GOOD SERVICING PRACTICES
REFRIGERATION & AIR-CONDITIONING SECTOR [RAC]

the GUIDEBOOK

جمهورية مصر العربية – وزارة البيئة
Arab Republic of Egypt-Ministry of Environment

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National Ozone Unit
وحدة الأوزون – جهاز شئون البيئة

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REPUBLIC OF LEBANON
MINISTRY OF ENVIRONMENT

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Acknowledgements

This guidebook was jointly produced by the National Ozone Unit in Lebanon, Ministry of Environment and UNDP country office as part of the activities under the context of the HPMP Stage-II project, addressed to the RAC sector technicians and vocational schools students in Lebanon.

This Guidebook was prepared by the National Ozone Unit of Lebanon.

Special thanks to UN Environment - Ozonaction for providing the data and technical information.

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Communication & Administration Officer - NOU

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This guidebook is not a replacement of proper training for refrigeration and air-conditioning technicians. Inclusion of images of equipment and tools in this guidebook does not constitute an endorsement of the companies or products.

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1. INTRODUCTION

Lebanon has been implementing ODS phase-out projects and programmes since 1998. Lebanon has developed its HPMP (HCFCs phase-out management plan) overarching strategy, through close collaboration and intensive consultation between government and industry. The NOU is implementing a new phase targeting the phase-down of HFCs in all sectors mainly the refrigeration and air-conditioning sectors (RAC) where a major component of this phase is to introduce into the market flammable refrigerants in the different sub-sectors (air-conditioning, domestic and commercial refrigeration, and mobile air-conditioning) with an integrated strategy of redesigning the RAC equipment to replace current refrigerants with low GWP/climate freindly alternatives. While simultaneously improving the equipment, energy efficiency could double the climate benefits from the HFC phase-down alone while also supporting development through improved energy security and reduced energy costs to government and consumers.

The aim of this guidebook is to provide RAC students and servicing technicians with a quick reference to the key safety classifications and technical properties of commercially available refrigerants. Additionally, it provides important safety guidance for servicing A/C systems and good servicing practices for handling flammable refrigerants.

2. COMMON TYPES OF REFRIGERANTS

Refrigerant Name:	R-22 (HCFC-22)
Refrigerant Type:	HCFC
Chemical Name:	Chlorodifluoromethane ($CHCLF_2$)
Main Usage:	Refrigerant, solvent, feedstock or propellant
Application:	Refrigeration systems for retail food display and vending, refrigerated transport, large supermarket refrigeration systems, residential, split and ducted ACs, portable and window units, cold rooms, chillers, heat pumps and industrial process refrigeration
Safety Classification:	A1
HS Code (2012):	2903.71
Alternative Refrigerants:	R-134a, R-507, R-404A, R-407C, R-410A, R-290, R-744, (CO_2), Ammonia (R-717), R-32 and HFOs

ODP = 0.055

GWP = 1,810

Refrigerant Name:	R-123 (HCFC-123)
Refrigerant Type:	HCFC
Chemical Name:	Dichlorotrifluoroethanes ($C_2HF_3CL_2$)
Main Usage:	Refrigerant used in low pressure refrigeration/HVAC systems
Application:	Chillers, heat pumps and industrial process refrigeration
Safety Classification:	B1
HS Code (2012):	2903.72

Alternative Refrigerants: R-717, R-744 and HFOs

ODP = 0.02

GWP = 77

Refrigerant Name:	R-134a (HFC-134a)
Refrigerant Type:	HFC
Chemical Name:	Tetrafluoroethane (CH_2FCF_3)
Main Usage:	Refrigerant, propellant
Application:	Automative air-conditioners, chillers, medium temperature commercial refrigeration, refrigeration appliances (domestic refrigerators), transport refrigeration, propellants (MDIs)
Safety Classification:	A1
HS Code (2012):	2903.39

Alternative Refrigerants: R-600a, R-717, R-744, HFOs (R-1234yf)

ODP = 0

GWP = 1,430

Refrigerant Name:	R-227ea (HFC-227ea)
Refrigerant Type:	HFC
Chemical Name:	Heptafluoropropane (CF_3CHFCF_3)
Main Usage:	Refrigerant, propellant (MDIs) and firefighting agent
Application:	Used as a component of a blend for refrigeration and air-conditioning systems, high temperature refrigeration applications and heat pumps
Safety Classification:	A1
HS Code (2012):	2903.39

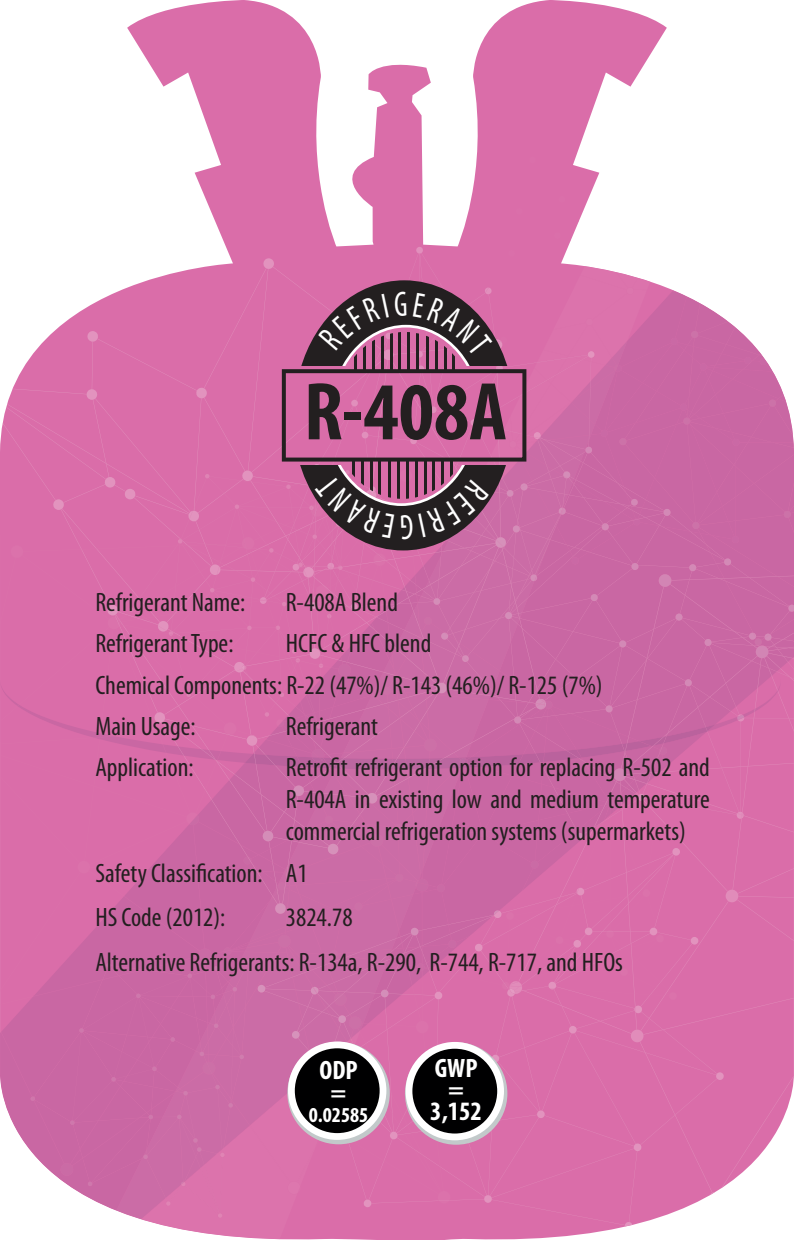
Alternative Refrigerants: R-290, R-600a and HFOs

