Absolutely Chilled Ltd.

Refra®
Sole UK Distributor

Heat Pumps & why they should only have Natural Refrigerants

CPD CIBSE APPROVED

Proud to be a NATIONAL ACR & HEAT PUMP AWARDS 2025 WINNER

Absolutely Chilled are the Sole Distributor for REFRA products in the UK

Refra® has been manufacturing refrigeration / Heat Pump products for over 30 Yrs and Hydrocarbon products for over 10yrs. They have a range of 24 ASHP's that span from 30kw to 450kw with max temp of 70°c , along with WSHP's up to 1.6MW producing max temp 85/90°c and are targeted to T/o € 45M in 2025

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NOTES: Absolutely Chilled Ltd , (ACL) Heat Pump Dept will shortly be changing its name to Absolutely Pumped to more accurately reflect our products for this market sector.

Agenda:

1, Current legislation

2, List of Gases it covers

3, The next and even bigger problem than GWP

4, The Solution

5, Summary

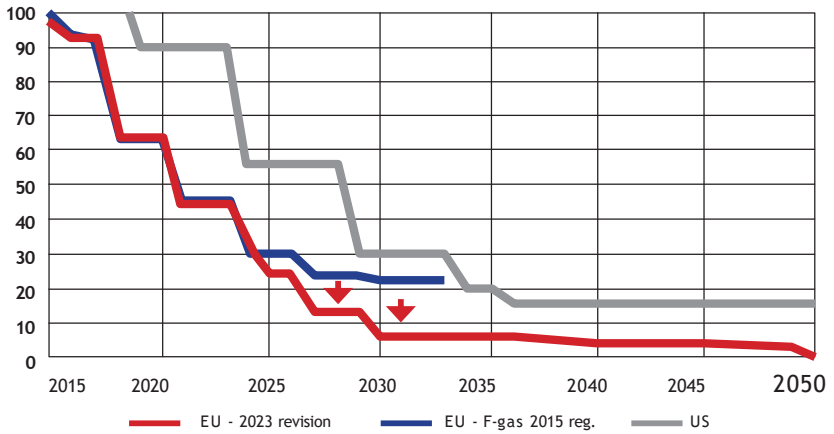
NOTES:

The review of the EU F-Gas regulation:

The EU F-gas regulation is considered a front runner, preceding the Kigali Amendment to the Montreal Protocol and going beyond the latter.

The first EU F-gas regulation came into force in 2006 with a focus on containment and service. In 2015 the second version came into force, introducing the phase down of high GWP hydrofluorocarbon (HFC) refrigerants. On February 20, 2024 the new EU F-gas regulation was published in the official Journal of the EU.

The latter is an extremely ambitious regulation with a long-term full phase out of F-gases. The EU and the US phase down are illustrated in Figure 1 where the 2015 F-gas regulation is shown in comparison with the new 2024 agreed phase down. From 2025 the quota is reduced significantly compared to the previous phase-down and from 2030 the available amount of F-gases even for service is challenged.



Source:
12.15-13.15(3)Euroklimat - Approved - Propane R290 - HVAC Standards & Safety - HVAC Thermodynamics

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NOTES: The phase down for HFC's (Hydrofluorocarbons) or also know as Fluorinated gases has been taking place since 2006 , with much more stringent criteria being applied as the damage being done became more apparent

You may recall a lot of talk about Ozone Depletion (ODP) being caused by these gases

It then moved on to Global Warming Potential (GWP) and this is brought about a figure that was attributed to all these gases in which they could be gauged how much they where contributing to Global Warming

For a bit of Context , when the phase down started the most popular gases like R502 and R12 had GWP's between 5 & 10,000.00

So what gases included in the revised proposal are likely to apply to the Heat Pumps you are likely to specify?

R454B A2L 467 GWP

R1234ZE A2L 7 GWP (HFO-PFAS)

R1234yk A2L 4 GWP (HFO/PFAS)

R32 A2L 675 GWP (HFC)

R513A GWP 631 HFC/HFO has a blend of PFAS as it contains R1234yf

R134A	GWP 1430 HFC
R410A	GWP 2088 HFC
R32	GWP 675 HFC

NATURALS

R290 / GWP 3	R717 / GWP 0
R600 / GWP 3	R744 / GWP 1

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NOTES: As you will now recognise high GWP is not the future and for the first time we see PFAS , more about this in a minute

Natural's , being R717 (Ammonia) R744 (Co2) and R290 (Propane) R600 Isobutane range between 0 & 5

You may recall a lot of talk about Ozone Depletion (ODP) being caused by these gases

It then moved on to Global Warming Potential (GWP) and this is brought about a figure that was attributed to all these gases in which they could be gauged how much they where contributing to Global Warming

Here is a list of the rest of them...

Refrigerants affected. The list of single component refrigerants defined as PFAS are:

- **HFC125**
- **HFC134a**
- **HFC143a**
- **HFO1234yf**
- **HFO1234ze(E)**
- **HFO1336mzz(E)**
- **HFO1336mzz(Z)**
- **HCFO1224yd**
- **HCFO1233zd(E).**

NOTES: these are a list of gases that is banned or in the process of being phased out .....in short

The potential bans on these single component gases affect the vast majority of refrigerant blends, some of which are already banned under the European F-gas regulations or under restrictions due to their high GWPs.

R407C

(HFC32/HFC125/HFC134a)

GWP1774. Replacement for R22 in AC equipment.

R407E

(HFC32/HFC125/HFC134a)

As above. HFC retrofit alternative to R22. GWP 1550.

R407F

(HFC32/HFC125/HFC134a)

A1 replacement for R22 and R404A in low and medium temperature applications. Its GWP is 1824

R407H

(HFC32/HFC125/HFC134a)

R22 retrofit replacement in refrigeration systems with limited modifications. It has a GWP of 1495.

R410A

(HFC32/HFC125)

Needs no introduction as a major refrigerant in larger AC systems.

R444B

(HFC32/HFC152a/HFO1234ze(E))

A replacement for R22, with a GWP under 350.

NOTES: these are a list of gases that is banned or in the process of being phased out .....in short

R446A

R447A

R447B

(HFC32/HFO1234ze(E)/R600)

Blends with differing ratios of R32, R1234ze and R600.

R448A

(HFC32/HFC125/HFC134a/HFO1234yf/HFO1234ze(E))

Honeywell's Solstice N40 for new and retrofit retail food refrigeration (refrigerated food processing and dispensing equipment). GWP 1387.

