ENGINEERING TOMORROW

Handling A2L and A3 refrigerants charging procedures and how to service

Jörg Saar – Global application manager

REFRIGERANT WEEK 2019

Accelerate refrigerant transition and turn down climate impact



Danfoss #RefrigerantWeek

CLIMATE WEEK NYC

BY THE CLIMATE GROUP

Official affiliate event



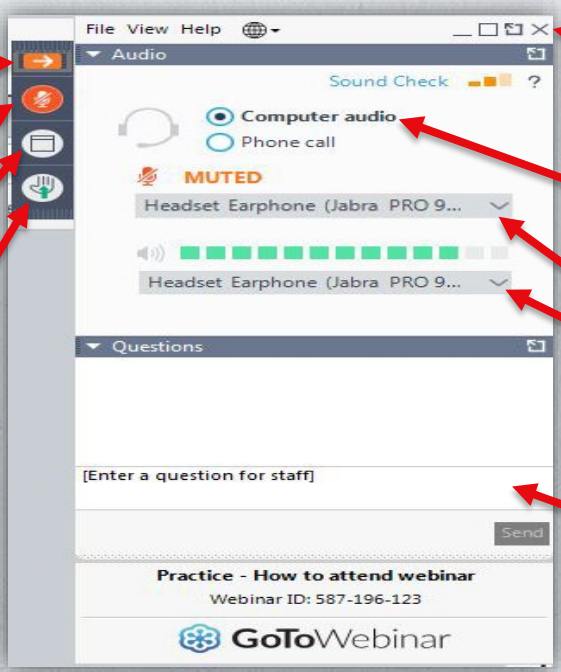
Practical information

To minimize the control panel

You are muted by default

To view full screen

To raise hand for questions



To exit webinar

Ensure computer audio is selected

Ensure both audio is selected as same

To type in your questions

You might also see some other windows popping up during the webinar:

- Poll Window
- Handout Window
- Chat Window

Please note this webinar will be recorded

ENGINEERING TOMORROW

Content

- HFC phase down, R404A Service ban (virgin refrigerant)
- Difference A1 to A2L & A3 refrigerants
- How to work with flammable refrigerants:
  - Can I continue to use my existing tools – why should I check ?
  - Personal safety
  - Personal education – know about the new refrigerants and rules
- Differences in charging process / service steps between A1 to A2L & A3 refrigerants
- Danfoss products and tools for A2L & A3 refrigerants for service

ENGINEERING TOMORROW

Disclaimer

Danfoss does not assume liability for any statements made in and during this presentation or any actions taken by its readers or users, which may cause unintended damage or injury as a result of any recommendations or inferences made within this presentation.

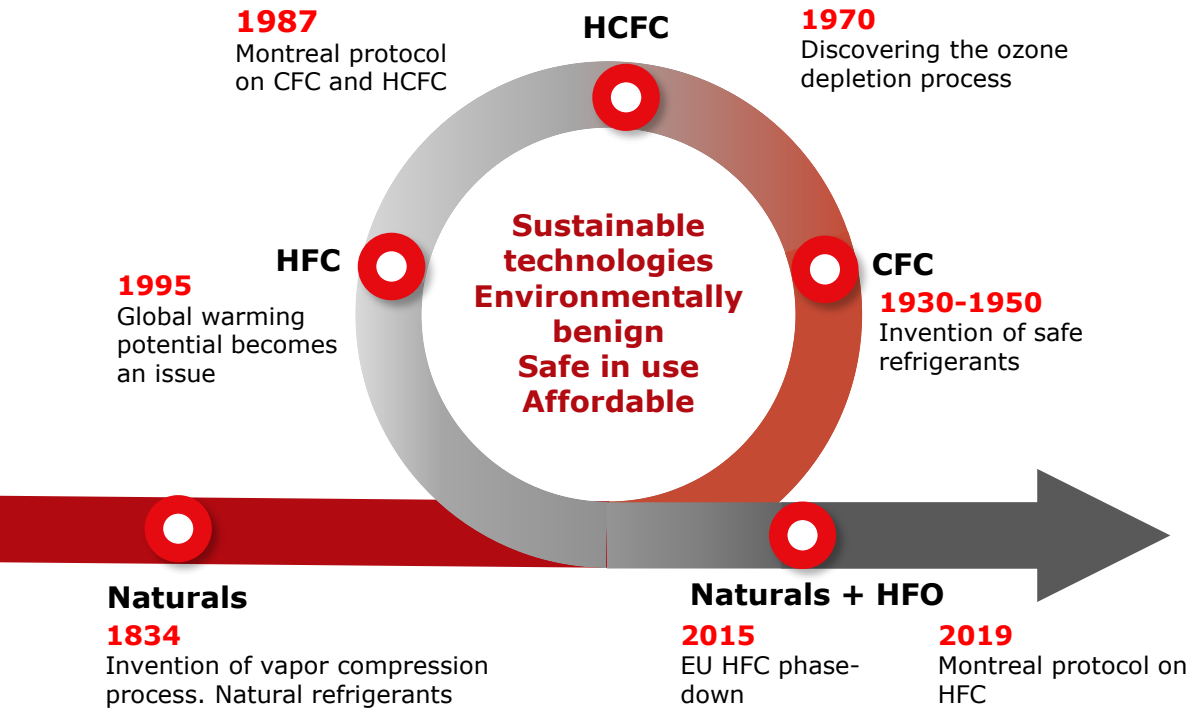
Please always refer to manufacturers' manuals and instructions.

Although all statements and information contained herein are believed to be accurate and reliable, they are presented without guarantee or warranty of any kind, expressed or implied.

