A2L Refrigerants

Application Information

Manual Revision 1.00

These instructions are intended as an aid to qualified, licensed installers and service personnel for proper installation, adjustment and operation of this unit. Read and understand these instructions thoroughly before attempting installation or operation. Failure to follow these instructions may result in improper installation, adjustment, service or maintenance possibly resulting in fire, electrical shock, carbon monoxide poisoning, explosion, personal injury or property damage.

www.engineeredair.com

INTRODUCTION

If any errors or omissions are noted, please contact the nearest Engineered Air Technical Service Department.

Copyright

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WARNINGS, CAUTIONS AND NOTICES

Warning, Caution and Notice statements are used throughout this manual to emphasize important and critical information. You must read these statements to help ensure safety and to prevent damage.

⚠ WARNING:
Indicates a hazardous situation that, if not avoided, could result in death or serious injury.

⚠ CAUTION:
Indicates a hazardous situation that, if not avoided, could result in minor or moderate injury.

⚠ NOTICE:
Indicates information considered important but not hazard related.

TABLE OF CONTENTS

This document is for Engineered Air appliances containing A2L flammable refrigerants. Confirm the refrigerant type and total charge on the appliance rating plate. The following is based on the requirements of standard CSA/UL 60335-2-40: Particular requirements for electric heat pumps, air-conditioners and dehumidifiers.

At all times Engineered Air Installation, Operation and Maintenance must be followed in addition to the requirements of the above standard. If in doubt, contact Engineered Air Service for assistance.

This symbol displayed below on the appliance indicates that this appliance is filled with an A2L class refrigerant pursuant to ISO 817, an odorless flammable refrigerant gas with low burning velocity. If the refrigerant is leaked, there is a possibility of ignition if it enters in contact with an external ignition source.

Refrigerant Safety Group A2L

Open source of ignition, including open flames, pilot flames, direct spark ignition or hot surface ignition or other similar sources of ignition in the combustion air-stream, if the combustion air is drawn from an unventilated space in which leaked refrigerant may enter through the combustion air intake, are allowed, when these appliances are provided with a flame arrest or equivalent to ensure that in the event of an ignition, the flame will not propagate. Marking to the equipment continues to be visible and legible. Markings and signs that are illegible shall be corrected. Other sources of potential ignition may not be obvious, such as lighters, light switches, vacuum cleaners, and electric heaters.

Qualification of Workers

Information of procedures additional to usual information for refrigerating appliance installation, repair, maintenance and decommission procedures is required when an appliance with flammable refrigerants is affected. Flammable refrigerants have an explosion potential and are dangerous when handled without care.

The training of these procedures is carried out by national training organizations or manufacturers that are accredited to teach the relevant national competency standards that may be set in legislation. The achieved competence should be documented by a certificate.

Temporary Storage

WARNING:

The appliance shall be stored in a room without continuously operating ignition sources (for example: open flames, an operating gas appliance or an operating electric heater.

Commissioning

Ensure that the floor installation area is sufficient for the refrigerant charge or that the ventilation duct is assembled in a correct manner. Connect the pipes and carry out a leak test before charging with refrigerant. Check safety equipment before putting into service.

Refrigerant Detection System

Approved leak detectors must be installed as per the manufacturer's instructions in the installation area and connected to the appliance to disable operation on alarm.

Duct Connections

Appliances connected via an air duct system to one or more rooms must have the supply and return air directly ducted to the space. For duct connected appliances, false ceilings for drop ceilings may be used as a return air plenum if a refrigerant detection system is provided in the appliance and any external connections are also provided with sensor immediately below the return air plenum duct joint.

WARNING: 	**Ducts connected to the appliance must not contain a potential ignition source. Only auxiliary devices approved by the appliance manufacturer or declared suitable with the refrigerant shall be installed in connecting ductwork.**

Non-ducted appliances with the supply and return air openings in the conditioned space may have the body of the appliance installed in open areas such as false ceilings not being used as a return air plenum as long as the conditioned air does not directly communicate with the air of the false ceiling.

Minimum Installation Area

Appliances containing flammable refrigerants must not be installed in an unventilated space if the area is less than the calculated minimum installation area. Where multiple refrigeration systems are in or servicing the same area, the system or circuit with the largest charge must be used for this calculation.