ODP = 0

GWP = 3,220

Refrigerant Name:	R-32 (HFC-32)
Refrigerant Type:	HFC
Chemical Name:	Difluoromethane (CH_2F_2)
Main Usage:	Refrigerant
Application:	Air-conditioning systems (split units), refrigeration, small air-conditioning and refrigeration equipment and a component of various HFC mixtures systems
Safety Classification:	A2L
HS Code (2012):	2903.39

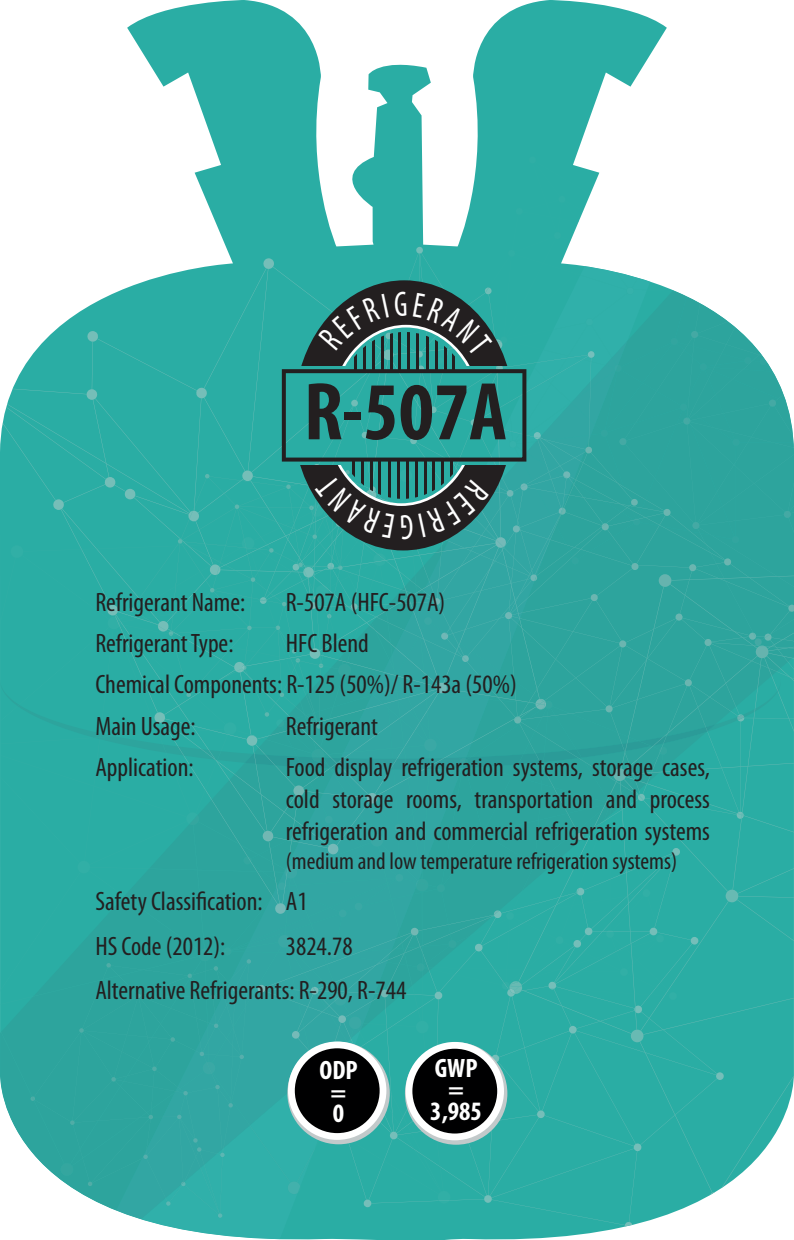
Alternative Refrigerants: R-290, HFOs



Refrigerant Name:	R-408A Blend
Refrigerant Type:	HCFC & HFC blend
Chemical Components:	R-22 (47%)/ R-143 (46%)/ R-125 (7%)
Main Usage:	Refrigerant
Application:	Retrofit refrigerant option for replacing R-502 and R-404A in existing low and medium temperature commercial refrigeration systems (supermarkets)
Safety Classification:	A1
HS Code (2012):	3824.78
Alternative Refrigerants:	R-134a, R-290, R-744, R-717, and HFOs

ODP = 0.02585

GWP = 3,152



Refrigerant Name: R-507A (HFC-507A)

Refrigerant Type: HFC Blend

Chemical Components: R-125 (50%)/ R-143a (50%)

Main Usage: Refrigerant

Application: Food display refrigeration systems, storage cases, cold storage rooms, transportation and process refrigeration and commercial refrigeration systems (medium and low temperature refrigeration systems)

Safety Classification: A1

HS Code (2012): 3824.78

Alternative Refrigerants: R-290, R-744

ODP = 0

GWP = 3,985

Refrigerant Name: R-404A (HFC-404A)

Refrigerant Type: HFC Blend

Chemical Components: R-125 (44%)/ R-143a (52%)/ R-134a (4%)

Main Usage: Refrigerant

Application: Freezers, coolers medium and low temperature refrigeration (supermarkets, cold rooms and ice machines)

