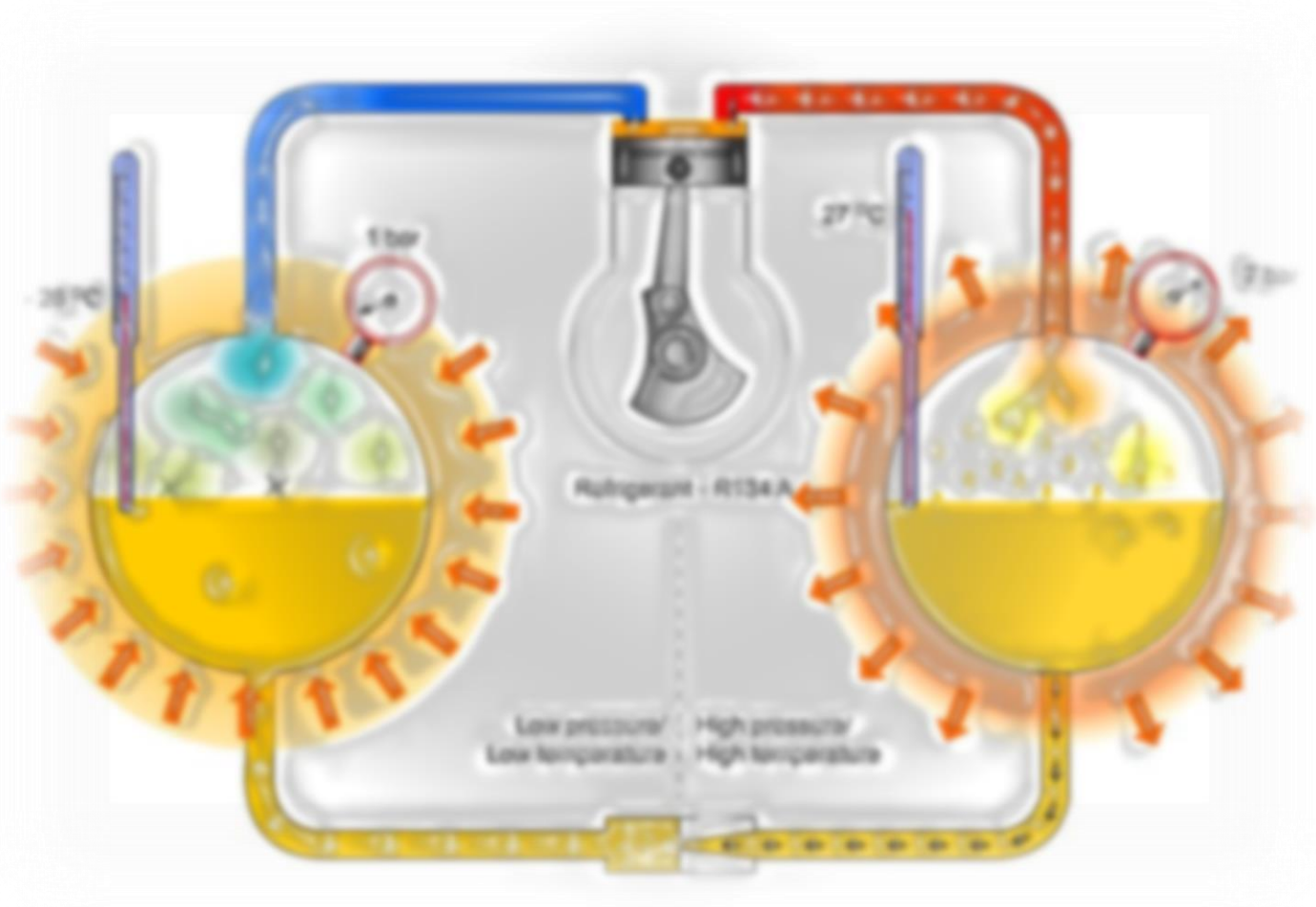
Module One

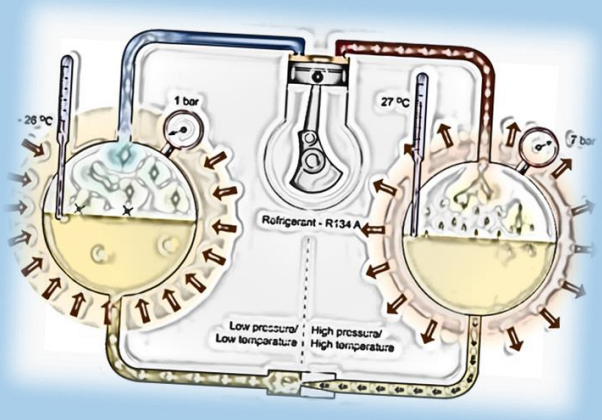
Good Practices for reducing refrigerant consumption and emissions



Michael Moller

michael@praxisvocational.com

This series of training modules offers practical assistance to HVAC technicians to assist in reducing refrigerant leaks.



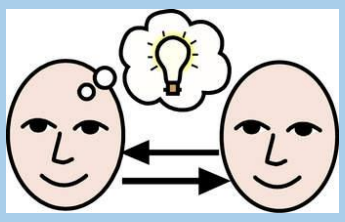
Module One: Good Practices in reducing leakage in systems

Module Two: Alternative Refrigerants including working with flammable refrigerants

Module Three: RAC Installation for efficiency and reliability

Module Four: Repair and Maintenance

Contents



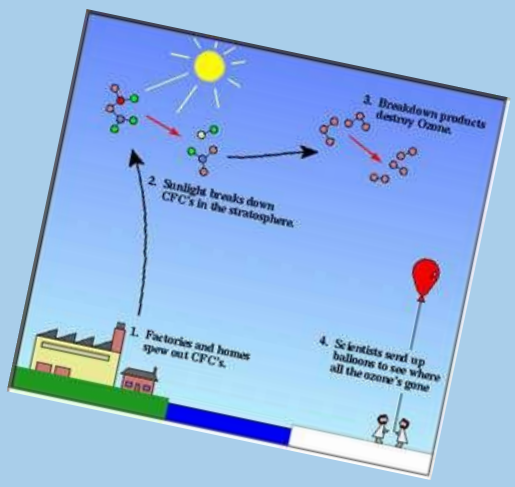
When you see this sign please discuss the questions

When you see this sign it means that you are the responsible person

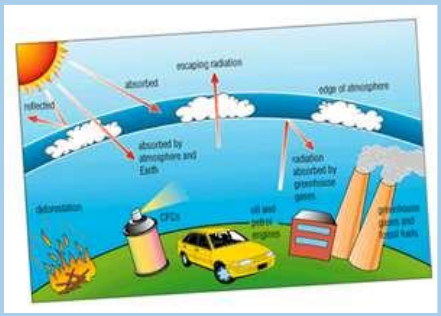
When you see this sign please stop and think about safety

Why phase out?????

Eye cataracts
&
Skin cancers

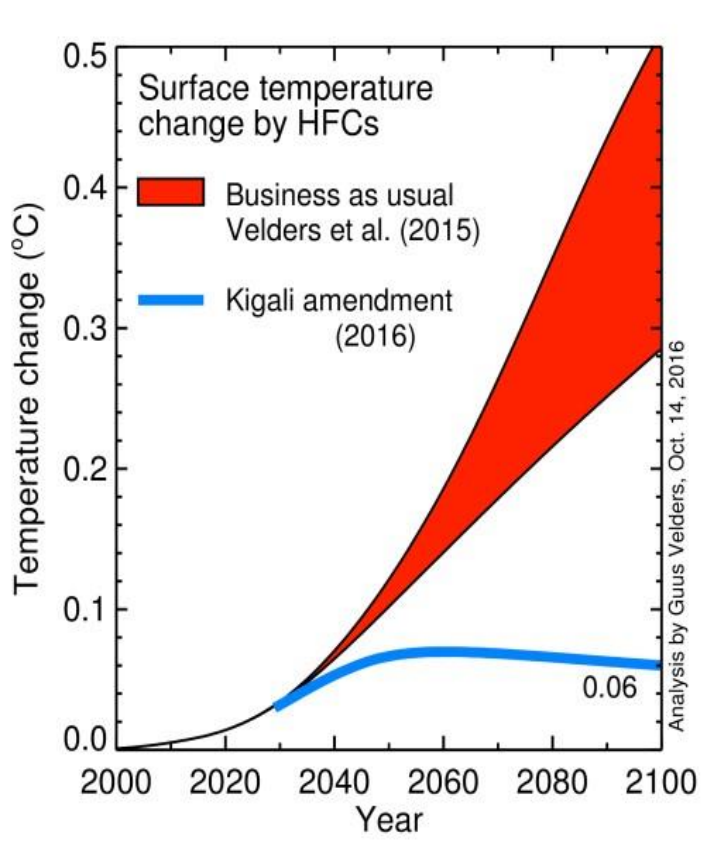


Depletion of the Ozone layer



Global warming = increased severe weather events, rising sea levels

Kigali Amendment: anticipated climate benefit



Without Kigali Amendment :

- Red area indicates global temperature increase if HFC use continues to grow (business-as-usual scenario).
- **Business-as-usual growth in HFCs** is estimated to contribute up to **0.4°C global warming by the end of this century**

With Kigali Amendment :

- Blue line indicates expected impact of Kigali Amendment – warming due to HFCs will be limited to about 0.06°C

Kigali update

On the 15 October 2016, the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer unanimously adopted the Kigali Amendment, paving the way for the reduction of powerful greenhouse gases - hydrofluorocarbons (HFCs).

Why *Phase Down* HFCs?

HFCs, or hydrofluorocarbons were introduced as substitutes for substances harmful to the ozone layer, which were being phased out under the Montreal Protocol.