Packaged factory circuits will have the factory charge amount noted on the rating plate. Split systems will require the total charge of each circuit to be noted by the installing contractor on the rating plate after installation. Installation areas, including any field piping, not able to meet the minimum area will require the addition of a ventilation system and interlocking to the appliance.

Minimum ventilation requirements are based on:

Amin – The calculated minimum area.
Mc - The largest system refrigerant charge that could be released to the indoor area in case of undetected refrigerant leak.
h_{inst} – Installed height in meters of the unit.
h_{rel} – The release offset height in meters from the bottom of the unit to the point of release
h_o – The release height, the vertical distance in meters from the floor to the point of release when the appliance is installed.
$h_o = (h_{inst} + h_{rel})$ or 0.6m, whichever is higher.
LFL – The lower flammability rating of the refrigerant. (R454B = 0.296 kg/m^3)

The CSA/UL 60335-2-40 Standard references installed heights (h_{inst}) as described below:

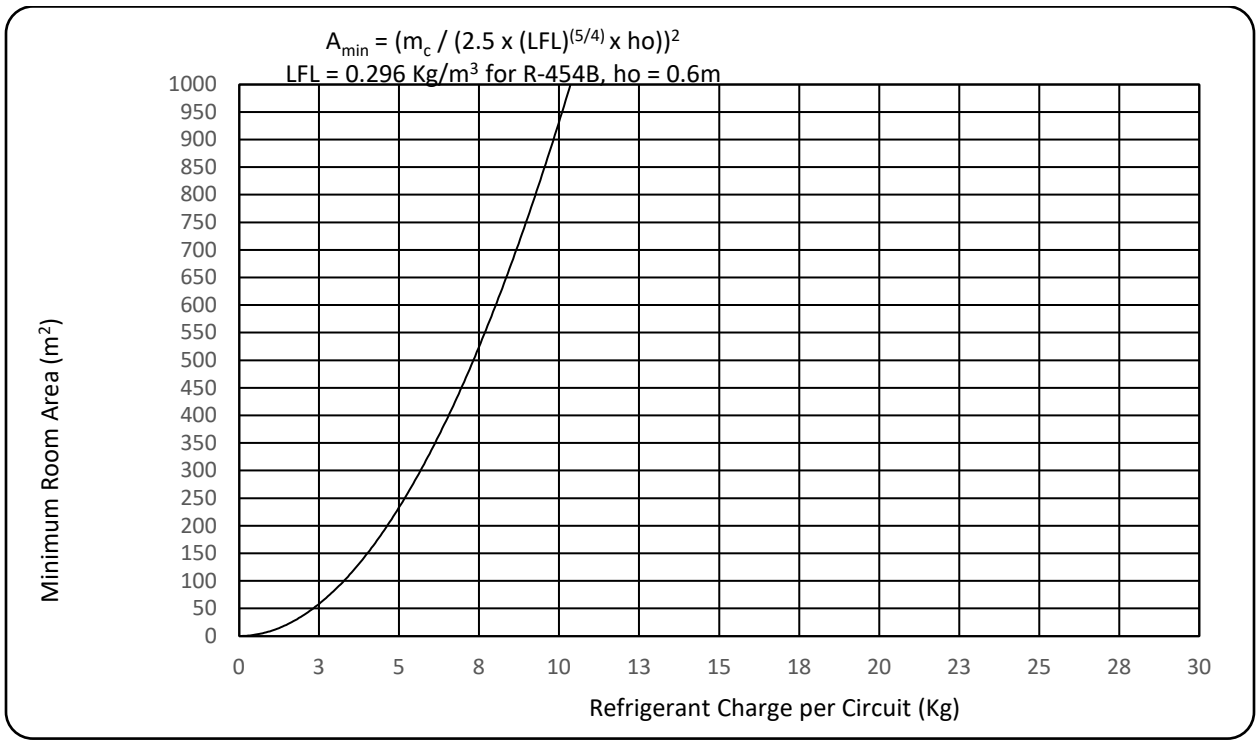
h_{inst} = 0.6m (24") for floor mounted
h_{inst} = 1.8m (71") for wall mounted
h_{inst} = 2.2m (87") for ceiling mounted

(A_{min}) Adjust and re-calculate based on specific site locations and charge amount if necessary. Contact Engineered Air Service Department for assistance.