Safety Classification: A1

HS Code (2012): 3824.78

Alternative Refrigerants: R-290, R-744, R-717, HFOs

ODP = 0

GWP = 3,922

Refrigerant Name: R-407A (HFC-407A)

Refrigerant Type: HFC Blend

Chemical Components: R-32 (20%)/ R-125 (40%)/ R-134a (40%)

Main Usage: Refrigerant

Application: Freezers, coolers medium and low temperature refrigeration (supermarkets, cold rooms and ice machines)

Safety Classification: A1

HS Code (2012): 3824.78

Alternative Refrigerants: R-744, R-290, HFOs

ODP = 0

GWP = 2,107

Refrigerant Name: R-407B (HFC-407B)

Refrigerant Type: HFC Blend

Chemical Components: R-32 (10%)/ R-125 (70%)/ R-134a (20%)

Main Usage: Refrigerant

Application: Freezers, coolers medium and low temperature refrigeration (supermarkets, cold rooms and ice machines)

Safety Classification: A1

HS Code (2012): 3824.78

Alternative Refrigerants: R-744, R-290, HFOs

Refrigerant Name: R-407C (HFC-407C)

Refrigerant Type: HFC Blend

Chemical Components: R-32 (23%)/ R-125 (25%)/ R-134a (52%)

Main Usage: Refrigerant

Application: Residential and commercial air-conditioning systems, heat pumps and medium temperature refrigeration systems

Safety Classification: A1

HS Code (2012): 3824.78

Alternative Refrigerants: R-290, R-410A, R-600a, HFOs

ODP = 0

GWP = 1,774

Refrigerant Name:	R-410A (HFC-410A)
Refrigerant Type:	HFC Blend
Chemical Components:	R-32 (50%)/ R-125 (50%)
Main Usage:	Refrigerant
Application:	Residential and central air-conditioning and heat pumps (split units and chillers)
Safety Classification:	A1
HS Code (2012):	3824.78
Alternative Refrigerants:	R-290, R-744, R-717

ODP = 0

GWP = 2,088

Refrigerant Name: R-1270

Refrigerant Type: Hydrocarbon (HC)

Chemical Name: Propene (C_3H_7)

Main Usage: Refrigerant

Application: Commercial and industrial refrigeration, vending machines (low and medium temperature refrigeration applications)

Safety Classification: A3

HS Code (2012): 2901.22

Alternative Refrigerants: None

Refrigerant Name:	R-600a (HC-600a)
Refrigerant Type:	Hydrocarbon (HC)
Chemical Name:	Isobutane (C_4H_{10})
Main Usage:	Refrigerant
Application:	Domestic, commercial and industrial refrigeration and vending machines
Safety Classification:	A3
HS Code (2012):	2901.10
Alternative Refrigerants:	None

Refrigerant Name: R-290 (HC-290)

Refrigerant Type: Hydrocarbon (HC)

Chemical Name: Propane (C_3H_8)

Main Usage: Refrigerant

Application: Split residential air conditioning systems, freezers, small commercial refrigeration appliances and vending machines

Safety Classification: A3

HS Code (2012): 2711.12

Alternative Refrigerants: None

Refrigerant Name:	R-717
Refrigerant Type:	Inorganic compound
Chemical Name:	Ammonia (NH_3)
Main Usage:	Refrigerant
Application:	Industrial refrigeration, transport refrigeration, industrial and commercial air-conditioning, chillers, industrial and commercial centrifugal compressors
Safety Classification:	B2L
HS Code (2012):	2814.10

Alternative Refrigerants: None

Refrigerant Name:	R-744
Refrigerant Type:	Inorganic compound
Chemical Name:	Carbon Dioxide (CO_2)
Main Usage:	Refrigerant
Application:	Commercial, transport and industrial refrigeration, mobile, industrial and commercial air-conditioning and industrial commercial centrifugal compressors
Safety Classification:	A1
HS Code (2012):	2811.21

Alternative Refrigerants: None

Refrigerant Name:	R-1234yf
Refrigerant Type:	Hydrofluoroolefin (HFO)
Chemical Name:	Tetrafluoropropene ($CF_3CF{=}CH_2$)
Main Usage:	Refrigerant
Application:	Mobile air-conditioning and domestic refrigeration
Safety Classification:	A2L
HS Code (2012):	2903.39

Alternative Refrigerants: None

Refrigerant Name:	R-1234ze (HFO-1234ze)
Refrigerant Type:	HFO
Chemical Name:	Transtetrafluoropropene ($C_3H_2F_4$)
Main Usage:	Refrigerant, foam blowing agent
Application:	Air and water cooled chillers for supermarkets and commercial buildings, foam blowing agent
Safety Classification:	A2L
HS Code (2012):	2903.39

Alternative Refrigerants: None

Refrigerant Name: R-1233zd (HFO-1233zd)

Refrigerant Type: HFO

Chemical Name: Chlorotrifluoropropene ($C_3H_2F_3CL$)

Main Usage: Refrigerant, foam blowing agent

Application: Air and water cooled chillers for supermarkets and commercial buildings, foam blowing agent

Safety Classification: A1

HS Code (2012): 2903.39

Alternative Refrigerants: None

ODP = 0.00034

GWP = 4

3. SAFE HANDLING OF FLAMMABLE REFRIGERANTS

3.1 Understanding the fire triangle

The fire triangle is composed of the three components that produce a physiochemical reaction to ignite a fire: heat, fuel, and oxygen. A fire can occur naturally when these three elements are simultaneously present in the appropriate proportions.

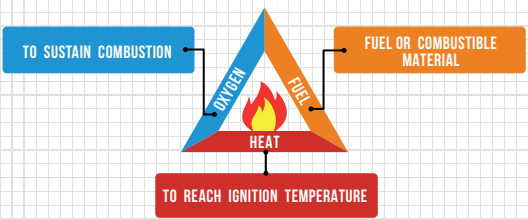


Figure 1: Fire triangle

The RAC servicing technician must organise and prepare work areas to avoid all potential fire hazard situations.

3.2 Flammability properties of refrigerants

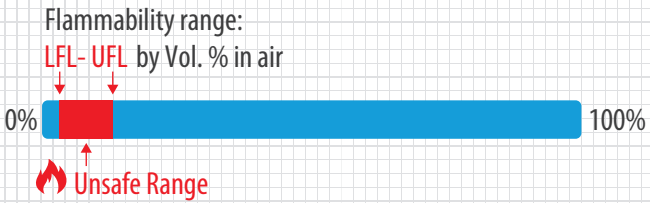


Figure 2: Flammability range

Lower flammability limit (LFL)
The minimum concentration of the refrigerant that is capable of propagating a flame.