But what was meant as a solution to the ozone hole problem, soon became a source of another major global threat, as it turned out that HFCs are powerful greenhouse gases, with a GWP (global warming potential) thousands of times larger than that of carbon dioxide (CO_2).

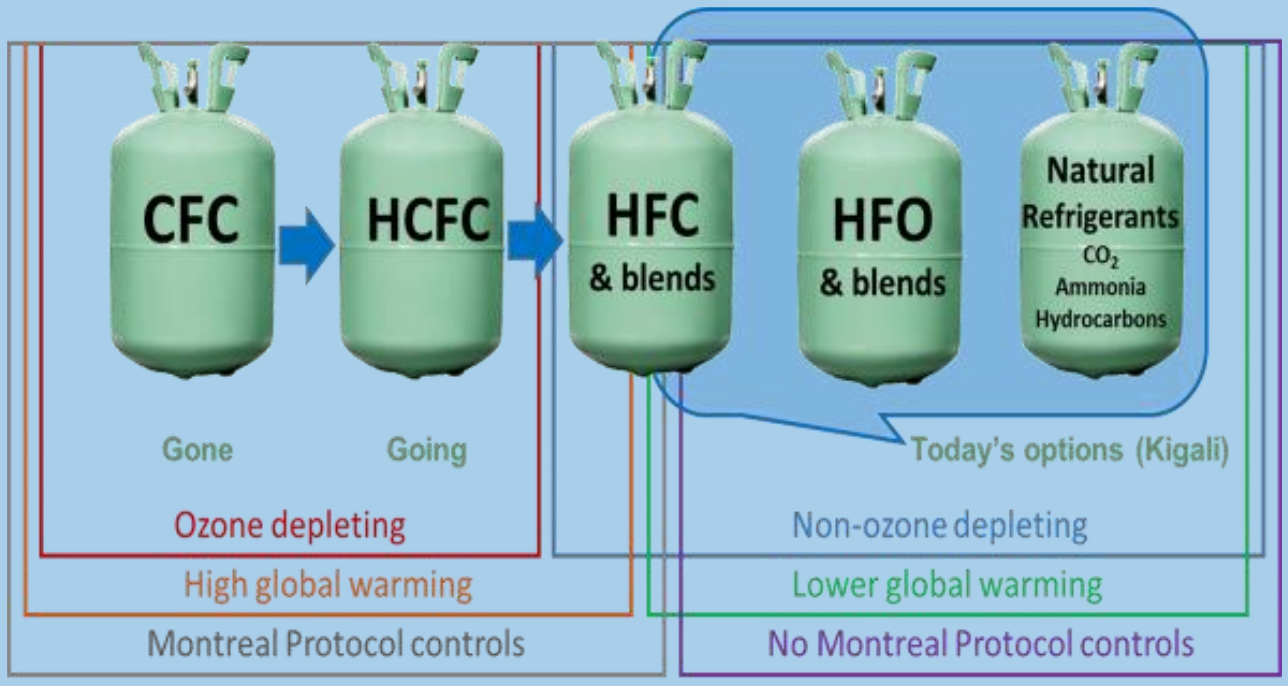
Kigali update

Under the Kigali Amendment countries have agreed to add HFCs to the list of controlled substances. They have also approved a timeline for their gradual reduction by 80-85 per cent by the late 2040s.

First reductions by developed countries are expected in 2019. Developing countries will follow with a freeze of HFCs consumption levels in 2024 and in 2028 for some nations.

HFC examples:
R134a
R410a
R404a

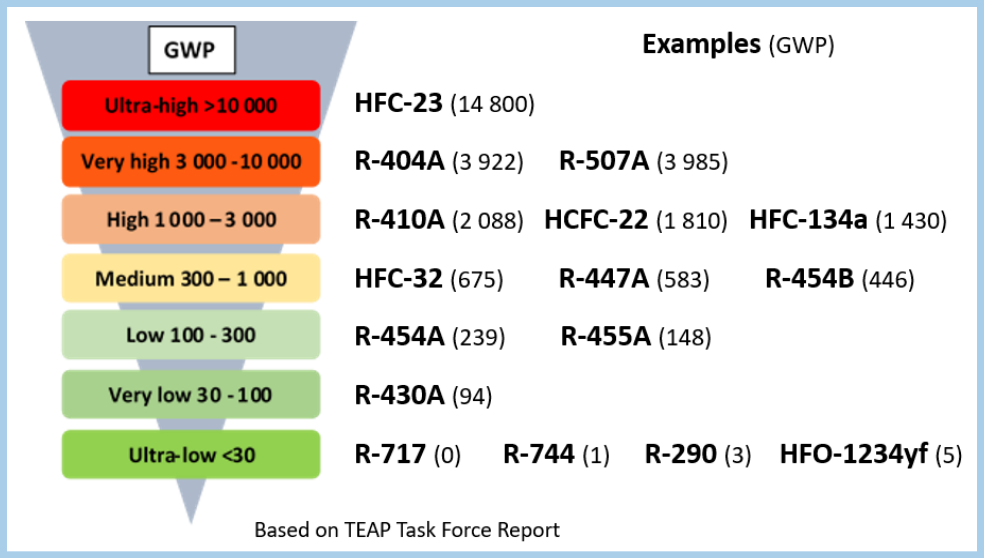
Refrigerant Evolution



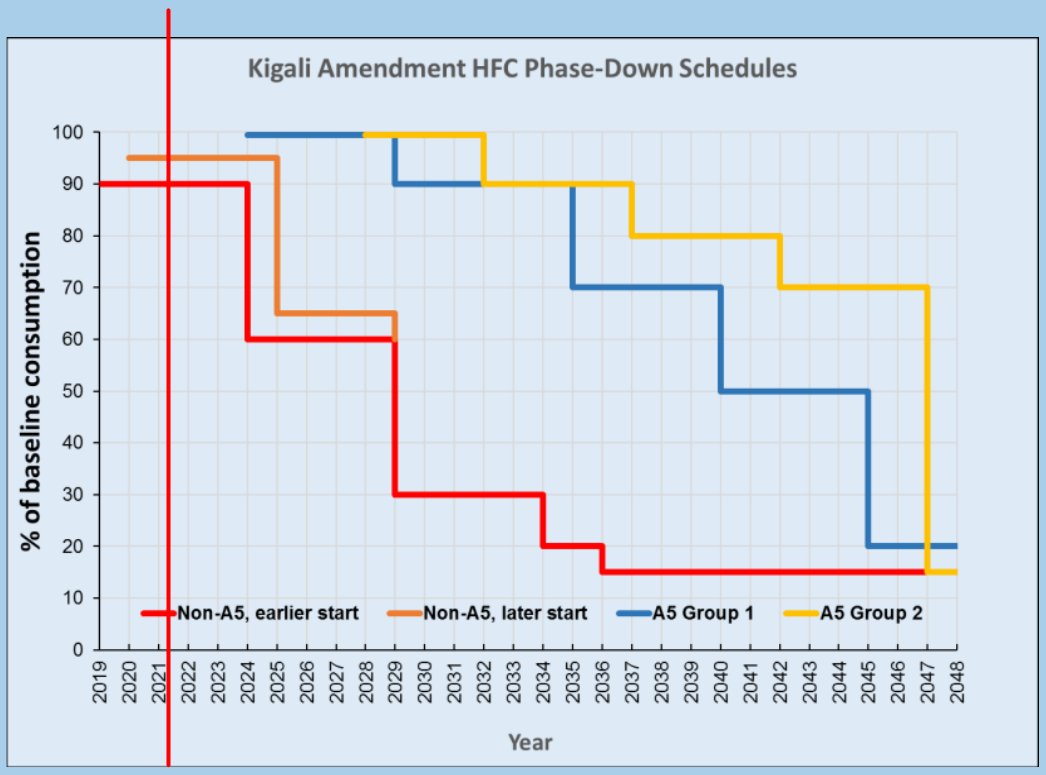
Where are refrigerants going?

The past

The future



How long will it take?



Source; Ozone Action factsheet

Phase down schedule

We are now calculating our baseline consumption

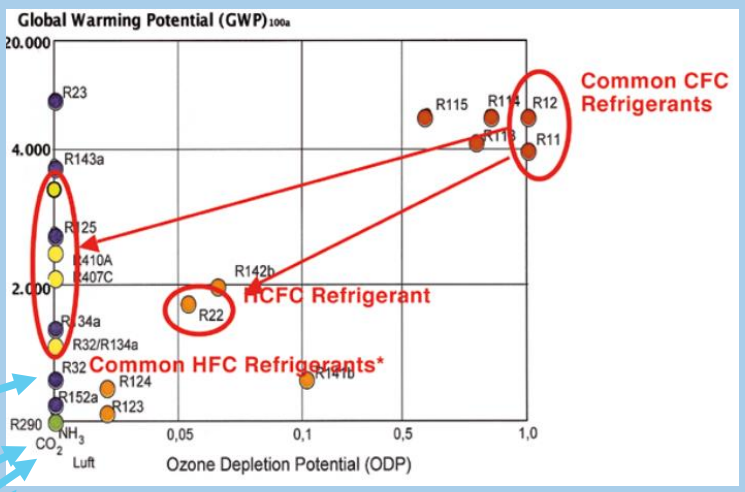
	Article 5 Parties: Group 1		Article 5 Parties: Group 2	
Baseline Years	2020, 2021 & 2022		2024, 2025 & 2026	
Baseline Calculation	Average production/consumption of HFCs in 2020, 2021, and 2022 *plus* 65% of HCFC baseline production/consumption		Average production/consumption of HFCs in 2024, 2025, and 2026 *plus* 65% of HCFC baseline production/consumption	
Reduction steps Freeze	2024		2028	
Step 1	2029	10%	2032	10%
Step 2	2035	30%	2037	20%
Step 3	2040	50%	2042	30%
Step 4	2045	80%	2047	85%

Article 5 Parties are divided into two groups:
Group 1: The majority of Article 5 Parties.
Group 2: Bahrain, India, Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, and the United Arab Emirates.