This presentation makes only general recommendations on the use of Low GWP refrigerants which do not compensate for individual guidance and instructions.

National laws and guidelines must be consulted and adhered to under all circumstances.

Refrigerants in 185 years
Closing the loop to greener refrigerants



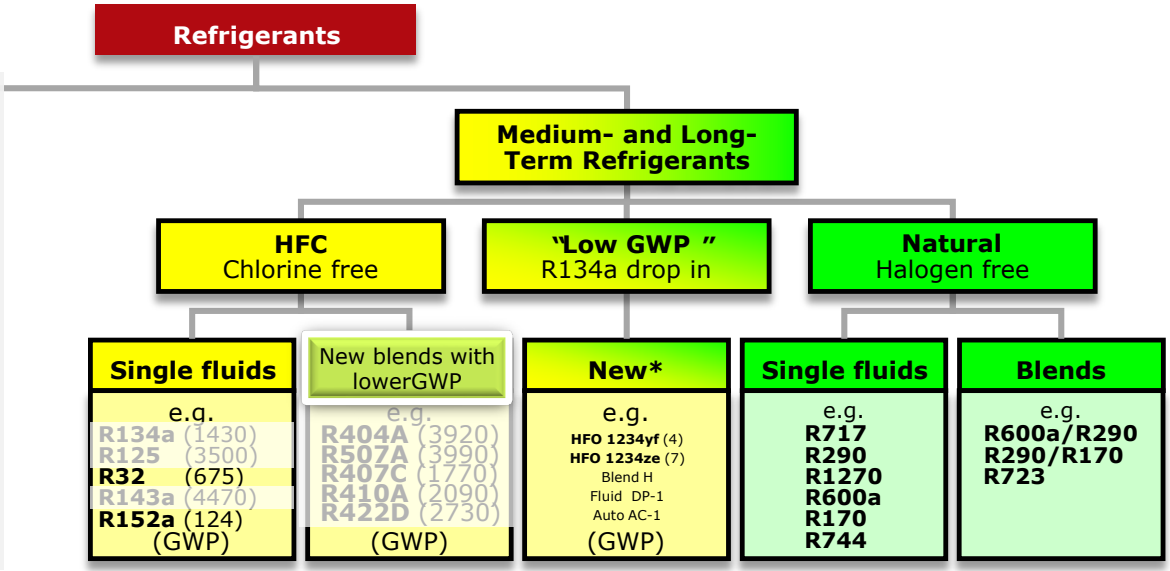
- The 4th big transformation is ongoing
- Safety is the qualifying parameter
- Energy Efficiency is the winning parameter
- Regulatory certainty is driving technology development

ENGINEERING TOMORROW

Refrigerants Options

Out due to Montreal Protocol

(Ozone Depletion Reduction)

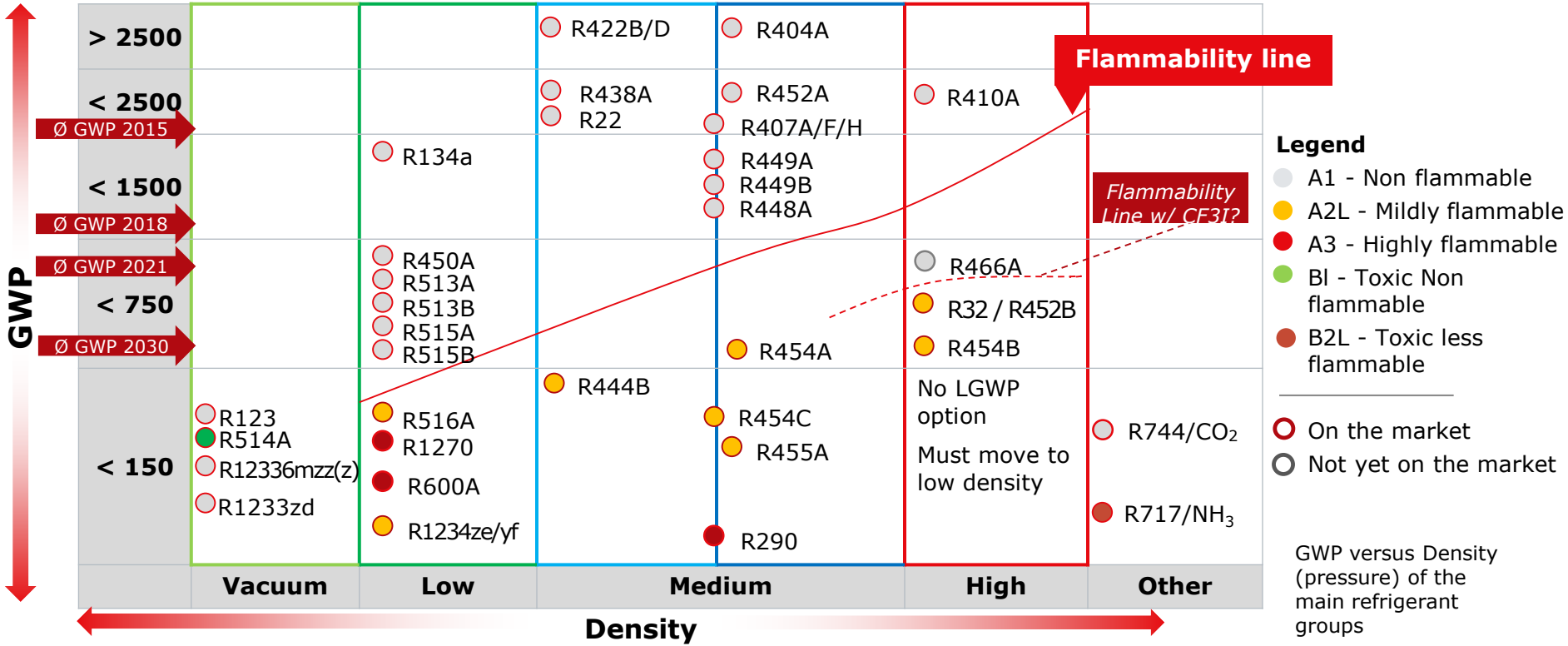


*called HFO. Molecules contain weak double bonds causing a fast breakdown in the atmosphere
*R32 (HFC) and many of the new refrigerants are flammable or mildly flammable.
Most natural refrigerants are flammable – except e.g. R744.