Upper flammability limit (UFL)
The maximum concentration of the refrigerant that is capable of propagating a flame.

! Since a flame can be propagated in the range between LFL-UFL, one should avoid the concentration of refrigerant in the working area reaching the LFL and the temperature of refrigerant from reaching the auto-ignition temperature.

3.3 Key properties of the more common and commercially-available refrigerants

Refrigerant	R-134a	R-22	R-404A	R-407C
Lower Flammability Limit **LFL**	 Not Flammable	 Not Flammable	 Not Flammable	 Not Flammable
Upper Flammability Limit **UFL**	 Not Flammable	 Not Flammable	 Not Flammable	 Not Flammable

Refrigerant	R-410A	R-32	R-290	R-600a
Lower Flammability Limit **LFL**	 Not Flammable	14.4% By volume	2.1% By volume	1.7% By volume
Upper Flammability Limit **UFL**	 Not Flammable	33.4% By volume	9.6% By volume	9.7% By volume

Refrigerant	R-1234yf	R-1234ze	R-1233zd
Lower Flammability Limit **LFL**	6.2% By volume	7% By volume	 Not Flammable
Upper Flammability Limit **UFL**	12.3% By volume	12% By volume	 Not Flammable

3.4 Understanding refrigerant safety classification

The International Organization for Standardization (ISO) standard **ISO-817: Refrigerants-designation and safety classification** categorizes refrigerants on the basis of:

Toxicity:
which is assigned by the character A or B

Flammability:
which is assigned a classification 1, 2, 2L or 3

Table 1: Refrigerant safety classification

Class	Safety group A Lower toxicity	Safety group B Higher toxicity
 **3: Higher flammability**	A3 e.g. R-290, R-600a	B3
 **2: Flammability**	A2 e.g. R-152a	B2
 **2L: Lower flammability**	A2L e.g. R-32, R-1234yf	B2L e.g. R-717 (amonia)
1: No Flame propagation	A1 e.g. R-22, R-134a, R-410A, R-404A, R-407C, R-744	B1 e.g. R-123

! Full safety checks and procedures must be followed at all times and for all refrigerants, even when they are classified as lower toxicity or non-flammable.

4. GOOD SERVICING PRACTICES FOR HANDLING FLAMMABLE REFRIGERANTS

! WARNING: During servicing and repair activities, there is a very high possibility that refrigerants may be released. There can be potential sources of ignition especially in areas surrounding refrigerant charging and recovery. This leakage can also occur in the process of connecting and disconnecting of hoses.

! WARNING: RAC equipment designed for non-flammable refrigerants e.g. R-22 or R-410A are not designed to be used with flammable refrigerants and vice versa.

- Technicians must **not** retrofit any RAC system to use flammable refrigerants;
- Technicians must **not** drop-in/top-up flammable refrigerants in any RAC system not originally designed and/or manufactured to use flammable refrigerants.

4.1 Temporary flammable zone

Technicians should always consider working areas as "temporary flammable zones" during installation and maintenance. **This zone must be free from all ignition sources.**

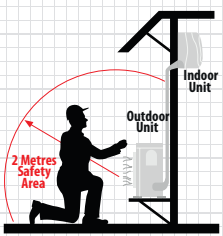


Figure 3: Temporary flammable zone

! A "Temporary flammable zone" is a minimum of 2 meters from the point in all directions for small appliances. For larger systems, a greater distance should be allowed.

4.2 Handling and storage of flammable refrigerants

Handling and storage requirements for flammable refrigerant cylinders are similar to those used for Liquefied Petroleum (LPG) cooking gas. As a normal rule, the maximum quantity of gas cylinders stored in residential premises must not exceed 50 liters (water capacity of cylinder).

Figure 4: Prohibited activities in cylinder storage area

The minimum fire protection for a storage facility of flammable refrigerants where the aggregate capacity is less than 1,000 liters (water capacity) is a water hose connected and ready for use.

! The following precautions should be observed:

- The storage area must be well ventilated and free of combustible material.
- Store the cylinders on the ground floor and above, but not in basements and other enclosed rooms.
- Keep the cylinders away from sources of heat and direct sun.
- Don't store the cylinders near sources of ignition (electrical sockets, power outlets, lights and switches, electric motors and similar equipment).
- Any potential ignition sources must be at least 2 meters away from the cylinder.
- Protect the cylinders from falling or being knocked over.
- Never place cylinders lying on their side.
- Have access to emergency services e.g. fire, police etc.

4.3 Good servicing practice procedures

Always comply with the equipment manufacturer's user manual for the specific system. Ensure that all good practice tools are readily available. Good RAC equipment servicing practices using flammable refrigerants should follow the following procedures.

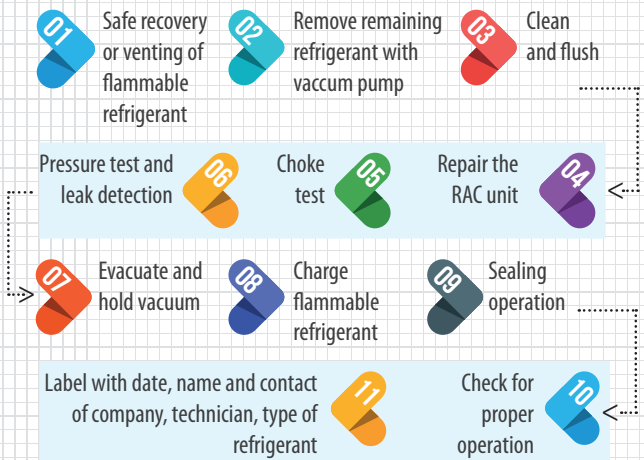


Figure 5: Good practice procedures

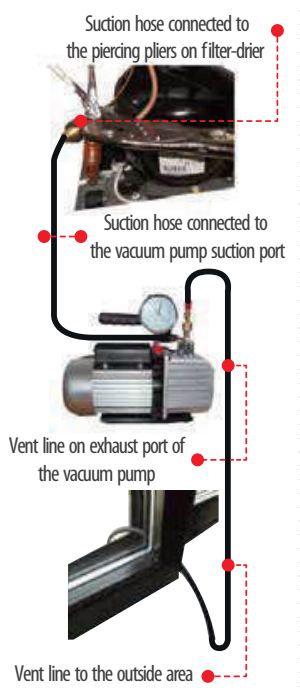
01 Safe recovery or venting of flammable refrigerant

R-32	Hydrocarbon (R-290 And R-600A)
With recovery machine - As R-32 has a moderate GWP, it should not be vented to the atmosphere. Use a suitable recovery machine to recover R-32 from the system.	**With recovery machine** - Use a suitable recovery machine to recover hydrocarbon refrigerants from the system. **Without recovery machine** - Safely vent using piercing pliers or piercing valve and a long hose to reach a safe area outside. Use suitable extractor fan or open window or door for ventilation.