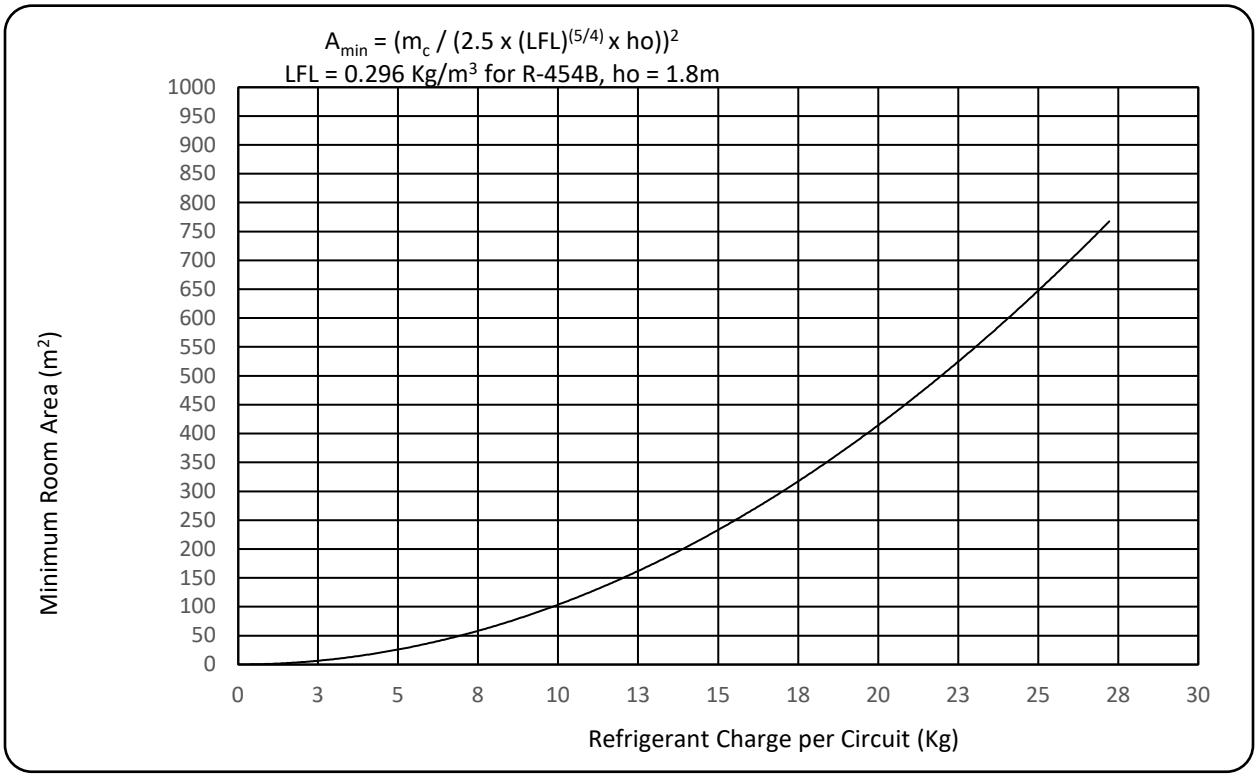
$Amin = (m_c / (2.5 \times (LFL)^{(5/4)} \times ho))^2$

See examples below for the reference graphs at 0.6m, 1.8m and 2.2m. Additional mitigation (ventilation) is required if the installation room area is less than the required minimum room area.

