procedure if leak is detected in the system and do proper repair procedure in accordance to accepted industry practice.

5.2 EVACUATION

5.2.1 Evacuate the system to at least 1000 microns (29.87 in.Hg) using an appropriate vacuum pump and an electronic/vacuum meter.

5.3 CHARGING

5.3.1 Initially charge the system, run the unit and add refrigerant until fully charged; and

5.3.2 Refer to manufacturer's data when charging refrigerant.

5.4 REFRIGERANT CONVERSION / RETROFITTING

(See diagram 2-1)

5.4.1 Recover refrigerant using the recovery machine operated by a certified technician before opening the refrigeration system:

5.4.1.1 Perform pump down procedure if the system is above 3 TR capacity then proceed to *refrigerant recovery;*

5.4.1.2 Proceed to refrigerant recovery if the system is 3 TR and below.

5.4.2 Properly label the recovered refrigerant and store only in a specified refillable cylinder;

5.4.3 Exert all efforts to prevent refrigerant emissions during recovery operation;

5.4.4 Drain and recover existing refrigeration oil charge, ensure that the residual refrigeration oil has been properly flushed out of the compressor. Then store and label properly recovered refrigeration oil;

5.4.5 Ensure that the alternative refrigeration oil is compatible with the alternative refrigerant;

5.4.6 Charge the system with new and correct amount of refrigeration oil as recommended by compressor/system manufacturer;

5.4.7 Replace all equipment components and accessories that will be affected by the alternative refrigerant and refrigeration oil (e.g., expansion valve, gaskets, filter drier, etc., as recommended by the manufacturer.);

5.4.8 Flush-out the system with appropriate flushing agent to remove residual refrigeration oil;

5.4.9 Leak tests the system with dry nitrogen and observe a 24-hour standing pressure. Make corrections if deemed necessary;

5.4.10 Evacuate system to at least 1000 microns (29.87 in.Hg) using appropriate vacuum pump and an electronic vacuum meter;

5.4.11 Charge the system with initial amount of alternative refrigerant;

5.4.12 Run the system and charge additional refrigerant until fully charged;

5.4.13 Observe and monitor the system operation and performance and make necessary adjustment; and

5.4.14 Label the system (see Annex 6).

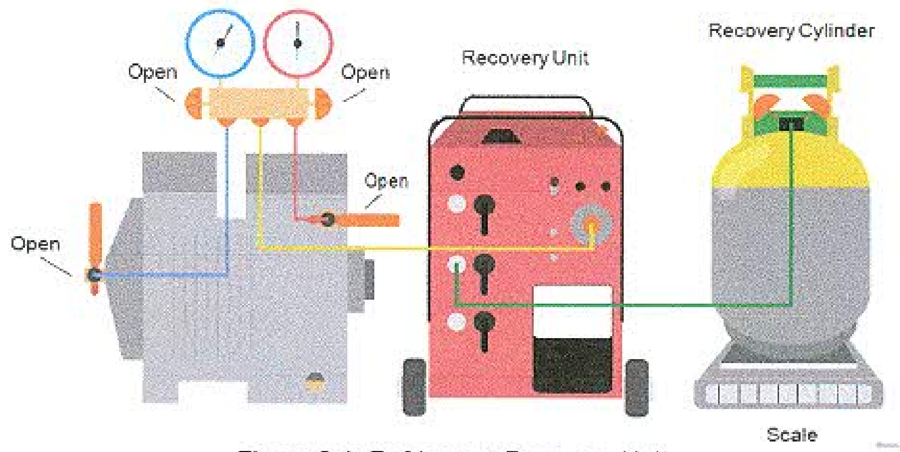


Figure 2-1: Refrigerant Recovery Unit

Figure 2-2: Connection of a recovery unit to a refrigeration system

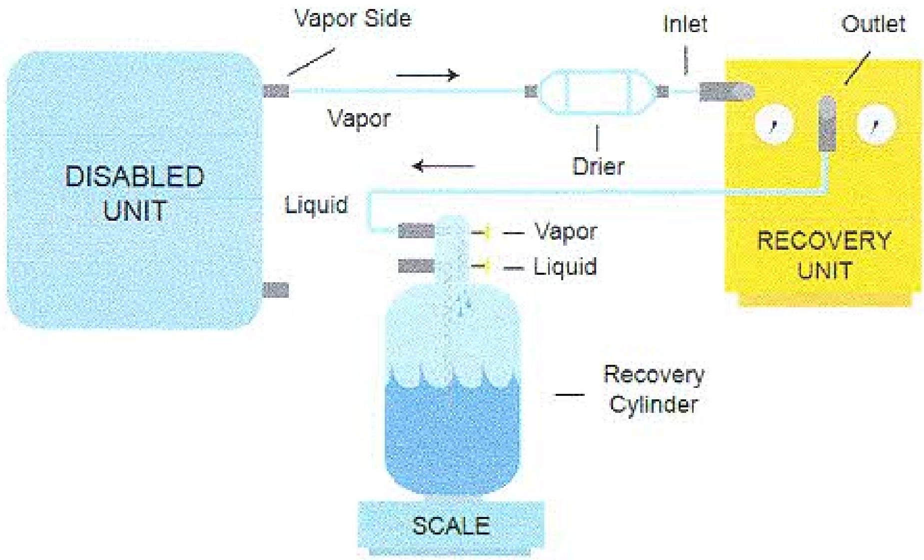


Figure 2-3: Vapour recovery mode

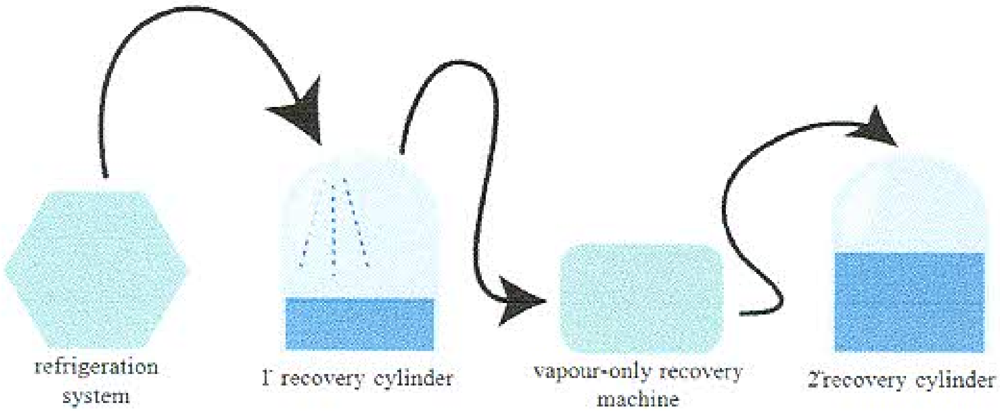


Figure 2-4: Liquid recovery using a vapour only recovery machine and two recovery cylinders

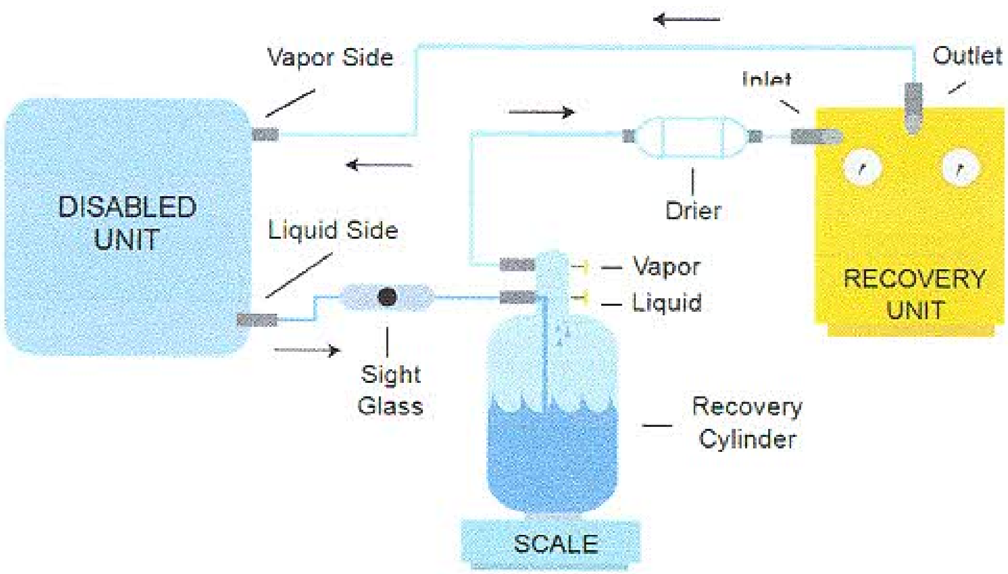
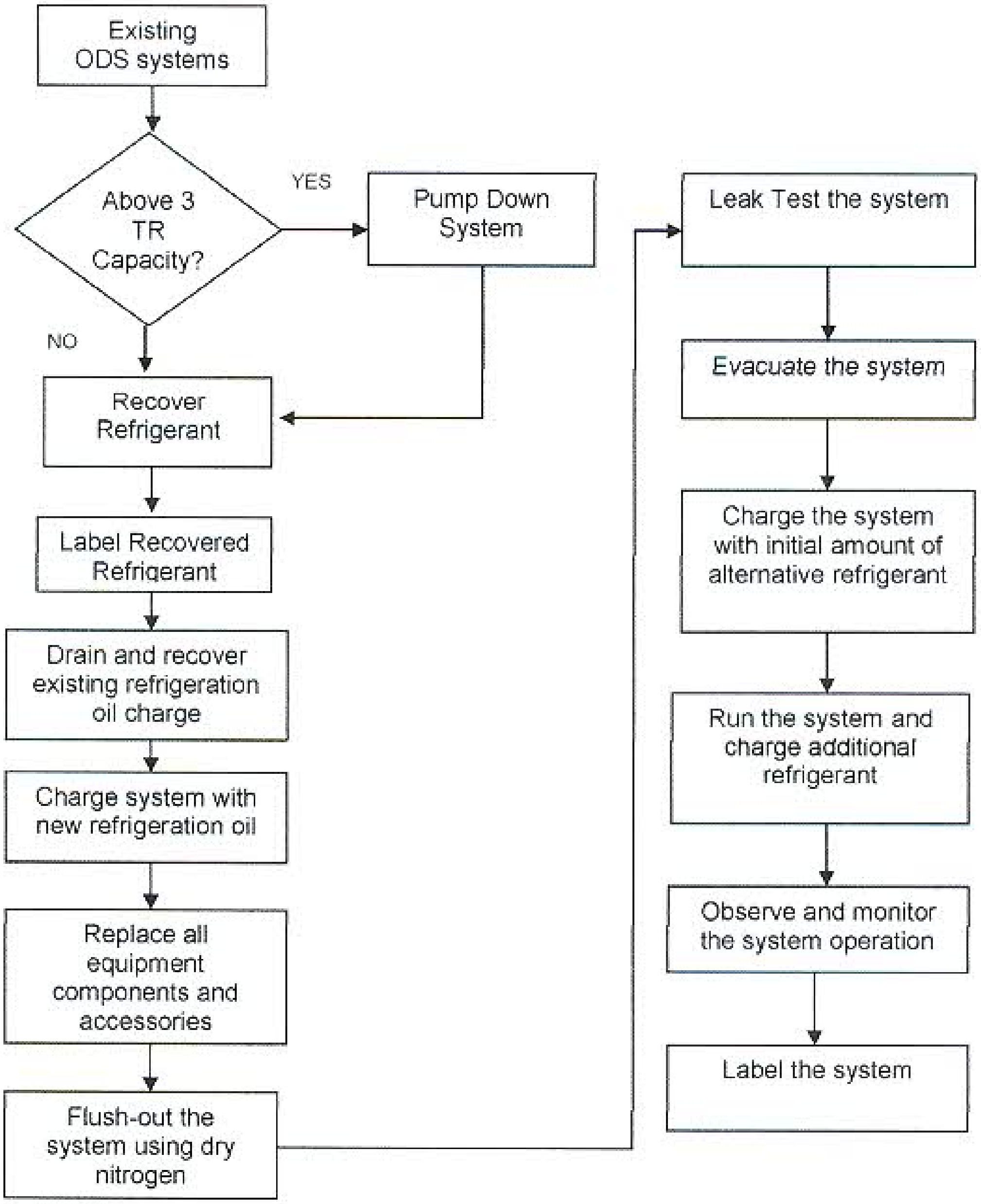


Figure 2-5: Push and pull recovery method

5.5 RETROFITTING PROCESS FLOW / REFRIGERANT COVERSION: (Diagram 2-1)



SECTION 6 - RECORD KEEPING AND DOCUMENTATION

Detailed and regular documentation of operating parameters is very important in maintaining a refrigeration or air conditioning system. If properly implemented, this will serve as the system history and would be the basis in the diagnosis of abnormal conditions that can happen in the future. The following should be implemented:

6.1 Accomplish daily log sheet report (for large refrigeration and air conditioning system) provided by the manufacturer where all operating parameters like suction and discharge pressures, amperages, temperatures, type of refrigerant and the like, will be recorded by the technician in-charge;

6.2 Compile daily log sheet and place inside the machine room or near the unit for future references;

6.3 Provide a service logbook and locate in a place accessible for service technicians and in close proximity to the refrigeration system. It should contain the following:

6.3.1 Service Record (Annex 1)

6.3.2 Refrigerant Conversion Data Sheet (Annex 2)

6.4 Locate and maintain equipment manual in a place near the service logbook. The manual should contain the following:

6.4.1 Equipment Nameplate (Annex 3)

6.4.2 User Specific Data (Annex 4)

6.4.3 Manufacturer's instruction/ operating manual

PART 2.3 – TRANSPORT REFRIGERATION AND AIR CONDITIONING

SECTION 1 – MARINE REFRIGERATION AND AIR CONDITIONING

1.1 MARINE REFRIGERATION

1.1.1 OPERATION

(NON-REEFER)

Before unit is set to operate, make sure that the following are strictly observed:

1. Switch off power supply (circuit breaker or On-Off switch) before performing pre-operational check-up;
2. Ensure that the crankcase heater is energized;
3. Check voltage and frequency;
4. Check dry battery of temperature recorder;
5. Ensure that the control box cover is tightly closed after the circuit breaker is turned-on;
6. Ensure that the temperature recorder is functioning;
7. Ensure that the recording paper is in placed with time and date set properly;
8. Ensure that the cooling water piping is properly connected and air is purged from condenser;
9. Ensure that all refrigerant service valves are open (back seated); and
10. Check oil failure pressure switch (is checked), reset if applicable (other unit may not start unless this switch is reset);

(After the above conditions have been met, switch on the power supply and run the system and observe.)

(REEFER)

Before unit is set to operate, make sure that the following are strictly observed:

1. Switch off power supply (circuit breaker or On-Off switch) before performing pre-operational check-up;
2. Ensure that the crankcase heater is energized;
3. Set voltage selector switch to the correct supply voltage and frequency;
4. Check dry battery of temperature recorder;
5. Ensure that the control box cover is tightly closed after the circuit breaker is turned-on;
6. Ensure that the temperature recorder is functioning;
7. Ensure that the recording paper is in placed with time and date is set properly;
8. Ensure that all refrigerant service valves are open (back seated); and
9. Check oil failure pressure switch, reset if applicable (other unit may not start unless this switch is reset);

(After the above conditions have been met, switch on the power supply and run the system and observe.)

1.1.2 MAINTENANCE

1. Refer to the manufacturer's recommendation when maintaining a refrigeration system;
2. Check for unusual noise and vibration;
3. Check suction and discharge pressures of the compressor;
4. Check oil level of compressor;
5. Check refrigerant content through the sight glass;
6. Check moisture content of the refrigerant through the sight glass (if applicable);
7. Check if temperature recorder operates according to space temperature;
8. Check solenoid valves;
9. Check switches and pilot lights;
10. Check voltage indicator of dry battery for temperature recorder;
11. Check temperature recorder quartz motor if functioning;
12. Check dual pressure switch;
13. Check oil failure pressure switch;
14. Check water pressure switch;
15. Check defrost timer;
16. Check heaters (defrost, dew point, crankcase heater, etc.);

17. Check room air vent;
18. Check defrost thermostat;
19. Ensure that the power cable plug is properly in place; and
20. Perform defrosting after every operation.

1.1.3 SERVICING AND REPAIR

1. Follow manufacturer's standard procedures when replacing parts and accessories of a system;
2. Check cause of melted fusible safety plug before replacement;
3. Refer to manufacturer's diagnostic chart for remedies when trouble shooting mechanical and refrigeration malfunctions; and
4. Perform servicing and repair of the system in reference to manufacturer's servicing manual.

1.2 MARINE AIR CONDITIONING

1.2.1 INSTALLATION

1. Follow manufacturer's recommended installation procedure;
2. Install only units designed for marine application;
3. Secure and fix properly the evaporator and condensing unit;
4. Install and secure properly electrical control lines and ducting (if applicable);
5. Install drain line to effect immediate flow of condensate and prevent from accumulation on the drain pan;
6. Check for tightness electrical connectors;
7. Check, leak test and dehydrate refrigerant piping including fittings; and
8. Control box cover shall be properly sealed after commissioning.

1.2.2 OPERATION AND MAINTENANCE

1. Refer to the manufacturer's recommendation when maintaining a refrigeration system;
2. Check for correct voltage before starting the unit;
3. Check for unusual noise and vibration;
4. Check suction and discharge pressures of the compressor;
5. Check oil level of compressor (if applicable);
6. Check refrigerant content through the sight glass;
7. Check moisture content of the refrigerant through the sight glass (if applicable);
8. Check solenoid valves (if applicable);

9. Check switches and pilot lights;
10. Check dual pressure switch (if applicable);
11. Check oil failure switch (if applicable);
12. Check fan motor;
13. Check water pump motor;
14. Check compressor motor;
15. Check condition of coils and fins; and
16. Check sump tank/drain pan of FCU/AHU including drain lines.

1.2.3 SERVICING AND REPAIR

1. Follow manufacturer's standard procedures when replacing parts and accessories of a system;
2. Ensure that faults are corrected before replacing defective parts;
3. Seal-off exposed pipe ends and fittings;
4. Replace filter drier after every repair; and
5. Follow standard procedure for servicing and repair of the system.

SECTION 2 – LAND REFRIGERATION AND AIR CONDITIONING

2.1 MOBILE AIR CONDITIONING

2.1.1 GENERAL CLASSIFICATION

A. ENGINE DRIVEN

1. SYSTEM OPERATION

Technician must ensure the following guidelines are observed:

1.1 That the air conditioner switch is off when starting the engine;

1.2 That the engine is properly warmed-up before starting the MAC system;

1.3 That the air vent is set at the re-circulation mode;

1.4 That the air conditioner blower and thermostat are set to maximum and adjust to desired setting as the cabin reaches comfortable temperature;

1.5 Avoid prolonged opening of windows and doors when the air conditioner is in operation;

1.6 Keep the car interior clean, especially the carpets; and

1.7 Turn off the air conditioner/blower switch before shutting off the engine.

2. MAINTENANCE

Guidelines:

2.1 Check for signs of leak on the systems' fittings and component parts that are readily accessible;

2.2 Check for any refrigerant lines that are not properly secured;

2.3 Check for any air conditioner electrical wirings and components that are not properly secured;

2.4 Check belt tension and alignment;

2.5 Check magnetic clutch gap;

2.6 Check for unusual sounds e.g. belt noise, bearing noise, vibrations, etc;

2.7 Check refrigerant content of the system through the sight glass;

2.8 Check systems' condition using gauge manifold;

2.9 Check condition of condenser;

2.10 Check condition of auxiliary fan;

2.11 Check condition of air conditioner switch;

2.12 Check condition of safety pressure switches;

2.13 Check condition of thermostat; and

2.14 Ensure that the refrigerant charging ports (suction & discharge) are properly capped.

3. SERVICING AND REPAIRS

Guidelines:

3.1 Identify first the type of system before attempting any service or repair. The most common means of identification of refrigerant in the system are as follows:

a. Through air conditioning labels, fittings and stickers;

b. Through standing pressure. *See Table 4. Pressure Temperature Chart for Refrigerants; and*

c. If applicable, through refrigerant identifier.

3.2 Recover refrigerant using the recovery machine operated by a certified technician before opening the refrigeration system;

3.3 Remove body personal effects that may inflict personal injuries and may cause damage to the exterior and interior parts of the vehicle;

3.4 Use proper and complete set of tools before starting a job;

3.5 Use appropriate gauge manifold for servicing and repair;

3.6 Use compatible refrigeration oil. Never convert an HFC 134a system to a CFC-12 system;

3.7 Use fender covers;

3.8 Use cover open or exposed pipes and fittings;

3.9 *Do not re-use O-rings;*

3.10 Ensure all fittings are properly tighten;

3.11 Use crimped connectors instead of hose clamp;

3.12 Use environment friendly and non-hazardous flushing solution;

3.13 Evacuate the system using vacuum pump;

3.14 Seal-off containers of HFC refrigeration oils to prevent moisture absorption;

3.15 Do not remove factory protective caps of the fittings until ready for connection particularly for receiver drier or compressor;

3.16 When connecting two pipes with fittings, observe the following:

a. Apply compressor oil to O-ring surfaces;

b. Check O-ring position if correctly seated on the groove;

c. Ensure that the pipe with the O-ring is aligned to the other pipe to prevent damage to the pipe sealing surface; and

d. Use two wrenches when tightening/loosening fittings to avoid twisting or bending the pipes. *Observe the following:*

i. Excessive tightening torque may cause gas leak;

ii. Visually inspect/check for cracks on fittings as a result *of over-tightening; and*

iii. Make sure that the surface of the fitting seat is corrosion-free and not deformed.