Source; UNEP

What refrigerants will we be using?

Moving from High GWP HFC's to third generation refrigerants: low GWP HFC, HFO and natural refrigerants



R32

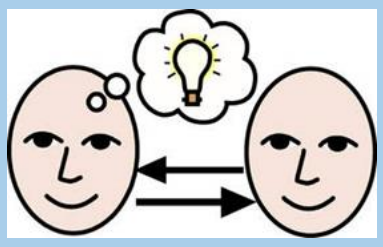
Hydrocarbons

Ammonia

CO2

Single component refrigerants

Test your knowledge: please discuss these questions



Why is the Ozone Layer important?

What is the difference between Ozone Depletion and Global Warming?

How do we contribute to Ozone Layer Destruction?

How can we help prevent Ozone destruction?

Inefficient poorly maintained machines cost more money to run and cost more to the environment through direct and indirect emissions

Our industry contributes significantly to Ozone depletion and Global warming

Leaking refrigeration systems are costly due to:

- Increased Ozone depletion
- Increased Green House Gas Emissions
- Increased energy costs
- Labour costs for repairs
- Increased down time
- Increase in food waste

Refrigeration mechanics have a responsibility to their customers and the environment to prevent emissions of refrigerant into the atmosphere when installing, servicing and repairing refrigeration systems.

Licensing and Regulation

Regulations on imports and handling of controlled substances are being implemented by governments through out the world

Base line consumption figures for HFC's will be calculated between 2020-2022

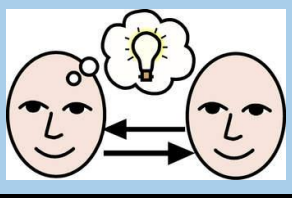
As for HCFC's there will be a gradual phase-down from this baseline

The introduction of flammable refrigerants into the industry has met that technicians need to be competent in the handling and use of dangerous chemicals.

Governments need to be confident that the industry has skilled technicians and citizens are protected from unskilled workers.

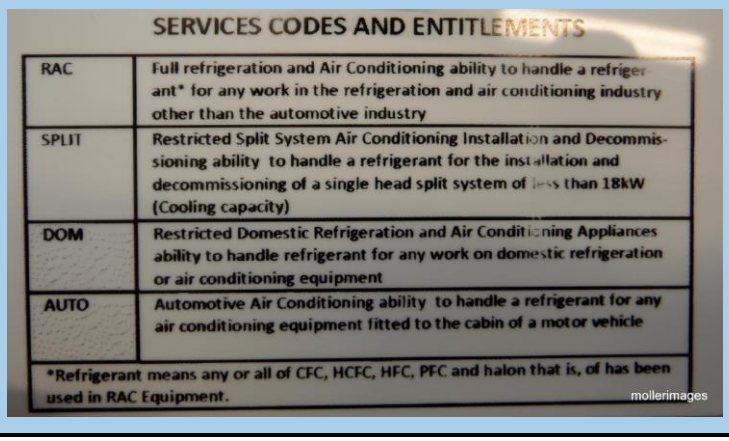
Licensing schemes are being introduced where technicians undergo ***education, training and certification of their skills*** to be able to work with flammable refrigerants.

What do you think of a licensing scheme for technicians? Will it improve your business?



Licenses can be created by government to industry needs and standards

Licenses can display the qualifications of individuals in specific areas



Appropriate Leak detection methods

System Leaks fall into one of five categories	Leak detection method
Leaks that can be detected from normal system pressures the most common	Use either visual or soapy water solution
High pressure leaks, or those that only leak when pressure increases over normal operating pressures	Use nitrogen with regulator at appropriate pressure for the refrigerant
Temperature leaks, or those that occur when the refrigerant piping expands or contracts due to pressure differences (most commonly on metering devices)	Electronic detection/dyes
Vibration leaks, or those that occur when excessive vibration exists commonly when compressor piping is not designed correctly	Electronic detection/dyes while system in operation
Micro leaks, or those that are extremely difficult to detect such as in mobile AC where refrigerant leaks through flexible hoses	Dyes

Reducing Leakage

Leak reduction should be considered at every stage of the refrigeration system;

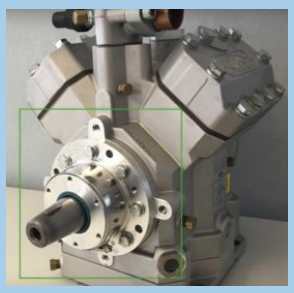
1.**System design.**
   a. Systems should have as few flared joints as possible, preferring soldered connections.
   b. All refrigeration piping should be secured to prevent vibration and cracking.
2. **Pressures**
   a. Operating pressures should be kept to a minimum with appropriate cut-out protection preventing pressures rising above designed conditions.
3. **Commissioning**
   a. Systems should be evacuated and pressure tested to designed standards for example sustaining 700 microns vacuum.
   b. Refrigeration systems should be commissioned to check for correct designed operating conditions
4. **Maintenance**
   a. Systems should be maintained regularly checking;
   b. Operating pressures and temperatures
   c. Leak checking
   d. Efficiency

Most leaks in a refrigeration system are due to poorly installed equipment. The most common of leaks occur on:

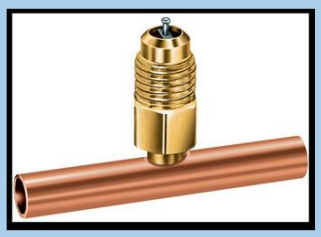
Flared joints

Pressure switches

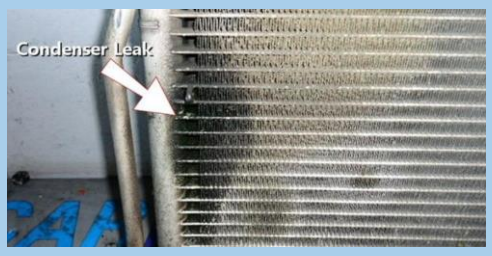
shaft seals



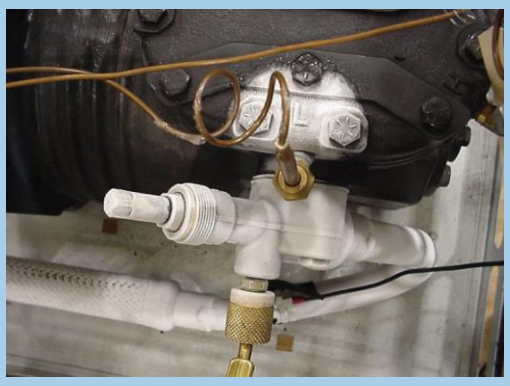
Schrader valves



Condensors



Mechanical joints



Leak testing

Pressure and leak test
Locating and repairing refrigerant leaks is one of the common duties of a refrigeration mechanic. Regulations in Australia pertaining to ODS (Ozone Depleting Substances) mean mechanics may be prosecuted for topping up a charge without searching for the source of a leaking system. There are many methods for finding leaks.

Detergent

Halide torch

Electronic

Ultraviolet

Ultrasonic

Leak testing methods & equipment

Make sure leak testing equipment is suitable for the refrigerant being tested

- Electronic: very sensitive, can sense fluorocarbons from other sources
- UV dye: has to be used in conjunction with UV light
- Vacuum test: unable to hold vacuum may indicate a leak however unreliable and not recommended as it may introduce moisture
- Soapy water solution

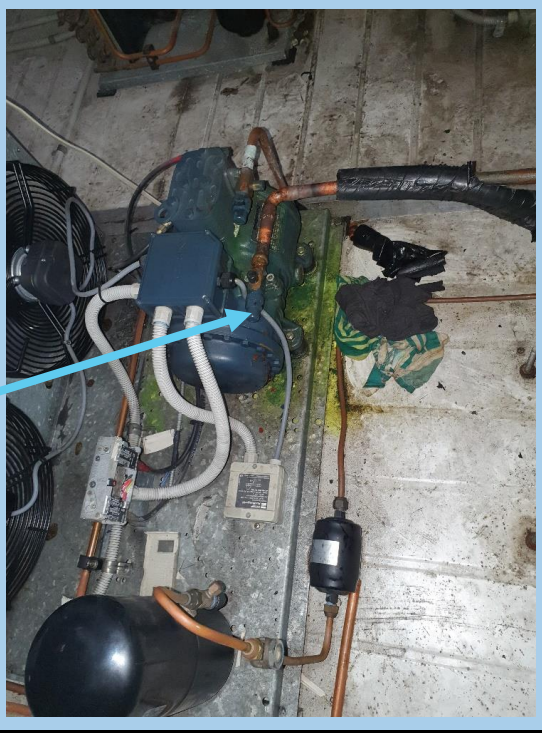
UV Dyes
Technicians are now using these dyes as part of their maintenance procedures