ENGINEERING TOMORROW

Main **alternative refrigerants** in play

A picture in continuous evolution



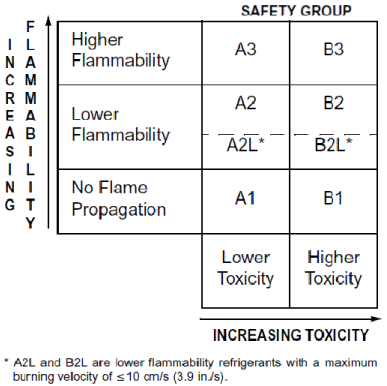
GWP versus Density (pressure) of the main refrigerant groups

ENGINEERING TOMORROW

Refrigerant Classifications

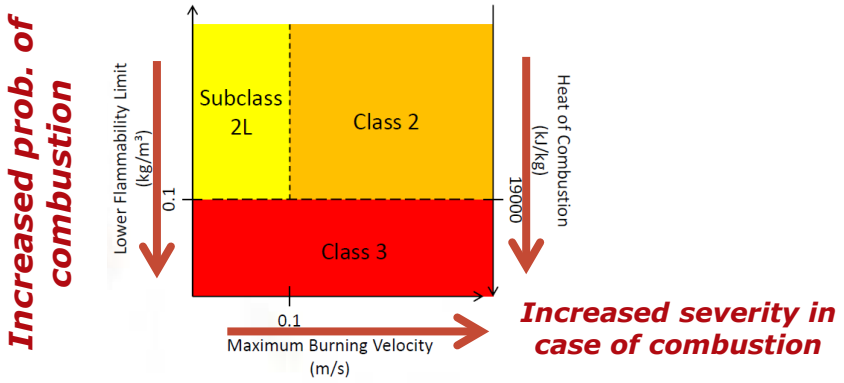
ASHRAE standards and risk assessment

ASHRAE Standard 34: 2010



* A2L and B2L are lower flammability refrigerants with a maximum burning velocity of ≤10 cm/s (3.9 in./s).

Risk of flammable Refrigerants



A2L refrigerants:

Exhibits flame propagation when tested at 60ºC

Lower flammability limit
> 100 g/m3

Heat of combustion
< 19 MJ/kg

Burning velocity
≤ 10 cm/s

ENGINEERING TOMORROW

Refrigerant Classifications

Extract of main lower-GWP refrigerants and key values

	Refrigerant	Auto ignition temperature (°C)	Burning velocity at 23°C dry air (cm/s)	Lower flammability level at 23°C, 50% RH (g/m3)	Heat of combustion (kJ/kg)	Min ignition energy at 23°C. 50% RH (MJ)
A2L	R-32	648	6.7	307	9.4	30-100
A2L	R454B	ND*	3.7	354		30-100
A2L	R452B	ND*	3	289		100-300
A2L	HFO-1234yf	405	1.5	289	10.7	5,000-10,000
A2L	HFO-1234ze	368	0	303	10.7	>61.000
A3	R290	470	46	38	50.3	0.25

*No data

ENGINEERING TOMORROW

R134a alternatives per application types

F-Gas bans and lots

			Ban 11		Ban 12	Ban 13	
			Refrigerators & Freezers		Stationary systems	Centralized systems > 40 kW	
			"Self contained units"		"Condensing Units"	Primary circuit of Cascade	Direct
			From 2020	From 2022	From 2020	From 2020	From 2022
Refrigerant	Safety	GWP	2500 limit	150 limit	2500 limit	1500 limit	150 limit
R134a	A1	1430	☺	⛔	☺	☺	⛔
R513A	A1	631	☺	⛔	☺	☺	⛔
R450A	A1	605	☺	⛔	☺	☺	⛔
R513B	A1	596	☺	⛔	☺	☺	⛔
R515A	A1	393	☺	⛔	☺	☺	⛔
R515B	A1	293	☺	⛔	☺	☺	⛔
New systems							
R1234ze(E)	A2L	7	☺	☺	☺	☺	☺
R1234yf	A2L	4	☺	☺	☺	☺	☺
R290	A3	3	☺	☺	☺	☺	☺
R1270	A3	2	☺	☺	☺	☺	☺

NB: R134a is a good refrigerant and still allowed in the frame of the F-Gas until 2022 in self-contained units, with a GWP of 1430. Yet some countries start phasing it down.