3.17 Clean evaporator properly following a standard procedure or enterprise policy;

3.18 Ensure that wire and wire connectors are properly labeled during dismantling/pulling-down of evaporator for repair or cleaning, to avoid misconnections upon re-installation;

3.19 Make sure all operating parameters like system pressures or temperatures are recorded to serve as reference data for after-service reading;

3.20 Always use PPE; and

3.21 Add refrigeration oil to the system if deem necessary. (See section 2.1.2.2 under Procedures).

B. DEDICATED ENGINE (SUB-ENGINE)

1. INSPECTION

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:

1.1 For Drive Engine

1.1.1 Check engine's oil condition and level, replace if necessary;

1.1.2 Check cooling water's condition in the radiator, replace if necessary;

1.1.3 Check belt tension, replace if necessary;

1.1.4 Check level of fuel tank, add fuel as needed;

1.1.5 Check bolts and nuts for tightness;

1.1.6 Check air cleaner element, clean or replace as needed;

1.1.7 Check intake air hose, clean or replace as needed;

1.1.8 Check radiator hose, clean or replace as needed;

1.1.9 Check fuel filter, clean or replace if needed;

1.1.10 Check rubber cushion and mounting bolts, replace if needed; and

1.1.11 Adjust idling, if necessary.

1.2 For Compressor

1.2.1 Check oil level at sight glass and add/replace if needed;

1.2.2 Check installation of mounting brackets and bolt tightness;

1.2.3 Check abnormal noise and vibration, correct if needed; and

1.2.4 Check shaft seal and other parts for oil leaks, replace if necessary.

1.3 For Condenser

1.3.1 Check condenser coil, clean if needed;

1.3.2 Check for leaks, repair if found;

1.3.3 Check condition of condenser motor and fan, repair/replace if needed; and

1.3.4 Check fan guard and blade, replace if needed.

1.4 For Evaporator

1.4.1 Check cooling coil, clean if needed;

1.4.2 Check air filter, clean if needed;

1.4.3 Check condition of evaporator blower and motor, repair/replace if needed;

1.4.4 Check for leaks, repair if found; and

1.4.5 Lubricate bearings as needed.

1.5 Expansion Valve

1.5.1 Check sensing bulb position, adjust if needed; and

1.5.2 Check for leaks, tighten/replace if needed.

1.6 Other Accessories

1.6.1 Check refrigerant piping, fittings and hoses for leaks, repair/replace if needed;

1.6.2 Check strainers/driers, replace if needed;

1.6.3 Check piping clamps, fix or replace if needed;

1.6.4 Check for any damage to flange couplings, replace if needed; and

1.6.5 Check loose electrical wirings and connections, tighten or replace if needed.

2.1.2 OPERATION AND MAINTENANCE PROCEDURES

2.1.2.1 CLEANING OF EVAPORATOR ASSEMBLY

If it is determined that the job would require to pull-out the evaporator assembly as for checking of leaks, replacement of expansion valve, fixing of mal-functioned air vent, damaged insulation, or plainly because of too much dirt; *proceed with utmost care as it is always a good* service management to prevent dashboard, seat covers and other interior part of the vehicle from getting dirty or stained when removing the evaporator assembly. The following steps are recommended:

1. FOR SINGLE EVAPORATOR SYSTEM
   a. Remove the evaporator assembly from the system, cap or cover the refrigerant lines or fittings. Remove the evaporator coil from its housing assembly;
   b. Remove the thermistor or sensor of the thermostat, taking note of its location so that it can be returned to the same place after cleaning the evaporator;
   c. Wash off dirt from the evaporator fins using pressure washer following the enterprise policy;

      EXTRA CARE SHOULD BE OBSERVED WHEN USING PRESSURE WASHER.
   d. Leak tests the evaporator coil, repair or replace if necessary.
   e. Check the expansion valve, replace if necessary;
   f. **Flush the evaporator coil with Nitrogen** to remove excess oil;
   g. Clean the evaporator housing. Check foam insulation, replace if necessary;
   h. Remove and clean the blower assembly. Check blower motor condition, repair/replace if necessary. Apply lubricating oil on motor shaft/bushing if applicable;
   i. Re-assemble and install the evaporator assembly; and
   j. Leak tests the assembly.

2. FOR DUAL A/C SYSTEM
   a. The same procedure shall be followed except new amount of refrigeration oil is

added in each of the evaporator coil before it is assembled. Refer to table 1; and

b. Check and clean magnetic and solenoid valves of systems with dual evaporator if necessary and in accordance with enterprise policy.

2.1.2.2 RECOMMENDED GUIDELINES FOR REPLENISHING OR ADDING REFRIGERATION OIL

1. Remove the compressor from the mounting bracket;
2. Cap/cover the suction and discharge ports of compressor;
3. Cover/plug the hose fittings from which the compressor was removed;
4. Drain oil through oil filled plug or drain plug;
5. Let the compressor sit for 5-10 minutes to completely drain all the oil;
6. Measure the quantity of the oil drained;
7. Replenish the same amount of new oil into the compressor; and
8. Remove the cap/cover when the compressor is to be connected to the system.

Ideally, adding or replenishing oil into the system is always recommended through the compressor. However, because of some constraints the following may be employed:

1. Replenish or add the amount of refrigeration oil needed into the part to be replaced or serviced. Add the right amount of refrigeration oil to be replenished into the system. Refer to Table below;

Component	Oil Amount
Evaporator	50cc
Condenser	40cc
Receiver	10cc
Pipes Hoses	10cc

Table 2-1: Amount of refrigeration oil to be added per *component in case no available information given by the* manufacturer

2. Connect the gauge manifold to the system and the vacuum pump;
3. Open the suction and discharge stop valve;

4. Start the vacuum pump;
5. Close the suction and discharge stop valves and turn off the vacuum pump once the desired vacuum is reached;
6. Transfer the center hose to the refrigeration oil container;
7. Open the suction stop valve and allow the refrigeration oil enter the system until such time that the refrigeration oil has completely entered the system; and
8. **DO NOT OPEN THE DISCHARGE STOP VALVE** Close the suction stop valve and vacuum the system.

2.1.2.3 LEAK TESTING

After the system has been assembled, leak test the system using dry Nitrogen. Use appropriate gauge manifold gauge manifold.

1. Connect the nitrogen regulator, connect the center hose of gauge manifold to the nitrogen regulator, open the nitrogen cylinder and set to the recommended pressure between 100-150 psig.

   BE SURE THAT THE GAUGE MANIFOLD ARE CLOSED;
2. Connect the gauge manifold hoses to the service ports;
3. Open the discharge and suction stop valve and allow Nitrogen into the system until it reaches the recommended desired pressure;
4. Close the discharge and suction stop valves of the gauge manifold then close the nitrogen cylinder valve;
5. Allow the pressure in the system to stand for at least thirty (30) minutes. Leak test all accessible fittings using soap solution;
6. If pressure drops, locate leak/s and repair;
7. Repeat leak testing procedure until system is leak-free; and
8. Disconnect the gauge manifold from the Nitrogen regulator, slowly release the pressure from the system and connect to the vacuum pump for evacuation.

2.1.2.4 EVACUATION

1. Check the gauge manifold. Make sure that fittings/quick connectors/adaptors are clean. Make

sure that hoses are fitted tightly to the adaptors and gauges before evacuating the system;

2. Use vacuum gauge;
3. Remove the cap of the system's charging ports and connect the gauge manifold;
4. Open the stop valves of suction and discharge side of the gauge manifold;
5. *Attach the center hose to the vacuum pump;*
6. Start evacuation until vacuum gauge reads at least 29.88 in Hg (1000 microns *1.3 mBar,);*
7. Close the suction and discharge stop valves of the gauge manifold; and
8. Switch-off vacuum pump and observe vacuum gauge to hold at least 29.88 in Hg (1000 microns (1.3 mBar, 29.87in Hg). for at least thirty (30) minutes to one (1) hour, if vacuum meter reading goes up, check for leaks and repeat process again.

2.1.2.5 CHARGING

Charge the system with the appropriate refrigerant.

LIQUID CHARGING

1. Determine the correct amount of refrigerant to be charged based on manufacturer's recommendation (manual, name plate, stickers, and label). In the absence of the manufacturer's recommendation refer to table below;

A/C Type	R-134a System		HC System at 1500 RPM	
	Lo side	Hi side	Lo side	Hi side
Single A/C	28-30 psig	200-220 psig	25-30 psig	150-225 psig
Dual A/C	30-40 psig	200-220 psig	30-40 psig	180-210 psig

Table 2-2: Average pressure reading of an air conditioning unit at 32 C

2. Disconnect the center hose from the vacuum pump and connect it properly to the refrigerant cylinder. Purge air out of the center hose;
3. With the cylinder placed on a weighing scale on it's **upside down** position, charge initial liquid refrigerant into the system through the discharge side. Open the discharge stop valve of the gauge manifold and allow refrigerant into the system until both suction and discharge gauges indicate similar pressures;
4. Allow the refrigerant to settle for about 3-5 minutes;
5. Set the following conditions before continuing to charge refrigerant into the system.

a. Engine Speed : correct idling speed
b. Aircon Switch : on
c. Blower Switch : Hi position
d. Vent Lever : recirculation
d. Doors : close
e. Windows : close

6. Close the discharge side stop valve of the gauge manifold, and continue to charge refrigerant thru the suction side stop valve;
7. Run the air conditioner for five (5) – ten (10) minutes to stabilize the system before completely filling it with refrigerant;
8. Continue to fill the system taking careful notice of the condition of the sight glass to show a stream of refrigerant with slight bubbles. Above conditions should prevail;
9. When the system is full, close the refrigerant cylinder and remove the discharge valve of the gauge manifold. Open both suction and discharge stop valve gradually to charge refrigerant left on the charging hose to the system. Remove the suction hose and re-place the port caps/cover; and
10. Turn-off the air conditioner and the engine.

VAPOR CHARGING

1. Determine the correct amount of refrigerant to be charged based on manufacturer's recommendation (manual, name plate, stickers, and label). In the absence of the manufacturer's recommendation refer to table below.

A/C Type	R-134a System	
	Lo side	Hi side
Single A/C	28-30 psig	200-220 psig
Dual A/C	30-40 psig	200-220 psig

Table 2-3: Average pressure reading of an air conditioning unit

2. Disconnect the center hose from the vacuum pump and connect it properly to the refrigerant cylinder. Purge air out of the center hose;
3. With the cylinder placed on a weighing scale on it's upside down position, charge initial liquid refrigerant into the system through the discharge side. Open

the discharge stop valve of the gauge manifold and allow refrigerant into the system until both suction and discharge gauges indicate similar pressures;

4. Allow the refrigerant to settle for about 3-5 minutes;
5. Set the following conditions before continuing to charge refrigerant into the system.

a. Engine Speed	:	correct idling speed
b. Aircon Switch	:	on
c. Blower Switch	:	Hi position
d. Vent Lever	:	recirculation
d. Doors	:	close
e. Windows	:	close

6. Close the discharge side stop valve of the gauge manifold, place the refrigerant cylinder in **upright position** and continue to vapor charge refrigerant through the suction side stop valve;
7. Run the air conditioner for five (5) – ten (10) minutes to stabilize the system before completely filling it with refrigerant;
8. Continue to fill the system taking careful notice of the condition of the sight glass to show a stream of refrigerant with slight bubbles. Above conditions should prevail;
9. When the system is full, close the refrigerant cylinder and remove the discharge valve of the gauge manifold. Open both suction and discharge stop valve gradually to charge refrigerant left on the charging hose to the system; and
10. Turn-off the air conditioner and the engine.

2.1.3 RECORD KEEPING AND DOCUMENTATION

Detailed service records are very important in maintaining the MAC system. If properly implemented, this will serve as the system history and would be the basis in the diagnosis of abnormal conditions that will happen in the future. Every manufacturer of the MAC system has its own suggested maintenance check-up schedule for their product. This should be followed specially during the first year of the units operation.

1. Recording of services done to the MAC system should start on the first warranty/service check-up of the unit (refer Annex 7);
2. Record every warranty check-up done on the system as recommended by the manufacturer;
3. Review service records before any service is done on the unit;
4. Update records after each performed service; and
5. Keep service records for future reference.

2.2 MOBILE REFRIGERATION

2.2.1 GENERAL CLASSIFICATION

1. ENGINE DRIVEN- unit that is directly driven by the transporter's engine.
2. DEDICATED ENGINE- unit that is driven by a separate engine.
3. ELECTRICALLY DRIVEN- unit that is driven by an electric motor connected to an outer source.

2.2.2 INSPECTION, OPERATION AND MAINTENANCE

1. Refer to manufacturer's inspection, operation and maintenance procedure;
2. Visually check unit for physical damage;
3. Check electrical connections, contacts, wires and cables. Tighten loose terminals in the control box;
4. Check battery charge, if low, re-charge or replace (for Dedicated Engine);
5. Check drain pan, de-clog/clean if needed;
6. Check system for leaks;
7. Check condition of evaporator and condenser coils, clean if needed;
8. Check mounting bolts on unit, compressor and fan motors, tighten if needed;
9. Install new temperature recorder chart;
10. Ensure that power selection switch is set to correct voltage setting;
11. Check condenser fan airflow direction or rotation;
12. Check evaporator blower wheel for proper rotation;
13. Unit should be operated before product loading;
14. Check compressor oil level at sight glass;
15. Check defrost control setting/adjustment; and
16. Ensure temperature recorder is operational.

2.2.3 SERVICING AND REPAIRS

1. Refer to manufacturer's manual for servicing and repairs;
2. Make sure that driers are replaced when the high side is opened or when low side is opened for an extended period;
3. Replaced clogged filter/drier;
4. Ensure that the unit power source is disconnected before performing any repair or servicing;
5. Replace the same amount of oil removed from the compressor after repair;
6. Maintain a minimum acceptable clearance between electric motor and compressor drive plates when re-installing compressor-motor assembly (Electrically Driven); and
7. Tighten mounting screw based on recommended torque.

PART 3: REFRIGERANT CONVERSION AND ALTERNATIVES

3.1 GENERAL GUIDELINES

Conversion from an ODS-using system to an ozone-friendly and low GWP refrigerant requires a thorough investigation and study of the system. Some factors that should be taken into account:

1. Convert the system if it is more cost effective than replacement. If a major repair (e.g. compressor change, etc.) or modification of an ODS using system is necessary it shall be evaluated if retrofit can be done at acceptable cost;
2. Upon evaluation of a system that requires major repair and is close to its technical/economical life, consider replacement if it is more cost effective than retrofitting;
3. The safety and environmental properties of alternative refrigerant to be used, such as flammability, toxicity, ozone depleting and global warming potential shall be considered;
4. Assessment of the compatibility of components and materials in the system in particular elastomers and oil. Also components like sight glasses and oil separators shall be checked for suitability;
5. Assess and examine the operating condition of the system and determine the service and its operational history; and
6. If necessary, consult equipment manufacturer for the recommended alternative refrigerant and lubricant for the system.

3.2 USE OF DROP-IN REFRIGERANTS

The phasing-out of ODS particularly CFCs and HCFCs in the refrigeration and air conditioning sector has led to the development of new refrigerants that claims to be direct replacements for ODS refrigerants. These refrigerants vary in compositions; some are single substance, others are blends and Hydrocarbons. As the manufacturer of these substances claims, existing mineral oil need not be replaced since they are compatible with the old oil in the system. These claims should be proven.

This Code is not against the use of these new substances, as long as health, safety and the environment aspects are addressed with. A careful technical assessment should be conducted, including a review of MSDS, occupational health and safety and other pertinent information related to the alternative substance(s) under consideration. Training should also be conducted to acquaint the technicians on the proper handling of these new refrigerants.

Hydrocarbons and some HFC's are flammable. This does not mean they will spontaneously ignite. The range of concentrations with air that most common flammable refrigerants will ignite is quite narrow, however the risk of ignition is still significant and must be given due consideration. Additionally, most of the flammable HFC's produce extremely toxic hydrogen fluoride and hydrofluoric acid. For this reason, education and information dissemination is very important.

Blends on the other hand are composed of different refrigerants that may act independently at certain temperature and pressure. Training is also very important in the proper handling of these substances, particularly on charging processes wherein they are charged on liquid state. During system leaks, a thorough investigation of the composition of the refrigerant left is very important since fractionation may have occurred and recharging after repairing faults or leaks will result in a system is inefficient or fails to function.

3.3 CONVERSION OF MOBILE AIR-CONDITIONING

Pursuant to the provisions of Joint Administrative Order No. 03 Series of 2006, (Enforcement of Regulation on the Implementation of the NCPP on Motor Vehicles under the Revised Chemical Control Order (CCO) for Ozone Depleting Substances (ODS) (DENR Administrative Order No. 2004-08, series of 2004), prohibit the back conversion and the use of CFC's in Mobile Air Conditioners (MACs) starting 2006 in motor vehicles manufactured and/or initially registered from 1999 onwards, and starting 2012 in all motor vehicles.

3.3.1 CONVERSION FROM CFC-12 TO HFC 134a

Retrofitting from CFC-12 to HFC-134a will require alterations on the system's existing parts. However, because of the difference of the physical properties of the two refrigerants (e.g. pressure of R-134a is higher than R-12 at high temperatures) there will be situations wherein replacements of some parts will be necessary. This may be determined during the initial evaluation of the R-12 system before and after retrofitting.

3.3.2 POINTERS FOR CONVERSION CFC-12 TO HFC-134a SYSTEM

(If no information available from the manufacturer):

Table 3-1

Component	Old	New
Refrigerant	CFC 12	HFC 134a
Compressor Oil	Mineral Oil	Synthetic Oil/ PAG
Piping Sealing Material	NBR O-ring	RBR/ HNBR O-ring
Comp. Sealing Material	NBR Gasket	RBR Gasket
Hose Material	NBR/ Nitrite hoses	CL-IIR / Lined Nylon hoses
Receiver Dessicant	Silica Gel	Zeolite
Safety Device	Fusible bolt	Pressure relief valve
Pressure Switch Setting	2.65 Mpa (386psig)	3.14 Mpa (457psig)
Relief Valve Setting	3.14 Mpa (457psig)	3.43 Mpa (500psig)

NBR-Nitrile Butadiene Rubber
HNBR - hydrogenated nitrile butadiene rubber

3.3.3 RECOMMENDED REFRIGERANT AND LUBRICANT CHARGES

(Or refer to manufacturer's recommendation)

Table 3-2

Component	CFC 12	HFC 134a
Refrigerant	Previous Charge	Previous Charge x 0.93
Lubricant	Previous Charge	Previous Charge x 1.20

3.3.4 RETROFITTING LABEL FOR MAC SYSTEM

(Refer to Annex 7).

3.3.5 RETROFITTING PROCEDURE

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.):

1. Leak check using hand held leak detector (refer also to PNS SAE J1628: 2003) set to detect CFC 12 and/or the soap bubble test. Make repairs if necessary;
2. Run the vehicle to obtain (suction/discharge pressures) and check again for leaks;
3. Recover all refrigerant from the system following standard procedure for CFC refrigerant recovery and store in a specified refillable container properly labeled;
4. Remove compressor from its mounting bracket and drain its refrigeration oil;
5. Rinse the internal parts by pouring alternative refrigeration 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;
6. Repeat oil rinsing procedure as necessary until reaching less than 5% oil contamination as indicated by the refractrometer. In the absence of refractrometer, repeat step 5 for at least three (3) times;
7. Pour proper amount of alternative refrigeration oil into the compressor as per Original Equipment Manufacturer (OEM) and cap suction and discharge lines until the system is ready for re-assembly;
8. Flush the entire system with Nitrogen and any environmental friendly cleaning solution;
9. Pressure tests each component for leaks. Repair or replace if necessary;
10. Replace expansion device and filter drier compatible to the alternative refrigerant;
11. Replace all O-ring seals on pipes and hoses with those approved for HFC 134a and PAG oils;
12. Re-install and assemble system components;
13. Modify access valves/fittings to accept only the new alternative refrigerant fittings;
14. 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;
15. Charge the system with alternative refrigerant (PNS SAE J1657 : 2003) as recommended by manufacturer whenever possible. Notice that optimum charge will change when systems are retrofitted;
16. Observe system operation and check again for leaks; and
17. Label system clearly.

3.3.6 CONVERTING CFC 12 MOBILE AIR CONDITIONER TO ALTERNATIVE REFRIGERANT (DROP-IN)

Retrofitting of mobile air conditioners to HFC 134a entails larger cost because of the materials involved as compared when converting it by using drop-in alternative refrigerants (hydrocarbon).

Although conversion is easier than retrofitting, conversion of mobile air conditioners to hydrocarbon requires technician who will perform the conversion to have acquired intensive training in handling flammable refrigerants.

Due to the High Global Warming Potential of the HFC 134a, some vehicle owners might want to convert their vehicle from HFC134a to hydrocarbon. Hydrocarbons work well with many mobile air conditioners running on HFC134a and CFC12.

Below are guidelines for using hydrocarbons in MAC. Use only appropriate alternative refrigerant type/blend for this application as specified by the alternative refrigerant supplier or manufacturer.

THE USE OF CHARGING WEIGH SCALES IS HIGHLY RECOMMENDED.