UV dyes
Injected into the system to identify leaks

Leak stop
Injected into systems to stop small leaks

Three strengths for different system volumes

This size for split system



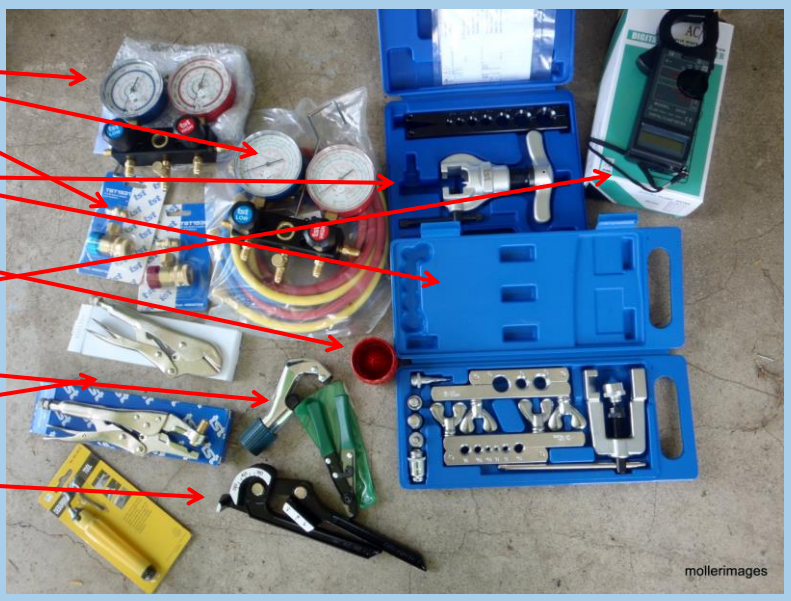
This is what a leak looks like with UV torch

Watch video 1 for use of dyes

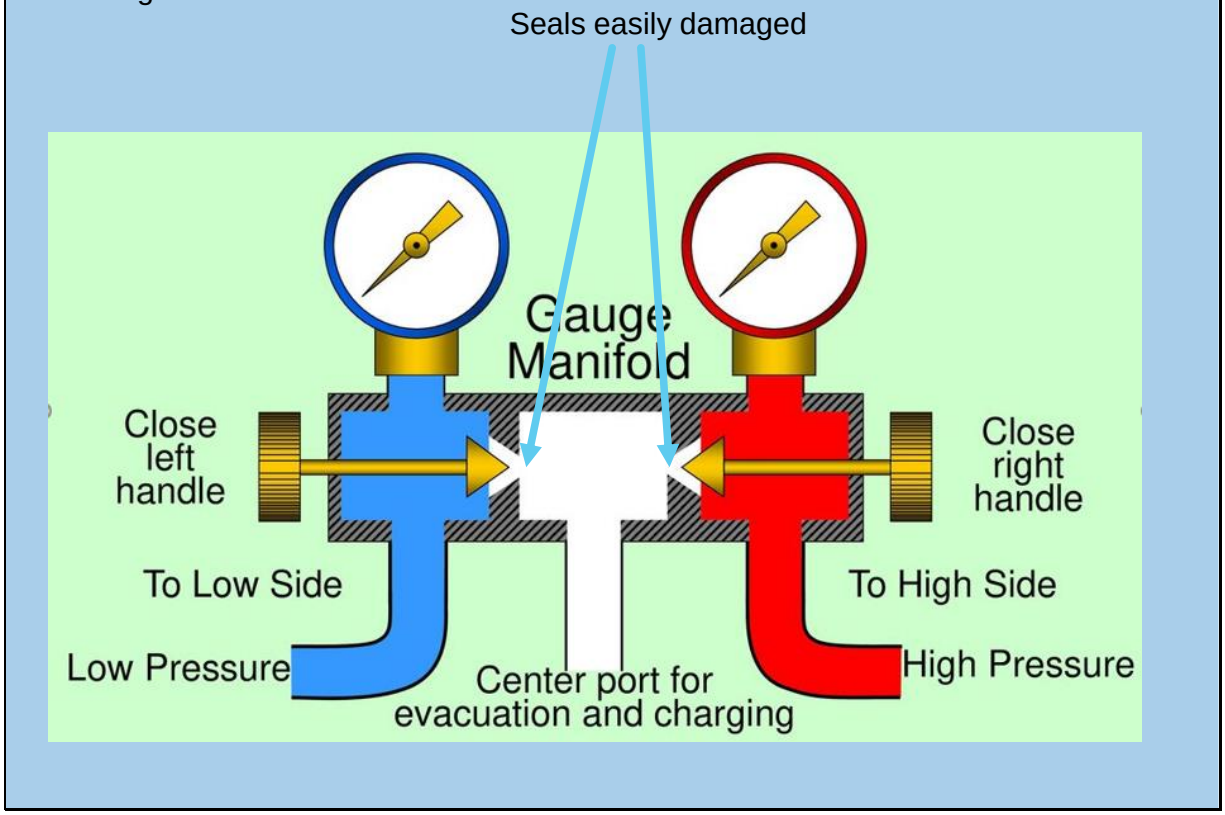
Refrigeration hand tools:

- Gauges R410 & R22
- Automotive connectors
- Flaring & swaging tools
- Deburring tools
- Clamp meter
- Tubecutter
- Pinchoff tools
- Tubebender
- Vacuum pump

Technician hand tools



Gauge manifold



Recovering of Refrigerant

Recovery: the process of removing refrigerant temporarily from a system to be reused

Recycling: the process of removing refrigerant from a system and 'cleaning' it through a series of filters that remove moisture and contaminants. **Importantly this system does not guarantee purity of the refrigerant.**

Reclaiming: the process of removing refrigerant from a system and returning it to its original pure state as per international standards. **This system guarantees pure refrigerant however requires specialized equipment and testing procedures**

- Disposable cylinders are not to be used for recovering
- Clean refrigerant cylinders are for charging equipment only and are fitted with a RPD (Refill Protection Device) to prevent back filling
- Pump Down cylinders are for the use of recovering clean refrigerant intended to be recharged into the same system after repairs have been carried out (Recovery & Recharge)
- Recovery cylinders are used to recover contaminated fluorocarbon refrigerant or refrigerant that cannot be reused. This refrigerant must be either recycled, reclaimed or destroyed at a suitable facility.

Refrigerant Identifiers

Identifiers are a great tool for checking to see what refrigerant is in the system, if there are contaminants and composition of blended refrigerants

Importantly though they cannot confirm purity to AHRI 700 which requires more specialized equipment

Tools for recovering refrigerant

Micron gauge

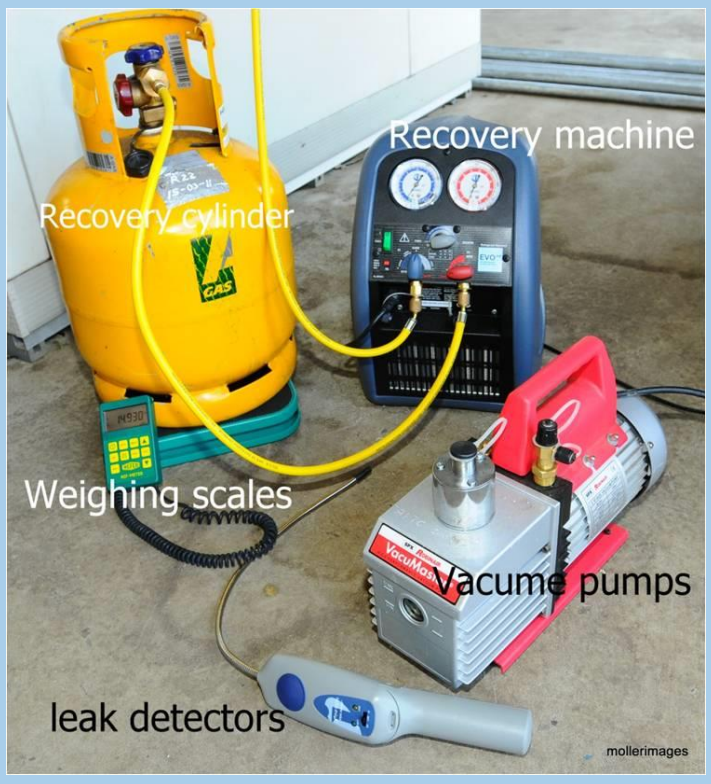
- Recovery cylinders
- Digital weighing scales
- Reclaim machines

Leak detectors

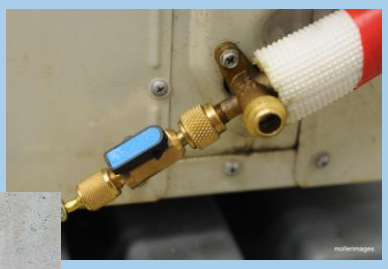
Tools for recovering

System Connections

Minimum requirements for trouble free servicing of refrigeration and air conditioning systems



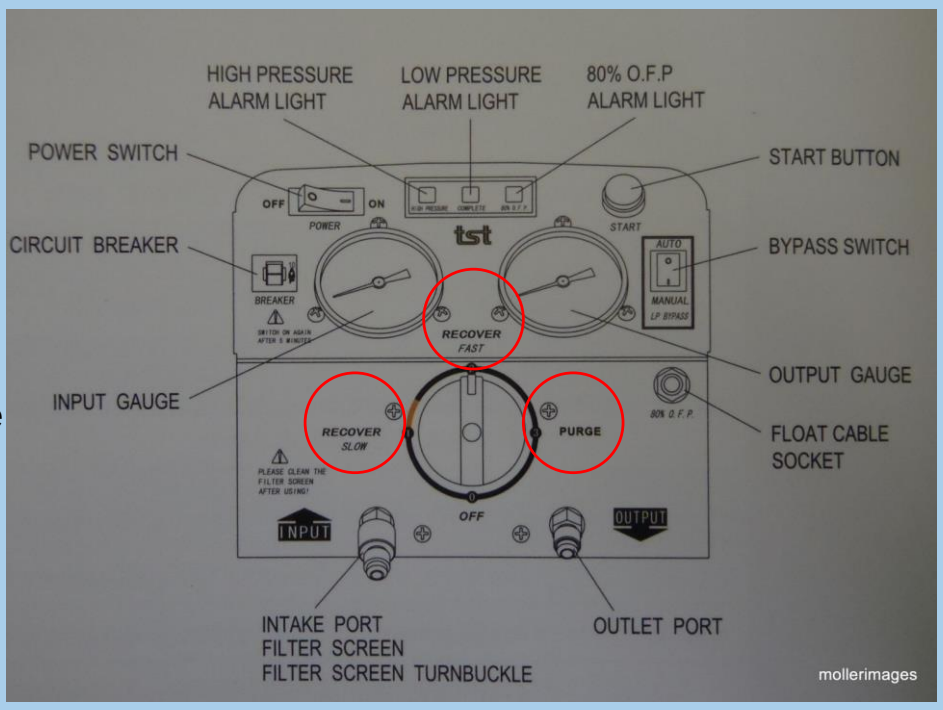
System connections



Isolation couplers are used
to eliminate emissions

Recovery steps

1. Vapour/liquid
2. Vapour only
3. Equalise pressure



Important points to note:

1. Disposable cylinders are not to be used for recovering
2. Recovery cylinders need to be kept clean
3. Contaminated refrigerant needs to be kept separate
4. All cylinders need to be labelled after use even if empty:
5. Refrigerant type
6. Date
7. Pure or contaminated
8. Name of technician

Safe filling of Recovery Cylinders

Overfilled cylinders can explode
Always monitor weight of cylinder when reclaiming refrigerant

Test date of cylinder

Tare **W**eight (weight of empty cylinder)

Water **C**ontent (amount of water in weight that the cylinder can hold)
W.C. x .8 = Safe Refrigerant capacity
21.8x.8 = 17.5KGs of recovered refrigerant can be safely added to the cylinder

Economics of Recovery

This 7KW machine has 2 KGS of refrigerant R22

Cost of R22 USD$546 / 13Kg cylinder
= $42/Kg

So for this machine
2 x 42 = $84 of refrigerant recovered in 30 minuets

If it was released to atmosphere the machine would require another 2 kgs to recharge

By recovering we have saved $84 in 30min

Vacuum systems and vacuum pumps

What is Vacuum?

Vacuum is the term for air pressures which lie below normal atmospheric pressure. The vacuum values used depend on the specific application.

For refrigeration related vacuum, a relatively high vacuum of better then 1 millibar (750 micron) absolute is required.

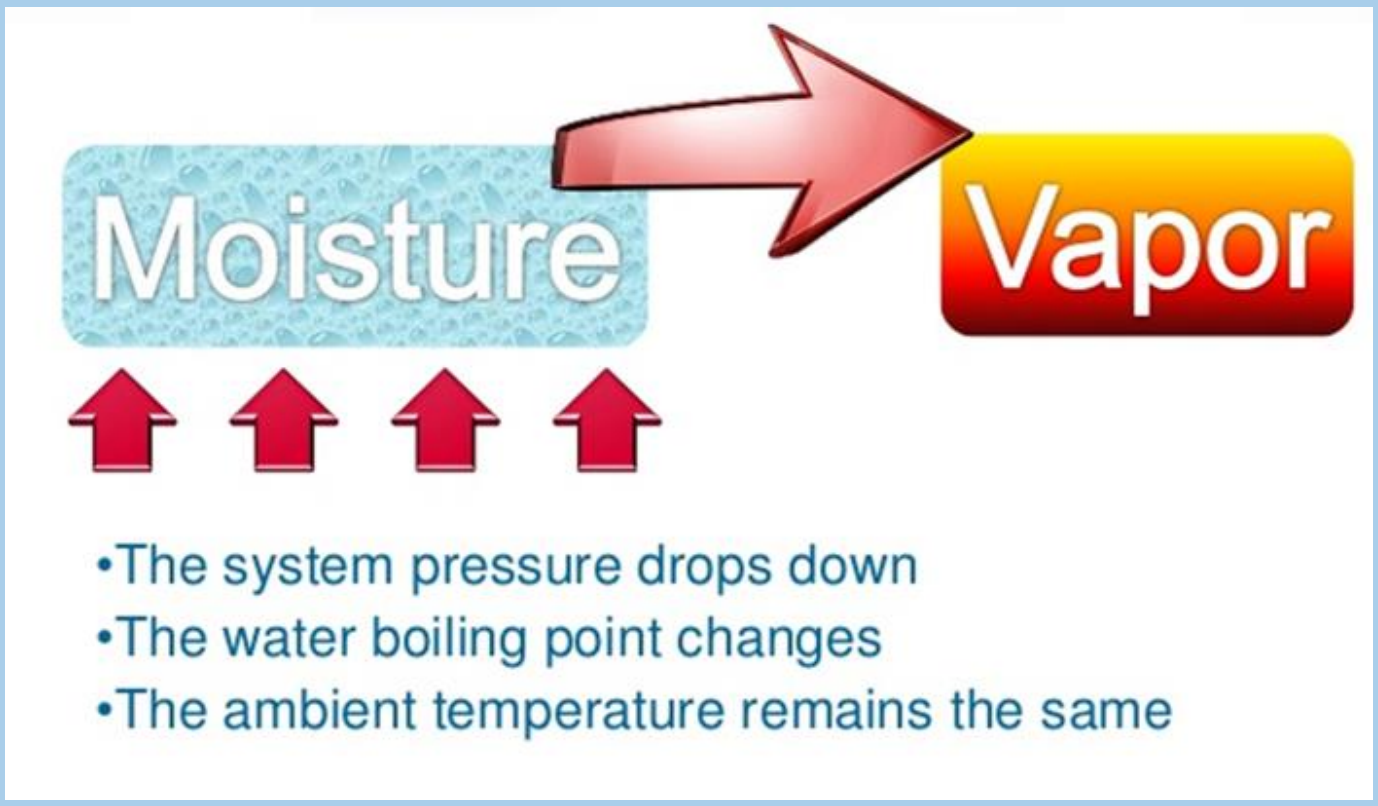
For recovery unit compressors, relatively low vacuum values are sufficient. These values lie in the range between 1 mbar and atmospheric pressure (1013 mbar) known as a “Rough Vacuum”

A poor vacuum can cause many problems because it doesn't dehydrate the system properly. Any moisture that is left combines with the oil and heat in the system to create acid. You can't rely on the filter drier to clean this out of the system.

Polyol ester oils are extremely hydroscopic meaning that they absorb moisture

When a system is opened to the atmosphere the oil acts like a sponge absorbing moisture out of the air

How is moisture removed from the system?

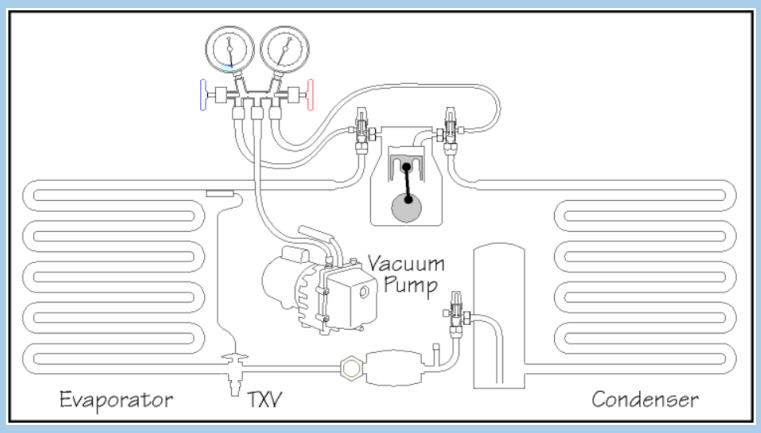


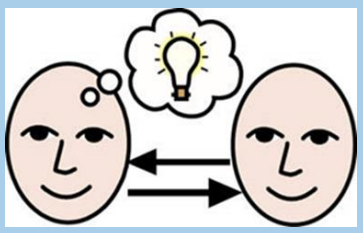
The vacuum pumps effectively remove moisture and non-condensable contaminants from HVAC systems. These contaminants in the process of been removed, become trapped in the pump's oil reservoir, which leads to malfunctioning and bad performance of the machine. For this reason, the need for frequent changes in the oil of your vacuum pumps is essential to maintain your HVAC systems.

The vacuum pump oil acts as a lubricant, coolant, and sealant for a pump. Just like in a car, its regular change is necessary and ensures optimal performance and a long time of operation of the machine.

Tip: If you are having trouble pulling a vacuum change the oil in the pump and check connections

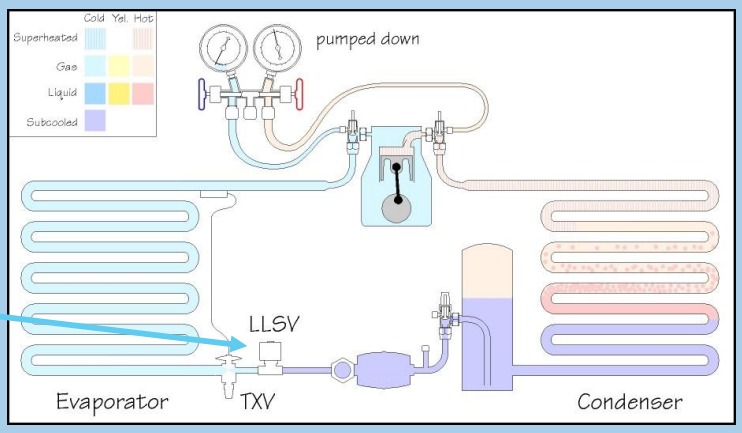
System connections





What considerations would we have to evacuate this system?

Hint: what is this?