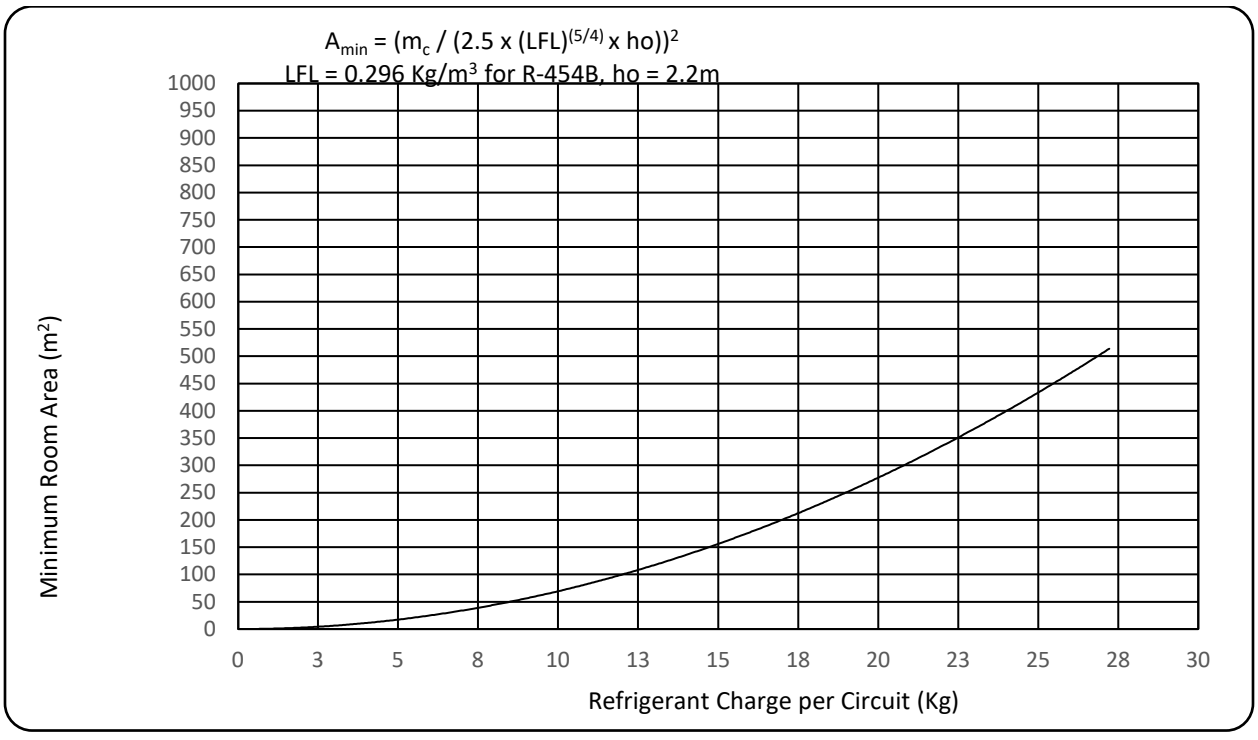
h_o = 0.6m



h_o = 1.8m


$A_{min} = (m_c / (2.5 \times (LFL)^{(5/4)} \times ho))^2$
LFL = 0.296 Kg/m³ for R-454B, ho = 1.8m
Minimum Room Area (m²)
1000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
0 3 5 8 10 13 15 18 20 23 25 28 30
Refrigerant Charge per Circuit (Kg)

h_o = 2.2m


$A_{min} = (m_c / (2.5 \times (LFL)^{(5/4)} \times ho))^2$
LFL = 0.296 Kg/m³ for R-454B, ho = 2.2m
Minimum Room Area (m²)
1000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
0 3 5 8 10 13 15 18 20 23 25 28 30
Refrigerant Charge per Circuit (Kg)

Ventilation

WARNING:

Keep any ventilation openings clear of obstructions.

If using mechanical ventilation, locate the extraction opening with the lower edge of the opening no more than 100mm (4”) above the floor. The air extraction openings shall be located a sufficient distance from the air intake openings to prevent re-circulation to the space, no less than 3 meters.

If using external dampers with mechanical ventilation, ensure that upon detection of a leak the dampers must be driven fully open prior to activating mechanical ventilation. Mechanical ventilation and space leak detection by others will require interlocking connections at the appliance. Review the field wiring diagram(s) provided for connection. Verify operation of the ventilation system.

Unventilated Areas

The unventilated area where the appliance using flammable refrigerants is installed shall be so constructed that should any refrigerant leak, it will not stagnate to create a fire or explosion hazard. Unventilated areas must not have any continuously operating open flames or other potential ignition sources. A flame-producing device may be installed in the same space if the device is provided with an effective flame arrest.

Working Procedures

Every working procedure that affects safety means shall only be carried out by competent people trained in the use and handling of flammable refrigerants. Prior to working on systems using flammable refrigerants ensure the risk of ignition is minimized or eliminated. Other personnel working in the local area must be informed of the work being performed. No person carrying out work in relation to a refrigerating system which involves exposing any pipe work shall use any sources of ignition in such a manner that it may lead to the risk of fire or explosion. All possible ignition sources, including cigarette smoking, should be kept a sufficient distance away from the site of installation, repairing, removing and disposal, during which refrigerant can possibly be released to the surrounding space. ‘No smoking’ signs shall be displayed.