The technician is always reminded **NOT TO OVERCHARGE THE SYSTEM**

Vehicles may have factory dealer or after-sales system which can result in charge weights that varying widely between several identical vehicles. It can be sometimes difficult to identify replacement parts from the original. Each and every replacement part can significantly after the refrigerant capacity of the system. System pressures and vent temperature should always be used to verify a system charge weight and performance.

If the vehicle you will work on has no indication of the amount of refrigerant on it, there are other methods to determine how much alternative refrigerant to use:

- The first method is to find the original charge weight on the system label under the hood, owner's manual, manufacturer sticker and calculate 33% (one third) of the original charge by weight. For example, a vehicle charged with 900 grams of HFC 134a or CFC 12 would require 300 grams of HC and 600 grams of carbon capacity system would require about 200 grams of HC;

  Original charge weight (grams) X 33% = appropriate HC charge weight (grams)

- The second method is by reading the gauge pressure and vent temperatures. This is the method commonly used when charging mobile air conditioners. The gauge reading for HC refrigerant should always be lower than HFC 134a. Typically between 15 to 25 psi (100-200 Kpa) on the low side and 150 to 225 psi (1000-

1600 Kpa) on the high side at 1500 RPM. These figures will depend on the ambient temperature, air flow and good decent size condenser. These contribute significantly to variations in the high pressure reading; and

- The third method is to charge by VOLUME using the scale on a dial charger and charging about 15% less by VOLUME (not weight) of the original fluorocarbon charge. Charge the system with about 85% of the original charge by VOLUME using a charging column/dial charger.

3.3.7 PROCEDURE IN CONVERTING FLUOROCARBON (HFC) CHARGED MOBILE AIR CONDITIONING TO HYDROCARBON (HC) REFRIGERANTS

After determining the required charge, the following steps should be carried out:

1. Recover all refrigerant from the system following standard procedure for CFC refrigerant recovery and store in a specified refillable container properly labeled (note: if there is any suggestion that the system may already contain flammable refrigerant, apply flammable refrigerant recovery/evacuation procedures instead – consult relevant flammable refrigerant codes of practice or flammable refrigerant supplier/manufacturer advice);
2. Flush the entire system with Nitrogen and any environmental friendly cleaning agent;
3. Pressure tests each component for leaks. Repair or replace if necessary. It is always recommended to use double jacketed ("full barrier") flexible hose during conversion;
4. Replace filter drier compatible to the alternative refrigerant;
5. Re-install and assemble system components;
6. 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;
7. Charge the system with alternative refrigerant following the guidelines above or as recommended by alternative refrigerant manufacturer/supplier;
8. Observe system operation and check again for leaks (taking care to use leak detection methods that are appropriate for flammable refrigerants);
9. Compare obtained new set of data to that obtained when the system was still using CFC; and
10. Label the system clearly, unambiguously indicating that the system is charged with flammable refrigerant.

3.3.8 CONVERSION OF HCFC-22 SPLIT-TYPE AIR-CONDITIONER TO HYDROCARBON (HC) REFRIGERANT

Taken from Giz (Gesellschaft für Internationale Zusammenarbeit) Manual on Operation of Split Air Conditioning Systems with Hydrocarbon Refrigerant.

INTRODUCTION

There are currently about 1 billion hydrochlorofluorocarbons (HCFCs) room air conditioners in operation worldwide, more than 100 million units are added annually (still with double digit growth rates due to higher demand). Each unit contains on average 1.6 kg of refrigerant, mainly R 22. The Global Warming Potential (GWP) of R 22 is 1810, amounting to almost 3,000 MT CO2 equivalent of emissions. Servicing needs amount to annually 800,000 T R 22, equal to about 1450 MT CO2 equivalent per year.

In response to the environmental impacts – primarily ozone depletion and global warming associated – arising from the release of HCFC and hydrofluorocarbons (HFCs), the use of natural refrigerants as alternatives to these is becoming more widespread. Amongst these natural refrigerants, hydrocarbons are being used widely in new air conditioning systems.

Under certain circumstances, there may be a desire to convert a refrigeration and air conditioning (R AC) system from a non-flammable refrigerant to use hydrocarbons (HCs). This approach may be considered for a number of reasons, such as:

- *An intention to improve the efficiency of a system*
- To minimize the environmental impact
- Because it may be more cost-effective than using other refrigerant options
- There are no other refrigerant replacements available

Refrigerants that may be used for such purposes could include R 290 (propane) or R1290 (propylene), where, for example, the system was previously charged with R 22 or R407C.

Of course, if the existing refrigeration system is working correctly, then there is normally no need to convert the system to use any alternative refrigerant.

These guidelines are intended to assist with the safe conversion of air conditioning systems to use flammable HC refrigerants. Converting a system from an HCFC to an HFC normally requires basic changes. However, converting a system from a non-flammable to a flammable refrigerant requires special considerations, which are summarized here.

BASIC PRINCIPLES AND WARNINGS

When applying a flammable refrigerant to a system that ordinarily uses a non-flammable refrigerant, the term "conversion" is applied. This is important as it distinguishes from other phrases such as "re-fill", "drop-in" and "retrofit". The reason for this is that when a non-flammable refrigerant (such as R12) is replaced by another non-flammable refrigerant (such as R134a), if any changes are required to the system, then they relate to performance (e.g., change of capillary tube length) or compatibility (e.g., change in oil type). However, when changing from a non-flammable refrigerant (such as R 22) to a HC refrigerant (such as R 290), additional considerations must be taken into account. These include identifying whether or not the HC can be applied given the particular circumstances from a safety perspective, and if so, carrying out the required changes to the equipment that are related to mitigating the flammability risk. A switch from a non-flammable to a flammable refrigerant should be considered in terms of an entire conversion of the equipment, not just a change of refrigerant.

It must be emphasized that carrying out a system conversion to use flammable refrigerant necessitates careful consideration of the implications and it is essential to weigh up the risks and benefits. If a conversion is to take place, then it should be done comprehensively, with care and with attention to detail.

Given that a conversion to a flammable refrigerant represents a significant change in the purpose of the system, it must be understood that the conversion can only take place provided that the final product meets the requirements of the relevant safety standards and national regulations.

SPECIAL INSTRUCTIONS

- Any technician involved with conversion must be fully trained, competent and certified to use this flammable refrigerant
- Only convert with permission of building owner
- Only use proper service equipment suitable for use with HC refrigerants
- Multi-split and ducted systems which use large refrigerant charges are not suitable for conversion to HC refrigerants
- Refrigeration systems with extensive pipe work and multiple evaporators, such as compound plants, are not suitable for conversions
- If the situation permits, it is recommended that the equipment is removed from its existing position to a controlled workshop environment where work can usually be conducted in a more controlled and safer manner

CONSIDERATIONS AFFECTING CONVERSIONS

When approaching the choice of converting a particular system, it is important to follow a logical sequence of safety-related considerations to help make the correct decision. Such considerations include the following issues:

- The type and complexity of the equipment to be modified
- The environment and location within which the equipment is installed
- The quantities of refrigerant involved (in relation to the system location)
- The ease or possibility of modifying parts of the system
- The ease or possibility of handling the potential sources of ignition
- The necessity to develop specific awareness for the system operation by the owner

A decision chart to assist with evaluating the suitability of the equipment (predominantly with respect to the requirements of the safety standards) is shown in Table 1. This may be used to provide a good indication as to whether a system can be converted to use an HC refrigerant, although other specific aspects may need to be considered in addition; i.e., the requirements elsewhere within this guidebook (for new systems) and the relevant safety standards.

Since the refrigerant charge and the location of the refrigerant-containing parts of the system have such a strong influence on whether or not a conversion is viable (from a safety point-of-view), the suitability can be approximated according to typical system types. Table 3-3 provides an indicative overview of the types of systems that have been found to be acceptable for conversion. The viability is indicated as follows:

✔ ✔ often suitable

✔ sometimes suitable

8 normally unsuitable

88 nearly always unsuitable

As previously explained, each situation is unique in terms of the combination of system design and installation location and therefore each must be evaluated independently.

Table 3-3: Typical suitability for conversion of systems to use hydrocarbons

Sector	Equipment type	System type	Suitability
Domestic air conditioners, dehumidifiers and heat pumps	Portable units	Integral	✔ ✔
	Window units	Integral	✔ ✔
	Through-wall units	Integral	✔
	Split units	Remote	✔ ✔
Commercial air conditioning and heat pumps	Split units	Remote	✔ ✔
	Multi-split/VRV	Distributed	88
	Packaged ducted	Remote	8
	Central packaged	Remote	88
	Positive displace chillers	Integral/Indirect	✔ ✔
	Centrifugal chillers	Integral/Indirect	88

Two things should be considered in carrying out a conversion.

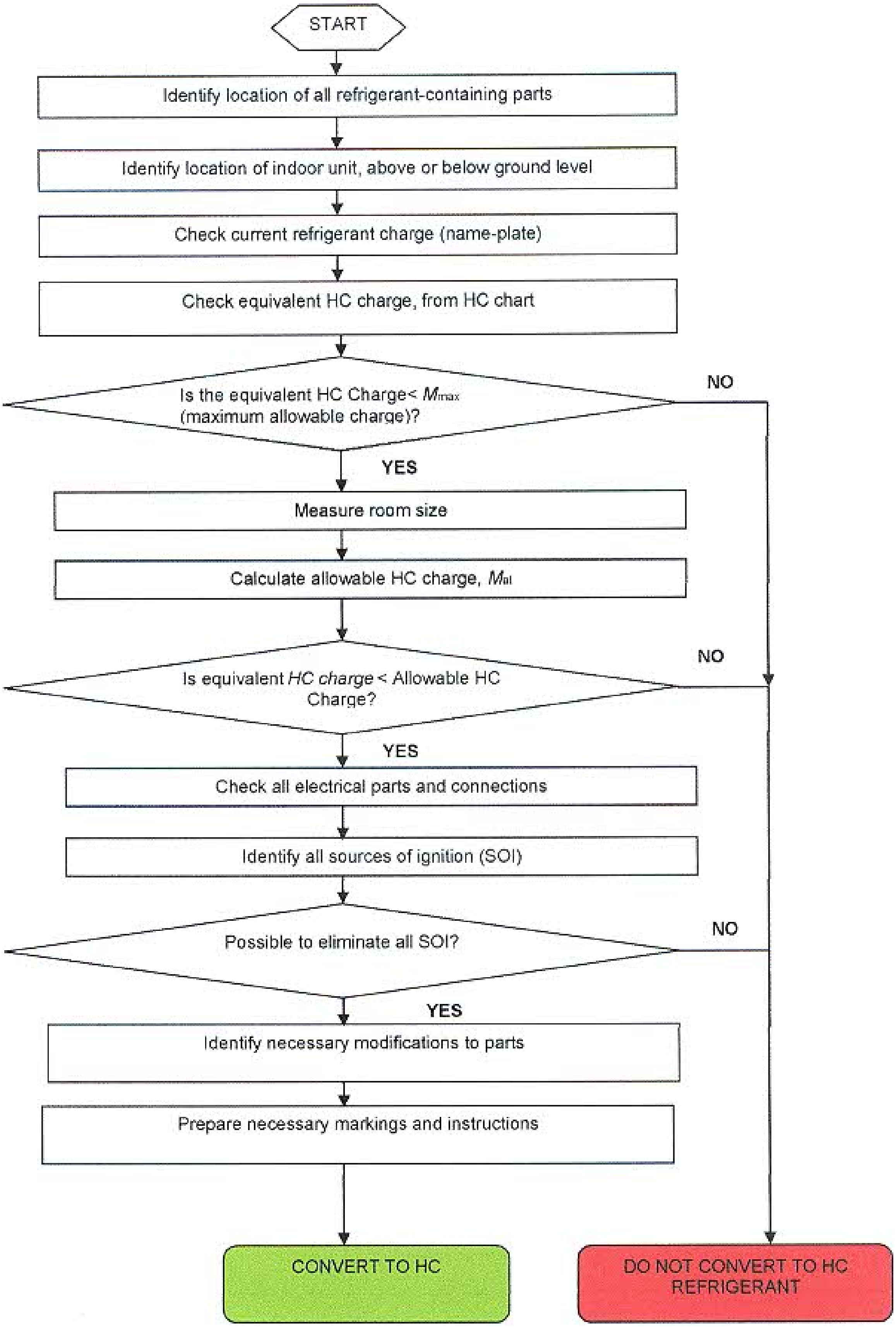
1. It is recommended that a special conversion work area be set up with enterprise policies, to include appropriate tools and equipment to carry out conversion. Advantages of having this special work area are as follows:

- Special tools and equipment are readily available or accessible
- Flammable refrigerants can be safely/handled properly
- Site activities for commissioning of HC refrigerants can be eliminated/minimized
- Technicians that specializes on HC refrigerants are available
- Parts and components for conversion are readily available or accessible

2. For equipment that cannot be brought to the special work area, this approach should be taken:

- Technicians involved in conversions of a particular type of system should have "Conversion kits"
- The decision chart, diagram 3-1 must be used as a guide by the technician in evaluating the unit for possible conversion.

Diagram 3-1: **Decision chart for determining whether it is possible to convert a system to HC refrigerant**



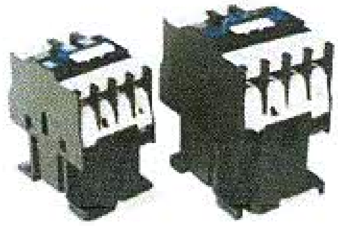
CONVERSION KITS

If enterprises are involved with carrying out conversions of existing systems, it is recommended that "conversion kits" are used. The reason for this is that it can be "inconvenient" for technicians – once at a site and already working on a system – to avoid using unsuitable methods for the conversion to HC refrigerants, which of course should be avoided. One way of helping to implement appropriate conversion methods is to issue technicians with a comprehensive conversion kit that contains all the necessary tools and parts. For example, such kits shall contain data sheets (with conversion factors, room size/charge size estimations, etc.), risk assessment forms, working instructions, sealed and solid-state electrical components, flammable gas stickers, valves, special fittings, and so on. If enterprises typically deal with a range of different systems, then it is sensible to have conversion kits that are better suited to each different type of system. An example of a conversion kit is shown in Table 3-4.

Table 3-4: Example of a standard conversion kit collection for small AC systems

Set of blade connectors, ring and spade terminals etc. Specific tools for connectors fixing	
Sealed box, size depending the components to be inserted (usually the mains contactor) together with fastening screws	
Different type of screwed cable glands	

Mains contactor according to the capacity required if replacement of existing device is indicated



Flexible electric cable
(wiring diameter according capacity of the system)

Different cable straps for the fixation of wires and cables and not intended for tubes fixing

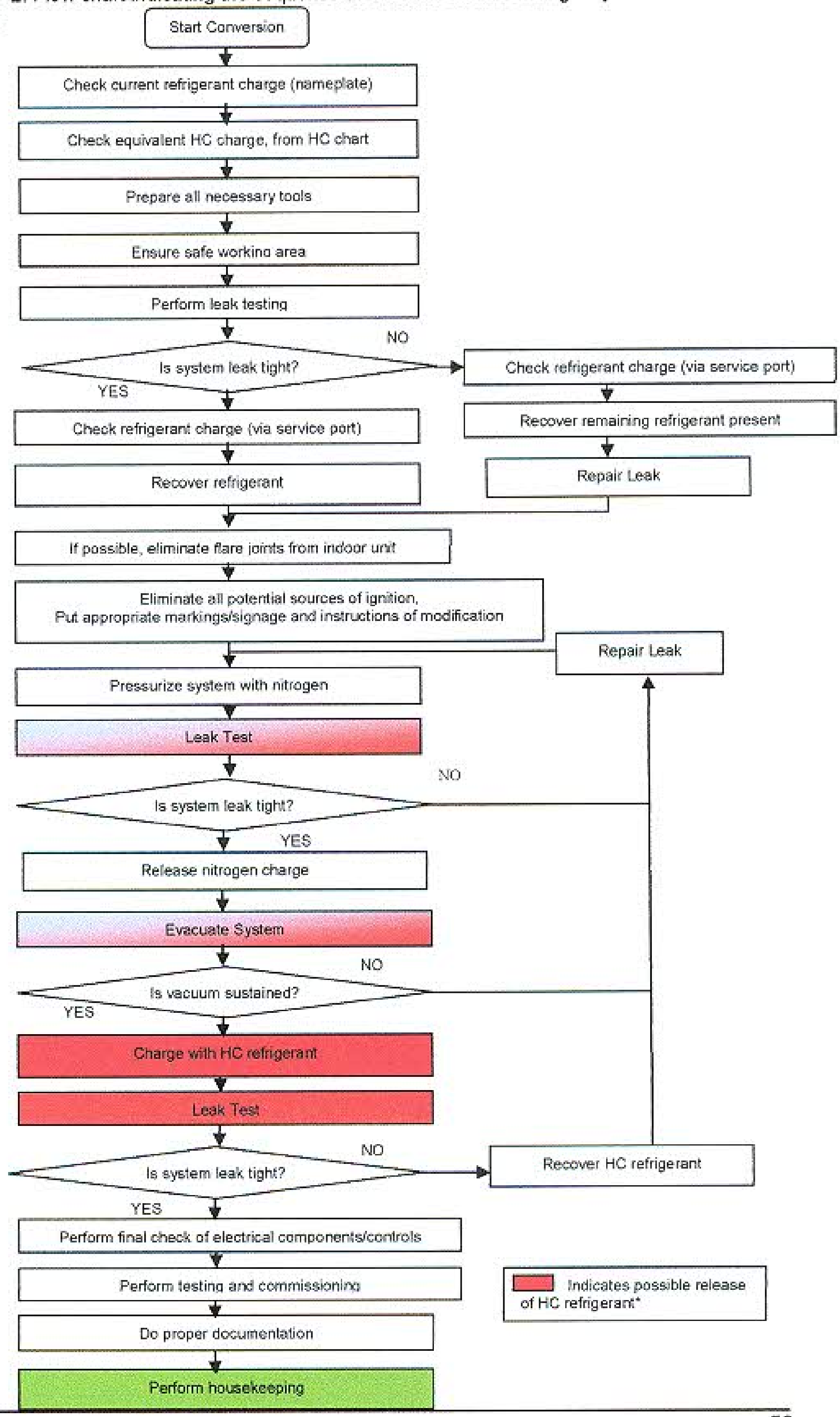
Electrical Tape

Commissioning report, conversion label and warning sign stickers (see also annex of this document)

CONDUCTING CONVERSIONS

When carrying out a conversion, the correct sequence of activities must be done in a way that both the safety of the workplace is maintained as well as ensuring the safety of the equipment. A process is provided in the flow chart in Diagram 3-2.

Diagram 3- 2: Flow chart indicating the sequence of activities for converting a system to use HC refrigerant



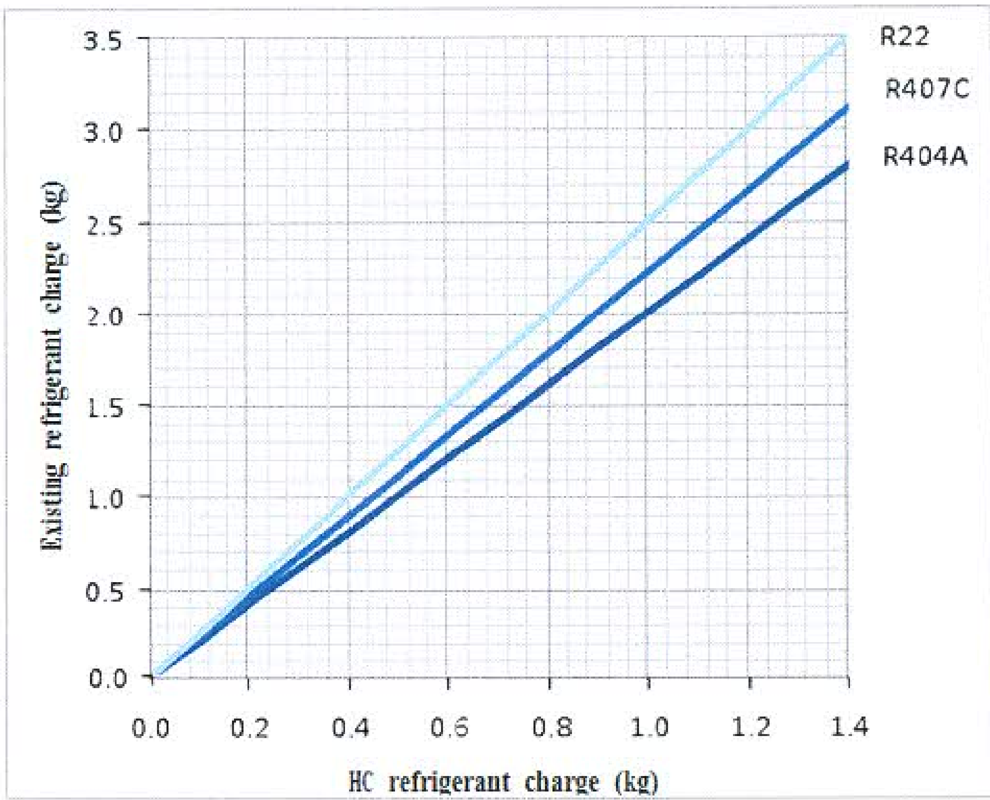
* ***HC refrigerant can be vented provided that no source of ignition is present and ensure that the work area is well ventilated.***

The following steps describe the process in Diagram 3-2 and describe the important stages in evaluating and carrying out those conversions.

Estimate the required HC refrigerant charge size

This can be done using the existing refrigerant charge. Obtain the current refrigerant type and charge size from the equipment data-plate and / or verifying the existing amount of "old" refrigerant during the recovery process. Using the Chart 3-1, estimate the equivalent mass of HC refrigerant.