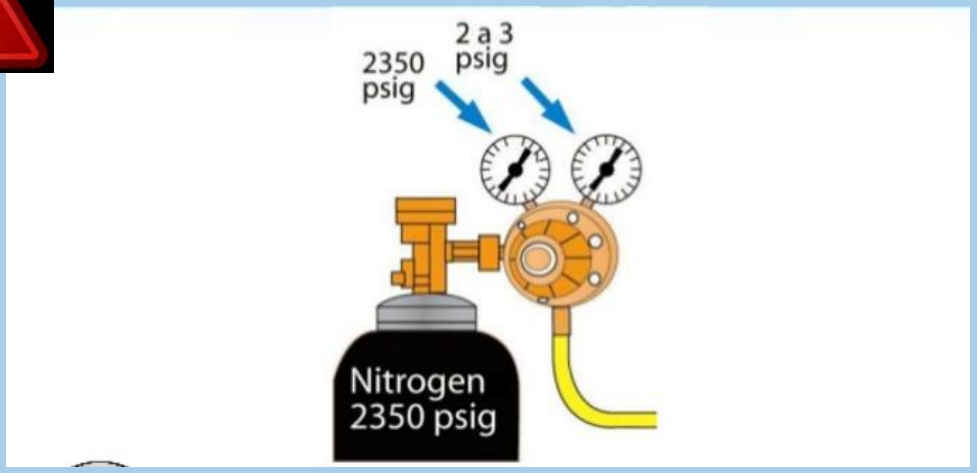


Pressure testing, dry nitrogen and the triple evacuation method:

Caution when using dry nitrogen

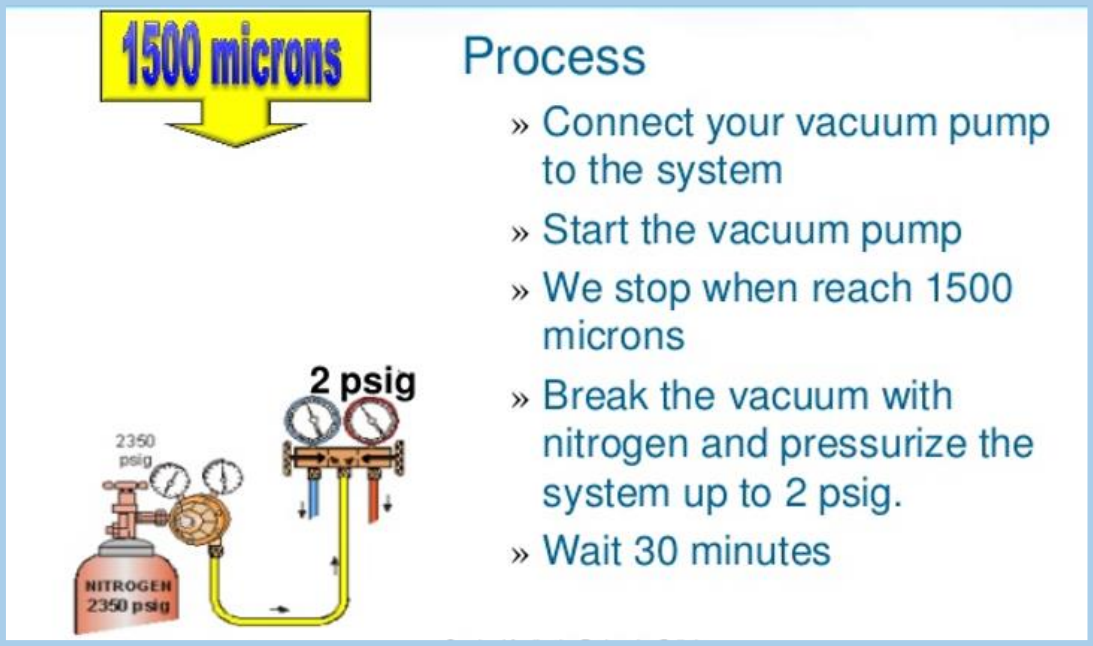
Notice the pressures!

Never pressurize a system without using a two stage nitrogen regulator



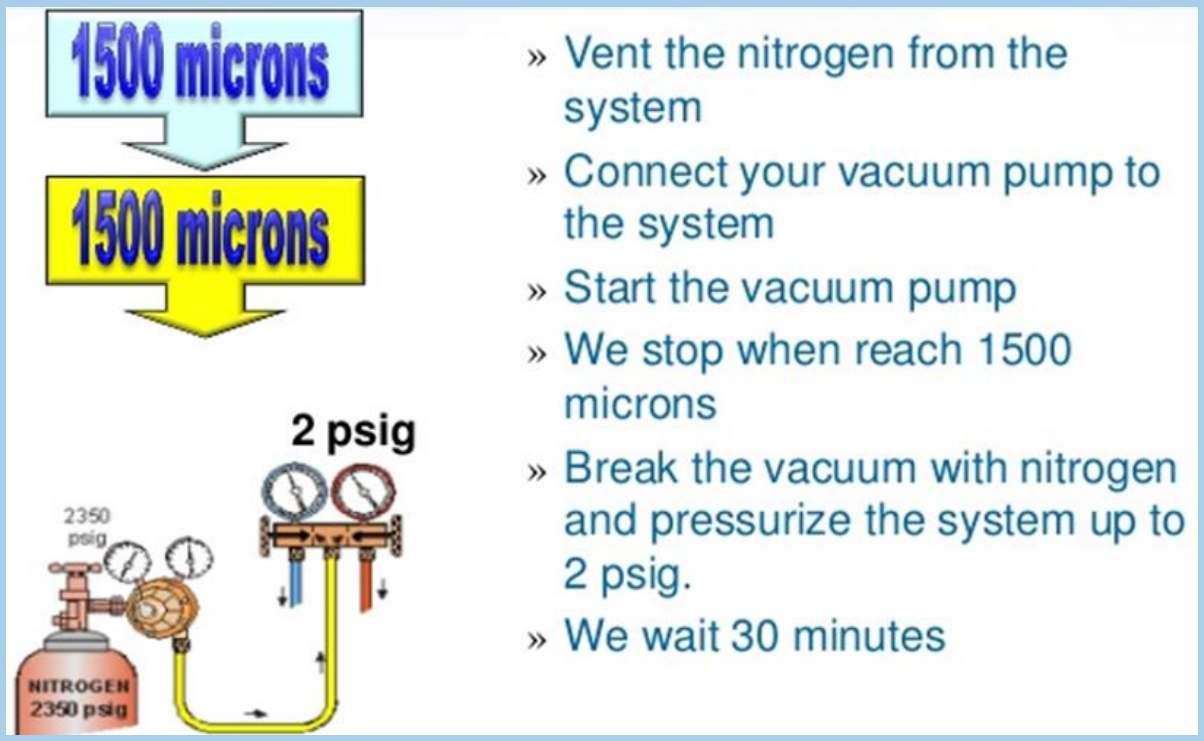
Pressure testing, dry nitrogen and the triple evacuation method:

Step 1



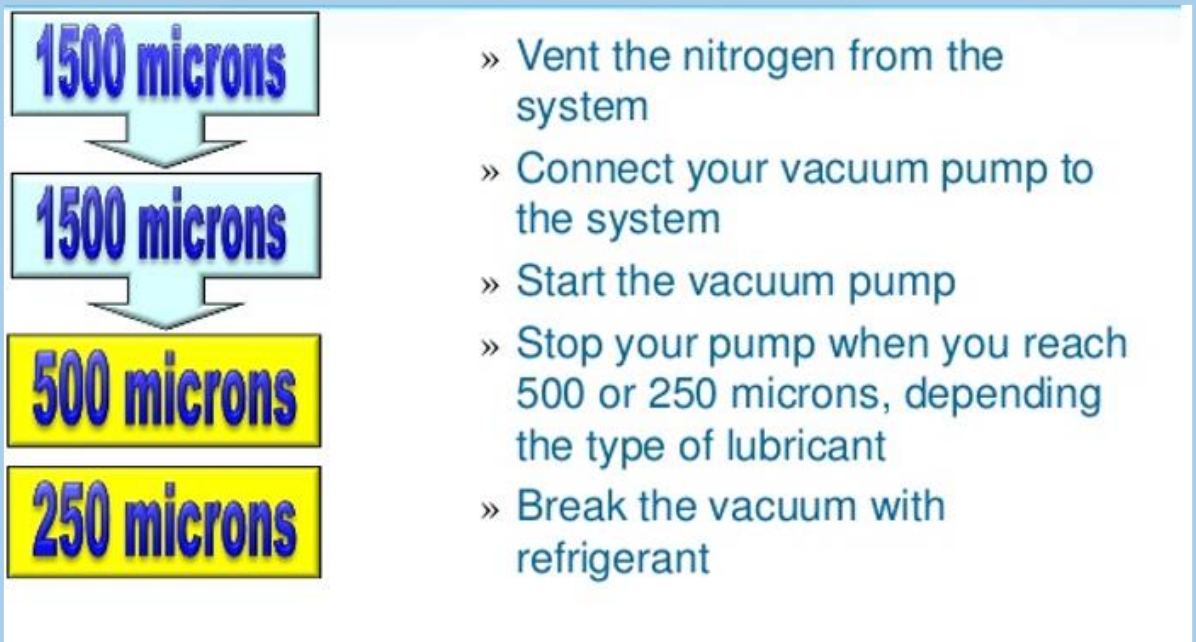
Pressure testing, dry nitrogen and the triple evacuation method:

Step 2



Pressure testing, dry nitrogen and the triple evacuation method:

Step 3



Nitrogen absorbs moisture so each time you reintroduce it into the system it is taking moisture out with it helping to dehydrate.

Contaminants in Refrigeration systems

Refrigeration systems are sealed systems.