Remove remaining refrigerant with vacuum pump

- Ensure that most of the refrigerant has been removed before opening the system by using a vacuum pump.

- Pressure in the system should not be reduced to below 2 pounds per square inch gauge (psig) or 0.14 bar.



Clean and Flush

After de-brazing the old filter from the repaired RAC equipment.

- Use dry nitrogen with a two stage regulator, at a pressure of about 5 bar.
- Use environmentally approved flushing solution where chemical cleaning is needed.
- Do not use carbon tetrachloride (CTC), R-141b, oxygen, air or petrol for flushing.

Nitrogen flush

Repair the RAC Unit

Follow the precautions summarized in the "Handling of flammable refrigerant" section above. Always follow the servicing procedures described in the manufacturer's user manual.

- Use correct components specially designed for flammable refrigerants.
- R-290 and R-600a are highly flammable refrigerants, servicing technicians are strongly advised not to braze the tube, but use 'Lokring' through mechanical extrusion of pipe connection and sealing, which is safe and reliable.
- For HFC-32, servicing technicians can braze the tube; always ensure that there is no refrigerant in the system.

Figure 6: Brazing

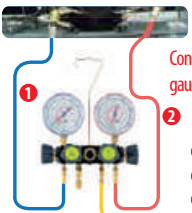
Choke test

Ensure that there are no chokes during brazing. Introduce dry nitrogen through the process tube checking for a free passage.
Use dry nitrogen with a two - stage nitrogen regulator.

Figure 7: Two stage regulator

Pressure test and leak detection

After the system is reassembled and sealed, use dry nitrogen for leak testing. **Do not use compressed air nor any refrigerant.**



Connect a 4-valve manifold gauge set to the system.

1. Low pressure side
2. High pressure side
3. Nitrogen supply

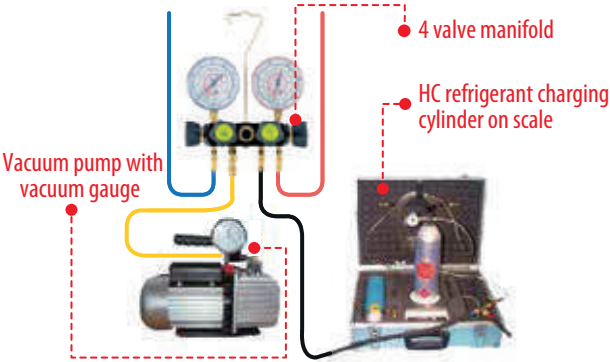
Test pressure to be regulated at 20 bar and close the cylinder valve when reading 20 bar.

Connect the Nitrogen cylinder to the centre port of the manifold gauge set.

Pressurize the system with dry nitrogen while transferring the gas from both, the high and low pressure side.

Use a soap solution → Brush/spray each joint – look for bubbles

Evacuation and hold vacuum



a. Connect to tube adapter or schrader valve (not piercing pliers).
b. Switch on pump, then open the valves.
c. Evacuate to at least 500 microns or lower.
d. Close the valves to isolate the pump.
e. In the absence of a micron vacuum gauge, the vacuum pump should be run for at least half an hour after the Bourdon - type vacuum gauge reading shows -30"/ -760 mm / 0 millibar (at sea level).
f. Do the vacuum holding for 5 minutes. There should not be a sharp rise in the micron gauge.
g. Vacuum pressure should be as low as possible. It must not be higher than 1,500 microns in the holding period of 5-10 minutes.

Charge flammable refrigerant

01 Only charge an evacuated system.

02 Charging should be done slowly/ gradually.

03 Use weighing scales for accurate charge quantity.

Figure 8: Refrigerant charging training

! Greater control and accuracy are required for hydrocarbons because of the smaller quantity of charge. The actual charge size depends on the original manufacturer charge, however it is limited to maximum charge as shown in the Table 7.3, page 63.

Sealing Operation

! For sealing the process tube of hydrocarbon, servicing technicians are strongly advised not to braze the tube, but use 'Lokring' through mechanical extrusion of pipe connection and sealing, which is safe and reliable (Figure 9).

! For split air-conditioners based on R-32 or R-290,
-> Close the valve properly -> Cap the valve -> Check for leaks

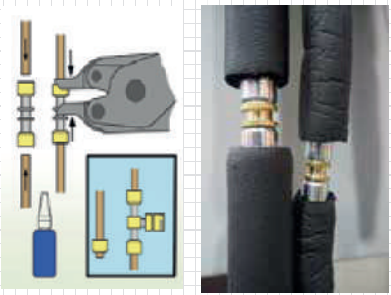


Figure 9: Lokring

Check for proper operation

Check and document the following:

01 Records of last service

02 Check temperature

03 Check pull down time

04 Check compressor current

05 Check vibration

Label with type of refrigerant, date, name and contact of company and RAC servicing technician

INSTALLATION / SERVICE STICKER

NOTICE : USE ENVIRONMENT FRIENDLY REFRIGERANT ONLY

INSTALLATION / SERVICE DATE	:	
REFRIGERANT TYPE	:	
FLAMMABILITY	:	
REFRIGERANT CHARGE	:	g
AMBIENT TEMPERATURE	:	°C
SYSTEM TEMPERATURE	:	°C
HIGH PRESSURE	:	psi
LOW PRESSURE	:	psi
RUNNING AMP	:	AMP
DONE BY	:	
CERTIFICATE NO	:	

NEXT SERVICE

NEXT SERVICE DATE :

FLAMMABLE REFRIGERANT

STICKER NO : 123456

Figure 10: Example of servicing label

5. REFRIGERANTS SERVICING TOOLS & EQUIPMENT

5.1 General Requirements

- Electrical and electronic tools used on systems containing flammable refrigerants should be rated for use in a hazardous area.
- The working area should be monitored with a leak detector designed for the refrigerant being installed/serviced to ensure that the concentration of refrigerant around working area does not exceed the limit.
- A dry-powder or CO_2 fire extinguisher must be available at the location.
- When working in a confined space or an area with insufficient natural ventilation, an explosion-proof or suitable ventilation fan should be used at all times. The electricity power switch for this fan must be outside of working area.