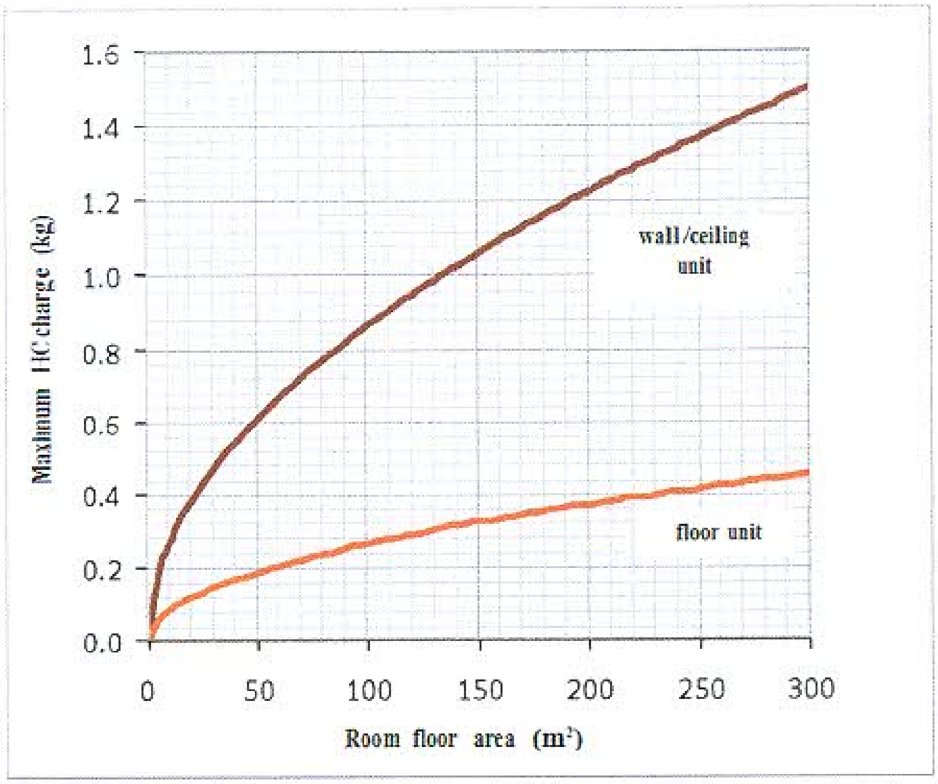
Chart 3-1: Conversion to estimate equivalent HC charge size

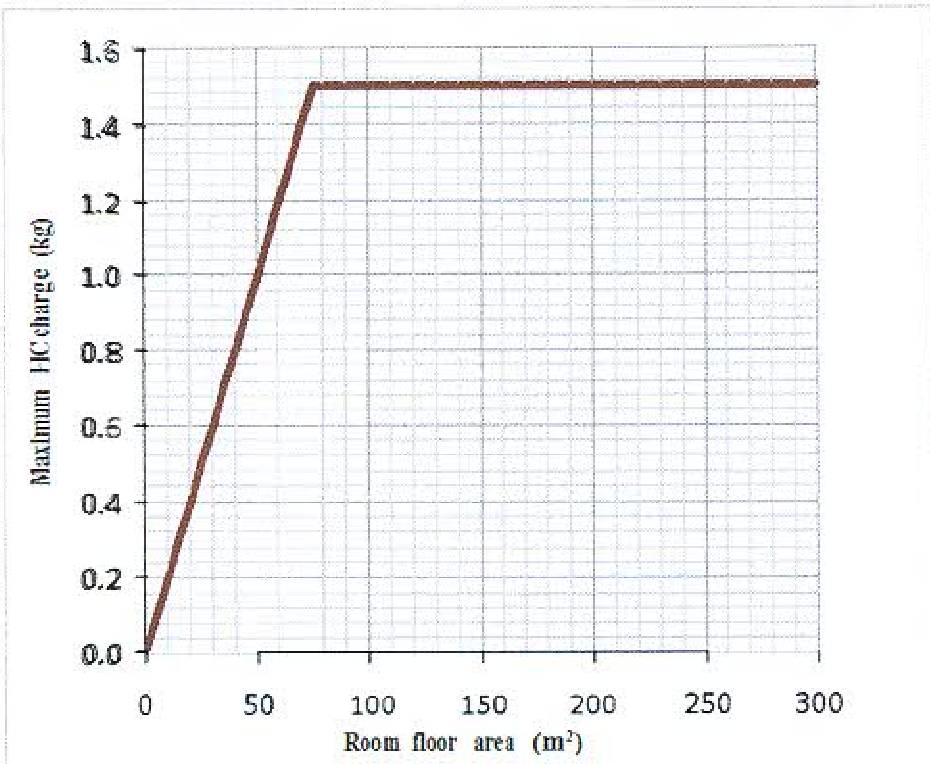


Check the refrigerant charge will be permissible

Ensure that the quantity of HC refrigerant to be used is permitted within the given room size. Calculate the occupied room area for the indoor unit and compare it with the HC charge size (Chart 3-2). For further information refer to GIZ-Proklima publication "Guidelines for the safe use of hydro- carbon refrigerants", Section 5.3 "Refrigerant charge size limits".

Chart 3-2: Minimum room sizes for a given refrigerant charge for air conditioners for human comfort (above) and air conditioning not for human comfort (below)





Check all necessary tools present

Prior to carrying out any work, it is essential to ensure all the tools, equipment, instrument and spare parts required for the work are on hands. In particular, this includes:

- General hand-tools appropriate for the use at refrigerant circuit components and electrics
- Refrigerant recovery machine (suitable for use with flammable refrigerants)
- Refrigerant recovery cylinder (two valves) HCFC
- Refrigerant recovery cylinder (two valves) HC (if it is decided to recover the HC refrigerant)
- Lubricant recovery cylinder (two valves)
- Refrigerant venting hose
- Comparator/pressure-temperature tables for HC refrigerant
- Vacuum pump
- Vacuum gauge (electronic) refrigerant balance (accuracy of at least ±3% full-scale)
- Handheld HC refrigerant gas detector
- Nitrogen service cylinder set
- Brazing set (oxygen/propane, oxygen/acetylene)
- Flammable gas (yellow triangle) stickers
- Flammable refrigerant warning signs
- Work area warning signs
- Safety gloves and goggles
- Fire extinguisher

The list comprises of both, equipment for work on HCFC and HC refrigerants.

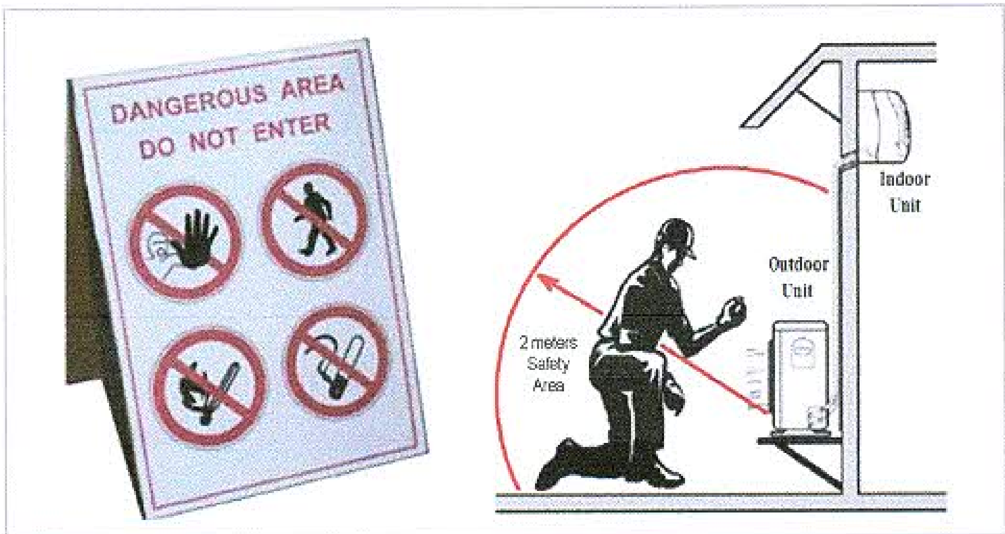
Check the working area and system

Ensure both the working area and the system is safe. This includes:

- All staff, maintenance staff and others working in the local area must be instructed that flammable refrigerants are being handled
- The area around the workspace must be sectioned off
- Working within confined spaces should be avoided
- No flammable materials are stored in the work area
- No ignition sources are present within a minimum of two meters anywhere in the work area
- Suitable fire extinguishing equipment (CO2 or dry-powder type) is available within the immediate area
- The work area is properly ventilated; ventilation should safely disperse any released refrigerant

- HC gas detectors are present and operating to warn workers of a dangerous concentration
- Put up appropriate signage, i.e. "flammable gas", "no open flames" and "do not enter the area"
- All appropriate and necessary tools and equipment are available
- The equipment should, whenever possible, be isolated from the electricity supply

Figure 3-1: Designated work area where potential Sources of Ignition (SOI) must not be present during service works



Initial leak check

Before removing the existing refrigerant, a leak check must be carried out. Search for leakage on the high-side of the system (while the system is operating) and on the low side (when the system is off). Use electronic gas detector and soapy water, where appropriate. If any leak is found, this must be repaired before conversion.

Access refrigerant circuit

Connect the refrigerant hose to service valve. The system must not be broken into, by means of cutting, breaking or brazing pipework, if it contains any flammable refrigerant or any other gas under pressure.

If it is necessary to break into a system, especially to change parts or to carry out brazing, all of the refrigerant must be recovered from the system and then flushed with nitrogen.

Recovery

Any remaining refrigerant within the system must be recovered, particularly CFC, HCFC or HFC. There are also safety implications associated with releasing non-flammable refrigerants. A recovery machine should be used to recover the existing refrigerant, and stored in a recovery cylinder approved for that refrigerant. Identify the existing refrigerant type and quality in order to decide to recover for recycling or destruction purpose. Identification may take place, taking the type of refrigerant from the data plate, comparing with temperature / pressure method or with the use of a quality identifier. Particular attention must be paid to prevent mixing refrigerants and to avoid overfilling the cylinder. Lastly, mark the cylinder appropriately after use.

Figure 3-2: Example testing the "old" existing HCFC R22 refrigerant quality

If recovering HC refrigerant, the recovery machine should be suitable for use with flammable refrigerants.

Repairs to the system

It may be necessary to carry out repairs to the system. In this case, all repairs must be completed before charging with HC refrigerant. If repairs to the refrigerant circuit have been made, it is necessary to carry out a thorough leak check using pressurized nitrogen before proceeding.

At this point, it may also be beneficial to take the opportunity to conduct other, less critical repairs, such as oil changes, replacing filter driers, internal cleaning of the circuits, replacing damaged parts, and so on.

Design changes

The design changes that are made to the R AC system are critical to ensure that the safety requirements are met. It is essential that, based on the system type, location, occupancy and HC refrigerant charge size, the appropriate safety features are integrated into the equipment. Failure to do this properly may result in a serious flammability hazard. The major considerations are usually:

- Elimination of all mechanical joints from occupied space and minimization of the possibility for leakage
- Elimination of all potential sources of ignition

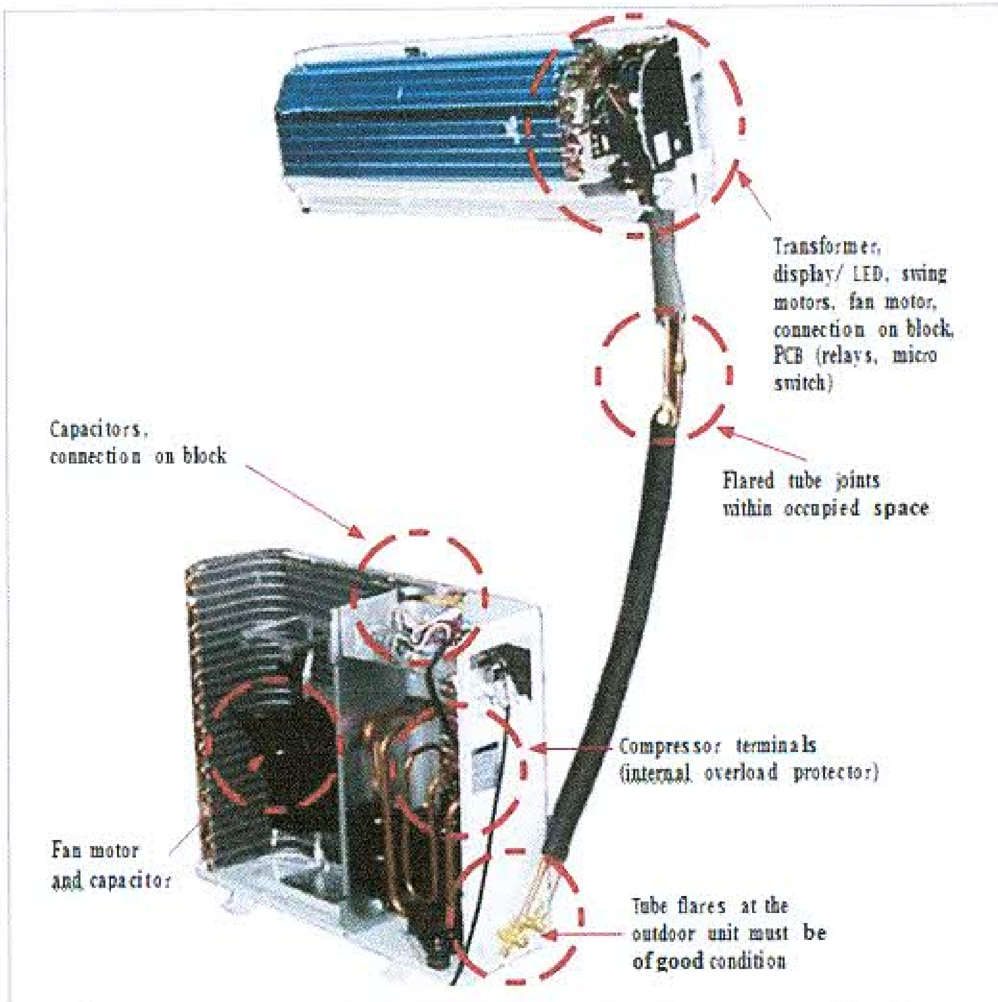
- Setting up of emergency detection/ventilation/alarm system, where applicable
- Application of relevant markings and modifications to instructions

  It is re-emphasized that particular attention must be paid to addressing the potential sources of ignition. In all cases the following assessment must be carried out:

- Inspect the system and associated equipment, noting down all electrical components
- Determine which of the components could act as a potential source of ignition
- Decide how each of those potential sources of ignition will be handled, for example:
  - by replacing with sealed components
  - using solid state devices or types
  - placing within a fully sealed enclosure
  - re-positioning outside the unit away from leaked refrigerant
- Consider also that electrical terminals and wiring connections must be adequately secured and sufficient insulation is provided to avoid shorting of parts
- Carry out the modifications accordingly

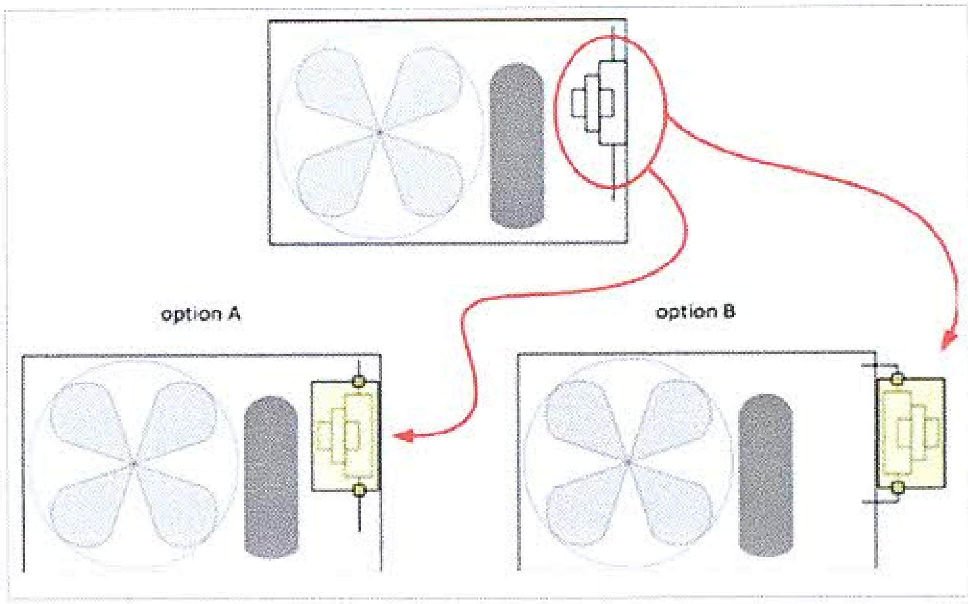
An example of aspects to look at is indicated in Figure 3-3.

Figure 3-3: Check for potential SOI sources and design changes, areas where interventions can be necessary



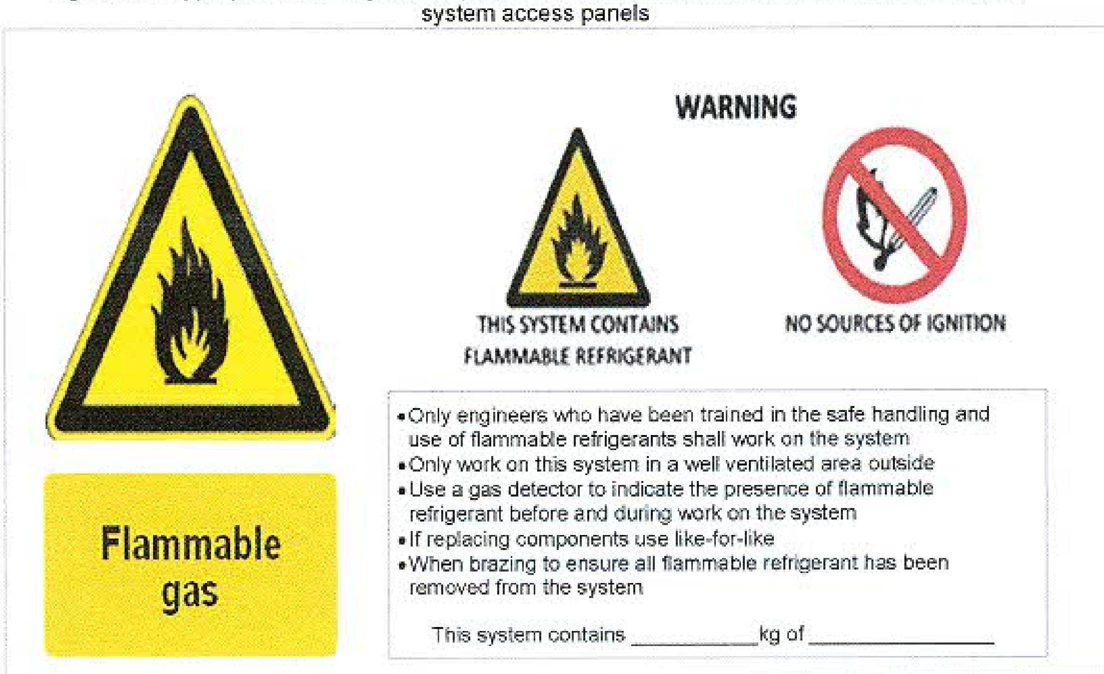
An example of options for modifying a potential source of ignition is provided in Figure 3-4.

Figure 3-4: Example of how to prevent electrical contactor acting as a source of ignition; "option A" is fitting the contactor within an sealed enclosure in its existing location and "option B" is relocating the contactor outside the housing within a separate enclosure



The marking of all equipment that contains HC refrigerant is also re-emphasized here. The appropriate "flammable gas" stickers must be placed on equipment housing entries and refrigerant access points, as well as on exposed piping (Figure 3-5). This should also be supplemented by a comprehensive warning sign applied to an access panel to provide advice to other technicians.

Figure 3-5: Appropriate warning sticker (left) and comprehensive warning sign (right) for use of system access panels



Sealing the system

Upon completion of the work to the system, the circuit must be sealed according to the guidelines. This means through either:

- Using compression (e.g., Lokring) connectors explain
- Brazing the service port (process tube) using pinch-off pliers
- Closing service valves

NOTE: The use of Schrader valves or line-tap valves should be generally avoided. Schrader valves can leak if not properly sealed and caps can be easily removed. Line-tap valves are for temporary use only (e.g. refrigerant recovery) but must not be left on the system.

Testing the integrity of the system

If the refrigerant circuit has been broken into, it is necessary to carry out leak tightness tests and strength pressure tests.

These may be carried out simultaneously by pressurizing the system with oxygen-free dry nitrogen to the maximum working pressure of the system (plus 10%) and then check every single joint, connection and component for bubbles using soapy water or other such fluids.

If a leak is identified, follow the appropriate procedures to repair it.

Evacuation

The system must be evacuated.

This requires a use of a suitable vacuum pump and electronic vacuum pressure gauges; the system should maintain a vacuum of 200 microns, held for at least 15 minutes (without the pressure changing).

Refrigerant charging[1]

Provided that the system is proved to be leak free, charge the quantity as determined above. Charging must be carried out by mass using an electronic balance (accuracy of at least ±3% full-scale). Avoid charging to system pressure/temperatures only.