R449A

(HFC32 /HFC125 /HFC134a/HFO1234yf)

Chemours' Opteon XP40 for new and retrofit retail food refrigeration (refrigerated food processing and dispensing equipment). GWP 1400.

R449B

(HFC32/125/HFC134a/HFO1234yf)

An Arkema blend similar to R449A, with a GWP 1410.

R450A

(HFC134a/ HFO1234ze(E))

Has been used in supermarkets in cascade systems with CO2. A GWP of around 601.

R452A

(HFC32/HFC125/HFO1234yf)

Sold by Chemours as Opteon XP44, R452A has a GWP of around 2141. Actively promoted as a "drop-in" conversion for

R404A in refrigerated transport and commercial refrigeration

R452B

(HFC32/HFC125/HFO1234yf)

A rival to R32 as an alternative to R410A, R452B is an A2L gas with a GWP of 676.

NOTES: these are a list of gases that is banned or in the process of being phased out .....in short

R454B
(HFC32/HFO1234yf)
Chemours R454B is a lower flammability A2L refrigerant blend with a GWP of 466. Adopted by some major manufacturers for chillers and rooftop units.

R455A

(CO2/HFC32/HFO1234yf)

R456A
(HFC32/HFC134a/HFO1234ze(E))
Koura's Klea 456A, a non-flammable refrigerant with a GWP of 626. Touted as a drop-in for R134a in mobile AC systems.

R459A
R459B
(HFC32 /HFO1234yf/HFO1234ze(E))

R469A
(CO2/HFC32/HFC125)
Developed by Weiss Technik, a German environmental test chamber manufacturer. An R23 replacement with a GWP of 1357 for low temperature applications.

R473A
(CO2/HFC23/HFC125/HFO1132a)
Koura gas with a GWP of 1830 for low temperature applications.

R508B
(HFC23/PFC116)
R508B is a blend of R23 and the perfluorocarbon R116. A high GWP of 13,396 with applications in low temperature refrigeration.

R513A
(HFO1234yf/HFC134a)
Manufactured and marketed by Chemours as Opteon XP10. A non-flammable A1 blend with a GWP of around 630. Uses in chillers and heat pumps.

R514A
(HFO1336mzz(Z)/R1130(E))
Developed by Chemours and marketed as Opteon XP30, R514A is designed as a replacement for R123 in centrifugal chiller applications.

R515B
(HFC227ea/HFO1234ze(E))
Replacement for R134a in new chiller applications. An A1, non-flammable refrigerant blend with a GWP of 293.

NOTES: these are a list of gases that is banned or in the process of being phased out .....in short

Although not specifically mentioned in the PFAS proposal document, the definitions could also affect:

R472A
(CO2/HFC32/HFC134a)
Developed by Angelantoni Test Technologies, R472A is another lower GWP replacement for R23 in ultra low temperature applications.

R454C
(HFC32/HFO1234yf)
Opteon XL20 low GWP (148) A2L alternative in refrigeration, air conditioning, dehumidification and heat pump applications.

R468A

R468B

R468C
(HFO1132a/HFC32/HFO1234yf)

R466A
(HFC32/HFC125/131I)
Honeywell's Solstice N41, the much vaunted but yet to be launched non-flammable replacement for R410A.

IN SHORT... IF THE GAS STARTS WITH AN R1. R4 OR R5, BE ALERT TO IT!

NOTES: these are a list of gases that is banned or in the process of being phased out .....in short