Figure 11: Explosion-proof ventilation fan

! Battery-powered hand drills and screwdrivers, heat guns, as well as domestic equipment such as hair dryers and the like should never be used in a confined area where flammable RAC equipment is being repaired since these tools can act as ignition sources.

5.2 Vacuum Pump

Only specifically-designed vacuum pumps suitable for flammable gases must be used. A two stage vacuum pump is recommended for evacuating moisture from a system being serviced, ideally pulling a vacuum in the system to 200-500 microns.

- Reciprocating compressors are unable to generate vacuums to the desired level.
- Using the refrigeration system's compressor for vacuuming may lead to compressor failure.

The vacuum pump should be positioned so that when it is switched on/off, it is located in a place where any leaked flammable refrigerants cannot reach it.

Figure 12: Compressors must not be used for vacuuming

5.3 Vacuum Gauge

A vacuum gauge capable of reading pressure in the 5- 5,000 micron range should be used when evacuating a system.

For electronic gauges, ensure that they are designed for use in the presence of flammable refrigerants by checking the user manual.

5.4 Refrigerant Charging Equipment

Careful control and monitoring of refrigerant charging during servicing for flammable refrigerants are very important. Very accurate weighing scales for RAC

servicing are required for all flammable refrigerants. Due to the small charges, the volume of refrigerant can only be known with accurate weighing scales. Electronic scales should be suitable for use in an area where flammable refrigerants may be present and as confirmed by the manufacturer.

Figure 13: Refrigerant charging equipment

5.5 Refrigerant Recovery Machine

There are recovery machines specifically designed for flammable refrigerants. Recovery machine for HCFC/HFC refrigerants should not be used for hydrocarbon (HC) refrigerants.

Always check with the user manual to confirm whether the recovery machine is suitable for the specific flammable refrigerant being recovered.

Figure 14: Recovery machine for hydrocarbon refrigerants

5.6 Manifold/Gauge/Hose Set

Material should be compatible with the relevant refrigerant (e.g. able to withstand the maximum pressure). In case of electronic gauges/ manifolds, these must be suitable for use in the presence of flammable refrigerants.

Figure 15: Manifold

5.7 Personal Protective Equipment (PPE)

Ensure that all necessary tools and personal protective equipment (PPE) are available. Ensure that technicians are properly trained on the use PPE.

Figure 16: Safety goggles and hand gloves

5.8 Recovery Cylinder

Never use disposable cylinders to recover refrigerants. Separate recovery cylinders must be used to recover different refrigerants. Technicians must always ensure that there is no mixing of refrigerants when using recovery cylinders. Each recovery cylinder must be properly labelled to indicate the recovered refrigerant type, owner and other data deemed useful.

Recovery cylinders must be hydrostatically tested and date stamped every 5 years and in accordance with international standards.

Figure 17: Recovery cylinder (left) and disposable cylinder (middle and right)

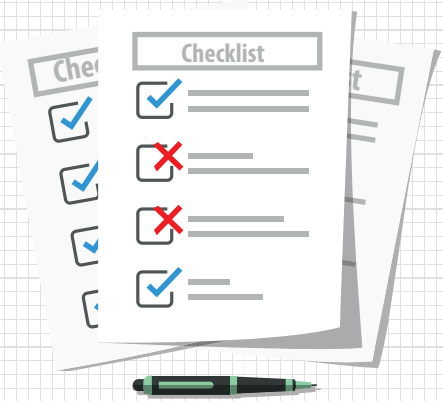
! Safe refrigerant capacity: A recovery cylinder must not be refilled with refrigerant to more than 80% of the water capacity (WC) in weight. Never expose a cylinder to direct sunlight or other sources of heat, this can lead to an explosion.

5.9 Leak Detector

When servicing RAC equipment that use hydrocarbon refrigerants, a special leak detector designed for combustible gases is mandatory. The device should have both audio and visual detections. HCFC and HFC leak detectors cannot detect hydrocarbons, and they are not safe for use with flammable refrigerants.

Figure 18: Leak detector for hydrocarbons

! Never use an open flame to perform leak testing of flammable refrigerants - it will cause ignition and which may lead to fire or explosion. For R-32, it can also form hydrogen fluoride, a toxic and corrosive substance.



6. DOS AND DON'TS CHECKLIST

- Work in a naturally well-ventilated area, outdoors or use forced / induced ventilation system.
- Wear proper safety gloves, goggles and clothing that cover exposed skin while handling refrigerants.
- Keep the cylinders away from sources of heat and direct sun.
- Store only a minimum number of hydrocarbon cylinders indoors.
- Work with skilled partners.
- Have a list of emergency contacts readily available.

- Do not smoke, drink or eat while in the work area.
- Do not store cylinder in basements and other enclosed rooms.
- Do not keep flammable refrigerants in an area that has naked flames, gas cookers, gas water heaters, gas/wood-fire room or space heaters.
- Do not allow any ignition source within 3 metres of the cylinder.
- Do not let flammable refrigerants accumulate.
- Do not place cylinders lying on their side.
- Do not work alone. At least two persons per site.

7. PRESSURE-TEMPERATURE CHARTS

7.1 Pressure-temperature chart of R-134a, R-22 and R-410A

All figures are in gauge pressure.