More information about the bans: see Danfoss refrigerant white paper

R404A alternatives per application types

F-Gas bans and lots

			Ban 11		Ban 12	Ban 13	
			Refrigerators & Freezers		Stationary systems	Centralized systems > 40 kW	
			"Self contained units"		"Condensing Units"	Primary circuit of Cascade	Direct
			From 2020	From 2022	From 2020	From 2020	From 2022
Refrigerant	Safety	GWP	2500 limit	150 limit	2500 limit	1500 limit	150 limit
R404A	A1	3922	⛔	⛔	⛔	⛔	⛔
R452A	A1	2140	☺	⛔	☺	⛔	⛔
R407A	A1	2107	☺	⛔	☺	⛔	⛔
R407F	A1	1825	☺	⛔	☺	⛔	⛔
R407H	A1	1495	☺	⛔	☺	☺	⛔
R449B	A1	1412	☺	⛔	☺	☺	⛔
R449A	A1	1397	☺	⛔	☺	☺	⛔
R448A	A1	1387	☺	⛔	☺	☺	⛔
R454A	A2L	239	☺	⛔	☺	☺	⛔
R454C	A2L	148	☺	☺	☺	☺	☺
R455A	A2L	148	☺	☺	☺	☺	☺
R290	A3	3	☺	☺	☺	☺	☺
R1270	A3	2	☺	☺	☺	☺	☺

New systems

Ban: The F-gas regulation imposes ban of refrigerants based on their GWP level. From the date mentioned, the use of the related refrigerant is not allowed anymore in new installations.

More information about the bans: see Danfoss refrigerant white paper

EU - F-gas regulation
Service ban

Ban on

servicing equipment with GWP >2500

(such as R404A/507 refrigerants)

- From 2020, only recycled refrigerant is allowed for servicing.
- From 2030, no service allowed.
  - Exemption for charge less than 40 tonnes CO_2 eq. (for R404A: 10,2kg).
  - Exemption for temperatures below -50°C.
  - Exemption for military equipment.

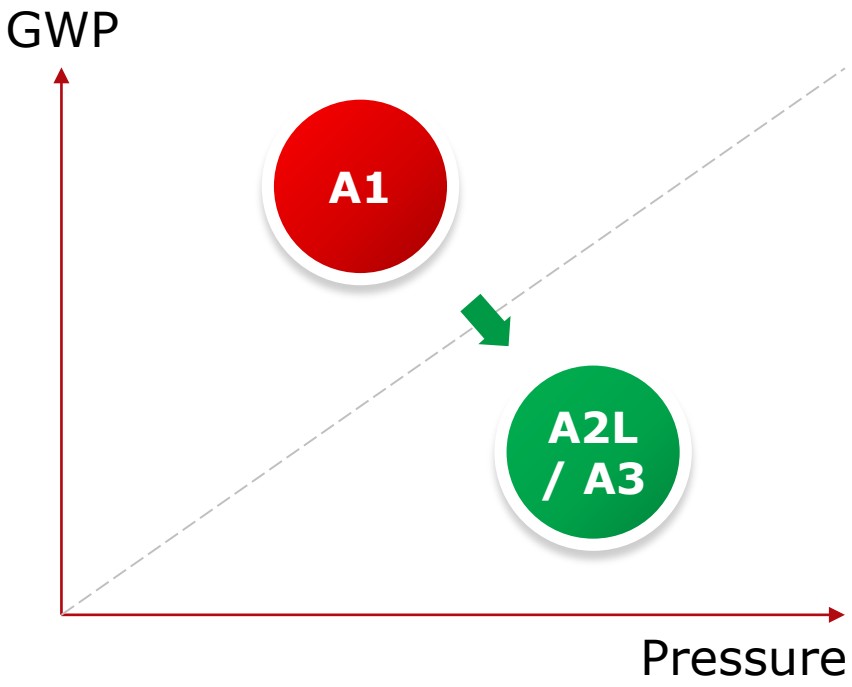
Impact

- Distributed R404A refrigeration systems in supermarkets.
- Solution : use recycled refrigerant or shift to new drop-in blends.

ENGINEERING TOMORROW

Familiarize yourself with flammables
and their impact on HVAC-R installations

- **Lower-GWP** refrigerants are often **flammable**
- **Questions and doubts** about systems using flammables and components
  - > Is ATEX needed, system safe?
  - > Risk assessment
  - > What if etc.?
- **ASERCOM guideline** released to clarify the use of components with flammable: http://asercom.org/guides



Are flammable refrigerants really dangerous?

- The **risks** of having a temporary flammable atmosphere during service **are real** and must be respected





- Follow the **service guidelines, avoid ignition sources** and **secure the ventilation**





- Learn about the new refrigerants, **regulations and standards**



Requirements for safe work

Eliminate ignition sources



Open flame



Smoking



Welding & Cutting



Hot surface

Solution :
Ground connection



Static charge



Mechanical sparks



Electric arc

ENGINEERING TOMORROW

Components – ignition sources



**if the surface temperature can exceed a temperature >100°C less than the self ignition temperature of the refrigerant, e.g. 370°C for R290.*

Requirements for safe service

Service

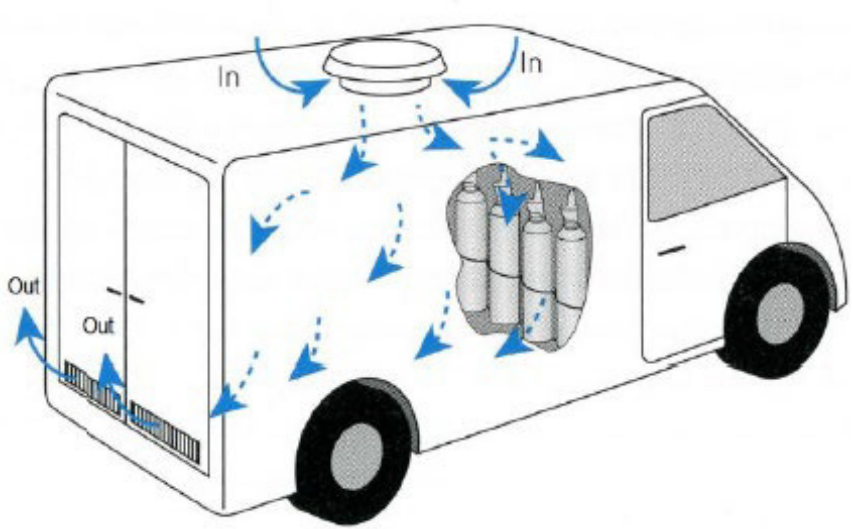


Switch off power to components

ENGINEERING TOMORROW

Transport of flammable refrigerants

- Limited quantity only (check ADR/ national legislation)
- Only from pick-up (e.g. your company) directly to worksite
- Preferably an open air truck
- If vehicle is enclosed, ensure proper ventilation