Contamination is introduced from our practices either during installation or servicing

Contaminants include;

- Air
- Moisture
- Acid
- Carbon
- Refrigerant mixtures

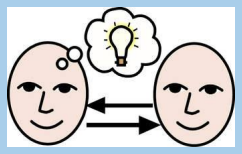
When refrigerant is contaminated it breaks down to form acids which can damage the system, either by dissolving motor windings and burning out compressor motors

Testing for acids

1 A small amount of oil is added to testing kit
2 Color is compared to chart to see if it is acidic

You are the only one who can introduce contaminants into the system

Example of challenges: cylinder safety



What safety concerns are there with these two different valves?

Disposable cylinder
Rupture disc

Refillable cylinder
Pressure relief valve

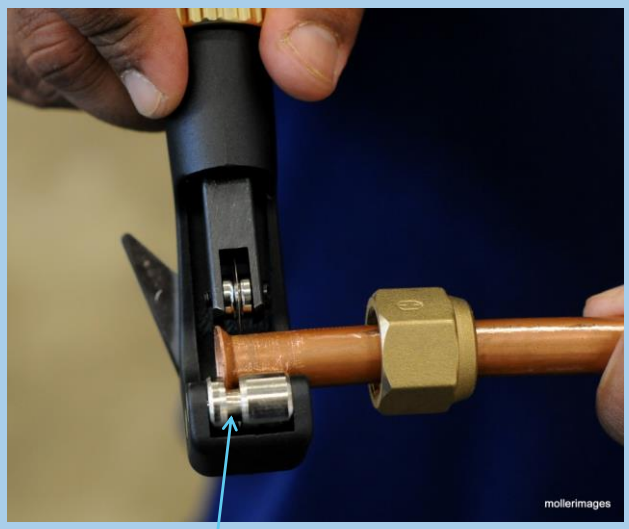
Servicing procedures
Flaring:

Flaring and swaging

Flaring 410a

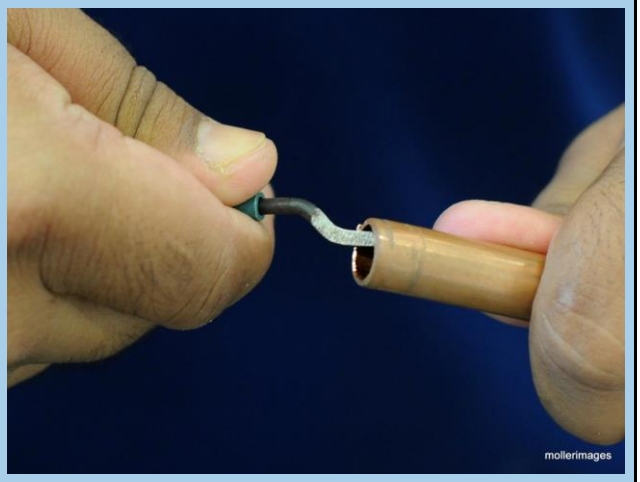
Step one:
Cutting and deburring copper tubing

Cut tube to length



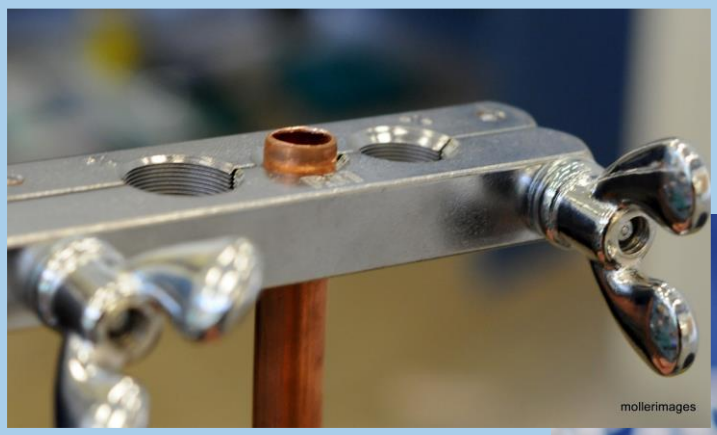
Notice groove in cutting wheel to fit flare

Deburr tubing



Step 2:
Flaring copper tube

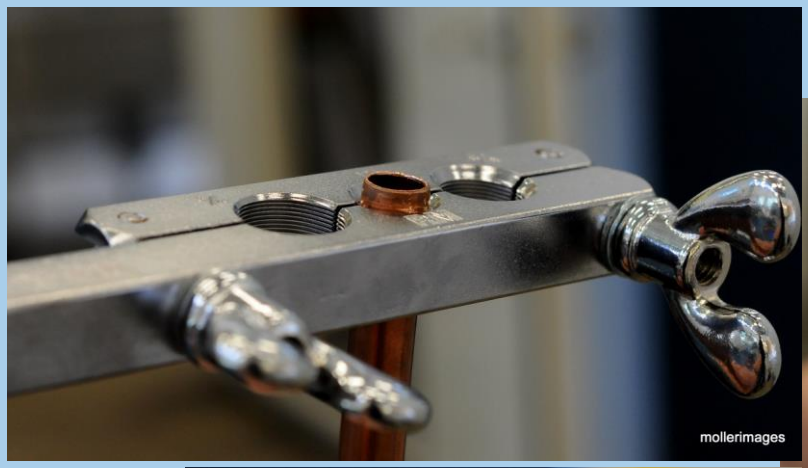
Position tubing correctly in flaring block

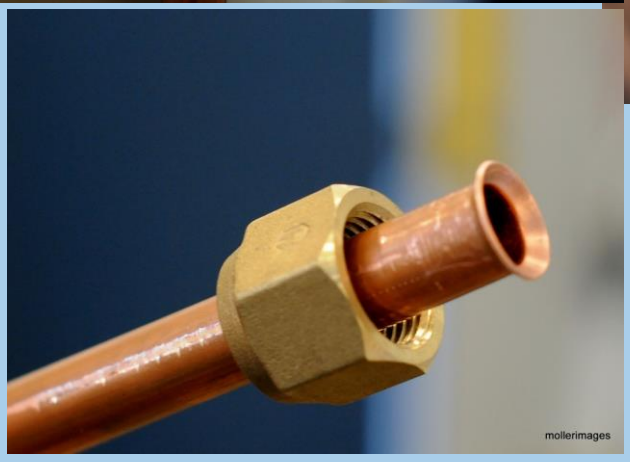


Too much and the flare wont fit into the flare nut

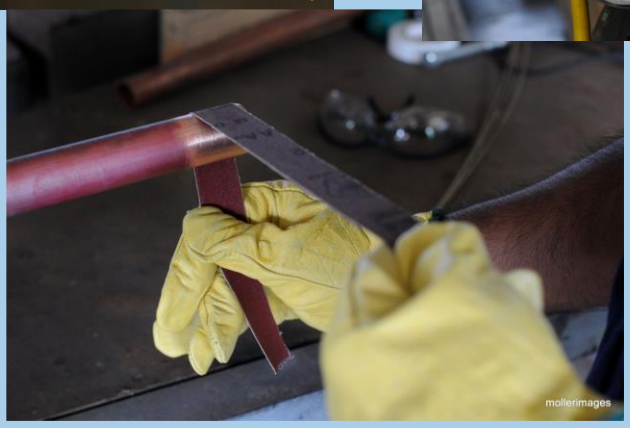
Not enough and the flare may pull through the flare nut