Temperature		R-134a		R-22		R-410A	
C	F	kPag	Psig	kPag	Psig	kPag	Psig
-40	-40	-48	-7.0	5	0.8	75	10.9
-38	-36	-43	-6.2	15	2.3	91	13.2
-36	-33	-37	-5.3	26	3.8	109	15.8
-34	-29	-30	-4.4	38	5.5	128	18.5
-32	-26	-23	-3.3	51	7.3	148	21.4
-30	-22	-15	-2.2	64	9.3	169	24.5
-28	-18	-7	-1.0	78	11.4	192	27.9
-26	-15	2	0.3	94	13.6	216	31.4
-24	-11	12	1.7	110	15.9	242	35.2
-22	-8	22	3.2	127	18.4	270	39.2
-20	-4	33	4.8	145	21.1	299	43.4
-18	0	45	6.5	165	23.9	330	47.9
-16	3	57	8.3	186	26.9	363	52.7
-14	7	71	10.3	207	30.1	398	57.8
-12	10	85	12.4	231	33.4	435	63.1
-10	14	101	14.7	225	37.0	474	68.7

Temperature		R-134a		R-22		R-410A	
C	F	kPag	Psig	kPag	Psig	kPag	Psig
-8	18	117	17.0	281	40.7	515	74.7
-6	21	134	19.5	308	44.7	558	81.0
-4	25	153	22.2	336	48.8	604	87.6
-2	28	172	25.0	366	53.2	625	94.5
0	32	193	28.0	398	57.7	702	101.8
2	36	215	31.3	431	62.5	755	109.5
4	39	238	34.5	466	67.6	810	117.5
6	43	262	38.0	502	72.9	868	125.9
8	46	288	41.7	541	78.4	929	134.7
10	50	315	45.6	580	84.2	992	143.9
12	54	343	49.8	622	90.2	1,059	153.6
14	57	373	54.1	666	96.6	1,128	163.7
16	61	404	58.6	711	103.1	1,201	174.2
18	64	437	63.4	759	110.0	1,277	185.2
20	68	472	68.4	808	117.2	1,356	196.6
22	72	508	73.7	859	124.6	1,438	208.5
24	75	546	79.2	913	132.4	1,523	220.9
26	79	585	84.9	968	140.5	1,612	233.8

Temperature		R-134a		R-22		R-410A	
C	F	kPag	Psig	kPag	Psig	kPag	Psig
28	82	627	90.9	1,026	148.8	1,705	247.3
30	86	670	97.2	1,086	157.5	1,801	261.2
32	90	715	103.7	1,148	166.6	1,901	275.7
34	93	762	110.5	1,213	175.9	2,004	290.7
36	97	811	117.6	1,280	185.6	2,112	306.3
38	100	862	125.0	1,349	195.7	2,223	322.4
40	104	915	132.8	1,421	206.1	2,338	339.1
42	108	971	140.8	1,495	216.9	2,457	356.4
44	111	1,028	149.1	1,572	228.0	2,581	374.3
46	115	1,088	157.7	1,651	239.5	2,709	392.8
48	118	1,149	166.7	1,733	251.4	2,840	412.0
50	122	1,214	176.0	1,817	263.6	2,977	431.8
52	126	1,280	185.7	1,905	276.3	3,118	452.2
54	129	1,349	195.7	1,995	289.3	3,263	473.2
56	133	1,421	206.1	2,087	302.7	3,413	495.0
58	136	1,495	216.8	2,183	316.6	3,567	517.4
60	140	1,571	227.9	2,281	330.8	3,726	540.4

7.2 Pressure-temperature chart of R-32, R-290 and R-600a

All figures are in gauge pressure.

Temperature		R-32		R-290 (Propane)		R-600a (Isobutane)	
C	F	kPag	Psig	kPag	Psig	kPag	Psig
-40	-40	80	11.6	12	1.7	-71	-10.3
-38	-36	96	13.9	21	3.1	-68	-9.9
-36	-33	114	16.5	32	4.6	-65	-9.4
-34	-29	133	19.2	43	6.3	-61	-8.8
-32	-26	153	22.2	55	8.0	-56	-8.2
-30	-22	174	25.3	68	9.9	-52	-7.6
-28	-18	197	28.6	81	11.8	-48	-6.9
-26	-15	222	32.2	96	13.9	-43	-6.2
-24	-11	248	36.0	111	16.1	-38	-5.5
-22	-8	276	40.0	127	18.5	-32	-4.7
-20	-4	305	44.2	144	20.9	-26	-3.8
-18	0	336	48.8	162	23.6	-20	-2.9
-16	3	369	53.6	182	26.3	-13	-1.9
-14	7	404	58.6	202	29.3	-6	-0.9
-12	10	441	64.0	223	32.3	2	0.2
-10	14	480	69.7	245	35.6	10	1.4

Temperature		R-32		R-290 (Propane)		R-600a (Isobutane)	
C	F	kPag	Psig	kPag	Psig	kPag	Psig
-8	18	522	75.7	269	39.0	18	2.7
-6	21	565	82.0	293	42.5	28	4.0
-4	25	611	88.6	319	46.3	37	5.4
-2	28	659	95.6	346	50.2	48	6.9
0	32	710	103.0	375	54.3	58	8.5
2	36	736	110.7	404	58.7	70	10.1
4	39	819	118.8	436	63.2	82	11.9
6	43	878	127.3	468	67.9	95	13.7
8	46	940	136.6	205	72.8	108	15.7
10	50	1,004	145.6	538	78.0	122	17.7
12	54	1,072	155.4	575	83.3	137	19.9
14	57	1,142	165.7	613	88.9	153	22.2
16	61	1,216	176.3	653	94.8	169	24.5
18	64	1,293	187.5	695	100.8	186	27.0
20	68	1,373	199.2	739	107.1	204	29.6
22	72	1,457	211.3	784	113.7	223	32.4
24	75	1,544	224.0	831	120.5	243	25.2
26	79	1,635	237.2	879	127.5	264	38.2

Temperature		R-32		R-290 (Propane)		R-600a (Isobutane)	
C	F	kPag	Psig	kPag	Psig	kPag	Psig
28	82	1,730	250.9	930	134.9	285	41.3
30	86	1,829	265.2	982	142.5	308	44.6
32	90	1,931	280.1	1,036	150.3	331	48.0
34	93	2,038	295.5	1,093	158.5	355	51.6
36	97	2,148	311.6	1,151	166.9	381	55.3
38	100	2,263	328.2	1,211	175.6	407	59.1
40	104	2,382	345.4	1,273	184.7	435	63.1
42	108	2,505	363.3	1,337	194.0	464	67.3
44	111	2,633	381.9	1,404	203.6	494	71.6
46	115	2,765	401.0	1,472	213.5	524	76.1
48	118	2,902	420.9	1,543	223.8	557	80.7
50	122	3,044	441.4	1,616	234.3	590	85.6
52	126	3,190	462.7	1,691	245.2	624	90.6
54	129	3,341	484.6	1,768	256.4	660	95.8
56	133	3,498	507.3	1,848	268.0	697	101.1
58	136	3,659	530.7	1,930	279.9	736	106.7
60	140	3,826	554.9	2,014	292.1	775	112.5