Source : AREA

ENGINEERING **TOMORROW**

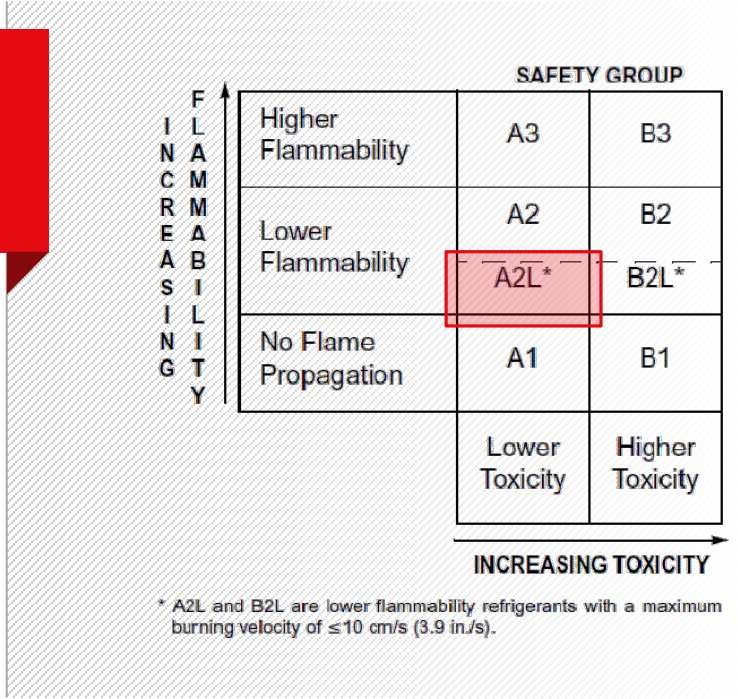
A2L refrigerants

e.g. R32, R1234yf, R1234ze, R444, R445A, R454A, R454B, …

With a few but important safety precautions they are not very different from use of HFCs class A1 refrigerants.

Important safety precautions :

- Handling only a trained and competent refrigeration service engineer
- Be aware of pooling = creating a temporary flammable zone when leaking refrigerant (heavier than air) gathers in small spaces.



ENGINEERING TOMORROW

A2L refrigerants

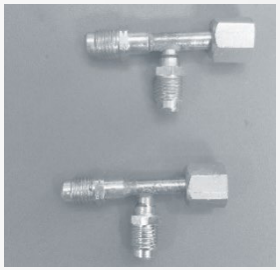
e.g. R32, R1234yf, R1234ze, R444, R445A, R454A, R454B, …

Tools and equipment

Some standard tools and equipment can be used safely with flammable refrigerants e.g.

- Gauge manifold sets
- Hoses
- Mechanical tools
- Manual valves









Source: Danfoss ATEX Lab

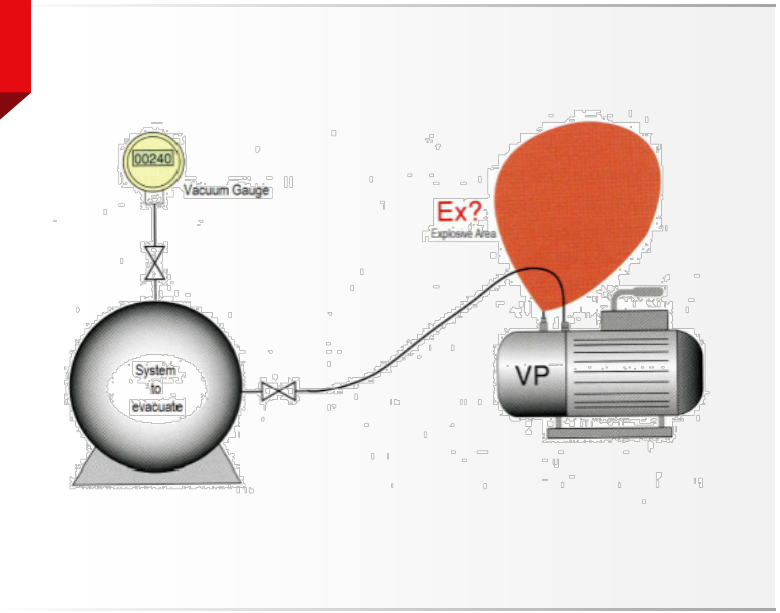
ENGINEERING TOMORROW

A2L refrigerants

e.g. R32, R1234yf, R1234ze, R444, R445A, R454A, R454B, …

Tools and equipment

Vacuum pumps use
A2L approved pumps only.
Do not use vacuum pumps with brushed motor. These motors can generate high energy spark = ignition source.
Vacuum pumps with brushless EC motors can be used if the pump is switched on by an external power source and not by the on/off switch mounted on the pump.
Vacuum pump exhaust from an system which was charged with A2L refrigerants :
Procedure after refrigerant is recovered :
Locate the vacuum pump in a well ventilated area – then it is usually safe to disperse the exhaust gas. (does not result in an explosive mixture.)