Prior to work taking place, the area around the equipment is to be surveyed to make sure that there are no flammable hazards or ignition risks. The area shall be checked with an appropriate refrigerant detector prior to and during work, to ensure the technician is aware of potentially toxic or flammable atmospheres. Ensure that the leak detection equipment being used is suitable for use with flammable R454B refrigerant.

If hot work is to be conducted ensure an appropriate (dry powder or CO_2) fire extinguisher is readily available.

Ensure that the area is in the open or that it is adequately ventilated before breaking into the system or conducting any hot work. A degree of ventilation shall continue during the period that the work is carried out. The ventilation should safely disperse any released refrigerant and preferably expel it externally into the atmosphere. Work in confined spaces shall be avoided.

Unventilated Area - Safety of the appliance does not depend on ventilation of the housing. Switching off the appliance or opening of the housing has no significant effect on safety. Nevertheless, it is possible that leaking refrigerant may accumulate inside the enclosure and flammable atmosphere will be released when the enclosure is opened.

Ventilated enclosure – Safety of the appliance depends on ventilation of the housing. Switching off the appliance or opening of the enclosure has a significant effect on safety. Care should be taken to ensure sufficient ventilation before.

Ventilated room – Safety of the appliance depends on the ventilation of the room. Switching off the appliance or opening of the housing has no significant effect on safety. The ventilation of the room shall not be switched off during repair procedures.

Repair and maintenance to electrical components shall include initial safety checks and component inspection procedures. If a fault exists that could compromise safety, then no electrical supply shall be connected to the circuit until it is satisfactorily dealt with. If the fault cannot be corrected immediately but it is necessary to continue operation, an adequate temporary solution may be used. This shall be reported to the owner of the equipment, so all parties are advised.

Initial safety checks shall include:

- that capacitors are discharged: this shall be done in a safe manner to avoid possibility of sparking,
- that no live electrical components and wiring are exposed while charging, recovering, or purging the system,
- that there is continuity of earth bonding.

During repairs to sealed components, all electrical supplies shall be disconnected from the equipment being worked upon prior to any removal of sealed covers, etc. If it is necessary to have an electrical supply to equipment during servicing, then a permanently operating form of leak detection shall be located at the most critical point to warn of a potentially hazardous situation.

Particular attention shall be paid to the following to ensure that by working on electrical components, the casing is not altered in such a way that the level of protection is affected. This shall include damage to cables, excessive number of connections, terminals not made to original specification, damage to seals, incorrect fitting of glands, etc. Ensure the apparatus is mounted securely. Ensure that seals or sealing materials have not degraded to the point that they no longer serve the purpose of preventing the ingress of flammable atmospheres. Replacement parts shall be in accordance with Engineered Air specifications and must be fit for the purpose and to the correct specification. Check that cabling will not be subject to wear, corrosion, excessive pressure, vibration, sharp edges or any other adverse environmental effects. The check shall also take into account the effects of aging or continual vibration from sources such as compressors or fans.

Under no circumstances shall potential sources of ignition be used in the searching for or detection of refrigerant leaks. A halide torch (or any other detector using a naked flame) shall not be used.

Electronic leak detectors may be used to detect refrigerant leaks but, in the case of flammable refrigerants, the sensitivity may not be adequate, or may need re-calibration. Detection equipment must be calibrated in a refrigerant-free area. Ensure that the detector is not a potential source of ignition and is suitable for the refrigerant used. Leak detection equipment shall be set at a percentage of the LFL of the refrigerant and be calibrated to the refrigerant employed, and the appropriate percentage of gas (25% maximum) is confirmed.

Leak detection fluids are also suitable for use with most refrigerants but the use of detergents containing chlorine shall be avoided as the chlorine may react with the refrigerant and corrode the copper pipe-work.

If an indirect refrigerating circuit is being used, the secondary circuit shall be checked for the presence of refrigerant.

Field Piping

The installation of field piping must be kept to a minimum.

Piping shall be protected from physical damage and, in the case of flammable refrigerants, shall not be installed in an unventilated space, if that space is smaller than the calculated minimum installation area.