Consider the following:

- Ensure there are no sources of ignition nearby
- Place an HC gas detector at floor level to warn of any inadvertent release
- When connecting hoses between the refrigeration system, manifold gauges and refrigerant cylinder, ensure that the connections are secure
- Ensure that the refrigeration system is earthed prior to charging
- Extreme care must be taken not to overfill the refrigeration system
- After charging, carefully disconnect the hoses so to minimize the quantity of refrigerant emitted
- The mass of refrigerant charged into the system should be noted in a log-book and marked on a nameplate

When charging be aware that HC refrigerant have a lower density than most other refrigerants; only 40 – 50% of the charge expected with HFC/ HCFC is needed. Remember that HC refrigerant blends must be charged in liquid state.

Final leak check

After charging with refrigerant, carry out leak tightness checks, using a combination of:

- HC gas detectors – check every single joint, connection and component for the presence of refrigerant
- Bubble test – check every single joint, connection and component is checked for bubbles using soapy water or other such fluids

Search for leakage on the high-side of the system (while the system is operating) and on the low side (when the system is off).

If a leak is identified, follow the appropriate procedures to repair it. Systems may have more than one leak, so the system should be repeatedly checked (including positions of recently repaired leaks).

Final checks

After charging and leak checking is complete, carry out final checks to ensure a safety and reliability of the system:

- Repeat checks to electrical components (i.e., there are no potential sources of ignition)
- Initiate the operation of the refrigeration machine and run the unit for a period of about 15 – 30 minutes
- Check for correct operating pressures, temperatures and current
- Ensure sealing caps have been replaced

1 A note on refrigerant purity: Refrigerant grade product should be used for all RAC systems.

Commercial grade HCs (e.g. liquefied petroleum gas, LPG) contains significant quantities of sulphur, water, and other impurities and could contribute to oil degradation, shorten compressor life and invalidate warranties. The composition of commercial LPG is variable so the thermodynamic properties of the fluid may vary significantly from cylinder to cylinder. Also, unlike commercial LPG, HC refrigerants are not odorized.

CONVERSION EXAMPLE FOR SPLIT AIR CONDITIONER

The following pictures provide an example of the various steps one may take to convert a split air conditioner from R 22 to R 290.

Identify problem with air conditioner

Proper operating RAC equipment generally should not be converted to any other refrigerant (do not touch a good running system). Systems which may bear major problems, such of corrosion of heat exchanger and main frame or the system is overaged, should not be subject for a conversion to HC refrigerant.

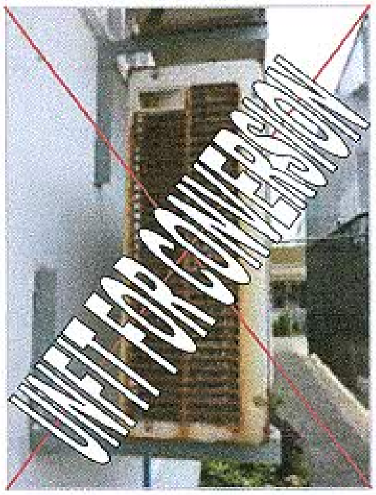


Figure 3-6: Example of AC system that is unsuitable for conversion

If the RAC system is in a generally good condition and subject to any repair or service where a breaking into the refrigerant circuit is necessary (e.g. damaged compressor, leaking system) considerations should be taken to convert the system to a HC refrigerant if safety considerations permit.

Assumption:
A fully functional system does not need to be converted. The only time when a system may be converted is when there is a problem with the equipment that at least requires handling of refrigerant and/or breaking into the system.

AC split system conversion activities from HCFC R22 to HC R290

This example explains the conversion of an HCFC R22 based AC Split system (2.8 kW / 9000 BTU – cooling only) after repairing a leaky suction line coupler between indoor and outdoor unit, identified during system fault finding procedure within the operational HCFC R22 system.

Step 1)
Obtain current charge size
-> 0.68 kg of R22

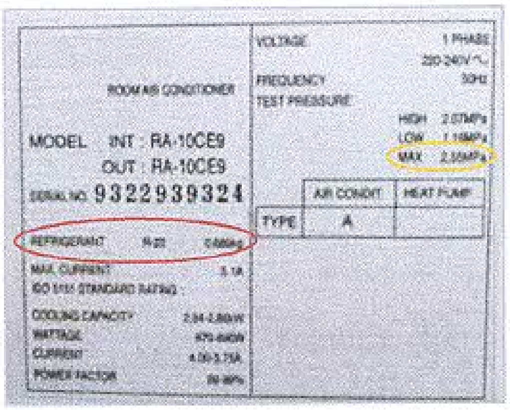


Figure 3-7: Split AC system data plate

The charge size is generally indicated with the data plate.
If there is no information available at the outdoor-unit (e.g. weather-beaten) check if there is information available at the indoor-unit.
Finally, the charge amount can also be estimated from the amount of recovered (old) HCFC refrigerant charge amount (assuming there was no leak prevailing).

Step 2)
Estimate equivalent HC charge
➔ Conversion to R290, R22 charge is 0.68 kg and equivalent HC charge according diagram (Figure 3-8) is 0.28 kg of HC R290

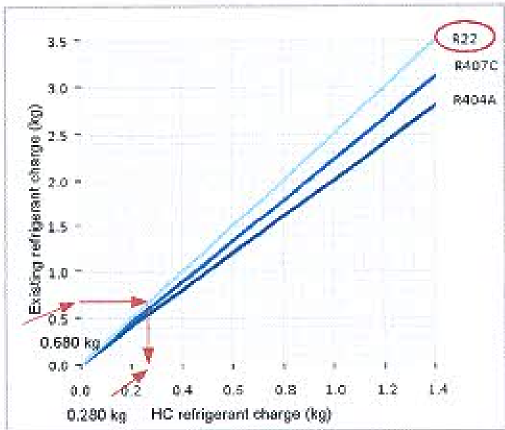


Figure 3-8: Refrigerant charge calculation diagram

Step 3)
Identify occupancies
➔ Outdoor unit is in well ventilated area, and general occupancy (category A) is above ground level

➔ Indoor unit within office for human comfort

Figure 3-9: Example AC system installation

Step 4)
Check charge size limits

- ➔ Charge size is below maximum limit of 1.5 kg (0.28 kg < 1.5 kg)
- ➔ Room size is 6 m × 5 m = 30 m², so below allowable charge (0.28 kg < 0.48 kg)

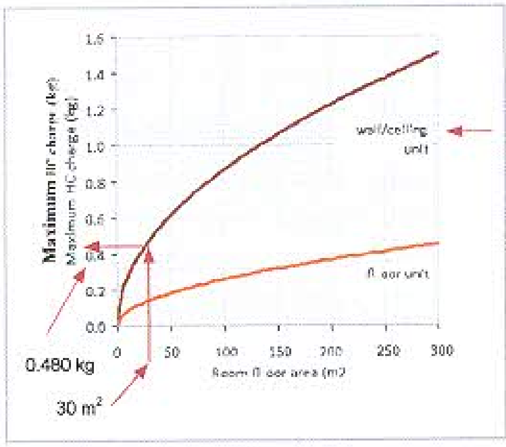
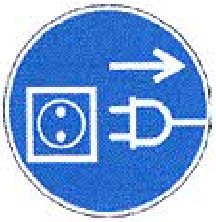


Figure 3-10: Maximum charge amount for existing room size

Step 5)
Check all necessary tools are present and the working area is safe

i) General hand-tools appropriate for the use at refrigerant circuit components and electrical circuits.
ii) Refrigerant recovery machine intended firstly for the HCFC R22 charge but suitable for use with flammable refrigerants (if subsequent service/repair with HC R290 is necessary)
iii) Refrigerant venting hose (only for venting of small amounts of HC during service or repair) and minimum of ½" OD
iv) Refrigerant recovery cylinder (two valves) for the existing R22
v) Lubricant recovery cylinder (two valves) utilized in series between recovery unit inlet and AC unit service port (oil-separator)
vi) Comparator/pressure-temperature tables for HC refrigerant (provided with the annex of this document)
vii) Vacuum pump with connector of the venting hose at the exhaust port
viii) Vacuum gauge (electronic), to check the 200 micron vacuum level
ix) Electronic refrigerant balance (accuracy of at least ±3% full scale)
x) Handheld HC refrigerant gas detector
xi) Nitrogen service cylinder with pressure regulator
xii) Brazing set (oxygen/propane)
xiii) Flammable gas (yellow triangle) stickers
xiv) Flammable refrigerant warning signs
xv) Work area warning signs
xvi) Safety gloves and goggles
xvii) Fire extinguisher



NOTE!

Whenever possible the system must be disconnected from power-supply!

Secure unintentional restarting of the system!

Step 6)
Eliminate all mechanical joints from occupied space!

In this specific case the identified leaking coupler within the suction line was removed and therewith the leak was repaired.

Figure 3-11 Mechanical connections in occupied space

Before repair: Arrow indicates leaky flared coupler within the suction line.

Figure 3-12 Removal of mechanical connections by joining tubes with brazing

After repair: Both mechanical joints are removed within the occupied space and doing so, the identified leak (suction line coupler) was repaired.

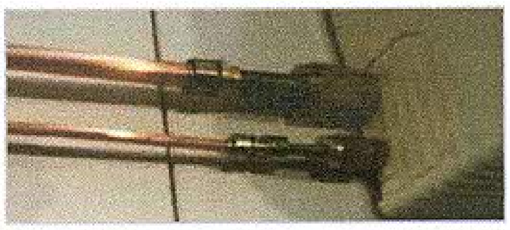


Figure 3-13 Joining tubes with Lokring couplers

Alternative repair: There where brazing is not possible or as general alternative tube joining method, pressing connection (Lokring) can be used.

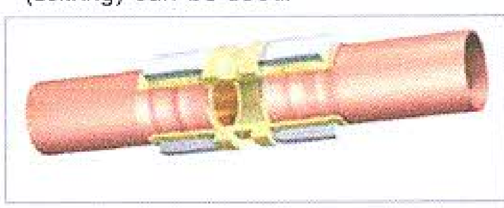


Figure 3-14: Lokring coupler for refrigerant transfer tubes

Step 7)
Reset pressure device

Not Applicable

Step 8)
Eliminate all potential sources of ignition

-> Inside unit: transformer, display/ LED, swing motors, fan motor, connection block, PCB (relays, micro switch) – all non-SOIs

-> Outdoor unit: – fan motor, capacitors, connection block, compressor terminals (internal overload) – all non-SOIs,

Figure 3-14 Checking for SOI at the indoor unit

In general, wire connection screws must be fastened and wires have to be in good condition. All electrical connections should be subject to quality and functional checks. Loose connection will, sooner or later, create sparks and components damage. Dirt and humidity will create short cuts.

Use blade connectors, ring and spade terminals and appropriate cable end sleeves. Ensure insulation of each single connection and between the different terminals. Loose flexible wires connected to terminals will cause arcing and sparks!

Figure 3-15 Appropriate wire connectors

Figure 3-16 Appropriate cable and sleeves

Step 8)

Compressor terminal sealing caps must be tight and the wire connection screws be fastened.

Wire connections should be in good condition and properly isolated to avoid arcing.

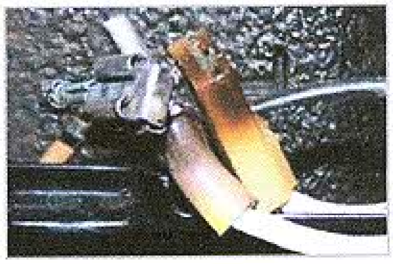


Figure 3-17: Loose connection causes arcing and short-cut

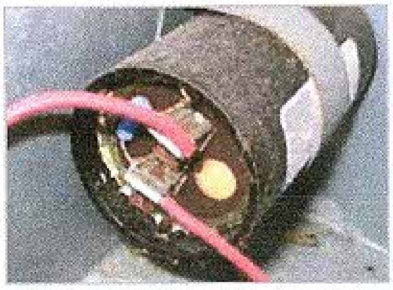


Figure 3-18: Not acceptable capacitor may cause short-cut and

Mains contactors (either the existing or new one) must be fitted into a sealed enclosure.

The clearance between fan blade and housing must be sufficient to avoid any impact.

Compressor rubber grommets and sleeves must be in good condition to avoid vibration.

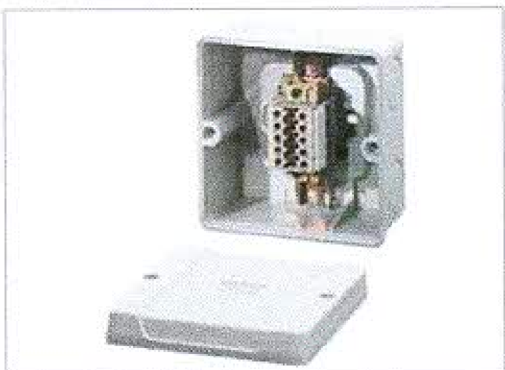


Figure 3-19: Replace contactor into isolated box!

The level of vibration associated with the system must be within normal, acceptable limits; too much vibration implies that there is a greater possibility of leakage therefore compromising safety.

Refrigerant transfer tubes most have enough space in-between to avoid rubbing on each other, so that chafing is avoided.

Capacitor connections should be either sealed with a cap and factory assembled cable, or the wires connected via an isolated spade type connector.

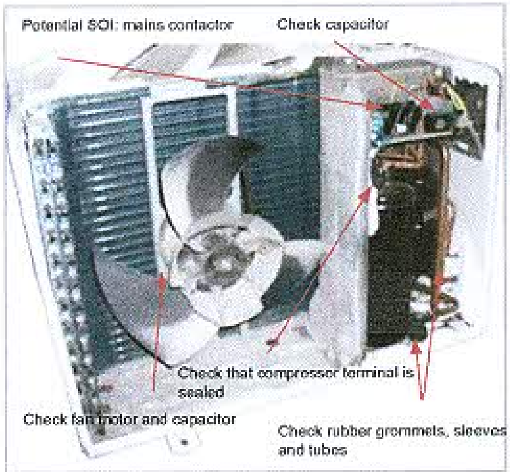


Figure 3-20: Checking the outdoor unit

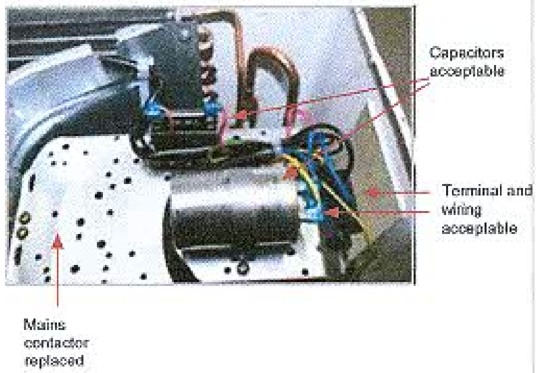


Figure 3-21: Replacing mains contactor and checking capacitors

Step 9)
Set-up emergency ventilation/detection and alarm system

Not Applicable

AC system commissioning with HC R290

Step 10)
Integrity test (pressure test / strength test)

Since the refrigerant circuit has been broken into by replacing the flared tube couplers / suction and liquid line and the filter-drier, it is necessary to carry out leak tightness tests and strength pressure tests.

This is carried out simultaneously by pressurizing the system with oxygen-free dry nitrogen (OFDN) to the maximum working pressure (PS) of the system or system sections (as stated on the data plate) plus 10% (according to EN 378-2).

Pressure Test Value =
1,1 × PS (2,55 × 1,1) = 2.80 MPa (28 bar)

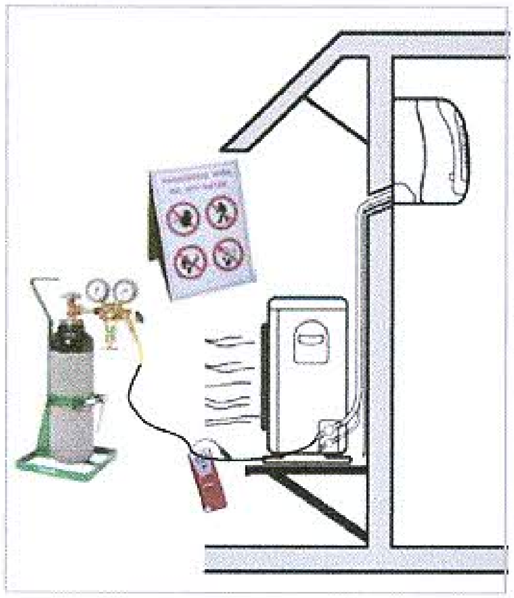


Figure 3-22: Pressure / strength test with OFDN

i) Nitrogen cylinder is connected with a common but reliable transfer hose to the service port of the outdoor unit. For safety reason, with starting of the test procedure, the pressure adjusting handle of the pressure regulator is back-seated (pressure regulator discharged).

ii) Nitrogen is now transferred to the system by slowly adjusting and opening the pressure regulator (pressure adjusting handle) and carefully applied at a pressure of 28 bar (2.8 MPa) to the system.

iii) Check every single joint, connection and component for bubbles using soapy water or other such fluids.
iv) If a leak is identified, follow the appropriate procedures to repair it.
v) If the system is found to be free of leaks, release the OFDN from the system slowly and carefully to the ambient.

Flushing the system with OFDN will require the same work activities and equipment provisions but with applying lower pressure (max. 10 bar).

Step 11)
Temporary flammable zones

Strategically plan the work schedule in order to have tools and equipment direct available and to avoid having to change the equipment and refrigerant hose interconnections during servicing the AC unit with HC.

When working on systems using flammable refrigerants, the technician should consider certain locations as 'temporary flammable zones'. These are normally regions where at least some emission of refrigerant is anticipated to occur during the normal working procedures, such as recovery, charging, and so on; typically where hoses may be connected or disconnected.

In general, the work schedule for refrigerant handling during service and repair activities should be arranged in a manner that the release of refrigerant is not necessary (e.g. 'pumping down' the system and moving the refrigerant charge to the high side of the system). In anticipation of the maximum quantity of refrigerant that may be released during such a procedure (such as disconnecting a hose while it is full of liquid refrigerant), the minimum distance in all directions and with respect of the occupied working area where the service equipment is placed, should be a minimum of two meters.

Place warning signs within the working area.

Make sure that the gas detector is operational and place it on the floor within the work area. This will give a clear indication if HC refrigerant is in the surrounding environment.

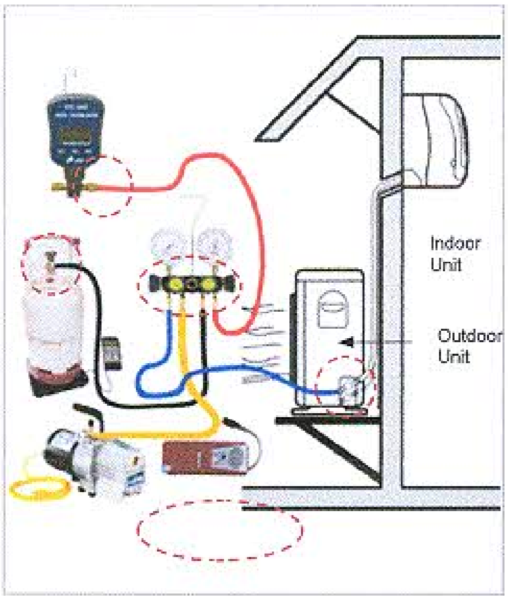


Figure 3-23: Temporary flammable zones

For any reason and under specific circumstances where service or repair activities have to be carried out at the indoor unit (breaking into the refrigerant caring system), the designated two (2) meters safety area will apply the same way as indicated for the outdoor unit!

Step 12)
System Evacuation and charging

The diagram below indicates the arrangement of equipment and tools and the interconnection with refrigerant hoses for drawing a vacuum at the system and finally charging with refrigerant. These are activities in general where flammable refrigerant can be present. It is important to respect the temporary flammable zones, as indicated before, for carrying out intended work activities and arrangement of the safety area.

The process of evacuation requires the use of a suitable vacuum pump and electronic vacuum pressure gauges; the system should maintain a vacuum of 200 microns (0.5 mbar, 50 Pa), held for at least 15 minutes (without the pressure changing).

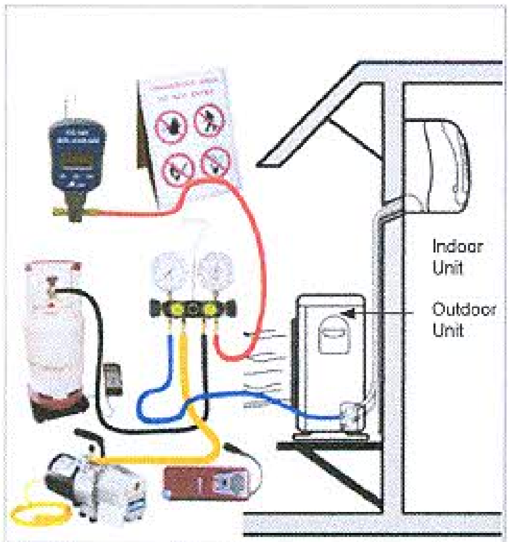


Figure 3-24: Equipment and tools arrangement for vacuuming and charging

The process of charging the AC systems with HC refrigerants is similar to those using halocarbon (e.g. HCFC R22) refrigerants. Since R290 is a pure refrigerant the charging can take place in gaseous or liquid state. For small amounts of refrigerant (as for this example 0.280 kg) the charging of this system can be done by taking only vapour from the refrigerant cylinder and charging to the suction line of the compressor by measuring the weight of refrigerant. If charging the refrigerant in liquid form to the suction side of the system it must be evaporated before it reaches the system. Inter- connect an expansion device (e.g. a short length of capillary tube) between the hose and the system, to enable the refrigerants evaporation. The charging amount should be monitored by the use of an accurate and sensitive scale. For safety reasons and to provide accurate charging, the smallest refrigerant cylinder sizes possible should be used.