7.3 Maximum allowable charge size of R-32 in air-conditioning equipment

Area [M^2]	M_{MAX} Floor Location [Kg]	M_{MAX} Window Mounted [Kg]	M_{MAX} Wall Mounted [Kg]	M_{MAX} Ceiling Mounted [Kg]
9	1.03	1.71	3.09	3.77
12	1.19	1.98	3.56	4.35
15	1.33	2.21	3.98	4.87
18	1.45	2.42	4.36	5.33
21	1.57	2.62	4.71	5.76
24	1.68	2.80	5.04	6.16
27	1.78	2.97	5.34	6.53
30	1.88	3.13	5.63	6.88
33	1.97	3.28	591	7.22
36	2.06	3.43	6.17	7.54
39	2.14	3.57	6.42	7.85
42	2.22	3.70	6.66	8.15
45	2.30	3.83	6.90	8.43
48	2.37	3.96	7.12	8.71
51	2.45	4.08	7.34	8.98

Area [M^2]	M_{MAX} Floor Location [Kg]	M_{MAX} Window Mounted [Kg]	M_{MAX} Wall Mounted [Kg]	M_{MAX} Ceiling Mounted [Kg]
54	2.52	4.20	7.56	9.24
57	2.59	4.31	7.76	9.49
60	2.66	4.43	7.97	9.74

! The RAC servicing technician must ensure that the actual charge size of refrigerant in the AC system being installed/serviced does not exceed the maximum charge size.

7.4 Maximum allowable charge size of R-290 in air-conditioning equipment

Area [M^2]	M_{MAX} Floor Location [Kg]	M_{MAX} Window Mounted [Kg]	M_{MAX} Wall Mounted [Kg]	M_{MAX} Ceiling Mounted [Kg]
9	0.08	0.13	0.23	0.28
12	0.09	0.15	0.26	0.32
15	0.10	0.16	0.29	0.36
18	0.11	0.18	0.32	0.39
21	0.12	0.19	0.35	0.42

Area [M^2]	M_{MAX} Floor Location [Kg]	M_{MAX} Window Mounted [Kg]	M_{MAX} Wall Mounted [Kg]	M_{MAX} Ceiling Mounted [Kg]
24	0.12	0.21	0.37	0.45
27	0.13	0.22	0.39	0.48
30	0.14	0.23	0.41	0.51
33	0.14	0.24	0.43	0.53
36	0.15	0.25	0.45	0.55
39	0.16	0.26	0.47	0.58
42	0.16	0.27	0.49	0.60
45	0.17	0.28	0.51	0.62
48	0.17	0.29	0.52	0.64
51	0.18	0.30	0.54	0.66
54	0.18	0.31	0.55	0.68
57	0.19	0.32	0.57	0.70
60	0.19	0.32	0.58	0.71

! The RAC servicing technician must ensure that the actual charge size of refrigerant in the AC system being installed/serviced does not exceed the maximum charge size.

GLOSSARY

Montreal Protocol:

The international treaty 'Montreal Protocol on Substances that Deplete the Ozone Layer' was agreed in 1987 after scientists discovered that certain man-made substances, such as CFCs, were contributing to the depletion of the Earth's ozone layer. The ozone layer protects life from harmful UV radiation. So far, it has been ratified by all countries worldwide (November 2009 - universal ratification). The protocol aims at protecting the ozone layer and therefore regulates the successive phase-out of substances that could harm the ozone layer through the restriction of production, import and use of such substances. The gradual phase-out of ODSs will enable the ozone layer to repair itself.

Ozone-Depleting Substances (ODS):

These are substances that damage the ozone layer in the upper atmosphere. They are widely used in refrigerators, air-conditioners, foam extrusion, fire extinguishers, industrial cleaning as solvents for cleaning, aerosols, electronic equipment and as agricultural fumigants. Ozone depleting substances include:

- Chlorofluorocarbons (CFCs)
- Halons
- Carbon Tetrachloride
- Methyl Chloroform
- Methyl Bromide
- Hydrobromofluorocarbons (HBFCs)
- Hydrochlorofluorocarbons (HCFCs)
- Refrigerant blends containing HCFCs
- Bromochloromethane (BCM)

Ozone Depletion Potential (ODP):

This is a relative value that indicates the potential of a substance to destroy ozone gas (and thereby damage the Earth's ozone layer) as compared with the impact of a

similar mass of chlorofluorocarbon-11 (CFC-11), which is assigned a reference value of 1. Thus, for example, a substance with an ODP of 2 is twice as harmful as CFC-11.

Phase-out of Ozone-Depleting Substances:
In this context, phase-out means a successive limitation and production ban on substances that deplete the ozone layer according to a defined schedule for different groups of countries as regulated under the Montreal Protocol.

Global Warming Potential:
Global Warming Potential (GWP) is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. It is a relative scale which compares the contribution to global warming of the gas in question to that of the same mass of Carbon Dioxide (CO_2) whose GWP is by definition 1 over a defined time horizon. For instance, Methane is a significant contributor to the greenhouse effect and has a GWP of 21 (100-yr time horizon). This means Methane is approximately 21 times more heat-absorptive than CO_2 per unit of weight.

Natural Refrigerants:
Natural refrigerants are naturally occurring substances, such as Hydrocarbons (e.g. Propane, Iso-Butane), Carbon Dioxide and Ammonia. These substances can be used (amongst others) as refrigerants in various kind of refrigeration and air-conditioning systems. The key characteristics of these refrigerants are that they don't contribute to depletion of the ozone layer and have no or only negligible global warming potential impact.

ACRONYMES

AC	Air-Conditioning	**LP**	Low Pressure
CFC	Chlorofluorocarbon	**LFL**	Lower Flammability Limit
CO_2	Carbon Dioxide	**MAC**	Mobile Air-Conditioning
GWP	Global Warming Potential	**ODP**	Ozone Depletion Potential
HC	Hydrocarbon	**ODS**	Ozone-Depleting Substances
HCFC	Hydrochlorofluorocarbon	**RAC**	Refrigeration & Air-Conditioning
HFC	Hydrofluorocarbon	**UFL**	Upper Flammability Limit
HP	High Pressure	**UV**	Ultra Violet

Safety Group Classification:

The classification consists of two alphanumeric characters (e.g. A2); the capital letter corresponds to toxicity and the digit to flammability.

Flammability /Toxicity	Low Toxicity	High Toxicity
High Flammability	A3	B3
Low Flammability	A2	B2
No Flame Propagation	A1	B1

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