ACRONYMS

1, GWP , Global Warming potential

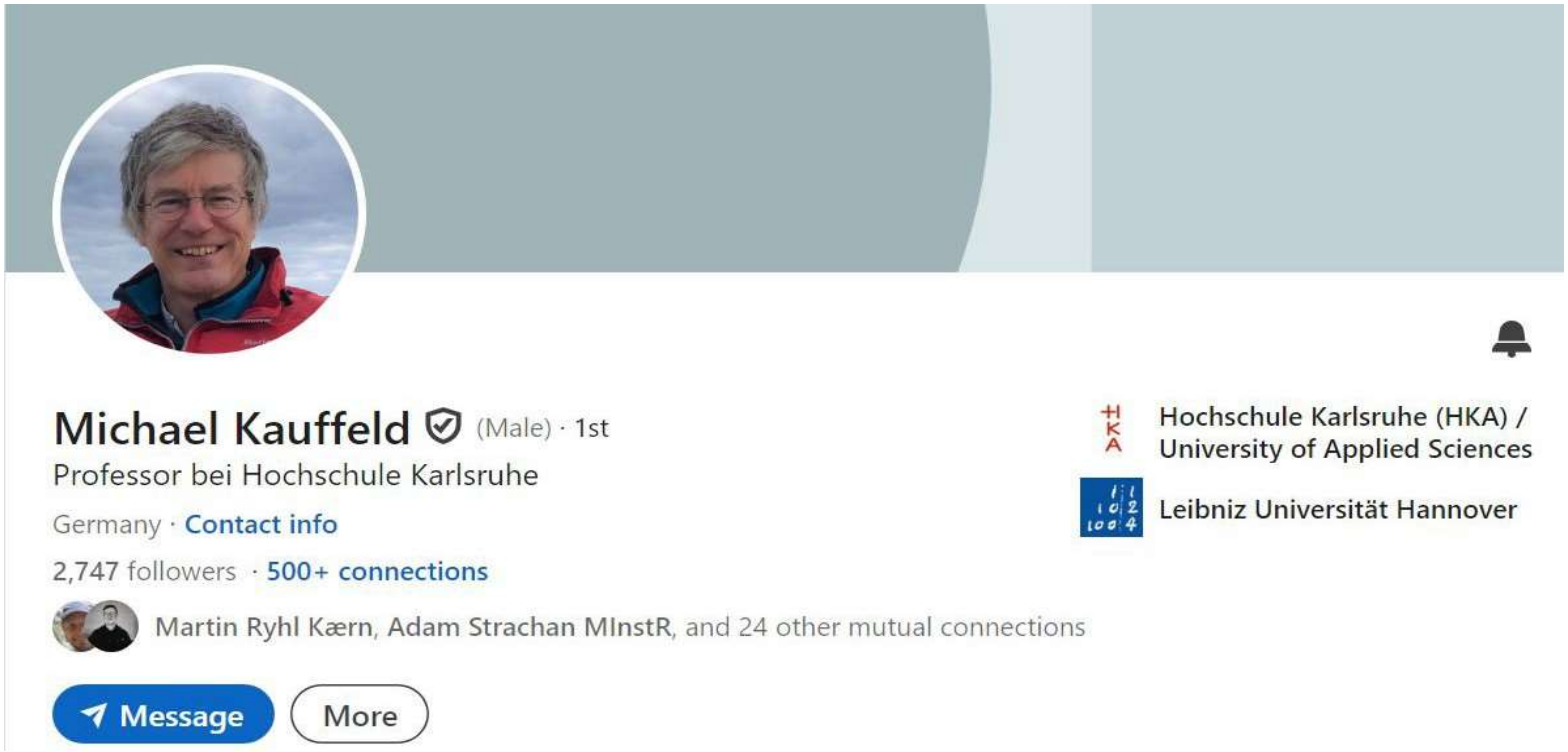
2, ODP , Ozone depleting Potential

3, PFAS , per-and polyfluoroalkyl substances, short: PFAS

This is an area some of you may be less familiar with … but this will become a bigger issue than GWP and ODP. It will be of the highest importance!

NOTES: So short recap on Acronyms and as you will have just seen we are rapidly dealing with the high GWP and ODP problems with the phase down However as you I am about to show you , we now have an even bigger problem with the next set of chemical gases that are offering ultra low GWP's They are PFAS's / also know as for ever chemicals

@MichaelKauffeld (on LinkedIn) is the recognised industry expert on PFAS.



Heat Pumps & why they should have Natural Refrigerants

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NOTES: Please note that I have included Dr Kaufelld , as I don't want you to walk away after today and think that all of what I have spouted is made up unverified nonsense , he brings the impartial facts. Dr K presentation is from 2024 ATMO conference in Prague.

Dr Kauffeld is a industry leading expert and I would urge anyone remotely interested in this subject to follow him on LINKEDIN There is some interesting push back from him to the chemical Co's who are trying to promote their wares

Around the same time the ozone hole was related to CFCs and the Montreal Protocol regulated their phase out. For society this hole was somewhere up the southern hemisphere. For sure not nice, but no reason to panic, just too far away…

HFCs came as they have no Ozone Depleting Potential. But HFCs contribute to global warming. Meanwhile climate change takes place in everybody's garden. 2024 is the warmest year since weather data recording. Climate change is already much closer…

Now low Global Warming Potential f-gases like HFOs are to minimize climate change. Yes, these molecules may decompose quickly in the atmosphere and have a low GWP. But many are directly classified as PFAS or their breakdown products forms Trifluoroacetic Acid (TFA), which also belongs to the PFAS family.

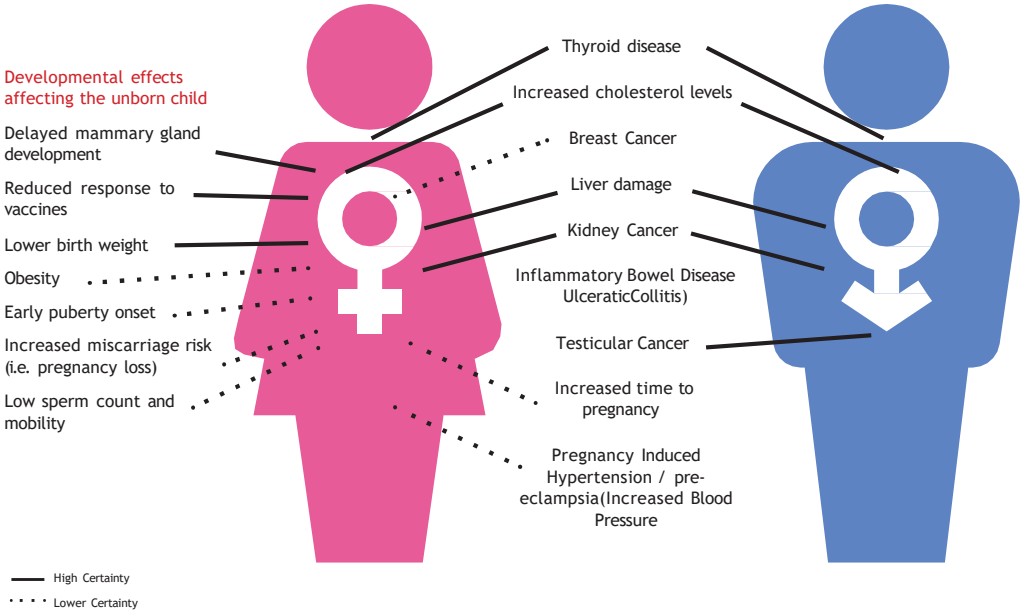
These per- and polyfluoroalkyl substances, short: PFAS are a problem. Named also "forever chemicals" they stay around for really long time. They are today found globally in soil and drinking water in critical concentrations. PFAS accumulate in people, animals and plants and have toxic effects. They are known to cause cancer and harm reproduction or the development of foetuses. This time the problem is really close: it is inside our bodies and impacts all of us directly…

PFAS will become a bigger issue than the ozone hole or even climate change.

NOTES: Possibly the most important slide on the whole presentation

If you don't pay attention to any others , just take this one on board. Highlighted text and Dr Kauffeld's quote in red

Effects of PFAS on human health



US National Toxicology Programme, (2016); C8 Health Project Reports, (2012); WHO IARC, (2017); Barry et al., (2013); Fenton et al., (2009) and White et al., (2011). https://www.eea.europa.eu/publications/emerging-chemical-risks-in-europe

There are indications from mammalian toxicity studies that TFA is toxic to reproduction and that it exhibits liver toxicity

Arp,, HPH.; Gredelj, A.; Gluge, I.; Scheringer, M.; Cousins, I.T.: The Global Thread from the Irreversible Accumulation of Trifluoroacetic Acid (TMA). Environ. Sci. Technol. 2024, 58, https://doi.org/10.1021/acs.est.4c06189