Step 13)

Apply relevant documentation and system markings.

Figure 30:

Warning sign at the compressor

Warning sign at the compressor

Conversion label with detailed information at the outdoor unit

Warning signs at the outdoor unit

Figure 3-25: Labeling of the outdoor unit

Step 14)

Final leak checking

With an HC gas detector – check every single joint, connection and component for the presence of refrigerant.

Using a bubble test – check every single joint, connection and component is checked for bubbles using soapy water or other such fluids.

End of AC system conversion

Figure 3-26: Bubble Test

Figure 3-27: Leak check with electronic leak detector

Note:

For the use with Hydrocarbon refrigerants (here HC R290) it is important to make sure that the detector is safe and sensitive for this refrigerant. Regular used electronic gas detectors for CFCs, HCFCs or HFCs refrigerants are in most cases not designed for the use with HC R290, so check with the equipment provider and review the product manual if the gas detector is safe for a specific use.

PART 4: REFRIGERANT HANDLING AND STORAGE

The following shall be observed when handling and working with refrigerants:

1. Color-coding for refrigerant cylinders should be maintained for new refrigerants (although there are concerns from some manufacturers regarding this). Refer to Table 1 for refrigerant cylinder color assignments.
2. Refrigerant manufacturer's recommended procedures shall be followed when handling refrigerants.
3. Refrigerant containers/cylinders shall be stored in a cool place or under a roof to protect it from weather extremes, away from the risk of fire and direct sunlight.
4. Extra care shall be taken not to drop refrigerant containers/cylinders that may damage the container or its valve.
5. When not in use, container valves shall be closed, the valve outlet cover nut fitted, and the valve protection cover replaced.
6. While charging, refrigerant containers/cylinders shall not be connected to a system of higher pressure to prevent back flow of refrigerant to the container/cylinder.
7. Cylinders intended for a certain type of refrigerant shall not be filled with another type unless they are properly evacuated and labeled.
8. Strictly follow cylinder capacity when re-filling with refrigerants.
9. When re-filling with recovered refrigerants, only 70% of the maximum capacity in weight for a particular type of refrigerant should be filled to a cylinder (since it may contain oil with lower density). Overfilling can cause the cylinder to explode leading to fatal danger.
10. Calibrated weighing scale shall be used when filling a cylinder.
11. Leaks on refrigerant cylinder valves shall be checked and repaired before storing in a ventilated area and on a vertical position.
12. Establish proper leak testing routine on charging hoses and refrigerant handling equipment.
13. Thorough check-up of refrigerant cylinders shall be done first before refilling.
14. Defective refrigerant cylinders shall not be repaired and re-used.
15. Refrigerant cylinders shall conform to appropriate standards.
16. Storage tank relief valves shall be checked to ensure that they are not leaking (shall conform to relevant PNS).
17. *Transfer pump seals of filling machines shall be regularly checked* for leaks.
18. Charging lines shall be kept as short as possible and be fitted with either check valves or isolation valve near the end of charging lines.
19. Whenever possible, use quick disconnect fittings with one-way valve in transferring or working with refrigerants.
20. Use PPE, such as side shield glasses/goggles, gloves, jackets, and safety shoes when handling containers.
21. Never apply direct flame or live steam to a container or valve.

22. Never refill disposable cylinders.
23. Never use a lifting magnet or sling (rope or chain) when handling cylinders.
24. Never use cylinders for rollers, supports, or any purpose other than to contain the refrigerant.
25. Protect cylinders from any object that will result in a cut or other abrasion on the surface of the metal.
26. Never tamper, repair or alter the safety devices of the cylinders.
27. Never force connections that do not fit.
28. When in doubt of refrigerant type, use electronic refrigerant identifier (will be available in all Regional EMB offices and TESDA accredited training institutions nationwide) to analyze its composition.
29. Avoid skin contact with refrigerants as they may cause frostbite and other skin irritations.
30. Blended refrigerants should only be charged into a system in liquid state.

PART 5: RECOVERY, RECYCLING, COLLECTION, TRANSPORT, STORAGE AND DISPOSAL

PART 5.1 – RECOVERY

5.1.1 Recovery of refrigerant shall be performed by a certified technician.

5.1.2 Service hoses to be used for recovery must have shut-off valves (PNS SAE J2197:2003)

5.1.3 All refrigerant content of a non-serviceable refrigeration or air conditioning system shall be recovered before it is disposed off. Recovered refrigerants shall be verified for re-use, recycling, reclaim or disposal/destruction.

5.1.4 Recovered refrigerants shall be stored only in Specified Refillable Container/Cylinder.

5.1.5 Recovered refrigerants shall be properly labeled.

PART 5.2 – RECYCLING

5.2.1 Recycled refrigerant shall be stored only in Specified Refillable Container.

5.2.2 Recycled refrigerants shall be checked for non-condensable gases (refer to PNS SAE J2211 and PNS SAE J1989 for the procedure) to verify if it is suitable for re-use or needs re-processing. As much as possible, use recycled refrigerant to the system where it was recovered.

PART 5.3 – COLLECTION, TRANSPORT AND STORAGE

The Collection, Transport and Storage (CTS) of Recovered Refrigerants Program is a sub-project under the Voucher System of the National Chlorofluorocarbon Phase-out Plan (NCPP). It is intended to assist refrigeration and air-conditioning (RAC) and mobile air-conditioning (MAC) service shops, RAC and MAC manufacturers and chiller owners in disposing their unwanted chlorofluorocarbons (CFCs), also known as R-12 or commonly known as "Freon", and other refrigerants like hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs).

With clearance from the World Bank, the DENR-EMB through the NCPP Project hired the services of Delsa Chemicals and Multi-products, Inc. to undertake the collection, transport and storage of the refrigerants recovered from RAC and MAC service shops and manufacturers and chiller owners that shifted to non-ODS technology.

5.3.1 CTS SCHEME

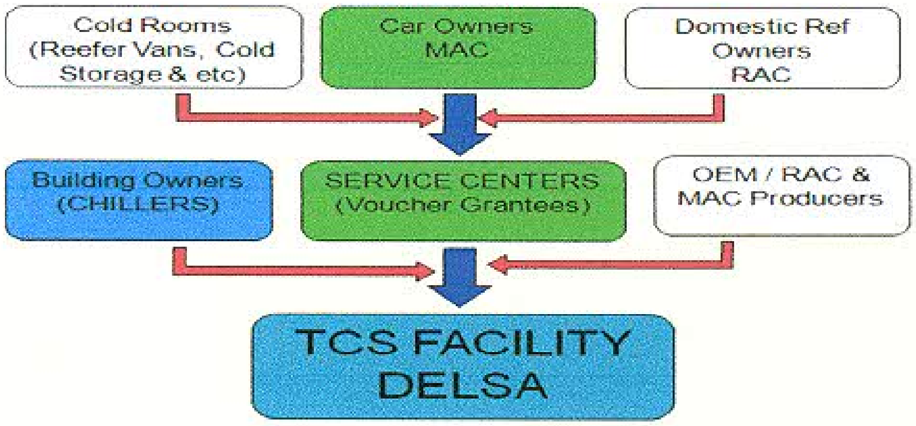


Figure 5-1

The CTS FACILITY starts with the establishment of a Retrieval Scheme. The bottom line of the system is the service shops or service technicians who will perform recovery of used refrigerants before servicing refrigeration and air conditioning equipment.

Under the Revised CCO, venting of ODS is an illegal act, thereby requiring all service technicians/shops to recover refrigerant before performing service or repair.

DELSA Chemicals is the duly authorized company by the DENR-EMB to manag and operate the CTS facility. A fund will be generated to be collected from refrigerant importers to help finance the facility's operational expenses. The operator on the other hand will have their investment on the physical establishments and logistical support.

5.3.2 CTS PROCESS FLOW

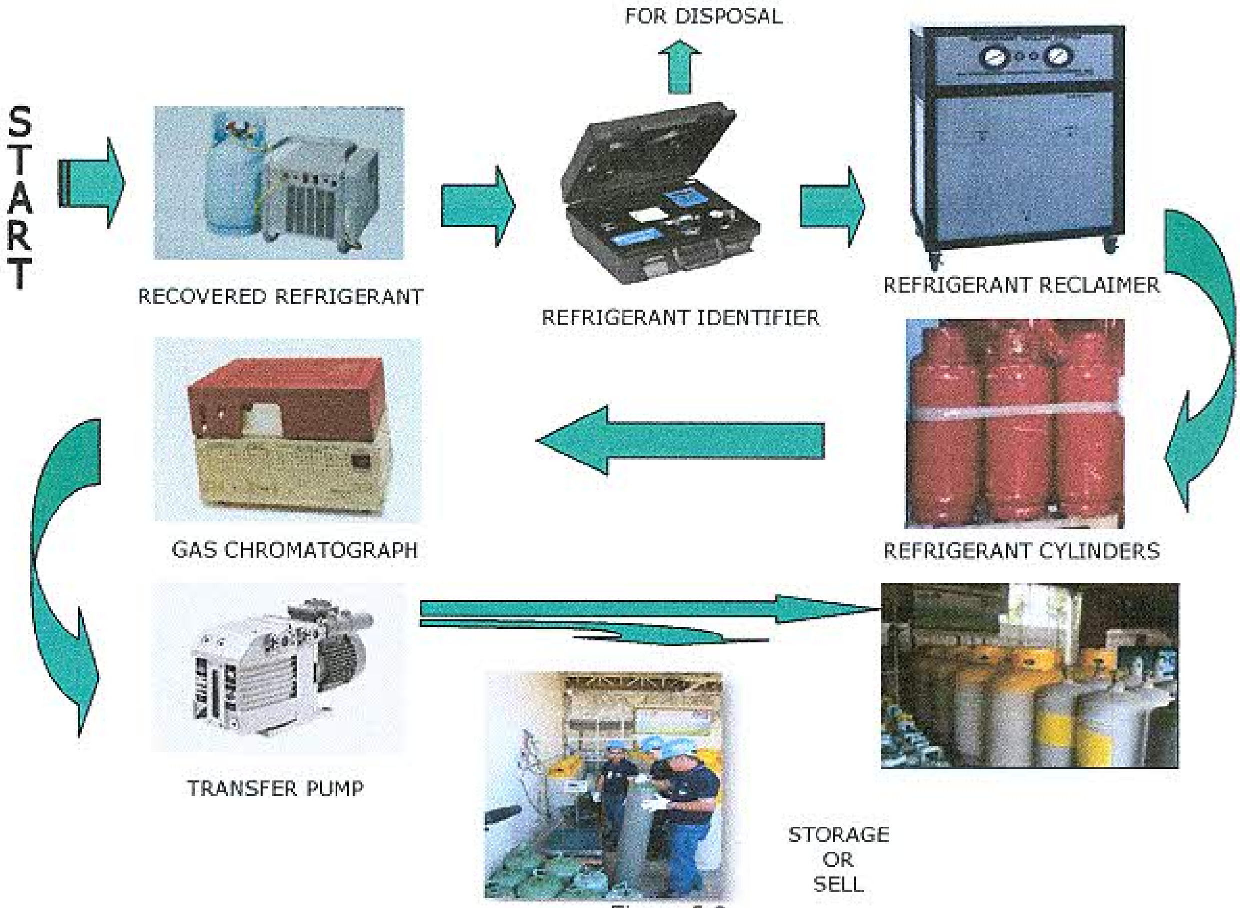


Figure 5-2

The process flow starts from the recovered refrigerants being checked by a Refrigerant Identifier whether mixed or a single substance. If it turned out to be mixed, then it will be stored to the facility, otherwise it will be processed by a Refrigerant Reclaimer. From the reclaimer, the refrigerant will be filled to refrigerant cylinders. A Gas Chromatograph will check the quality of reclaimed refrigerant if it meets the ARI 700 standard. Then it may be transferred to bigger storage cylinders or remain in smaller cylinders using a transfer pump either for storage or reselling.

CONTACT INFORMATION FOR CTS (ODS RECOVERY):

DELSA CHEMICALS & MULTI-PRODUCTS, INC.

Km. 24 East Service Road, Bo. Cupang Muntinlupa City 1771 Philippines

Tel nos.	:	(632) 842-8729
		(632) 842-9052
		(632) 850-2964
Contact	:	Judith R. Rostro
Persons	:	Romel Y. Dimaano

PART 5.4 – DISPOSAL

5.4.1 Confirmed mixed refrigerant are automatically subject for disposal.

5.4.2 Until suitable disposal methods are available, contaminated refrigerants should be properly labeled and stored by concerned stakeholder.

5.4.3 Mixed refrigerant recovered from service shops/technicians through the reclamation scheme shall be stored at the CTS facility.

5.4.4 Non-reclaimable refrigerant will be stored in the facility until final means or method will be approved by concerned agency.

PART 6: SAFETY ASPECT

(SAFETY REQUIREMENTS)

1. PPE is compulsory when handling and working with refrigerants.
2. Always ensure good ventilation while working on refrigeration systems.
3. Ensure that refrigerant cannot accumulate in low areas where they can cause fatal accidents.
4. Specific color-coding shall be followed for cylinders/containers of different refrigerants (refer to Table 1).
5. Pressure safety devices (i.e. pressure relief valves, safety pressure switches) shall be installed to prevent the equipment from operating over the maximum working pressure and must be calibrated.
6. A dual pressure-relief valve with changeover device shall be installed for larger systems to facilitate the repair/replacement without impairing system protection.
7. Appropriate safety precautions shall be observed for systems converted with hydrocarbon.
8. Proper protective caps shall be used on valves of refrigerant cylinders to prevent damage to valves that will cause refrigerant leaks.
9. Avoid contact with liquid refrigerants that can cause severe frostbite.
10. Hydrochloric and hydrofluoric acids may be present in contaminated recovered refrigerant and oils. Utmost care must be taken to prevent contact, even with oil spills when servicing contaminated equipment.
11. Recovered refrigeration oil should be properly stored for proper disposal.
12. Never exceed the cylinder's safe liquid weight level based on net weight. Maximum capacity of any cylinder is 80% by maximum gross.
13. Appropriate wheeled device must be used to transport larger cylinders. Ensure that the cylinder is securely strapped when moving from one location to another. Never roll a cylinder on its side.
14. Good quality hoses/manifolds should always be used with seals/gaskets in place.
15. Never refill disposable cylinders.
16. Never braze or unbraze refrigeration piping system that has not been fully/properly evacuated of refrigerant for servicing and filled with inert gas (e.g. dry nitrogen).
17. Never use "halide torch method" (flame test) for leak testing to an unidentified refrigerant in a system.
18. Never use oxygen or compressed air for pressure or leak testing or when blowing-off piping to remove welding, brazing or cutting debris.
19. Avoid inhalation or exposure to refrigerant and lubricant vapor or mist. This will irritate skin, eyes, nose, and throat.
20. Never open refrigerant drums (for low pressure refrigerants) until it is cooled down to atmospheric pressure/temperature when replacing its cap with valves.
21. Electrical wirings should be kept away from contact with the system's discharge line. This will damage the wire's insulation that may cause short circuit.
22. All power supply should be disconnected and disabled to any equipment from which refrigerant is being recovered.

23. Never connect grounding wire to gas pipes, water pipes, telephone grounds, and lightning arresters.
24. Never use refrigerants without first understanding the associated MSDS.
25. Use tools with insulated handles that are in good condition when working with the system's electrical lines.

PART 7: LEGISLATION AND REGULATION

PART 7.1 - DENR ADMINISTRATIVE ORDER No. 2013 – Revised Regulations on the Chemical Control Order for Ozone Depleting Substances (ODS)

NOTE: The following are applicable sections for the refrigeration related acts and practices under the revised Regulations on the CCO for ODS:

Section 5. BAN ON IMPORTATION OF ODS

5.1. This CCO affirms the previous ban on importation, except for essential uses, in any amount, of the following substances, whether alone or in mixtures, as provided under the Department's Notice to the Public dated December 1998, relevant administrative orders, and listed in Appendix I of this CCO:

5.1.1. Annex A, Group I

(a) CFC 11 and CFC 12 banned for importation for manufacturing products and equipment since 01 January 1998;

(b) CFC 113 since 01 January 1996;

(c) CFC 114 and CFC 115, except as component in R-502, since 01 January 1998.

5.1.2. Annex A Group II since 01 January 1999

5.1.3. Annex B Group I since 01 January 1999

5.1.4. Annex B Group II since 01 January 1996

5.1.5. Annex B Group III since 01 January 1996

5.1.6. Annex E Group I: Non-QPS Methyl Bromide since 01 January 2009.

5.2. Notwithstanding the above provisions, the importation of CFC 11, regardless of sector or purpose, is absolutely banned starting on 01 January 2005. Further, importation of all CFCs, including those in R-502, regardless of sector or purpose, is absolutely banned starting on 01 January 2010.

Section 6. PHASE-OUT SCHEDULE AND CONTROL OF IMPORTATION OF ODS (HCFCs)

6.1. For Annex C, Group 1 (HCFCs):

6.1.1. By 01 January 2013, imports shall not exceed the recorded baseline consumption in ODP tonnes.

6.1.2. By 01 January 2015, imports shall have been reduced by 10% based on the recorded baseline consumption in ODP tonnes.

By this date, all importation of HCFC 141b and pre-blended polyols for foam (rigid and flexible) manufacturing will also be absolutely prohibited, except for the servicing and solvent sectors.

6.1.3. By 01 January 2020, imports shall have been reduced by 35% based on the recorded baseline consumption in ODP tonnes.

By this date, all importation of HCFC 22 for the manufacturing of refrigeration and air-conditioning will also be absolutely prohibited, except for the servicing sector.

6.1.4. By 01 January 2025, imports shall have been reduced by 67.5% based on the recorded baseline consumption in ODP tonnes.

By this date, all importation of HCFC 123 as cooling agent for chillers and fire extinguishing agent will likewise be absolutely prohibited, except for the servicing sector.

6.1.5. By 01 January 2030, imports shall have been reduced by 97.5% based on the recorded baseline consumption in ODP tonnes.

By this date, all importation of blends containing HCFCs will likewise be absolutely prohibited.

6.1.6. By 01 January 2040, importation shall have been absolutely prohibited.

By this date, all kinds of importation of HCFC substances for manufacturing and servicing sector, except for essential use, will be prohibited.

6.1.7. However, during the period 2030-2040, importation of 2.5% of the baseline consumption shall be allowed for the servicing sector.

6.2. Consistent with Section 6.1-6.1.7, an annual import quota allocation system shall be implemented by the Department through the Bureau.

6.3. The annual import quota is non-cumulative, thus, any remainder of the quota allocation for a particular substance is deemed consumed at the end of the calendar year. The total annual imports shall be in accordance with the phase-out schedule outlined in Section 6.1-6.1.7.

6.4. The Department, through the Bureau, may accelerate the phase-out schedule for servicing as it may deem necessary through the issuance of an appropriate policy instrument.

Section 7. REGISTRATION AND RENEWAL OF REGISTRATION OF IMPORTERS OF ODS

7.1 Any person who imports ODS (regardless of source as allowed under the agreements of the Montreal Protocol, as amended) for any industry or activity, such as those listed under Appendix IV, must register with the Department through the Bureau.

7.2. A Certificate of Registration issued by the Department through the Bureau is valid only for the calendar year when it was obtained. An application for the renewal of registration for every succeeding period prior to any importation must be submitted within the last thirty (30) days of the current calendar year.

Section 9. REGISTRATION AND RENEWAL OF DEALERS, RETAILERS, AND RE-SELLERS OF ODS

9.1. Consistent with the Department's Memorandum Circular No. 2005-23, any person who is engaged in trading, selling, and/or distribution of ODS (regardless of source as allowed under the agreements of the Montreal Protocol, as amended) for any industry or activity, such as those listed under Appendix IV, must first register with the Department through the concerned Regional Office of the Bureau in order to determine their capability in handling and using these substances. Such registration is on an enterprise and site-specific basis, and not on a chemical basis.

9.4. A Certificate of Registration issued by the Department through the Regional Offices of the Bureau is valid only for the calendar year when it was obtained. Applicants are thus encouraged to submit their respective applications for renewal and accompanying documents within the last thirty (30) days of the current calendar year.

9.5. Only dealers, retailers, and re-sellers registered by the Department through the Regional Offices of the Bureau may purchase, re-sell, and distribute the ODS listed under Section 2 for allowable uses in Appendix IV. The ODS may only be sold or distributed to service providers that are duly registered under Section 10.

Section 10. REGISTRATION AND RENEWAL OF SERVICE PROVIDERS OF ODS-USING EQUIPMENT

10.1. Service providers of ODS-using equipment must register with the Department through the Bureau to determine their capability in handling and working on these substances. However, a Certificate of Registration may only be granted by the Department upon showing proof that the service provider has been duly certified by TESDA in case of individual mechanics or accredited by DTI in case of service/repair shops.

10.2. Service providers should have the capability to take effective measures, including the necessary equipment, technology, training and infrastructure, for the purpose of effectively handling ODS, including responsible re-use of refrigerants, minimizing their emissions, and ultimately phasing out their use by replacing with substitutes or alternatives duly recognized and certified by the Department and the Bureau.