- Precautions should be taken to avoid excessive vibration or pulsation to the refrigerating piping.
- Provisions shall be made for expansion and contraction of long runs of piping.
- Piping shall be so designed and installed to minimize the likelihood of hydraulic shock damaging the system.
- Solenoid valves shall be correctly positioned in the piping to avoid hydraulic shock.
- Solenoid valves shall not block in liquid refrigerant unless adequate relief is provided to the refrigerant system low pressure side.
- Steel pipes and components shall be protected against corrosion with a rustproof coating before applying any insulation.
- Refrigerating pipe or components are installed in a position where they are unlikely to be exposed to any substance which may corrode refrigerant containing components, unless the components are constructed of materials which are inherently resistant to being corroded or are suitably protected against being so corroded.
- Flexible pipe elements shall be protected against mechanical damage, excessive stress by torsion, or other forces. They should be checked for mechanical damage annually.
- The indoor equipment and pipes shall be securely mounted and guarded such that accidental rupture of equipment cannot occur from such events as moving furniture or reconstruction activities.
- Protection devices, piping and fittings shall be protected as far as possible against adverse environmental effects, for example, the danger of water collecting and freezing, the accumulation of dirt and debris or corrosion.
- Where safety shut off valves are specified, the minimum room area may be determined based on the maximum amount of refrigerant that can be leaked.
- Field-made refrigerant joints must be tightness tested. The test method shall have a sensitivity of 5 grams per year of refrigerant or better under a pressure of at least 0.25 times the maximum allowable pressure. No leak shall be detected.

Refrigerant pipes containing A2L refrigerant which connect refrigerating system components are not considered a source of leaked refrigerant for the purpose of evaluating potential for fire or explosion hazard relative to potential ignition sources within the appliance if the piping within the area of the appliance to be evaluated complies with all of the following:

- no connecting joints;
- no bends with centerline bend radius less than 2.5 times the external pipe diameter;
- protected from potential damage during normal operation, service, or maintenance.

Pipe-work including piping material, pipe routing, and installation shall include protection from physical damage in operation and service, and be in compliance with national and local codes and standards, such as ASHRAE 15, ASHRAE 15.2, or CSA B52. All field joints shall be accessible for inspection prior to being covered or enclosed.

Confirm the actual refrigerant charge is in accordance with the room size.

Pressure Testing

After completion of field piping for split systems, the field pipework shall be pressure tested with an inert gas and then vacuum tested prior to refrigerant charging.

The minimum test pressure for the low side of the system shall be the low side design pressure. The minimum test pressure for the high side of the system shall be the high side design pressure, unless the high side of the system cannot be isolated from the low side of the system, in which case the entire system shall be pressure tested to the low side design pressure.

The test pressure after removal of pressure source shall be maintained for at least 1 hour with no decrease of pressure indicated by the test gauge, with test gauge resolution not exceeding 5% of the test pressure.

Initial Evacuation

During the evacuation test, after achieving a vacuum level of 500 microns or less, the refrigeration system shall be isolated from the vacuum pump and the pressure shall not rise above 1500 microns within 10 min.

The vacuum pressure level shall be the lessor of 500 microns, or the value required for compliance with national and local codes and standards. This may vary between residential, commercial, and industrial buildings.

System Charging Procedure

In addition to conventional charging procedures, the following requirements must be followed.

- Ensure that contamination of different refrigerants does not occur when using charging equipment.
- Hoses or lines shall be as short as possible to minimize the amount of refrigerant contained in them.
- Cylinders shall be kept in an appropriate position according to the instructions.
- Ensure that the refrigerating system is earthed prior to charging the system with refrigerant.
- Label the system when charging is complete (if not already).
- Extreme care shall be taken to not overcharge the system.

Prior to recharging the system, pressure-test with an appropriate purge gas (dry Nitrogen). The system must be leak-tested on completion of charging, prior to commissioning. A follow up leak test must be carried out prior to leaving the site.

WARNING:

If a leak is suspected, all naked flames shall be removed/extinguished.
If a leakage of refrigerant is found which requires brazing, all of refrigerant shall be recovered from the system, or isolated in a part of the system remote from the leak.

Recovery

When removing refrigerant from a system, either for servicing or decommissioning, it is recommended good practice that all refrigerants are removed safely. When transferring refrigerant into cylinders, ensure that only appropriate refrigerant recovery cylinders are employed. Ensure that the correct number of cylinders for holding the total system charge is available. All cylinders to be used are designated for the recovered refrigerant and labelled for that refrigerant (i.e. special cylinders for the recovery of refrigerant). Cylinders shall be complete with pressure-relief valve and associated shut-off valves in good working order. Empty recovery cylinders are evacuated and, if possible, cooled before recovery occurs.