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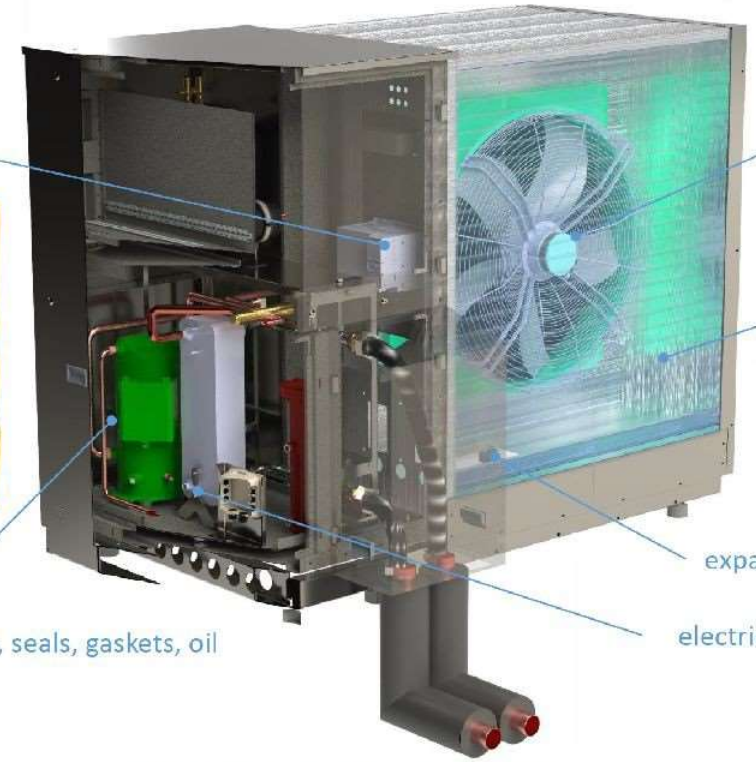
NOTES: So maybe your thinking that al a bit dramatic. Well here is some details form the US National Toxicology Program report in 2016 and lets just ignore the low certainty lines and stick with the high certainty.

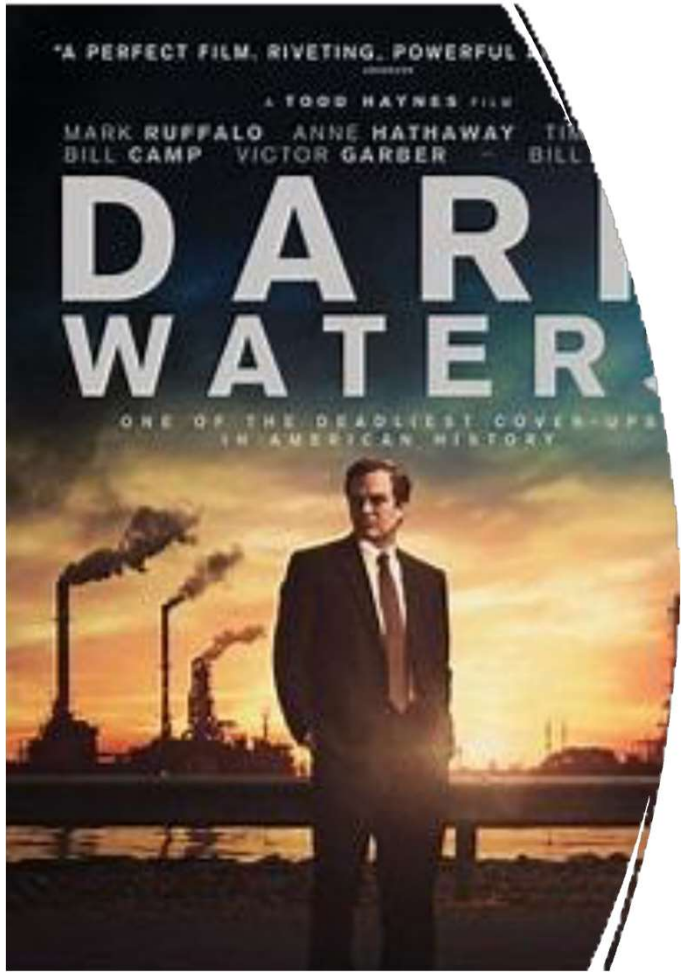
KIDNEY CANCER
THYROID DISEASE
TESTICULAR CANCER
LOWER BIRTH WEIGHT
REDUCED RESPONSE TO VACCINES

PFAS in HVACR systems – example heat pump



- PFAS only make up a small percentage of a heat pumps weight.
- Main fraction is the refrigerant
- In the environment, 60 % of PFAS is from refrigerants

NOTES: 60% OF THE PFAS COMES FROM THE GAS



A more accesible and interesting way to communicate the dangers and downsides of PFAS - Based on a True Story.

DARK WATERS

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NOTES: So , If you are an old sceptic like me or a there's a bit of the Donald Trump in you and you think this is all made up crap.

Take 2 hrs and watch Dark Waters , this is a dramatization of a lawyer fighting the chemical company Dupont who manufactures many products that contain PFAS , one of their companies manufactures refrigerant gases.

In short the chemical company paid out over $1B USD , sounds to me like there is some truth in this .

So what's stopping you from using a Hydrocarbon?

1: Efficiency?

2: Lifecycle Cost?

3: Safety?

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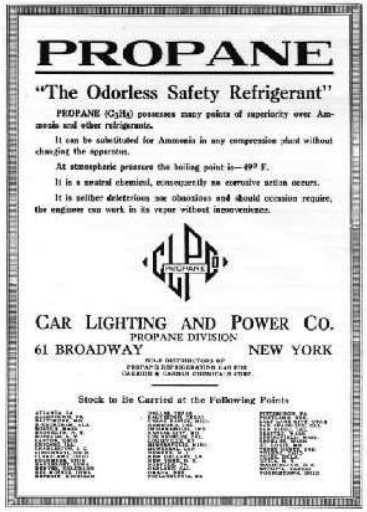
NOTES: It's a real shame what we have been doing to the environment , especially when we have had viable alternatives around for such a long time or well before the chemical Co's pushed there products

PFAS free refrigerants for HVACR systems

- Ammonia
- CO_2
- Propane
- Propene
- Iso-Butane
- Pentane
- Water



PROPANE

"The Odorless Safety Refrigerant"

PROPANE (C_3H_8) possesses many points of superiority over Ammonia and other refrigerants.

It can be substituted for Ammonia in any compression plant without changing the apparatus.

At atmospheric pressure the boiling point is—49° F.