Source: AREA

ENGINEERING TOMORROW

A2L refrigerants
e.g. R32, R1234yf, R1234ze, R444, R445A, R454A, R454B, …

Tools and equipment

Recovery machines

A2L synthetic refrigerants (as HFOs and R32) must be recovered as the HFC refrigerants and not vented to the atmosphere.
use A2L approved recovery machines only.
Standard machines for A1 cannot be used for A2L refrigerants.
Reason : several ignition sources inside the machines (e.g. relays, switches, motor)
Leaks can lead to flammable mixtures in and around the machines.



Source: Danfoss ATEX Lab

ENGINEERING **TOMORROW**

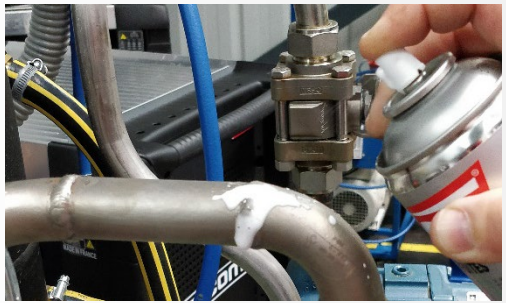
A2L refrigerants
e.g. R32, R1234yf, R1234ze, R444, R445A, R454A, R454B, …

Tools and equipment

Leak detection equipment

Use A2L specific electronic detectors only.
Most electronic leak detectors for HFC and HCFC are not safe and sensitive for A2L refrigerants.
Leak detection spray ok to be used for A2L as well.





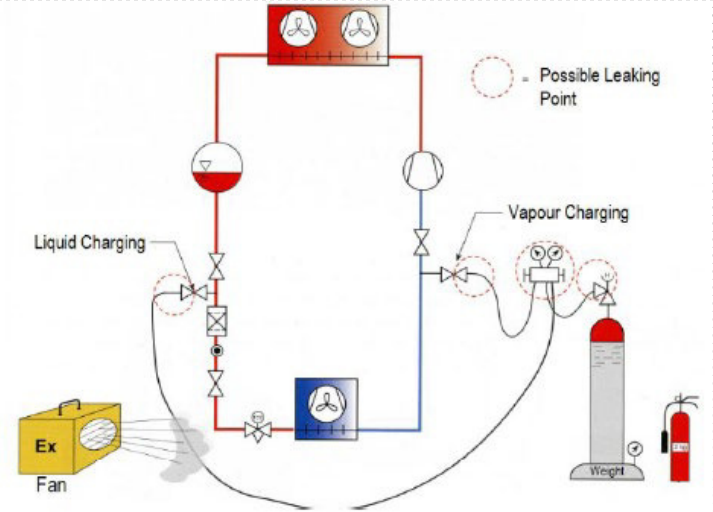
Source: Danfoss ATEX Lab

ENGINEERING TOMORROW

A2L refrigerants

e.g. R32, R1234yf, R1234ze, R444, R445A, R454A, R454B, …

Process



Possible sources for leakage and safety equipment used when charging flammable refrigerants

Source : AREA

ENGINEERING TOMORROW

A3 refrigerants

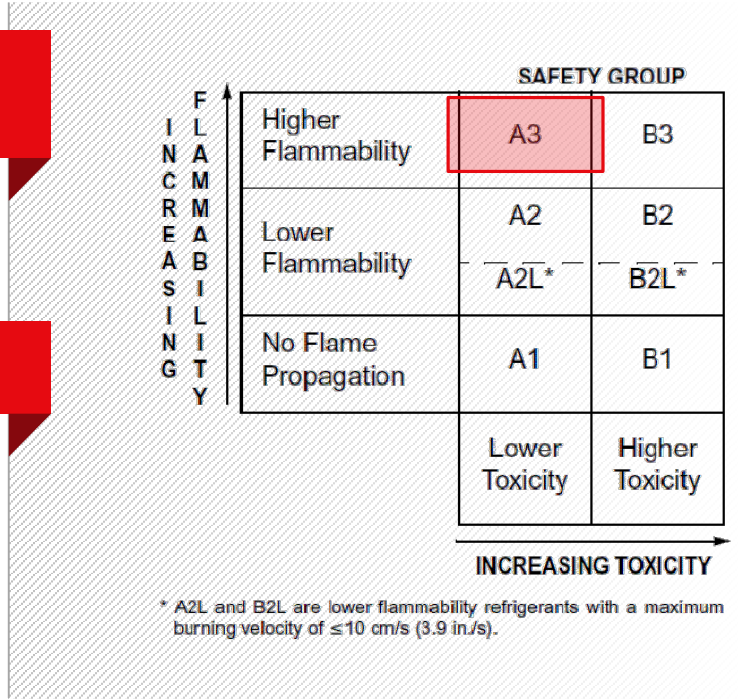
Typically hydrocarbons e.g. R290 (propane), R1270 (propylene), R600 (butane), R600a (isobutane)

A3 refrigerants have higher flammability.
This means even weak sparks need to be avoided.
Examples of sparks to be avoided during work:

- Sparks from clothing
- Sparks from iron screw drivers
- Sparks due to bad electrical grounding

High awareness of safety is needed.
!!! A3 trained personal only !!!

- No ignition source within 3 m of work area
- Warning sign
- Good ventilation
- Avoid any leaks
- Avoid potential pooling of refrigerant
- Always use a personal leakage detector
- Electric tools need to have A3 approval (typically ATEX Zone 2 approval)



ENGINEERING TOMORROW

A3 refrigerants

Typically hydrocarbons e.g. R290 (propane), R1270 (propylene), R600 (butane), R600a (isobutane)

Traditional HFCs refrigerants have right threaded connections.
For safety reasons (e.g. to avoid unintended mixing) refrigerant cylinders for flammable refrigerants have left threaded connections.