10.3. Service providers shall adhere to the good practices in handling and working with refrigerants set forth in the Code of Practice for Refrigeration and Airconditioning approved and adapted by the Department-Bureau in 2004.

10.4. Service providers shall also participate in a system to recover, reclaim, and re-use refrigerants that will be led by the Department.

10.5. A Certificate of Registration issued by the Department through the Bureau is valid for a period of three (3) years. Applications for renewal may thus be submitted within the last thirty (30) days of the third calendar year.

Section 14. RECORDS KEEPING

14.2. All service providers shall likewise keep a record of all transactions, including quantity of recovered refrigerants, for purposes of validation by the Bureau.

14.3. Records retained by importers, exporters, dealers, retailers, and re-sellers must be available for inspection at any time by an authorized officer of the Department through the Bureau.

Section 17. ADMINISTRATIVE VIOLATIONS

In addition to the relevant provisions of RA 6969, RA 8749, DAO No. 29 series of 1992, and other violations arising from the implementation of Sections 4-14 of this DAO, the following acts and omissions shall be considered as administrative violations:

17.1. Back conversion;

17.2. Installation of CFC-using system;

17.3. Sale and use of small disposable containers (less than 1 kg) with CFCs;

17.4. Importation or manufacturing or placing in the market of products or equipment containing Halons or CFCs;

17.5. Use of CFC-containing equipment in mobile transportation starting in 2012;

17.6. Use of CFC-11 as blowing agent for foam manufacturing;

17.7. Intentional release or venting of ODS;

17.8. Use of CFC-11 and other banned ODS as flushing or cleaning agent; and;

17.9. Possession of unregistered refrigerants, including mislabeling of controlled substances

Section 18. PENAL PROVISIONS

Any person who violates any provision of this DAO shall be administratively and criminally liable pursuant to Sections 13, 14, and 15 of RA No. 6969, Sections 43 and 44 of DAO 92-29 and other applicable laws, rules and regulations.

Such violation shall also constitute grounds for the Department through the Bureau to:

18.1. cancel the registration of importers, exporters, dealers, retailers, and resellers;

18.2. recommend the cancellation of the DTI accreditation of service or repair shops; and

18.3. recommend the cancellation of the TESDA certificates of competency of technicians, mechanics, contractors, and other service providers.

The foregoing administrative and penal provisions shall not prevent the Department through the Bureau from issuing interim orders to stop the continued commission of the pertinent violation.

Section 21. EFFECTIVITY

This Order shall take effect fifteen (15) days after its publication in a newspaper of general circulation and upon acknowledgment of receipt of a copy hereof by the Office of the National Administrative Register (ONAR).

ANNEX II

List of Controlled Substances of the Montreal Protocol On Substances that Deplete the Ozone Layer[1]

ANNEX A: CONTROLLED SUBSTANCES

Group	Substance	Ozone-Depleting Potential*	Global Warming Potential (100)	Common Uses
Group I				
$CFCl_3$	CFC-11	1.0	4,750	Refrigerant Blowing agent Propellant
CF_2Cl_2	CFC-12	1.0	10,890	Refrigerant Propellant Blowing agent
$C_2F_3Cl_3$	CFC-113	0.8	6,130	Cleaning agent Solvent
$C_2F_4Cl_2$	CFC-114	1.0	10,040	Cleaning agent Solvent
C_2F_5Cl	CFC-115	0.6	7,370	Refrigerant
Group II				
CF_2BrCl	(halon-1211)	3.0		Fire Extinguishant
CF_3Br	(halon-1301)	10.0		Fire Extinguishant
$C_2F_3Cl_3$	Halon-2402)	6.0		Fire Extinguishant

**These ozone depleting potentials are estimates based on existing knowledge and will be reviewed and revised periodically.*

[1]United Nations Environment Programme. Ozone Secretariat. Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer. Ninth Edition (2012).

ANNEX B: CONTROLLED SUBSTANCES

Group	Substance	Ozone-Depleting Potential	Global Warming Potential (100)	Common Uses
Group I				
CF_3Cl	CFC-13	1.0		Refrigerant
C_2FCl_5	CFC-111	1.0		
$C_2F_2Cl_4$	CFC-112	1.0		
C_3FCl_7	CFC-211	1.0		
$C_3F_2Cl_6$	CFC-212	1.0		
$C_3F_3Cl_5$	CFC-213	1.0		
$C_3F_4Cl_4$	CFC-214	1.0		
$C_3F_5Cl_3$	CFC-215	1.0		
$C_3F_6Cl_2$	CFC-216	1.0		
C_3F_7Cl	CFC-217	1.0		
Group II				
CCl_4	Carbon tetrachloride	1.1		Cleaning Agent Solvent
Group III				
$C_2H_3Cl_3$	1,1,1-trichloroethane*/ methyl chloroform	0.1		Cleaning Agent Solvent

**This formula does not refer to 1, 1, 2-trichloroethane*

ANNEX C: CONTROLLED SUBSTANCES

Group I	Substance	Ozone-Depleting Potential*	Global Warming Potential (100)	Common Uses
$CHFCl_2$	HCFC-21**	0.04		
CHF_2Cl	HCFC-22**	0.055	1810	Refrigerant
CH_2FCl	HCFC-31	0.02		
C_2HFCl_4	HCFC-121	0.01-0.04		
$C_2HF_2Cl_3$	HCFC-122	0.02-0.08		
$C_2HF_3Cl_2$	HCFC-123**	0.02-0.06	77	Fire Extinguishant
$CHCl_2CF_3$	HCFC-123	0.02		Refrigerant Blowing Agent
C_2HF_4Cl	HCFC-124**	0.02-0.04	620	
$CHFClCF_3$	HCFC-124	0.022		Refrigerant Blowing Agent
$C_2H_2FCl_3$	HCFC-131	0.007-0.05		
$C_2H_2F_2Cl_2$	HCFC-132	0.008-0.05		
$C_2H_2F_3Cl$	HCFC-133	0.02-0.06		
$C_2H_3FCl_2$	HCFC-141	0.005-0.07		
CH_3CFCl_2	HCFC-141b**	0.11	700	Blowing Agent
$C_2H_4F_2Cl$	HCFC-142	0.008-0.07		
CH_3CF_2Cl	HCFC-142b**	0.065	2400	
C_2H_4FCl	HCFC-151	0.003-0.005		
C_3HFCl_6	HCFC-221	0.015-0.07		
$C_3HF_2Cl_3$	HCFC-222	0.01-0.09		
$C_3HF_3Cl_4$	HCFC-223	0.01-0.08		

* *Where a range of ODP is indicated, the highest value in that range shall be used for the purpose of the Montreal Protocol. The ODPs listed as a single value have been determined from calculations based on laboratory measurements. Those listed as a range are based on estimates and are less certain. The range pertains to an isometric group. The upper value is the estimate of the ODP of the isomer with the highest ODP, and the lower value is the estimate of the ODP of the isomer with the lowest ODP.*

***Identifies the most commercially viable substances with ODP values listed against them to be used for the purposes of the Protocol.*

Group I	Substance	Ozone-Depleting Potential*	Global Warming Potential (100)	Common Uses
$C_3HF_4Cl_3$	HCFC-224	0.01-0.09		
$C_3HF_3Cl_2$	HCFC-225	0.02-0.07		Cleaning Agent Solvent
$CF_3CF_2CHCl_2$	HCFC-225ca	0.025		Cleaning Agent Solvent
CF_2ClCF_2CHClF	HCFC-225cb	0.033		Cleaning Agent Solvent
C_3HF_6Cl	HCFC-226	0.02-0.10		
$C_3H_2FCl_3$	HCFC-231	0.05-0.09		
$C_3H_2F_2Cl_4$	HCFC-232	0.08-0.10		
$C_3H_2F_3Cl_3$	HCFC-233	0.007-0.23		
$C_2H_3F_4Cl_2$	HCFC-234	0.01-0.28		
$C_3H_3F_5Cl$	HCFC-235	0.03-0.52		
$C_3H_3FCl_4$	HCFC-241	0.004-0.09		
$C_3H_3F_2Cl_3$	HCFC-242	0.005-0.13		
$C_3H_3F_3Cl_2$	HCFC-243	0.007-0.12		
$C_3H_3F_4Cl$	HCFC-244	0.009-0.14		
$C_3H_4FCl_3$	HCFC-251	0.001-0.01		
$C_3H_4F_2Cl_2$	HCFC-252	0.005-0.04		
$C_3H_4F_3Cl$	HCFC-253	0.003-0.03		
$C_3H_5FCl_2$	HCFC-261	0.002-0.02		
$C_3H_5F_2Cl$	HCFC-262	0.002-0.02		
C_3H_6FCl	HCFC-271	0.001-0.03		

Group II	Substance	Ozone-Depleting Potential	Global Warming Potential	Common Uses
$CHFBr_2$		1.00		
CHF_2Br	(HBFC-22B1)	0.74		
CH_2FBr		0.73		
C_2HFBr_4		0.0-0.8		
$C_2HF_2Br_3$		0.5-1.8		
$C_2HF_3Br_2$		0.4-1.6		
C_2HF_4Br		0.7-1.2		
$C_2H_2FBr_3$		0.1-1.1		
$C_2H_2F_2Br_2$		0.2-1.5		
$C_2H_2F_3Br$		0.7-1.6		
$C_2H_3FBr_2$		0.1-1.7		
$C_2H_3F_2Br$		0.2-1.1		
C_2H_4FBr		0.07-0.1		
C_3HFBr_6		0.3-1.5		
$C_3HF_2Br_5$		0.2-1.9		
$C_3HF_3Br_4$		0.3-1.8		
$C_3HF_4Br_3$		0.5-2.2		
$C_3HF_5Br_2$		0.9-2.0		
C_3HF_4Br		0.7-3.3		
$C_3H_2FBr_5$		0.1-1.9		
$C_3H_2F_2Br_4$		0.2-2.1		
$C_3H_2F_3Br_3$		0.2-5.6		
$C_3H_2F_4Br_2$		0.3-7.5		
$C_3H_2F_5Br$		0.9-1.4		
$C_3H_3F_2Br_3$		0.1-3.1		
$C_3H_3F_3Br_2$		0.1-2.5		
$C_3H_3F_4Br$		0.3-4.4		
$C_3H_4FBr_3$		0.03-0.3		
$C_3H_4F_2Br_2$		0.1-1.0		
$C_3H_4F_3Br$		0.07-0.8		
$C_3H_5FBr_2$		0.04-0.4		
$C_3H_5F_2Br$		0.07-0.8		
C_3H_6FBr		0.02-0.7		

Group III	Substance	Ozone-Depleting Potential	Global Warming Potential (100)	Common Uses
CH2BrCl	bromochloromethane	0.12		

ANNEX E: CONTROLLED SUBSTANCE

Group I	Substance	Ozone-Depleting Potential*	Global Warming Potential (100)	Common Uses
CH_3Br	methyl bromide	0.6		quarantine pre-shipment

PART 7.2 - ACCEPTABLE INDUSTRY STANDARDS FOR MAC SYSTEMS

PNS SAE J639 APR94 -	Safety Containment of Refrigerant for Mechanical Vapor Compression Systems Used for MAC Systems/ Vehicle Service Coupling Air Conditioning System
PNS SAE 1770 OCT95 -	Automotive Refrigerant Recovery/Recycling Equipment Intended for Use with both R-12 and R-134a
PNS SAE J1732 DEC94 -	HFC-134a Extraction Equipment for Mobile Automotive
PNS SAE J1628 JUN93 -	Technician Procedure for Using Electronic Refrigerant Leak Detectors for Service MAC Systems
PNS SAE J1657 JUN93 -	Selection Criteria for Retrofit refrigerants to Replace CFC-12 in MAC System
PNS SAE J1660 JUN93 -	Fittings and Labels for Retrofit of CFC-12 MAC Systems to R-134a
PNS SAE J1661 JUN93 -	Procedure for Retrofitting CFC-12 in MAC System
PNS SAE J1662 JUN93 -	Material Compatibility with Alternate Refrigerants
PNS SAE J1990 MAR92 -	Extraction and Recycle Equipment for R-12 MAC Systems
PNS SAE J1989 OCT89 -	Recommended Service Procedure for the Containment of R-12
PNS SAE J2197 JUN92 -	HFC-134a Service Hose Fittings for Automotive AC System
PNS SAE J2209 JUN92 -	CFC-12 Extraction Equipment for MAC System
PNS SAE J2210 DEC91 -	Refrigerant Recycling Equipment for R-134a MAC System
PNS SAE J2211 DEC91 -	Recommended Service Procedure for the Containment of HFC-134a

PART 8: ANNEXES AND TABLES

PART 8.1 – ANNEXES

Annexes herein are sample forms for the concerned stakeholder to adopt, although they may have option to create their own form that they think would best suit their needs as long as all the important data are indicated.

PART 8.2 – TABLES AND CHARTS

Tables and Charts herein will serve as reference for technicians as well as practitioners in the refrigeration and air conditioning sector.

ANNEX 1 - SERVICE RECORD

ANNEX 1 – SERVICE RECORD

CONTRACTOR / SERVICE COMPANY

Name of Company: ______________________________
Address: ______________________________
Tel. No.: ______________ Fax No.: ______________
Accreditation No.: ______________ Expiry Date: ______________
Date of Service: ______________ Certificate No.: ______________
Name of technician: ______________________________
Time In: ______________ Time Out: ______________

SERVICED COMPANY

Name: ______________________________
Address: ______________________________
Tel. No.: ______________ Fax No.: ______________

UNIT / EQUIPMENT

Type of Compressor:
- ❑ Reciprocating
- ❑ Scroll
- ❑ Screw
- ❑ Rotary

Type of Unit:
- ❑ Packaged/Split Type
- ❑ Unitary Type
- ❑ Window Type
- ❑ Chiller
- ❑ Others (Specify) ______________

Brand: ______________
Capacity: ______________
Area Served: ______________
Unit No./Designation: ______________
Model No.: ______________
Serial No.: ______________

SERVICE CARRIED OUT

INSPECTION
Findings: ______________________________
Recommendations: ______________________________

REPAIR
Defect: ______________________________
Job Done: ______________________________

Method/Equipment Used:
- ❑ Electronic
- ❑ UV/Halogen
- ❑ Soap Bubble
- ❑ Others (Specify) ______________

READING

BEFORE SERVICE		AFTER SERVICE	
Suction Pressure:	______	Suction Pressure	______
Discharge Pressure:	______	Discharge Pressure	______
Amperages: L1:	______	Amperages: L1:	______
L2:	______	L2:	______
L3:	______	L3:	______

REFRIGERANT

Type: ______________
Total Charge (kg) ______________
Quantity Recovered (kg): ______________
Quantity Lost (kg): ______________
Quantity for Recycling (kg): ______________
Quantity of Old Refrigerant Recharged (kg): ______________
Quantity of New Refrigerant Recharged (kg): ______________
Accredited Company In-charged for Reclaim/recycle: ______________

SUPERVISING ENGINEER: ______________ TECHNICIAN'S SIGNATURE: ______________
(Name and Signature)

ANNEX 2 - RETROFITTING DATA SHEET

ANNEX 2 – RETROFITTING DATA SHEET

SERVICED COMPANY

Name: ______________________________

Address: ______________________________

Tel. No.: ____________________ Fax no.: ____________________

UNIT / EQUIPMENT

Type of Compressor:
- ❑ Reciprocating
- ❑ Scroll
- ❑ Screw
- ❑ Rotary

Type of Unit:
- ❑ Packaged/Split Type
- ❑ Unitary Type
- ❑ Window Type
- ❑ Chiller
- ❑ Others (Specify)____________________

Brand: ______________________________

Capacity: ______________________________

Area Served: ______________________________

Unit No./Designation: ____________________

Model No.: ______________________________

Serial No.: ______________________________

CONTRACTOR / SERVICE COMPANY

Name of Company: ______________________________

Address: ______________________________

Tel. No.: ____________________ Fax No.: ____________________

Accreditation No.: ____________________ Expiry Date: ____________________

Name of Technician: ____________________ Certificate No.: ____________________

DATES

Date Started: ____________________ Date Finished: ____________________

DATA

	OLD	NEW
A. REFRIGERANT SPECS		
Type	________	________
Quantity	________	________
B. LUBRICANT/OIL		
Type	________	________
Quantity	________	________
C. READINGS		
Suction Pressure	________	________
Discharge Pressure	________	________
Amperages: L1	________	________
L2	________	________
L3	________	________

LEAK TEST METHOD

- ❑ Soap and bubble
- ❑ Electronic
- ❑ Others (Specify) ____________________

REFRIGERANT CONTAINMENT

- ❑ Recovered for re-use
- ❑ Recovered for recycling

Company In-charged for Reclaim/recycling: ____________________

____________________ SUPERVISING ENGINEER'S NAME & SIGNATURE

____________________ TECHNICIAN'S SIGNATURE

END USER'S NAME & SIGNATURE: ____________________

ANNEX 3 - EQUIPMENT NAME PLATE

ANNEX 3 – EQUIPMENT NAMEPLATE

SERVICED COMPANY

Name: ____________________
Address: ____________________
Tel. No.: ____________________ Fax No.: ____________________

UNIT / EQUIPMENT

Brand: ____________________ Type: ____________________
Unit No.: ____________________ Capacity: ____________________
Location: ____________________
Manufacturer: ____________________
Model No.: ____________________ Serial No.: ____________________ Year: __________

TECHNICAL DATA

Maximum allowable pressure: ____________________
Test Pressure: ____________________
Max. Allowable Temp.: ____________________
Min. Allowable Temp.: ____________________
Low Pressure Switch Setting: ____________________
High Pressure Switch Setting: ____________________

REFRIGERANT

Type: ____________________ Quantity: ____________________

OIL / LUBRICANT

Type: ____________________ Quantity: ____________________ Viscosity: ____________________

SAFETY RELATED DATA

Person in-charge: ____________________ Telephone No.: ____________________

SERVICE CONTRACTOR

Company Name: ____________________
Address: ____________________
Telephone No.: ____________________ Fax No.: ____________________
Accreditation No.: ____________________

ANNEX 4 - USER SPECIFIC DATA

ANNEX 4 – USER SPECIFIC DATA

OWNER DATA

Name: ______________________________
Address: ______________________________
Telephone No.: ______________ Fax No.: ______________
E-mail Address: ______________________________

EQUIPMENT DATA

Capacity: ______________ Type: ______________
Brand: ______________________________
Model No.: ______________ Serial No.: ______________

LOCATION

Room: __________ Floor: __________
Name of Building: ______________________________
Building Address: ______________________________

RESPONSIBILITY

Department: ______________________________
Supervising Engineer: ______________________________
Telephone: ______________________________

SERVICE CONTRACT

Name of Contractor: ______________________________
Address: ______________________________
Telephone No.: ______________ Fax No.: ______________
E-mail Address: ______________________________
Technician In-charge: ______________________________
Certificate No.: ______________________________
Expiration of Contract: ______________________________
Service Interval: ______________________________

ANNEX 5 – SERVICE REPORT

COMPANY NAME
ADDRESS
CONTACT NO.
ACCREDITATION NO.

SERVICE REPORT

Customer ______________________ Tel. No. ______________ Date ________
Address ______________________________ Car Type ________________

JOB DONE

❑ PULL DOWN EVAPORATOR	( ) CLEANING	( ) WELDING	( ) REPLACEMENT
❑ REPLACE	( ) EXPANSION VALV	( ) RECEIVER DRIER	
❑ PULLDOWN COMPRESSOR	( ) OVERHAUL	( ) SEMI-OVERHAUL	( ) CHANGE OIL
	( ) REPLACE COMP.	( ) LEAK REPAIR	( ) REPLACE MAGNETIC COIL
	( ) REPLACE COMP. INCL. BRACKET FABRICATION		( ) REPLACE CLUTCH BEARING
❑ ELECTRICAL REPAIR/CHANGE WIRING	( ) SINGLE/DUAL	( ) MAJOR/MINOR	
❑ PULLDOWN CONDENSER/RADIATOR	( ) REPLACE/REPAIR	( ) CLEANING	( ) RETIGHT ROTOR
❑ AUXILIARY FAN	( ) REPLACE/REPAIR	( ) INSTALL	
❑ REPLACE/MODIFY	( ) D-HOSE	( ) S-HOSE	( ) H-HOSE
❑ PULLDOWN PIPES	( ) REPAIR WITH BRAZING	( ) MODIFY	( ) REPLACE
❑ FLUSHING OF A/C SYSTEM	( ) SINGLE	( ) DUAL	
❑ REPLACE	( ) IDLER BEARING	( ) PULLEY	( ) BELT
❑ OTHERS, PLEASE SPECIFY			

____

PARTS/CONSUMABLES

ITEM	QUANTITY	DESCRIPTION
❑		COMPRESSOR
❑		EVAPORATOR
❑		EXPANSION VALVE
❑		RECEIVER DRIER
❑		CONDENSER
❑		AUXILIARY FAN
❑		O-RING ( ) RBR ( ) NBR
❑		OIL ( ) PAG/SYNTHETIC ( ) MINERAL
❑		REFRIGERANT ( ) R 134a ( ) R 12 ( ) Others________
❑		IDLE BEARING
❑		MAIN BEARING
❑		CENTER BEARING
❑		CLUTCH BEARING
❑		HOSES
❑		NITROGEN
❑		COIL CLEANER
❑		FLUSHING SOLUTION (NON-CFC)
❑		OTHERS, PLEASE SPECIFY

READINGS

SUCTION PRESSURE: ______________________ DISCHARGEPRESSURE:______________________

TECHNICIAN: ______________________________ CERTIFICATE NO.: ______________________
Name and signature

OWNER: ______________________________
Name and signature

No. 00000

ANNEX 6 – REFRIGERANT CONVERSION LABEL

COMPANY NAME
ADDRESS
CONTACT NO.
ACCREDITATION NO.