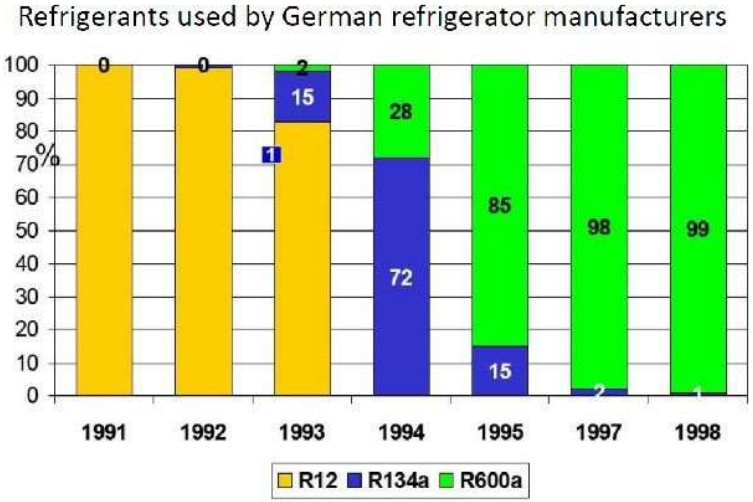
It is a neutral chemical, consequently no corrosive action occurs.

It is neither deleterious nor obnoxious and should occasion require, the engineer can work in its vapor without inconvenience.

CAR LIGHTING AND POWER CO.
PROPANE DIVISION
61 BROADWAY NEW YORK

Stock to Be Carried at the Following Points

Ad in American refrigeration magazine, 1922



Heat pump industry will follow same pattern

just 30 years later

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NOTES: Why did we ever start using these when we had such viable alternatives for so long?

This week we walked down to Lake Constance: beautiful, the first snow in the mountains and lots of clear water around me. But PFAS concentration go up here, too. So, I got the idea for this post and we took a picture of me pointing up to the sky.

Besides me you see various PFAS sources: Firefighting foam or agriculture substances bring PFAS directly in contact with soil and ground water. With beauty products, non-stick surfaces for food and drinks or clothing we are in direct contact to PFAS. And aerosols or gases like refrigerants take PFAS into the atmosphere.

1. **First good news:** Legislators start to react: Organisation like ECHA clarify the next steps to restrict PFAS under REACH.
2. **Second good news**: Refrigerants related PFAS contaminations can be avoided: Do just not use f-gases.
3. **Third good news:** My thermodynamic professor was right: All was known. Old books from before the f-gases era describe how all refrigeration can be based purely on natural refrigerants.

After 30 years in this industry I am sure that any application performs perfect with natural refrigerants, even at lower first cost and for sure when considering f-gas related clean-up. Therefore, hashtag#GoNatRefs and contribute to a hashtag#pfasfree world.

The first step in solving a problem is recognising there is one.

Professor Michael Kauffeld

Feb 2025

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NOTES: ECHA is: European Chemical Agency

REACH is a regulation of the European Union, adopted to improve the protection of human health and the environment from the risks that can be posed by chemicals,

EFFICIENCY

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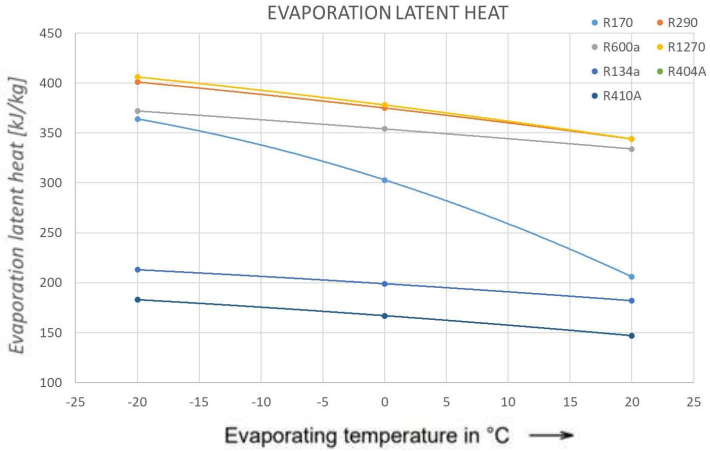
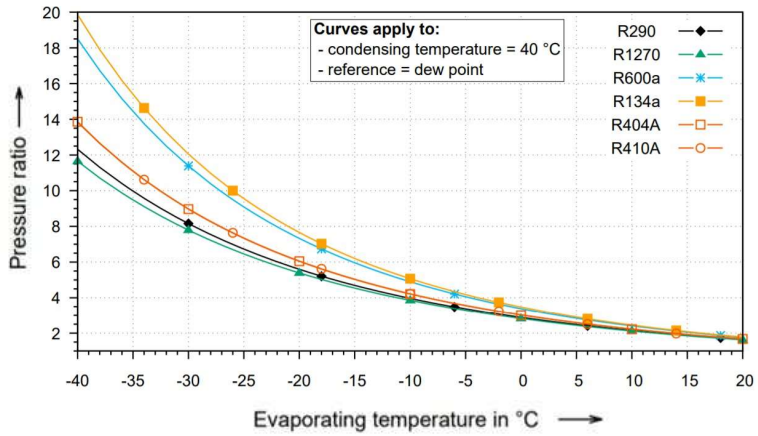
NOTES:

THERMODYNAMIC ADVANTAGES





High heat transfer performance

Low pressure ratio (condensation on evaporation pressure)

Thanks to the excellent thermodynamic properties of propane, smaller heat exchangers are required

Space reduction

**Source:*
12.15-13.15(3)Euroklimat - Approved - Propane R290 - HVAC Standards & Safety - HVAC Thermodynamics

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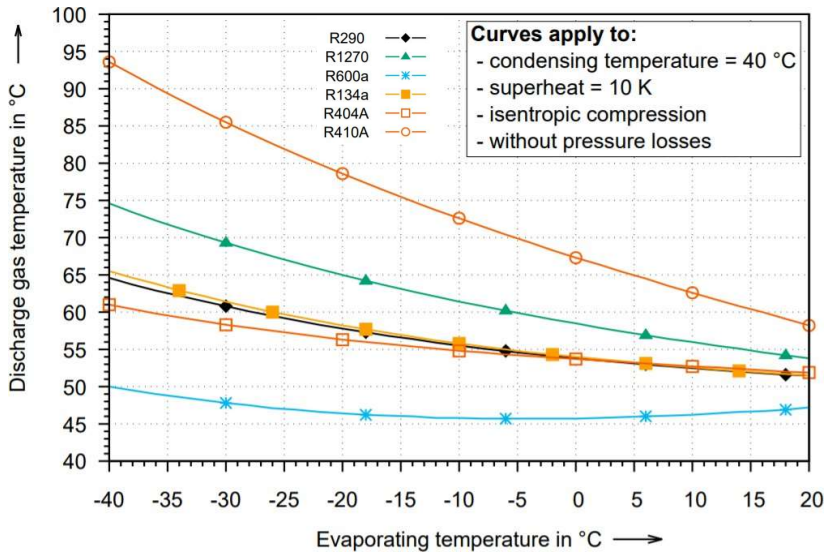
NOTES: The 3 best performing refrigerants for high heat transfer are all naturals.