The recovery equipment shall be in good working order with a set of instructions concerning the equipment that is at hand and shall be suitable for the recovery of the flammable refrigerant. If in doubt, the manufacturer should be consulted. In addition, a set of calibrated weighing scales shall be available and in good working order. Hoses shall be complete with leak-

free disconnect couplings and in good condition. The recovered refrigerant shall be returned to the refrigerant supplier in the correct recovery cylinder, and the relevant waste transfer note arranged.

The recovered refrigerant shall be processed according to local legislation in the correct recovery cylinder, and the relevant waste transfer note arranged. Do not mix refrigerants in recovery units or cylinders.

If compressors or compressor oils are to be removed, ensure that they have been evacuated to an acceptable level to make certain that flammable refrigerant does not remain within the lubricant. The compressor body shall not be heated by an open flame or other ignition sources to accelerate this process. When oil is drained from a system, it shall be carried out safely. The evacuation process shall be carried out prior to returning the compressor to the suppliers. Only electric heating to the compressor body shall be employed to accelerate this process.

Refrigerant Removal and Evacuation

When opening the refrigerant circuit to make repairs or for any other purpose conventional procedures shall be used following national and local regulations. However, for flammable refrigerants it is important that best practice be followed, since flammability is a consideration. Safely remove refrigerant following local and national regulations. The following procedure must be adhered to.

- Remove the refrigerant;
- purge the circuit with inert gas (optional for A2L);
- evacuate (optional for A2L);
- continuously flush or purge with inert gas when using flame to open circuit; and
- open the circuit by cutting or brazing.

The refrigerant charge shall be recovered. For appliances containing flammable refrigerants, the system shall be purged with oxygen-free nitrogen to render the appliance safe for flammable refrigerants. This process might need to be repeated several times. Compressed air or oxygen shall not be used for purging refrigerant systems.

For appliances containing flammable refrigerants, refrigerant purging shall be achieved by breaking the vacuum in the system with oxygen-free nitrogen and continuing to fill until the working pressure is achieved, then venting to atmosphere, and finally pulling down to a vacuum. This process shall be repeated until no refrigerant is within the system. When the final oxygen-free nitrogen charge is used, the system shall be vented down to atmospheric pressure to enable work to take place.

The outlet from the vacuum pump shall not be close to any potential ignition sources, and ventilation shall be available.

Repair and Maintenance

Repair and maintenance to electrical components shall include initial safety checks and component inspection procedures. If a fault exists that could compromise safety, then no electrical supply shall be connected to the circuit until it is satisfactorily dealt with. If the fault cannot be corrected immediately but it is necessary to continue operation, an adequate temporary solution shall be used. This shall be reported to the owner of the equipment so all parties are advised. Initial safety checks shall include:

- that capacitors are discharged: this shall be done in a safe manner to avoid possibility of sparking:
- that no live electrical components and wiring are exposed while charging, recovering or purging the system;
- that there is continuity of earth bonding.

During repairs to sealed components, all electrical supplies shall be disconnected from the equipment being worked upon prior to any removal of sealed covers, etc. If it is absolutely necessary to have an electrical supply to equipment during servicing, then a permanently operating form of leak detection shall be located at the most critical point to warn of a potentially hazardous situation. Particular attention shall be paid to the following to ensure that by working on electrical components, the casing is not altered in such a way that the level of protection is affected. This shall include damage to cables, excessive number of connections, terminals not made to original specification, damage to seals, incorrect fitting of glands, etc. Ensure that the apparatus is mounted securely. Ensure that seals or sealing materials have not degraded to the point that they no longer serve the purpose of preventing the ingress of flammable atmospheres.

WARNING:

- **Do not use any means to accelerate the defrosting process.**
- **Do not pierce any piping or components.**
- **Refrigerant may not be odorized.**

Decommissioning

This product shall not be mixed with general waste at the end of its life, and it shall be retired according to the appropriate local or national regulations in an environmentally correct way.

Due to the refrigerant, oil and other components contained in this appliance, its dismantling must be done by a professional installer according to the applicable local, regional, or federal regulations.