NOTICE : RETROFITTED TO R 134a

RETROFIT PROCEDURE CONFORMED WITH PNS SAE J1661
USE ONLY R 134a AND SYNTHETIC OIL

REFRIGERANT CHARGE/AMOUNT : ______________________
LUBRICANT AMOUNT : ______________________

- ❑ PAG
- ❑ ESTER

Retrofitted by: ______________________ Signature: ______________
CertificateNo.:______________________Date:________________

DO NOT REMOVE

Flammable Refrigerant R290 Service	
Company	
Name of Technician	
Address	
Telephone & Fax No.	
Certificate No.	
 Flammable Refrigerant	This System is charged with the natural and environmental protective Refrigerant R290
Refrigerant Charge in kg	
Lubricant Type & Charge	
Date:	
Signature:	

ANNEX 7 – START-UP DATA SHEET

COMPANY NAME
ADDRESS
TEL. NO.
ACCREDITATION NO.

START-UP DATA SHEET

OWNER DATA

Name of Owner: ______________________________
Address: ______________________________
Contact Person: ______________________ Tel. No.: ____________

INSTALLATION DATA

Technician In-charge: ____________________ Accreditation No.: __________
Date Started: __________ Date Finished: __________ Start-up Date: __________
FCU Model No. __________________ ACCU Model No.: __________________
FCU Serial No.: __________________ ACCU Serial No.: __________________

OPERATING DATA

Suction Line Temperature: __________ Suction Line Pressure: __________
Discharge Line Temperature: __________ Discharge Line Pressure: __________
FCU Intake Air Temperature: __________ FCU Discharge Air Temp.: __________
ACCU Intake Air Temperature: __________ ACCU Discharge Air Temp.: __________
Room Temperature: __________ Ambient Temperature: __________

ELECTRICAL PARAMETERS

Power Supply (Voltage), L1: __________ L2: __________ L3: __________
Overall Ampere Readings, L1: __________ L2: __________ L3: __________
Current Draws, Compressor: ______ ACCU Fan Motor: ______ FCU Fan Motor: ______

OTHER INSTALLATION DATA

Refrigerant Piping:
Suction Diameter: __________ Length: __________ Insulation Thickness: __________
Discharge Diameter: __________ Length: __________ Insulation Thickness: __________
Drain Line:
Drain Line Diameter: __________ Length: __________ Insulation Thickness: __________
Electrical Lines:
Feeder Line Conduit Diameter: __________ Feeder Line Wire Size: __________ Length: ______
Control Line Conduit Diameter: __________ Control Line Wire Size: __________ Length: ______
Circuit Breaker: __________

Technician's Signature : ____________________

Owner's Signature: ____________________

ANNEX 8 - INSPECTION CHECKLIST

ANNEX 8 – INSPECTION CHECKLIST		
	Date	
	Technician Signature	
	Value/ Remarks	Value/ Ok
3.1	**General**	
3.1.1	Inspect panels (insulated cabinet, control panel, etc.); schedule repair, if necessary.	
3.1.2	Inspect unit switches for unusual or abnormal condition.	
3.1.3	Check bearings for any unusual sound and vibration. Apply grease or oil, if necessary.	
3.1.4	Check tightness of all bolts and screws; tighten, if necessary.	
3.1.5	Check fan and fan housing for dirt accumulation; clean, if necessary.	
3.2	**Refrigerant/oil system**	
3.2.1	Inspect condition of refrigerant piping insulation, and schedule repair or replacement, if necessary.	
3.2.2	Inspect sight glass (if present) for refrigerant flow/quality.	
3.2.3	Visually inspect for refrigerant leaks as indicated by oily spots and use appropriate leak detector to accurately locate the leak.	
3.2.4	Check schrader/access valves, packing glands, O-rings and service caps for tightness.	
3.2.5	Check compressor oil level (if applicable). If it is low, report for further analysis.	
3.2.6	Check oil for discoloration indicating that oil need to be replaced and system checked. If it is discolored, report for further analysis.	
3.2.7	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.	
3.2.8	Check Oil Failure Pressure Switch (if applicable).	
3.2.9	Check operating pressures:	
3.2.10.1	Suction	
3.2.10.2	Discharge	
3.2.10.3	Oil Pressure (if applicable)	
3.3	**Secondary warm side**	
3.3.1	Check condenser coils for dirt accumulation; clean, if necessary.	
3.3.2	Condenser Water Supply (if applicable)	
3.3.3	Condenser Water Return (if applicable)	
3.3.4	Check operating temperatures:	
3.3.4.1	Condenser water supply (if applicable)	
3.3.4.2	Condenser water return (if applicable)	
3.3.4.3	Condenser Supply Air (if applicable)	
3.3.4.4	Condenser Return Air (if applicable)	
3.3.5	Check condenser water pumps' operating parameters (if applicable):	
3.3.5.1	Suction pressure	
3.3.5.2	Discharge pressure	
3.3.6	Check cooling tower's water level, make-up water and other operating parameters and abnormalities.	
3.4	**Secondary Cold side**	
3.4.1	Check evaporator coils for dirt accumulation; clean, if necessary.	
3.4.2	Check drain pan for any dirt accumulation; clean, if necessary.	
3.4.3	Check drain line to ensure continues condensate flow, de-clog, if necessary.	
3.4.4	Check chilled water expansion tank's water level and float valve.	
3.3.6	Check cooling tower's water level, make-up water and other operating parameters and abnormalities.	
3.4.5	Check operating temperatures:	
3.4.5.1	Evaporator water supply (if applicable)	
3.4.5.2	Evaporator water return (if applicable)	
3.4.5.3	Evaporator Supply Air (if applicable)	
3.4.5.4	Evaporator Return Air (if applicable)	
3.4.5.5	Chilled Water Supply Pressure (if applicable)	
3.4.5.6	Chilled Water Return Pressure (if applicable)	
3.5	**Electrical/control system**	
3.5.1	Check and clean all electrical contacts and terminals. Tighten loose terminals.	
3.5.2	Check quality of power supply. Ensure that power supply is within ±10% of the rated voltage requirement of the equipment.	
3.5.3	Take reading of compressor motor current draw.	
3.5.4	Overload relays	
3.5.5	Check belt tensions and alignment of pulley; adjust, if necessary.	
3.5.6	Check belt for any abnormal wear. Determine its cause and make necessary correction.	
3.5.7	Take reading of fan and pump motor current draw.	
3.5.8	Check all electrical controls; calibrate, if necessary:	
3.5.8.1	High and Low Pressure switch	
3.5.8.2	Timers	
3.5.8.3	Thermostat	
3.5.8.4	All other electronically controlled devices	

TABLE 1 – ARI REFRIGERANT CONTAINER COLOR ASSIGNMENT

ASHRAE Number	Color Assignment
R-11	Orange *
R-12	White *
R-13	Light Blue (Sky) *
R-13B1	Pinkish-Red (Coral)
R-14	Yellow Brown (Mustard) *
R-22	Light Green *
R-23	Light Blue Gray
R-113	Dark Purple (Violet) *
R-114	Dark Blue (Navy) *
R-123	Light Blue-Grey *
R-124	Deep Green (DOT Green) *
R-125	Medium Brown (Tan)
R-134a	Light Blue (Sky)
R-141b	Unassigned *
R-401a	Pinkish-Red (Coral)
R-401b	Yellow-Brown (Mustard)
R-401c	Blue-Green (Aqua)
R-402a	Light Brown (Sand) *
R-402b	Green-Brown (Olive) *
R-404a	Orange
R-407a	Lime Green
R-407b	Cream
R-407c	Medium Brown
R-408a	Medium Purple *
R-409a	Medium Brown (Tan) *
R-410a	Rose
R-410b	Maroon
R-411a	Dark Purple (Violet) *
R-411b	Blue Green (Teal) *
R-414b	Medium Blue *
R-416a	Yellow-Green (Lime)
R-500	Yellow *
R-502	Light Purple (Lavender) *
R-503	Blue-Green (Aqua) *
R-507a	Blue-Green (Teal)
R-508b	Dark Blue (Navy) *

Note: * – Contain ODS

TABLE 2 - MAXIMUM ALLOWABLE CONTAINER PRESSURE FOR R-12

ENGLISH UNITS									
TEMP °F	PSIG	TEMP °F	PSIG	TEMP °F	PSIG	TEMP °F	PSIG	TEMP °F	PSIG
65	74	75	87	85	102	95	118	105	136
66	75	76	88	86	103	96	120	106	138
67	76	77	90	87	105	97	122	107	140
68	78	78	92	88	107	98	124	108	142
69	79	79	94	89	108	99	125	109	144
70	80	80	96	90	110	100	127	110	146
71	81	81	98	91	111	111	129	111	148
72	83	82	99	92	113	113	130	112	150
73	84	83	100	93	115	115	132	113	152
74	86	84	101	94	116	116	134	114	154

METRIC UNITS									
TEMP °C	PRES	TEMP °C	PRES	TEMP °C	PRES	TEMP °C	PRES	TEMP °C	PRES
18.3	5.20	23.9	6.11	29.4	7.17	35.0	8.29	40.5	9.56
18.8	5.27	24.4	6.18	30.0	7.24	35.5	8.43	41.1	9.7
19.4	5.34	25.0	6.32	30.5	7.38	36.1	8.57	41.6	9.84
20.0	5.48	25.5	6.46	31.1	7.52	36.6	8.71	42.2	9.98
20.5	5.55	26.1	6.6	31.6	7.59	37.2	8.78	42.7	10.12
21.1	5.62	26.6	6.74	32.2	7.73	37.7	8.92	43.3	10.26
21.6	5.76	27.2	6.88	32.7	7.8	38.3	9.06	43.9	10.4
22.2	5.83	27.7	6.95	33.3	7.94	38.8	9.13	44.4	10.54
22.7	5.9	28.3	7.03	33.9	8.08	39.4	9.27	45.0	10.68
23.3	6.04	28.9	7.1	34.4	8.15	40.0	9.42	45.5	10.82

Note: PRES in kg/sq.cm.

TABLE 3 - MAXIMUM ALLOWABLE CONTAINER PRESSURE FOR R-134a

METRIC UNITS							
TEMP °C	kPa	TEMP °C	kPa	TEMP °C	kPa	TEMP °C	kPa
18	476	26	621	34	793	42	1007
19	483	27	642	35	814	43	1027
20	503	28	655	36	841	44	1055
21	524	29	676	37	876	45	1089
22	545	30	703	38	889	46	1124
23	552	31	724	39	917	47	1158
24	572	32	752	40	945	48	1179
25	593	33	765	41	979	49	1214

ENGLISH UNITS							
TEMP °F	psig	TEMP °F	psig	TEMP °F	psig	TEMP °F	psig
65.0	69.00	79.0	90	93.0	115	107.0	144
66.0	70	80.0	91	94.0	117	108.0	146
67.0	71	81.0	93	95.0	118	109.0	149
68.0	73	82.0	95	96.0	120	110.0	151
69.0	74	83.0	96	97.0	122	111.0	153
70.0	76	84.0	98	98.0	125	112.0	156
71.0	77	85.0	100	99.0	127	113.0	158
72.0	79	86.0	102	100.0	129	114.0	160
73.0	80	87.0	103	101.0	131	115.0	163
74.0	82	88.0	105	102.0	133	116.0	165
75.0	83	89.0	107	103.0	135	117.0	168
76.0	85	90.0	109	104.0	137	118.0	171
77.0	86	91.0	111	105.0	139	119.0	173
78.0	88	92.0	113	106.0	142	120.0	176

Note: PRES in kg/sq.cm.

TABLE 4 - PRESSURE TEMPERATURE CHART FOR REFRIGERANTS

°F	°C	R123	R22	R407C Liquid Pressure	R407C Vapor Pressure	R410A	R12	R134A	R404A	R507	R502	R402A
-40	-40		0.5	3	4.4	11.6	11	14.8	4.3	5.5	4.1	6.3
-35	-37.2		2.6	5.4	0.6	14.9	8.4	12.5	6.8	8.2	6.5	9.1
-30	-34.4		4.9	8	1.8	18.5	5.5	9.9	9.5	11.1	9.2	12.1
-25	-31.7		7.4	10.9	4.1	22.5	2.3	6.9	12.5	14.3	12.1	15.4
-20	-28.9	27.8	10.1	14.1	6.6	26.9	0.6	3.7	15.7	17.8	15.3	18.9
-15	-26.1	27.4	13.2	17.6	9.4	31.7	2.4	0.6	19.3	21.7	18.8	22.9
-10	-23.3	26.9	16.5	21.3	12.5	36.8	4.5	1.9	23.2	25.8	22.6	27.1
-5	-20.6	26.4	20.1	25.4	15.9	42.5	6.7	4	27.5	30.3	26.7	31.7
0	-17.8	25.9	24	29.9	19.6	48.6	9.2	6.5	32.1	35.2	31.1	36.7
5	-15	25.2	28.2	34.7	23.6	55.2	11.8	9.1	37	40.5	35.9	42.1
10	-12.2	24.5	32.8	39.9	28	62.3	14.6	11.9	42.4	46.1	41	48
15	-9.4	23.8	37.7	45.6	32.8	70	17.7	15	48.2	52.2	46.5	54.2
20	-6.7	22.8	43	51.6	38	78.3	21	18.4	54.5	58.8	52.4	60.9
25	-3.9	21.8	48.8	58.2	43.6	87.3	24.6	22.1	61.2	65.8	58.8	68.1
30	-1.1	20.7	54.9	65.2	49.6	96.8	28.5	26.1	68.4	73.3	65.6	75.8
35	1.7	19.5	61.5	72.6	56.1	107	32.6	30.4	76.1	81.3	72.8	84
40	4.4	18.1	68.5	80.7	63.1	118	37	35	84.4	89.8	80.5	92.8
45	7.2	16.6	76	89.2	70.6	130	41.7	40.1	93.2	98.9	88.7	102
50	10	14.9	84	98.3	78.7	142	46.7	45.5	103	109	97.4	112
55	12.8	13	92.6	108	87.3	155	52	51.3	113	119	107	123
60	15.6	11.2	102	118	96.8	170	57.7	57.5	123	130	116	134
65	18.3	8.9	111	129	106	185	63.8	64.1	135	141	127	146
70	21.1	6.5	121	141	117	201	70.2	71.2	147	154	138	158
75	23.9	4.1	132	153	128	217	77	78.8	159	167	149	171
80	26.7	1.2	144	166	140	235	84.2	86.8	173	180	161	185
85	29.4	0.9	156	180	153	254	91.8	95.4	187	195	174	200
90	32.2	2.5	168	195	166	274	99.8	104	202	210	187	215
95	35	4.3	182	210	181	295	108	114	218	226	201	232
100	37.8	6.1	196	226	196	317	117	124	234	244	216	249
105	40.6	8.1	211	243	211	340	127	135	252	262	232	267
110	43.3	10.3	226	261	229	365	136	147	270	281	248	286
115	46.1	12.6	243	280	247	391	147	159	289	301	265	305
120	48.9	15.1	260	300	266	418	158	171	310	322	283	326
125	51.7	17.8	278	321	286	446	169	185	331	344	301	347
130	54.4	20.6	297	342	307	476	181	199	353	368	321	370
135	57.2	23.6	317	365	329	507	194	214	377	393	341	393
140	60	26.8	337	389	353	539	207	229	401	419	363	418
145	62.8	30.2	359	-	-	573	220	246	426	446	-	443
150	65.6	33.9	382	-	-	608	234	263	453	475	-	470

Note: For R402A, R402B, R404A and R408A Saturated Vapor Temperatures are shown.

VAPOR PRESSURES - psig

RED FIGURES (IN Hg) VACUUM

TABLE 4 - PRESSURE TEMPERATURE CHART

TEMPERATURE		HR600a		HR290		HR601a	
°C	°F	kPa	psi	kPa	psi	kPa	psi
-40	-40	-72.2	-10.5	13.6	2.0	-96.7	-14.0
-38	-36	-69.2	-10	23.5	3.4	-96.1	-14.0
-36	-33	-65.9	-9.6	34	4.9	-95.5	-13.9
-34	-29	-62.3	-9	45.2	6.6	-94.8	-13.8
-32	-26	-58.5	-8.5	57.1	8.3	-94	-13.6
-30	-22	-54.3	-7.9	69.8	10.1	-93.2	-13.5
-28	-18	-49.9	-7.2	83.2	12.1	-92.3	-13.4
-26	-15	-45.1	-6.5	97.5	14.2	-91.2	-13.2
-24	-11	-39.9	-5.8	112.7	16.4	-90.1	-13.1
-22	-8	-34.4	-5	128.7	18.7	-88.9	-12.9
-20	-4	-28.5	-4.1	145.6	21.1	-87.6	-12.7
-18	0	-22.2	-3.2	163.6	23.7	-86.1	-12.5
-16	3	-15.5	-2.3	182.5	26.5	-84.6	-12.3
-14	7	-8.4	-1.2	202.4	29.4	-82.8	-12.0
-12	10	-0.8	-0.1	223.4	32.4	-81.0	-11.8
-10	14	7.3	1.1	245.5	35.6	-79.0	-11.5
-8	18	15.9	2.3	268.8	39.0	-76.8	-11.2
-6	21	25	3.6	293.2	42.6	-74.5	-10.8
-4	25	34.6	5	318.9	46.3	-72	-10.5
-2	28	44.8	6.5	345.8	50.2	-69.3	-10.1
0	32	55.5	8.1	374.1	54.3	-66.4	-9.6
2	36	66.9	9.7	403.6	58.6	-63.3	-9.2
4	39	78.9	11.4	434.6	63.1	-60.0	-8.7
6	43	91.5	13.3	466.9	67.8	-56.5	-8.2
8	46	104.7	15.2	500.7	72.7	-52.7	-7.7
10	50	118.7	17.2	536.1	77.8	-48.7	-7.1
12	54	133.3	19.3	572.9	83.2	-44.4	-6.4
14	57	148.7	21.6	611.3	88.7	-39.8	-5.8
16	61	164.8	23.9	651.4	94.5	-35.0	-5.1
18	64	181.7	26.4	693.1	100.6	-29.8	-4.3
20	68	199.3	28.9	736.5	106.9	-24.4	-3.5
22	72	217.8	31.6	781.7	113.5	-18.6	-2.7
24	75	237.1	34.4	828.6	120.3	-12.5	-1.8
26	79	257.2	37.3	877.4	127.3	-6.0	-0.9

28	82	278.3	40.4	928.1	134.7	0.8	0.1
30	86	300.2	43.6	980.6	142.3	8.1	1.2
32	90	323.0	46.9	1035.1	150.2	15.6	2.3
34	93	346.8	50.3	1091.6	158.4	23.6	3.4
36	97	371.5	53.9	1150.1	166.9	32.1	4.7
38	100	397.2	57.7	1210.7	175.7	40.9	5.9
40	104	424.0	61.5	1273.4	184.8	50.2	7.3
42	108	451.7	65.6	1338.2	194.2	60.0	8.7
44	111	480.5	69.7	1405.3	204	70.2	10.2
46	115	510.3	74.1	1474.6	214	80.9	11.7
48	118	541.3	78.6	1546.1	224.4	92.1	13.4
50	122	573.3	83.2	1620	235.1	103.9	15.1
52	126	606.4	88.0	1696.2	246.2	116.2	16.9
54	129	640.8	93.0	1774.8	257.6	129.0	18.7
56	133	676.2	98.1	1855.8	269.4	142.4	20.7

TABLE 5 - CONVERSION CHARTS AND TABLES

TABLE A- PRESSURE SCALES COMPARISON

PRESSURE TYPE	POUNDS PER SQUARE INCH		INCHES MERCURY VACUUM In. Hg.	MPa	Bar
	ABSOLUTE	GAUGE			
POSITIVE PRESSURE	105 90 75 60 45 30	90 75 60 45 30 15		0.725 0.621 0.518 0.414 0.311 0.207	7.143 6.122 5.102 4.082 3.061 2.041
ATM. PRESSURE	14.7	0		0.101	1.0
NEG. PRESS. OR VACUUM	10 5 0	-5 -10 -15	10 20 29.9	0.069 0.035 0	0.680 0.340 0

TABLE B- CONVERSION CHART

Metric	x	= English	x	= SI
Area				
sq.cm sq.m	0.1550 10.76	sq.in sq.ft	645.2 0.09290	sq.mm sq.m
Length				
mm m m	0.03937 3.281 1.094	in ft yd	25.4 0.3048 0.9144	mm m m
Mass				
g kg	0.03527 2.205	Oz lb	28.35 0.4536	g kg
Power				
kcal/h kcal/h Mcal/h	 3.968 0.3307	 Btu/h Ton ref	1.163 0.2931 3.517	W W kw
Pressure				
kg/sq.cm kg/sq.cm	 14.22	 Psi Psi	98.07 6.895 0.006	KPa KPa MPa

OTHER CONVERSION FACTORS

Fahrenheit to Celsius
°C =0.55 (°F-32)

Celsius to Fahrenheit
°F = (1.8 x °C) +32

One ton of refrigeration = 12000 Btu/Hr or 3.517 kW/hr

1 HP = 0.7457 kW =2545 BTU/hr = 550 ft-lb/s

1kW = 3413 Btu/hr = 1.341 HP = 737.6 ft-lb/s

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