The graph on the right demonstrates the naturals R290 and R1270 working at lower pressure.

COMPRESSOR'S GAS DISCHARGE TEMPERATURE - A COMPARISON

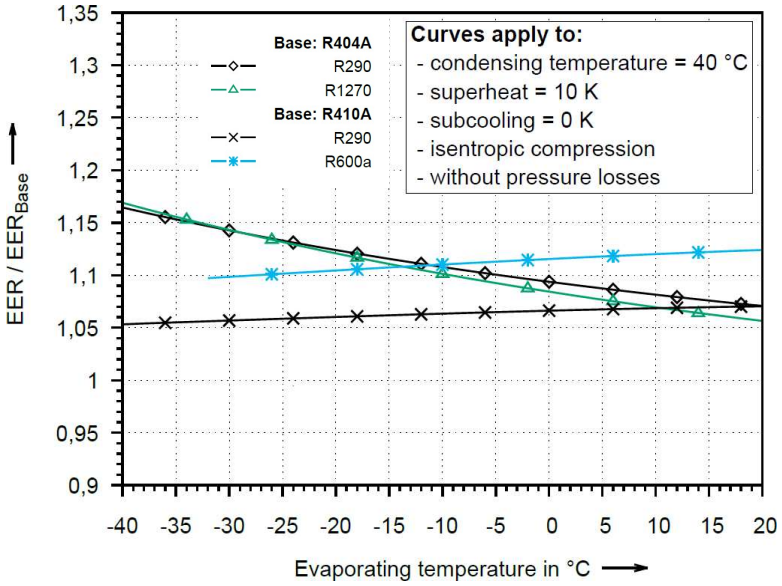


Source:
12.15-13.15(3)Euroklimat - Approved - Propane R290 - HVAC Standards & Safety - HVAC Thermodynamics

- If the discharge gas temperature is too high, decomposition of lubrification oil occurs
- **Low discharge temperature has a positive effect** on compressor materials, components and stability of the oil

NOTES:

EER COMPARISON



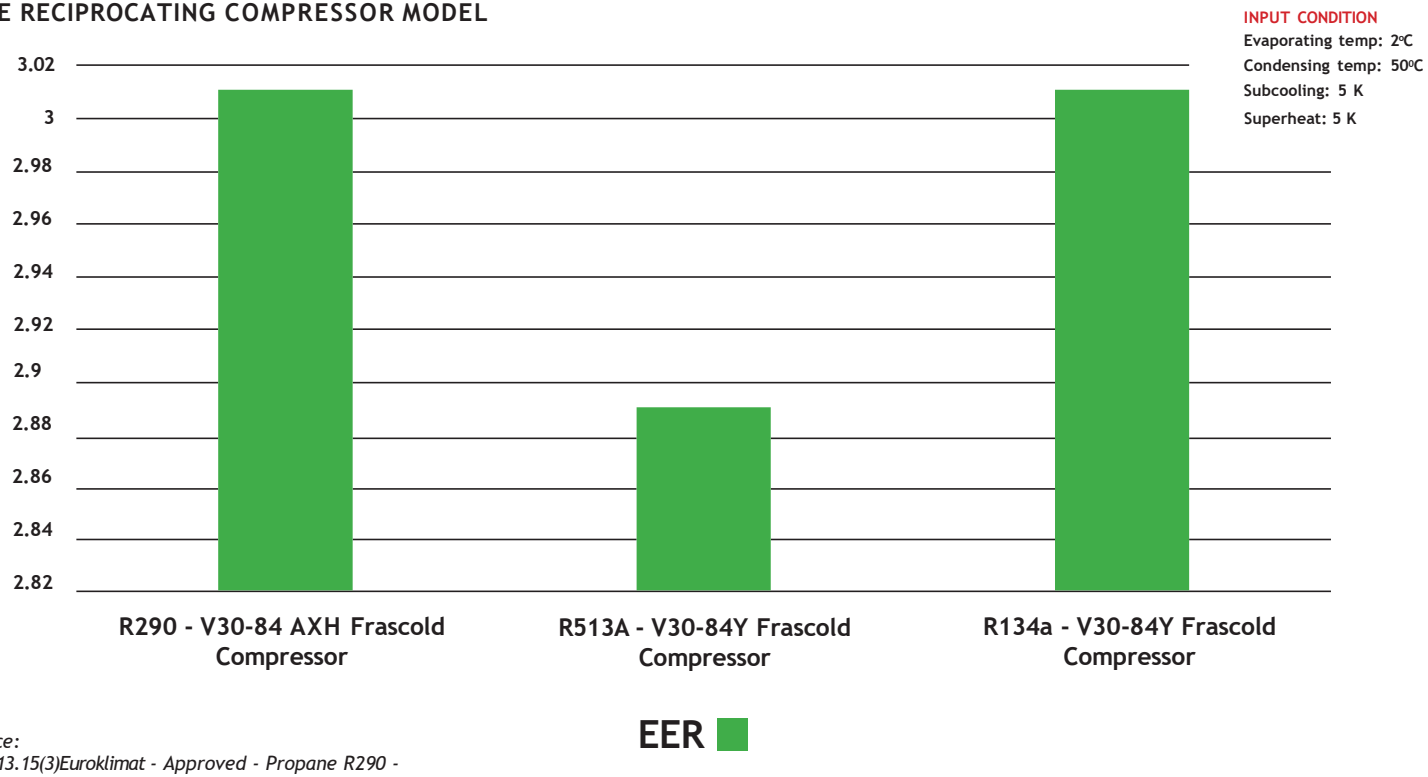
**Source:*
12.15-13.15(3)Euroklimat - Approved - Propane R290 - HVAC Standards & Safety - HVAC Thermodynamics

- Ratios of refrigeration capacity to required compressor power **for an ideal cycle**.
- Hydrocarbons EER relative to those of the fluorocarbon baseline refrigerants.
- **Compared to R410A** EERs for R290 and R600a are **between 5% and 12% higher**.
- This simplistic comparison of EERs is indicative of the **strong potential for energy efficient operation of HC systems**.