Use refrigerant grade propane only

Do not use gas for grills, camping etc.



ENGINEERING TOMORROW

A3 refrigerants

Typically hydrocarbons e.g. R290 (propane), R1270 (propylene), R600 (butane), R600a (isobutane)

Recommended basic procedure for servicing small refrigeration units with A3 refrigerants:

1. Set up warning sign to alert others that you are working with flammable gases



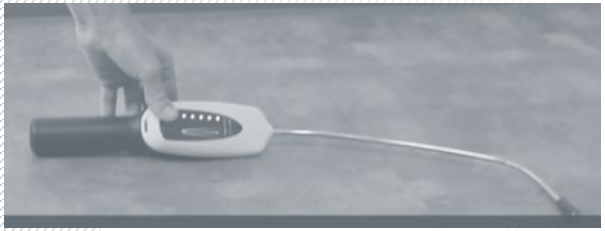
A3 refrigerants

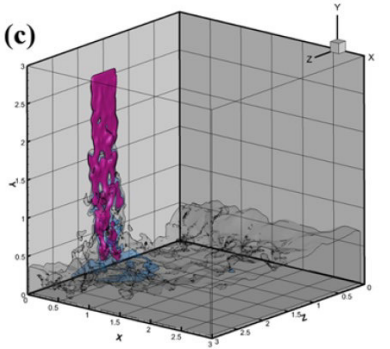
Typically hydrocarbons e.g. R290 (propane), R1270 (propylene), R600 (butane), R600a (isobutane)

Recommended basic procedure for servicing small refrigeration units with A3 refrigerants:

2 Switch on a hydrocarbon detector and put it on the floor

R290, R1270, R600, R600a are heavier than air and will accumulate on the floor when leaking out





ENGINEERING TOMORROW

A3 refrigerants

Typically hydrocarbons e.g. R290 (propane), R1270 (propylene), R600 (butane), R600a (isobutane)

Recommended basic procedure for servicing small refrigeration units with A3 refrigerants:

3 Plug in the ventilation fan 3m from the working area and position at floor level



airflow



ENGINEERING TOMORROW

A3 refrigerants

Typically hydrocarbons e.g. R290 (propane), R1270 (propylene), R600 (butane), R600a (isobutane)

Recommended basic procedure for servicing small refrigeration units with A3 refrigerants:

4 Plug in the Recovery unit at least 3m from the working area and recover the hydrocarbon refrigerant. Wait until low pressure signal is reached



=>3m





Make sure the suction side of recovery unit is tight to avoid air intake.

ENGINEERING TOMORROW

A3 refrigerants

Typically hydrocarbons e.g. R290 (propane), R1270 (propylene), R600 (butane), R600a (isobutane)

Recommended basic procedure for servicing small refrigeration units with A3 refrigerants:

5

Break vacuum with dry oxygen free nitrogen



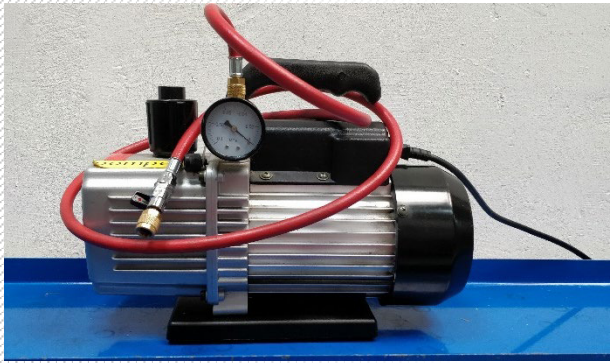
ENGINEERING TOMORROW

A3 refrigerants

Typically hydrocarbons e.g. R290 (propane), R1270 (propylene), R600 (butane), R600a (isobutane)

Recommended basic procedure for servicing small refrigeration units with A3 refrigerants:

6 Evacuate the system again



Source: Danfoss ATEX Lab

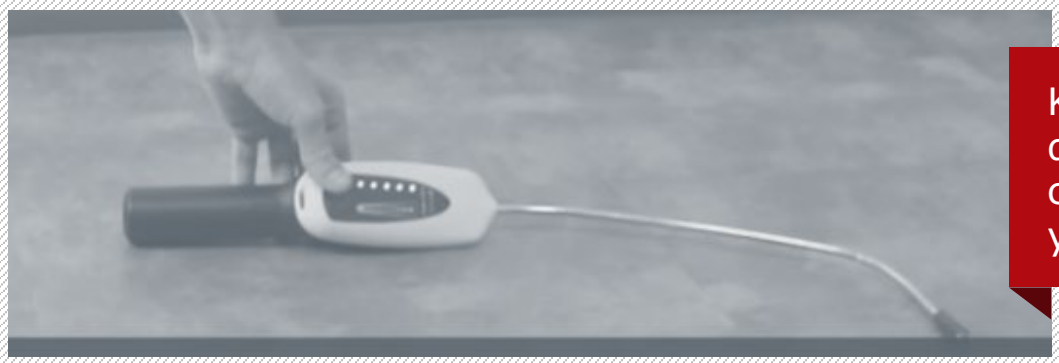
ENGINEERING TOMORROW

A3 refrigerants

Typically hydrocarbons e.g. R290 (propane), R1270 (propylene), R600 (butane), R600a (isobutane)

Recommended basic procedure for servicing small refrigeration units with A3 refrigerants :

7 Check with hydrocarbon sensor that no hydrocarbon refrigerant is in the air (only now you can light a torch if needed)



Keep hydrocarbon detector on to constantly monitor your work area.