Before carrying out this procedure, it is essential that the technician is completely familiar with the equipment and all its details. All refrigerants are to be recovered safely. Prior to the task being carried out, an oil and refrigerant sample shall be taken in case analysis is required prior to re-use of recovered refrigerant. It is essential that electrical power is available before the task commences.

- Become familiar with the equipment and its operation.
- Isolate the system electrically.
- Before attempting the procedure, ensure that:
  - mechanical handling equipment is available, if required, for handling refrigerant cylinders;
  - all personal protective equipment is available and being used correctly;
  - the recovery process is supervised at all times by a competent person, and;
  - recovery equipment and cylinders conform to the appropriate standards.
- Pump down refrigerant system, if possible.
- If a vacuum is not possible, make a manifold so that refrigerant can be removed from various parts of the system.
- Make sure that cylinder is situated on the scales before recovery takes place.
- Start the recovery machine and operate in accordance with instructions.
- Do not overfill cylinders (no more than 80 % volume liquid charge).
- Do not exceed the maximum working pressure of the cylinder, even temporarily.
- When the cylinders have been filled correctly and the process completed, make sure that the cylinders and the equipment are removed from site promptly and all isolation valves on the equipment are closed off.
- Recovered refrigerant shall not be charged into another refrigerating system unless it has been cleaned and checked.

Equipment shall be labelled stating that it has been de-commissioned and emptied of refrigerant. The label shall be dated and signed. For appliances containing flammable refrigerants, ensure that there are labels on the equipment stating the equipment contains flammable refrigerant.

Refrigerant Detectors

Leak detectors must conform to the specific refrigerant detector's installation and operation manual in addition to being certified to CSA/UL 60335-2-40: Particular requirements for electric heat pumps, air-conditioners and dehumidifiers. Replace only with sensors/detectors specified by Engineered Air.

If installed in the appliance by Engineered Air, the Danfoss DST G54B leak detector has a date code that notes the sensor must be replaced within 15 years of that date.

General Indoor Location

Ensure that the area being sampled is sufficiently monitored. Do not skimp on sensors. Place the sensor(s) in the location(s) most likely to develop a gas leak, including mechanical joints, seals, and where there are regular changes in the system's temperature and pressure, or excessive vibration, such as compressors and evaporator control valves.

The most appropriate method is selected depending on the size and nature of the site.

- If mechanical ventilation exists in a machinery room, air will move towards the fan.
- In a cold store, sensors should, if possible, be placed on the wall in the return airflow.
- Consideration should also be given to the possibility of pockets of gas collecting in the event of a leak.
- Do not mount to a structure that is subject to vibration and shock, such as piping and piping supports.
- Do not locate near excessive heat or in wet or damp locations.
- Do not mount where it will be exposed to direct solar heating.
- Do not install in areas where condensation may form.
- Do not install in areas with excessive temperature and humidity fluctuations.

Danfoss R454B Refrigerant Sensor – DST G54B

https://www.danfoss.com/en/products/dcs/sensors-and-transmitters/gas-detecting-sensors/a2l-refrigerant-detection-sensors/

Sensor and Performance Specifications

Refrigerant	R454B
Measurement Range	0 – 25% LFL
Alarm Threshold Range	10 – 20% LFL
Alarm Threshold	18% LFL
Operating Temperature	-40 – 80°C (176°F)
Maximum Temperature	-40 – 95°C (203°F)
Operating Pressure	700 – 1200 mbar
Operating Humidity	0 – 100% RH with condensation
Flame Rating	UL 94 V-0
Accuracy at Ambient 15-25°C, 30-70%RH	±2.5% LFL
Accuracy across operating range	±5.0% LFL

Response Time	<15 secs
Sensor Recovery Time	<5 min clean air
Sensor Lifetime	Min 15 year, self monitoring

Alarm Response

When the sensor has a gas reading at or above the alarm threshold, the Relay is de-energized which opens the relay contacts during the alarm.

Alarm Reset

For the alarm to be reset, the sensor reading must be a minimum of 2.5% below the alarm threshold. The relay is then re-energized, and the sensor returns to normal operation. The relay will remain open for 5 seconds following alarm reset.

Power Up Diagnostics

Power Up self diagnostics are executed when the sensor is first energized. The test validates the integrity of the memory, embedded program, and power supply.

Runtime Diagnostics

Continuous diagnostics are performed on the sensor integrity (shorts, opens, out of range, comm errors) as well as the integrity of the on-board memory, programming, oscillator, and voltage levels.