NOTES:

PERFORMANCE COMPARISON

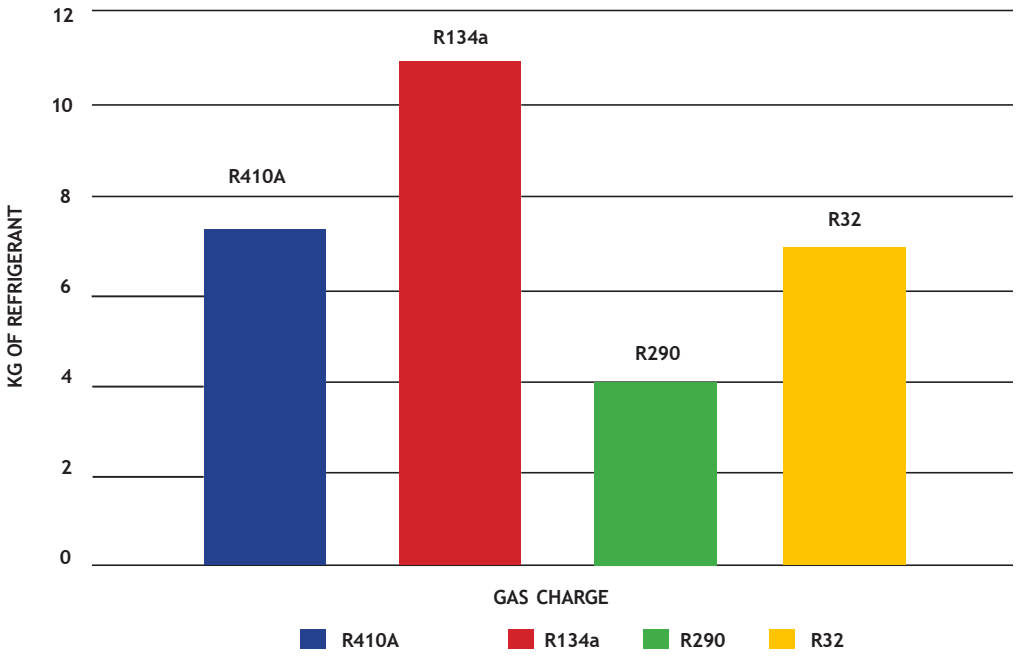
SAME RECIPROCATING COMPRESSOR MODEL



*Source:
12.15-13.15(3)Euroklimat - Approved - Propane R290 - HVAC Standards & Safety - HVAC Thermodynamics*

NOTES:

GAS CHARGE COMPARISON



INPUT CONDITION
Cooling Capacity: 50KW
User Temperature: HT
Application: process

Every unit that operates with natural refrigerant R290 instead of R410A allows to save CO_2 emmission equivalent to an average car journey of 42,000km, a complete trip around the world.

Source:
12.15-13.15(3)Euroklimat - Approved - Propane R290 - HVAC Standards & Safety - HVAC Thermodynamics

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NOTES:

LIFECYCLE COST

If you dont use a natural then shortly the gas will be come difficult to obtain. Therefore reducing the lifespan of the equipment. This is before you even consider any damage to the planet or individual human beings.

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NOTES:

1. Naturals are not getting phased out
2. At least as efficient in most scenarios
3. Require smaller heat exchangers and smaller gas charges
4. This is before you consider using gases that damage the environment, people and animals.

SAFETY

NOTES:

SAFETY

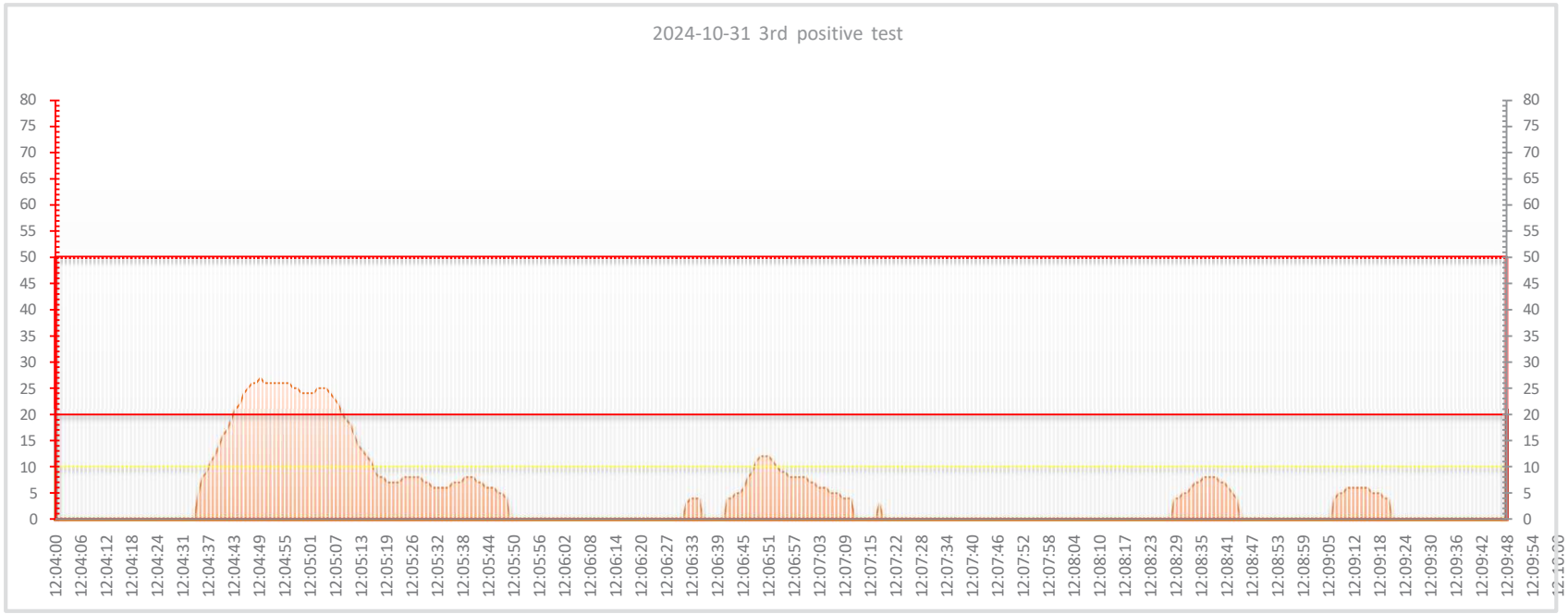
111. Conclusions

REFRA chiller CW-C22R1192IX with thin frame and special leak algorithm, with constantly working emergency fan 1 and emergency fan 2 in case of leak detection, during the testing did not reach LFL level more than 50% of LFL.