ENGINEERING TOMORROW

A3 refrigerants

Typically hydrocarbons e.g. R290 (propane), R1270 (propylene), R600 (butane), R600a (isobutane)

Recommended basic procedure for servicing small refrigeration units with A3 refrigerants :

8

Cut the connections and complete the service operation

Keep nitrogen flowing whilst working on the system.
Remark leak test :

- Never do the pressure test with a mixture of flammable refrigerant and air
- A mixture of dry oxygen free nitrogen and a flammable refrigerant is acceptable
- Best practice: use dry oxygen free nitrogen for pressure testing only





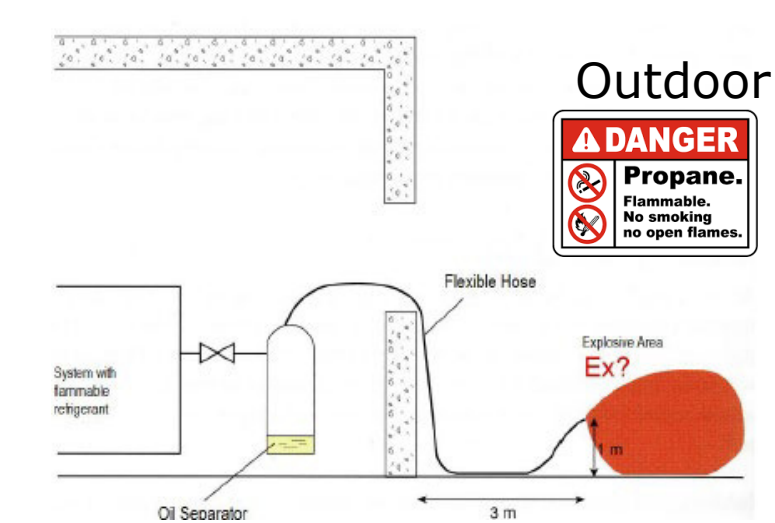
ENGINEERING TOMORROW

A3 refrigerants

Typically hydrocarbons e.g. R290 (propane), R1270 (propylene), R600 (butane), R600a (isobutane)

For small quantities of hydrocarbons to be evacuated from the system, it is possible to vent those to the atmosphere (see below) – but always refer to your national legislation.

- Make sure venting area has no ignition sources
- Hydrocarbons are heavier than air = they flow down
- Make sure vented refrigerant cannot flow into lower areas
- Set up danger sign in venting area



ENGINEERING TOMORROW

How to keep the system safe?

Use approved components only: Danfoss portfolio with A2L & A3

Valves and Controls


DML


ACB


TD1


TU/TC


ETS


EVUL


EVR v2


WVO

Compressors



Light Commercial
Compressors
For R290 and R600a

Controllers


ERC


ETC


EKE

Heat Exchangers


BPHE


MCHE

ENGINEERING TOMORROW

How to keep the system safe ?

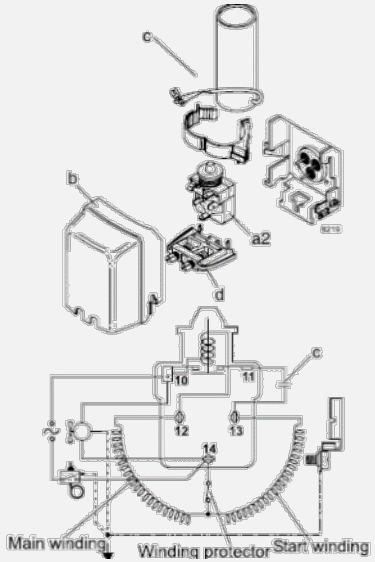
Use approved components only

Relays must comply to IEC 60079-15 Explosive atmospheres

- Part 15: Equipment protection by type of protection “n”

Use components approved for these compressors only.

No mixing with spare parts from “the collection box”



ENGINEERING TOMORROW

The Danfoss Cool Tools



Retrofit Guideline

Coolselector®2

Low-GWP Tool

TXV SH Tuner

Refrigerant Slider

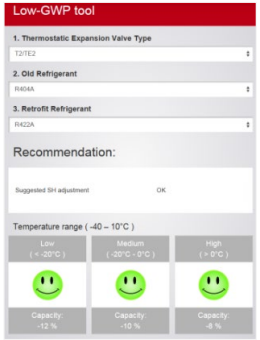
Online resources 24/7:

refrigerants.danfoss.com



Cool Tools

- Retrofit Guideline
- Low-GWP brochure
- Coolselector2
- Refrigerant slider
- Low-GWP tool
- TXV SH Tuner



Cool School

White paper | E-lessons On demand webinars | Videos





What’s next?



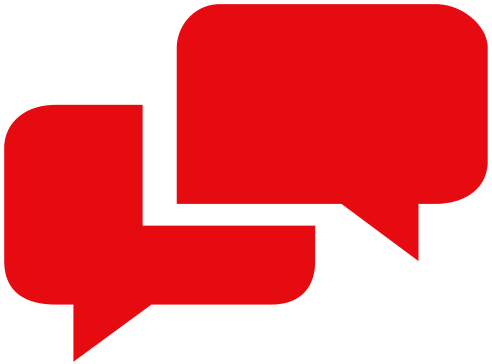
EMAIL

- Link to sign up form
- Link to recording & webpage
- Link to survey

SURVEY

- Share your feedback & let us know what you need

We will appreciate your feedback!



Many thanks for your attention!
Questions and feedback



ENGINEERING
TOMORROW