A correct flare fits the nut

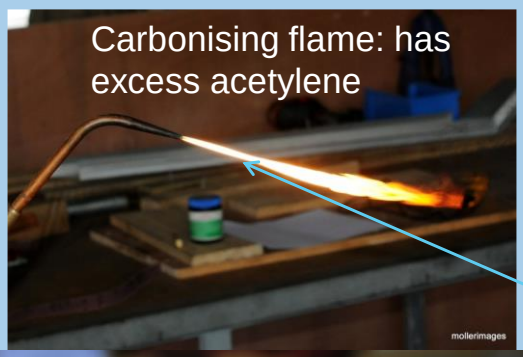


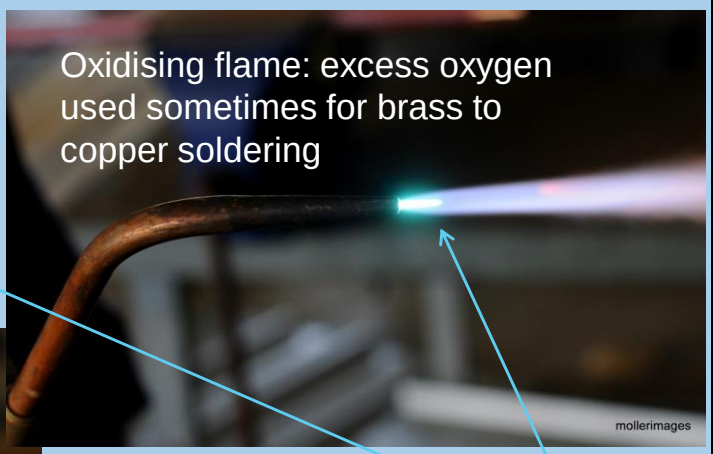


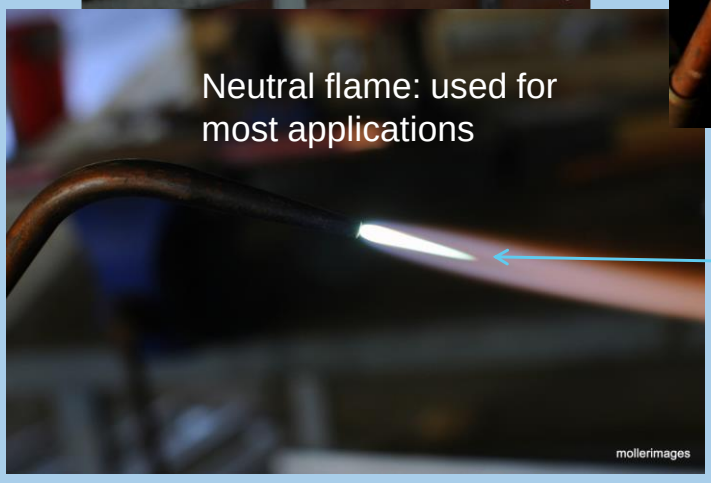
Soldering



Nitrogen regulator





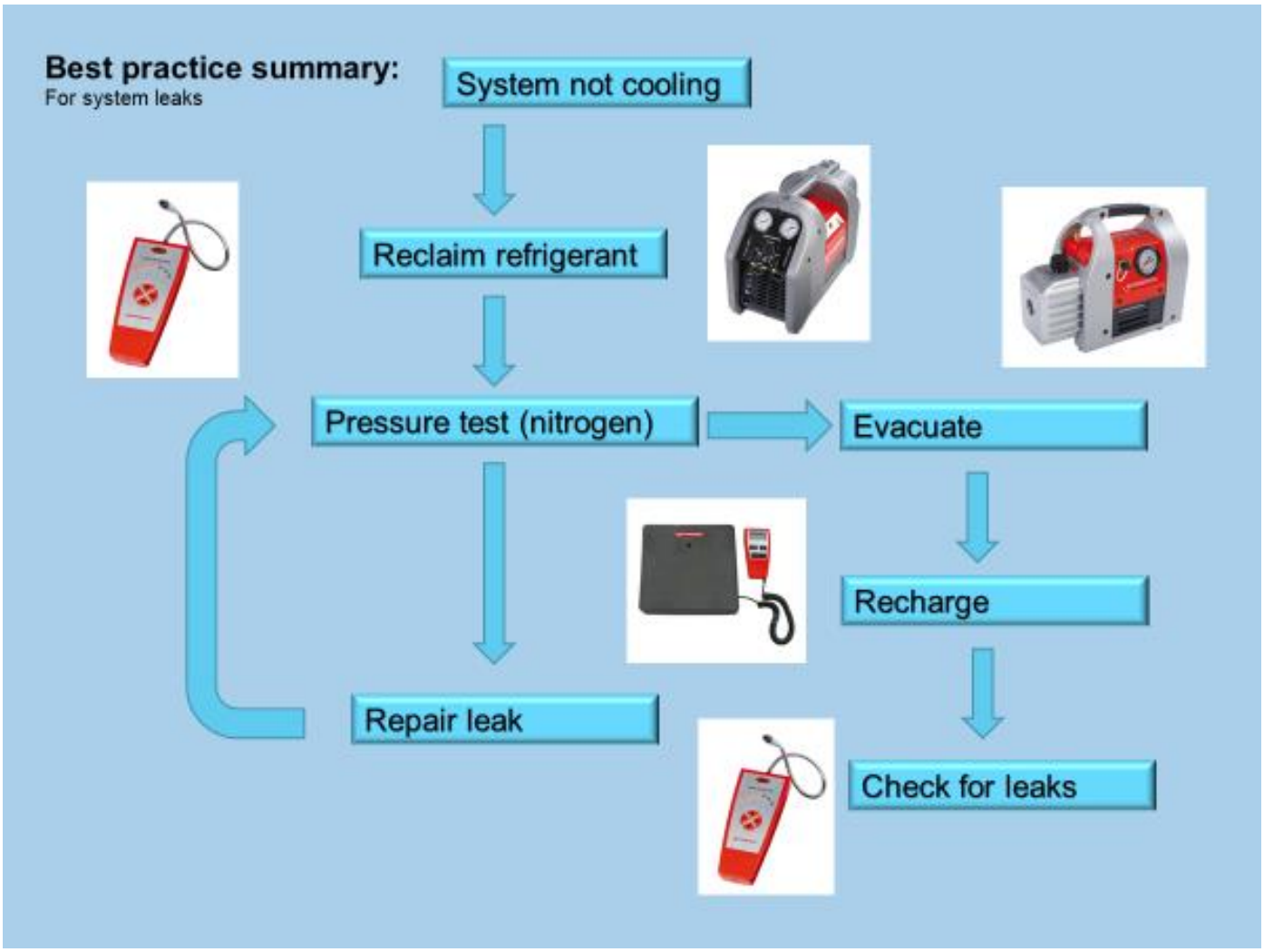


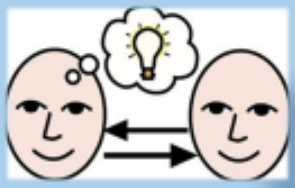
Difference in flame cone size

Oxy acetylene soldering

When soldering always purge with nitrogen : this reduces the build up of oxidising agents inside the tubing……

This is the result annealing two identical tubes, one purging with nitrogen one without


Best practice summary:
For system leaks
System not cooling
Reclaim refrigerant
Pressure test (nitrogen)
Evacuate
Recharge
Check for leaks
Repair leak



Test your knowledge: please discuss these questions

List two reasons why it is important to reclaim refrigerant?

List three contaminants that form in refrigeration systems?

What critical tools do refrigeration mechanics require to do their job?

Where do most leaks in refrigeration systems come from ?

Working with flammable refrigerants

Some standard tools and equipment can be used safely with HC's, including gauge manifold sets.

Most standard vacuum pumps can be safely used, because the only potential source of ignition is the off/on switch. The HC's discharged by the pump should be either burned off or vented safely and the pump should be turned off and on outside of the safe working area.

Standard recovery machines cannot be safely used to recover HC's as they have several sources of ignition, such as safety and pressure switches. In addition a leak would result in a flammable zone around the machine. A recovery machine designed for HC's must be used.

For more detailed information on flammable refrigerants please see Module 2 Low GWP Alternatives

Special considerations for working with Flammable Refrigerant

- Appropriate cylinders must be used (e.g. collar protection for valves)
- Same as for other classes of flammable gases such as acetylene
- Ensure area is well ventilated
- Don't store near sources of ignition e.g. power points, electric motors
- Keep out of direct sun and away from heat sources
- Protect from falling
- Storage area free of combustible or waste materials
- Locked away from unauthorised persons
- Area should be labelled with hazard signage and have access to fire extinguisher

Service and Maintenance

Pre-service safety : **Risk assessment**

•Do you know exactly what refrigerant is in the system?
if unsure treat as flammable!

Minimise risk of ignition

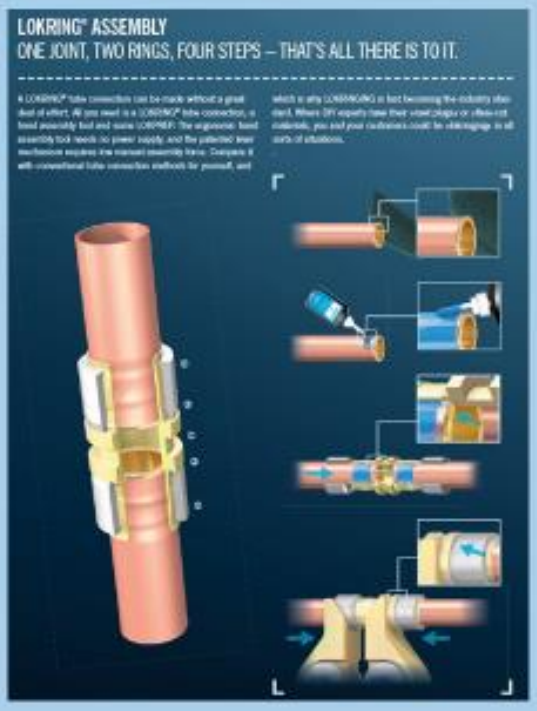
Temporary flammable zone
•Establish the area required and display appropriate signage.
•Remove sources of ignition

Refrigerant recovery
•Do not recover hydrocarbons into HFC reclaim cylinders
•Is the recovery equipment suitable for flammable gases?
•Note: Equipment suitable for A2L refrigerants may not be suitable for A3 hydrocarbons
•The major wholesalers have a range of equipment for flammable refrigerants
•For R32 use dedicated R32 reclaim cylinders

Note –the standard HFC/HCFC reclaim cylinders are not suitable for flammable gases. They do not have the appropriate pressure rating or labelling

Solderless joining

Particularly suited to working with flammable refrigerants this method is gaining popularity with installers due to its failsafe and leak proof joining, and for the mining and medical industries, the ability to install systems with out using an oxy torch.



Other brands are emerging offering slightly different connecting methods

Watch video in module 2 for this tool in action!

Further information on refrigerants: downloadable apps from UNEP

https://play.google.com/store/apps/details?id=com.UNEP.OzonAction.WhatGas

https://play.google.com/store/apps/details?id=com.UNEP.OzonAction.RacVideo

https://play.google.com/store/apps/details?id=com.UNEP.OzonAction.RefrigerantGuide

These guides are a useful tool to have in the field to help identify refrigerants and show correct handling and safety procedures

Evaluation	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
The training improved my understanding of recover techniques					
The training improved my knowledge of low GWP alternative refrigerants					
I will share the knowledge and resources from this training in my workplace					
I would like to be part of an industry association in my country					
Delivery of theoretical sessions was effective and easy to follow.					
The training manual was helpful and relevant.					
The presenter has knowledge of the area of study.					
Before the training I **was not aware** of ODS licensing and regulations in my country					
I will seek further training in refrigeration and air conditioning trade					
I would like to be ***certified*** as competent in the refrigeration trade					

Many thanks for your attention

Questions/feedback:

michael@praxisvocational.com