	First positive test	Second positive test	Third positive test
Start Time	11:46:00	11:55:30	12:04:10
Start pressure, bar	8,10 bar	8,30 bar	7,70 bar
End Time	11:51:05	12:00:30	12:09:50
End pressure, bar	6,90 bar	6,70 bar	6,20 bar
Avarage leak rate g/s	3,20 g/s	3,60 g/s	3,40 g/s
Max LFL levell.	14%	25%	27%

NOTES: REFRA's test results as per EN378 requirements
Each heat pump has these tests carried out and results are available.
each heat pump comes with a complaint DESEAR report from an independent DESEAR consultant.

SAFETY



**Source:*
Refra Gal02 Annex Leak Report

NOTES:

Leak simulation test 2024.10.31 Absolutely Chilled

Refra®

Annex 4

LST EN 378-2:2017
EN 378-2:2016 (E)

Annex I
(informative)

Leak simulation test for A2L, A2, A3, B2L, B2, B3 refrigerants

A leak simulation test according to 6.2.14 should comply with following method.

A leak simulation test is carried out by introducing a release of refrigerant from a suitable container at a position on the refrigeration system. Refrigerant is released at the critical failure point. A critical failure point is any refrigerant containing part (pipework or component) that will result in the highest concentration of refrigerant at the potential source of ignition.

A suitable container is separate from the refrigeration system and may be a refrigerant cylinder, hose and suitable release point.

The equipment/system shall be arranged as intended for its installation and according to the installation manual. Where there are various possibilities for the installation, the arrangement that gives the most unfavourable result shall be used.

For joints and components within the scope of EN 16084 the mass flow shall not be less than 1 g/s ± 5 %. For all other cases the mass flow rates shall not be less than 3 g/s ± 5 %.

The refrigerant shall be released in vapour phase.

The refrigerant is released in the direction that results in the highest concentration at the source of ignition being tested.

The refrigerant shall be released at a pressure of at least 0,25 × PS of the applicable part of the system and not less than 2 bar.

The total mass of the released refrigerant shall not be less than the charge of the refrigeration system or until the concentrations have not increased or changed by more than ± 10 % of the mean value within three minutes.

NOTE Identify possible channels, ducts and cable sheathing that the refrigerant could possible pass through, e.g. leaks from within pipe insulation where the refrigerant may travel to other locations from where the leak originally occurs.

During the test the system is switched off or operated under normal operation at rated voltage, whichever gives the most unfavourable result unless ventilation is activated prior to energizing any loads, in which case the test shall be conducted with the appliance operating. During a test where the appliance is operating, the refrigerant release is started at the same time as the appliance is switched on.

If a part of the system has a minimum room size associated with it according to Part 1, the test is carried out in a room of that size within ± 20 %. The test is conducted in a room that has a residual airspeed of not more than 0,1 m/s.

The gas concentration is measured at intervals of no more than 5 s.

The measured concentration of refrigerant gas surrounding the component shall not exceed 50 % of the refrigerant LFL for the duration of the test.

The test is performed twice and is repeated a third time if one of the tests gives more than 40 % of the LFL.

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Leak simulation test 2024.10.31 Absolutely Chilled

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Annex 4

LST EN 378-2:2017
EN 378-2:2016 (E)

The instrument used for monitoring the refrigerant gas concentration shall have a fast response to the gas concentration, typically 2 s to 3 s and shall be located so as to not unduly influence the results of the test.

The duration of test shall be at least two times the duration of the leak for the refrigerant charge to be released or until the concentrations have not increased or changed by more than ± 10 % of the mean value within three minutes.

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Heat Pumps & why they should have Natural Refrigerants

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NOTES:

SAFETY LOGIC

1: Leak detection , 2 STAGE ACTIVATION 10% ALARM 20% ALL POWER IS HUT DOWN , Atex fans run

2: Audio / Visual alarm , activated at 10& LFL

3: Pressure switch , Subject to the size of the unit , it may have 1 or 2 ATEX fans that are sized to remove 800M3 P/ Hr . If 1 it runs continuously to prevent stagnation / any potential pockets of R290 forming , if 2 fans , the run alternatively and are supervised by a pressure switch , should there bo no pressure , the ASHP shuts down

4: ATEX FAN

Heat Pumps & why they should have Natural Refrigerants

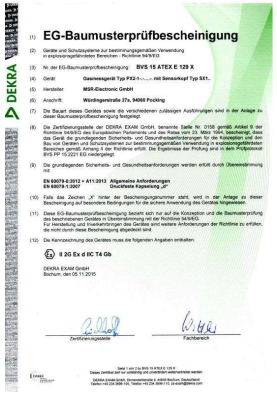
DETECTOR

PolyXeta System

- Every unit is equipped with a stand-alone gas detection sensor.
- The sensor is **ATEX Certified** and is pre-calibrated at the factory.
- Standard Alarm setting: **10% of LFL**

PolyXeta Systems - Main Features

- ATEX/IEC Ex certificates
- Type “Ex d” with flame-proof enclosure
- 4-20 mA output signal
- **RS485-Modbus** output signal
- Alarm and fault signal relay
- Continuous monitoring


EG-Baumusterprüfbescheinigung


IECEx Certificate of Conformity

INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC Certification Scheme for Explosive Atmospheres

NOTES: Explain leak detection and safety shutdown procedure highlighting ATEX fans and ventilation.

SUMMARY

1, We started phasing out gases with a GWP of 10,000.00 nearly 20 years

2, By 2030 , the vast majority of these gases will be reduced to approximately 5/10% of there original amount in the market and leading to a total ban

3, 99% of non naturals either effect GWP or are PFAS

4, Before you consider specifying a heat pump , check what the gas is

5, Why use a gas that is destroying OUR world , when you have alternatives that are as or more efficient and have no environmental side effects

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NOTES:

THANK YOU FOR YOUR ATTENTION AND TIME.

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NOTES:

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NOTES: