

Natural Refrigerant Training Summit

Building a Sustainable Workforce

R290 Overview of Micro Distributed Systems & Plug-In Units

Jim Standeford & Dan May
AHT Cooling Systems USA, Inc.



Natural Refrigerant Training Summit

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PROPANE (R290)

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with **AHT Cooling Systems, USA**

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AHT, WHO?

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We manufacture, install and service refrigeration equipment, including:

- Plug-in chest units.
- Merchandizers.
- Cases for micro-distributed waterloop systems.
- These are typically used in grocery stores and c-stores

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WHAT IS R290 PROPANE?



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R-2-WHAT?

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“R290” refers to the propane used as a refrigerant.

Propane (R290) is natural, making it an **environmentally friendly** option compared to synthetic refrigerants like hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs), which contribute to **global warming**.

Uses and applications include:

- 1.Domestic Refrigeration.
- 2.Commercial Refrigeration.
- 3.Air Conditioning Units.
- 4.Heat Pumps.
- 5.Transport Refrigeration.




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WHERE IS R290 MANUFACTURED?

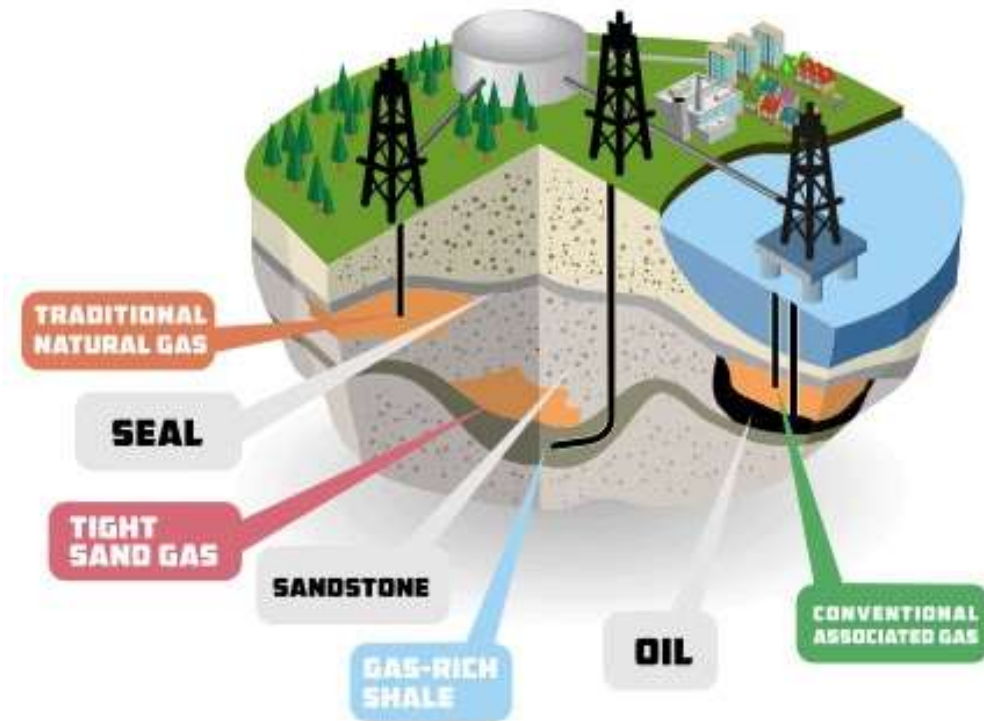
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Its not manufactured! R290 is derived from **naturally** occurring gas that is extracted from beneath the earths surface and then processed.

It occurs over millions of years. With pressure, heat and many many years, decomposing plants and animals transform into natural materials, including natural gas.

The first industrial extraction of natural gas was in New York State in 1825. 

The **U.S.** alone has proven and recoverable reserves to last for another **84 years!**



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PROPERTIES

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R290

- R290 can also be stored and transported in liquid state.
- The propane for kitchen use or your BBQ-Grill is propane, however, it's different to propane R290. 😊
- It has a purity level of 97.5%.
- R290 is flammable. 🔥
- R290 is odorless! Sometimes scent is added for safety reasons.

Chemical composition	HgC ₃
Molecular mass	44 gr/mol
Boiling temperature	-42 °C
Critical temperature	96.7 °C
Latent heat (-10°C)	375 kJ/kg
Density saturated liquid (-10°C)	542 kg/m ³
Volumetric capacity (-10 °C)	1846 kJ/m ³
COP (-10/+45 °C)	3.7
GWP	3
Class	A3
Lower flammability limit	0.038kg/m ³
Combustion heat	2200 kJ/mol
Auto-ignition temperature	470 °C
Practical limit	8 gr/m ³

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“GWP”...GARY WANTS PIZZA? 🍕

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We like Gary Busey movies. And, we love pizza! But GWP really stands for **Global Warming Potential**.

- GWPs are calculated over 100 years. Carbon dioxide is taken as the gas of reference with a 100-year GWP of 1.
- The larger the GWP, the more that a given gas warms the Earth compared to CO₂ over that time period.
- Low GWP = **good**. High GWP = **bad**.
- Studies report the GWP of R290 as **3**.
- However, some recent publications state the GWP of R290 as **0.072** !



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HOW DOES A R290 PROPANE REFRIGERATION CIRCUIT WORK?

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1. Compression: The process begins with the compressor. The compressor pressurizes the R290 refrigerant gas, causing it to become a high-pressure, high-temperature vapor.

1. Condensation: The high-pressure vapor then flows into the condenser coil, the hot vapor releases heat to the surrounding air or water, causing it to condense into a high-pressure liquid.

2. Expansion: The high-pressure liquid R290 refrigerant then passes through an expansion valve or capillary tube, the pressure decreases suddenly, leading to a rapid drop in temperature.

3. Evaporation: The low-pressure, low-temperature refrigerant mixture enters the evaporator coil. As the warm air from the cooling space passes over the evaporator coil, the refrigerant absorbs heat, causing it to evaporate and turn into a low-pressure vapor.

4. Return to Compressor: The low-pressure vapor is then drawn back into the compressor.

LIKE ANY OTHER REFRIGERATION CYCLE!



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IS USING PROPANE (R290) AS A REFRIGERANT DANGEROUS?

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About 20 lbs. (9 kg) of
propane.



No more than 0.33 lbs. (150
grams) per circuit.

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- **Yes. R290 is flammable.** 🔥
- Always follow the manufacturers guidelines and adhere to all safety standards and procedures.
- Use caution.
- Only a properly trained and licensed refrigeration technician should be used for installation and repairs.
- If the entire charge leaked out inside all at once and it manages to form a mixture between the LEL and UEL at an ignition source, there could be a fire or explosion. It's not very likely to happen.
- Like when you are grilling. Use caution. If use correctly, working with R290 is safe.

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WHY?

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- Many refrigerants, such as chlorofluorocarbons (CFCs) damage the ozone layer, while others are extremely potent greenhouse gases.
- 2 lbs of R410a has the same greenhouse impact as two tonnes of carbon dioxide, which is the equivalent of running your car for six months.
- The average-size grocery store in the U.S. is 50,000 square foot which emits 1,900 tons of gas into the atmosphere each year — equivalent to the emissions from 360 vehicles in one year.
- The refrigeration industry

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NEEDS TO DO SOMETHING!

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R290 PROPANE

1959



1983



2017



2019

2024

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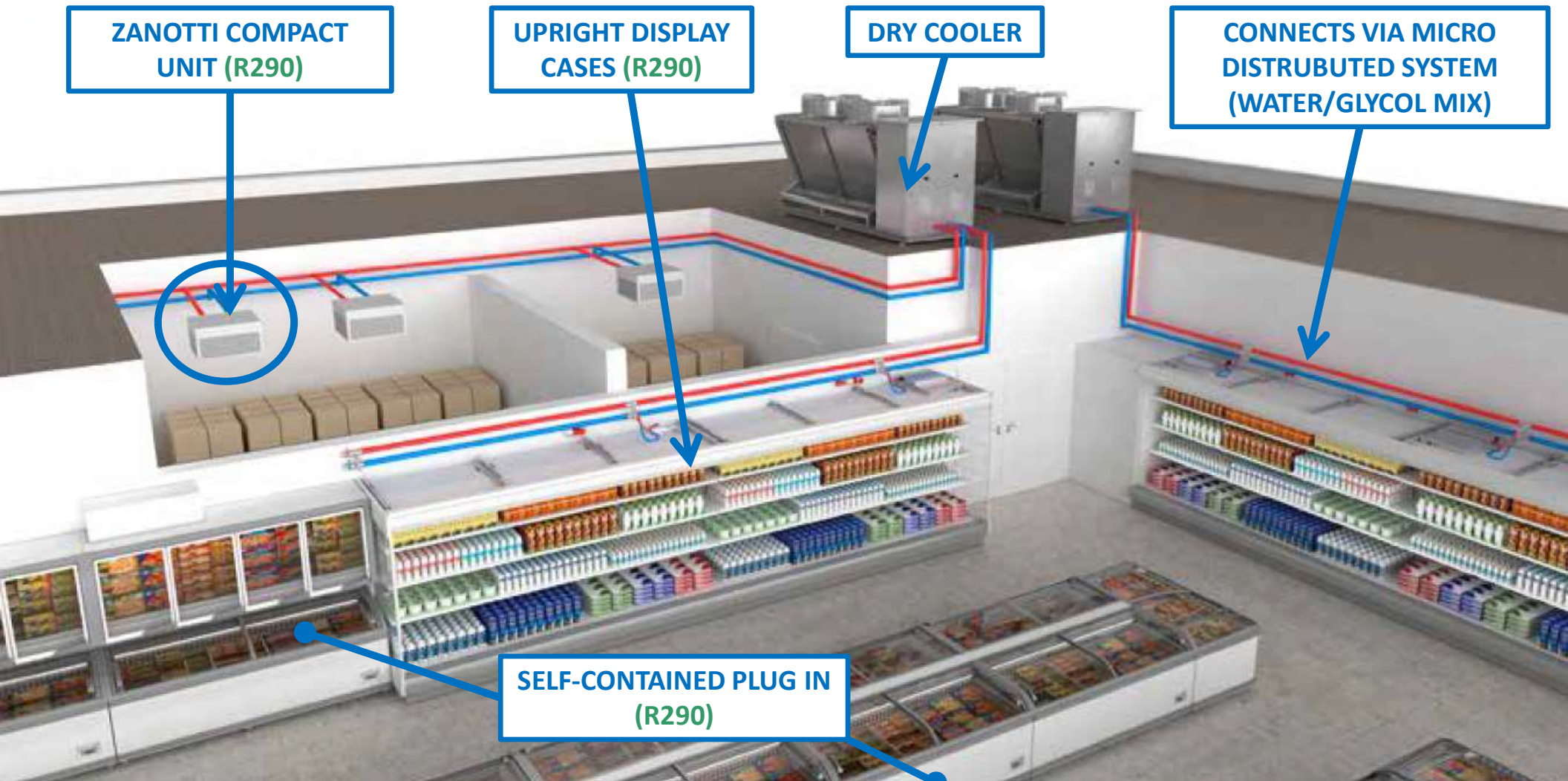
ZANOTTI COMPACT
UNIT (R290)

UPRIGHT DISPLAY
CASES (R290)

DRY COOLER

CONNECTS VIA MICRO
DISTRIBUTED SYSTEM
(WATER/GLYCOL MIX)

SELF-CONTAINED PLUG IN
(R290)



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AHT IN 2024

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What is R290?

Global warming potential

GWP is a measure of how much heat a greenhouse gas traps in the atmosphere up to a specific time horizon, relative to carbon dioxide.

Carbon dioxide has a GWP of exactly 1 - since it is the baseline unit to which all other greenhouse gases are compared.

IPCC6 GWP 0.02 R290 of 100 year

IPCC6 GWP 1 R744



Refrigerants / Brand Name	Type	Composition	IPCC AR4 (2007)		IPCC AR6 (2021)		PFAS
			GWP 100 years	Real GWP 20 years	GWP 100 years	Real GWP 20 years	
R143a	HFC	100% R143a	4470	5890	5810	7840	Yes
R125	HFC	100% R125	3500	6350	3740	6740	Yes
R134a	HFC	100% R134a	1430	3030	1530	4140	Yes
R32	HFC	100% R32	650	2330	771	2690	No
R404A Freon 404A	HFC	44% R125 / 4% R134a / 52% R143a	3922	6010	4728	7208	Yes
R407A Freon 407A	HFC	20% R32, 40% R125, 40% R134a	2102	4538	2262	4890	Yes
R410A Freon 410A	HFC	50% R125 / 50% R32	2075	4340	2255	4715	Yes
R407C Freon 407C	HFC	23% R32 / 25% R125 / 52% R134a	1768	4115	1908	4457	Yes
R452A Opteon XP44	HFC/ HFO	11% R32 / 59% R125 / 30% R1234yf	2137	4003	2292	4273	Yes
R449A Opteon XP40	HFC/ HFO	24.3% R32 / 24.7% R125 / 25.7% R134a / 25.3% R1234yf	1390	3119	1504	3383	Yes
R448A Solstice N40	HFC/ HFO	26% R32 / 26% R125 / 21% R134a / 7% R1234ze / 20% R1234yf	1379	3062	1494	3321	Yes
R449C Opteon XP20	HFC/ HFO	20% R32 / 20% R125 / 29% R134a / 31% R1234yf	1245	2847	1346	3087	Yes
R452B Opteon XL55	HFC/ HFO	67% R32 / 7% R125 / 26% R1234yf	681	2006	779	2275	Yes
R454B Opteon XL41	HFC/ HFO	68.9% R32 / 31.1% R1234yf	448	1606	531	1854	Yes
R513A Opteon XP10	HFC/ HFO	44% R134a / 56% R1234yf	629	1686	673	1823	Yes
R450A Solstice N13	HFC/ HFO	42% R134a / 58% R1234ze	601	1611	643	1742	Yes
R454C Opteon XL20	HFC/ HFO	78.5% R1234yf / 21.5% R32	140	502	166	580	Yes
R455A Solstice L40X	HFC/ HFO	75.5% R1234yf / 21.5% R32 / 3% R744	140	502	166	580	Yes
R744	Natural	CO ₂	1	1	1	1	No
R600a	Natural	Isobutane	<1	<1	<1	<1	No
R290	Natural	Propane	<1	<1	<1	<1	No
R1270	Natural	Propylene	<1	<1	<1	<1	No
R717	Natural	NH ₃	0	0	0	0	No
R718	Natural	H ₂ O	0	0	0	0	No
R729	Natural	Air	0	0	0	0	No

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Which refrigerants are counted as Natural Refrigerants?

NH3	Ammonia	R717
CO2	Carbon dioxide	R744
H2O	Water	R718

Hydrocarbons (Commonalities of these substances: Highly flammable!)

CH4	Methane	R-50
C2H6	Ethane	R-170
C2H4	Ethylene	R-1150
C3H8	Propane	R-290
C3H6	Propene	R-1270
C4H10	n-Butane	R-600
C4H10	Isobutane	R-600a
C5H12	n-Pentane	R-601
C5H12	Isopentane	R-601a
C5H12	Neopentane	R-601b



Natural Refrigerants common characteristics:

ODP (Ozone Depletion Potential): 0

GWP (Global Warming Potential): < 3

Compared to CFCs: ODP:1 GWP: 10,720

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What is R290?

Characteristics

The gas originates from the extraction and processing of natural gas or crude oil and can be stored and transported in liquid form.

Chemical formula: C₃H₈

Risks:

- Displaces air and impairs breathing
- Flammable gas

The propane for kitchen use or the cylinder for your BBQ-Grill is propane, but it is NOT R290!

- R290: Purity Level $\geq 99.5\%$ | Propane: Purity Level $< 97.5\%$
- R290: Very low levels of unsaturated hydro-carbons
- R290: Moisture < 10 ppm
- R290: Non-condensables $< 1.5\%$ by volume
- R290: is odorless! | Propane: Scent is added, so has odor.



Gas/vapor heavier than air. May accumulate in confined spaces, particularly at or below ground level.

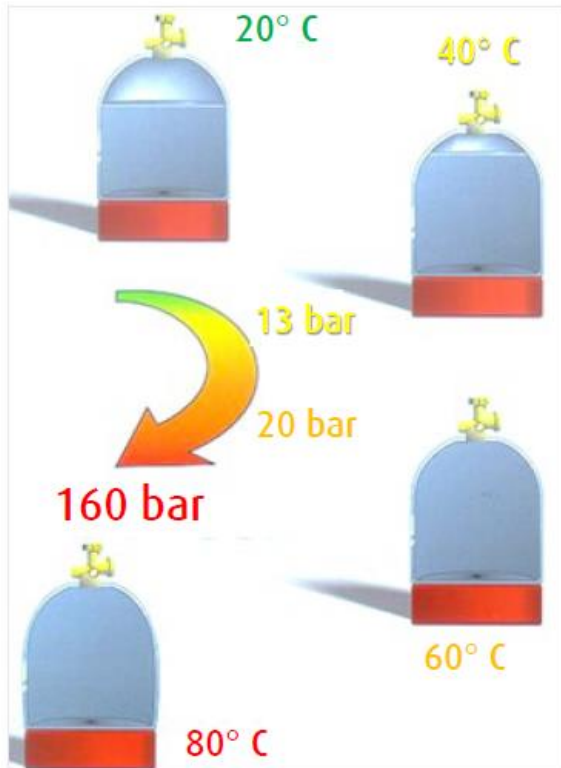
Storage Of Flammable Gasses

- Gas bottles need to be protected against stronger warming, fire, dangerous corrosion, mechanical damage and unauthorized access.
- The compressed gas tank must be stored upright or lying and secured.
- Liquid gas tanks must be stored upright.
- When they are stored in basements, sufficient ventilation must be ensured.
- Valves must be protected with protective caps.
- Transferring gasses in storage rooms is not permitted!



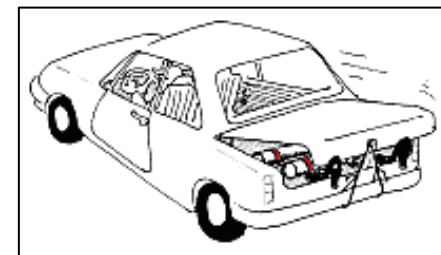
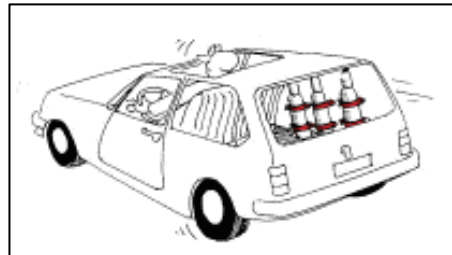
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Storage Of Flammable Gasses



Transport In Motor Vehicle

- It is only permitted to transport small quantities of gasses in vehicles.
- For larger quantities, at least 2 ventilation openings of 4x4in. or 100x100mm are required.
- Ventilation openings must not be sealed or closed
- Bottles must be secured adequately
- Valves must be closed, and caps must be screwed on
- Transport with fittings screwed on is not permitted
- A fire extinguisher must be present for flammable gasses



Flammable Refrigerants General Precautions

- ✓ **Do I need a certification or specialized training to service R290?**
 - This depends on local legislation. Check your local legislation.
 - It is strongly recommended that a local Hands-On Training on R290 is followed locally.
- ✓ **Is special labeling on equipment required?**
 - Yes, the unit has to be labelled with a clear indication that it is an R290 Unit.
- ✓ **What is the amount of R290 that is in the unit I'm serving?**
 - Please have a look on the type plate
 - plug in cabinets do have normally less than 150g, others like Heat pumps, Chillers could have significantly more



Refrigerant:	
Type	R410A / GWP 2088
Quantity	2,40 / 5,011 kg / ton CO ₂ eqv
Max working pressure HP:	4,5 (45) MPa (bar)
Max working pressure LP:	2,5 (25) MPa (bar)
Test pressure:	3,1 (31) MPa (bar)
Contains fluorinated greenhouse gases covered by the Kyoto Protocol in a hermetically sealed system	
Electrical:	
Voltage	400V 3N~ 50Hz
Max Operating Current:	6 A
Max Current Compressor:	5 A
Physical:	
Weight:	167 kg
Size:	1100x1070x512 mm
COP A2/W35: (acc. to EN 14511)	
Power Input:	0,91 kW
Heating Capacity:	4,03 kW
COP:	4,43
COP A1/W35: (acc. to EN 14511)	
Power Input:	0,99 kW
Heating Capacity:	4,77 kW
COP:	4,82
Compressor working range	
Water supply At air temp.	
60 °C (max)	-25 °C (min)
65 °C (max)	-4 °C
65 °C (max)	36 °C (max)

Flammable Refrigerants General Precautions

- ✓ R290 is odorless!
- ✓ Provide adequate ventilation
- ✓ Monitor gas concentration
- ✓ In case of leakage, eliminate all ignition sources
- ✓ Keep concentrations well below lower explosion limits
- ✓ Consider the risk of potentially explosive atmospheres
- ✓ Prevent from entering sewers, basements and confined spaces, or any place where its accumulation can be dangerous.
- ✓ Evacuate/secure working area => Place signs of service works, warn others on ignition sources: make sure no one plugs, unplugs, connects or disconnects any type of power plug while you are servicing the unit! Cell-phones, electronic devices could also be sources of ignition!
- ✓ Monitor the concentration of the released product.



Flammable Refrigerants Safety Precautions When Repairing

✓ **Exclude (electrical) ignition sources**

- Disconnect the electric circuits of the unit and neighboring units
- Smoking is forbidden during the repair!

✓ **Exclude explosive atmosphere**

- Attention to residual gas (Even after flushing with nitrogen residual gas has to be expected)
- Ensure that the room has adequate ventilation.
- Pay attention to drains in the floor, basement windows, air shafts or the like.

✓ **Exclude unauthorized presence**

- Please have a look during the work that nobody unattended is in the area (eg.: close the area with a warning tape, that no untrained personnel, or bystanders are in the area.)



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Flammable Refrigerants Leak Detection

- ✓ Make sure electronic leak detector is ON immediately after you enter service area.
- ✓ R290 is heavier than air and will accumulate in the deepest part when there's a leak.
- ✓ Do not turn the leak detector OFF until you leave the service area when the work is done.
- ✓ Use an electronic leak detector dedicated for combustible gases.
 - Any other type leak detector or halide leak detectors ARE NOT ALLOWED for servicing R290!
 - Any leak test dyes ARE NOT ALLOWED for servicing R290!
 - Soap bubbles may still be used but electronic leak detector is a must to give service to an R290 unit.
- ✓ Sampling of the soldered and pressed joints with a leak detection device for each at least 5 sec.



Flammable Refrigerants Service Tools Refrigerant Recovery

- ✓ **R290 is to be vented, what then?**
 - DO NOT VENT R290 inside a building under any circumstance.
 - DO NOT VENT R290 in a public area, explore surroundings for any trace of ignition sources, open flames, smoking areas. Please remember that cell phones, electronic devices might also be an ignition source.
 - You HAVE TO inform everyone in the immediate area that you are venting flammable gas to the atmosphere.
 - ENSURE all local legislations are fulfilled!
 - DO NOT VENT into a low-lying area where R290 might accumulate. Remember, it is heavier than air!
 - After venting, purge the system with dry nitrogen at least for 10 seconds to displace any trapped R290 in the system. Trace amounts of R290 will remain trapped in the POE oil of the compressor!
- ✓ **Legislation-wise, since R290 has ODP=0 and GWP=3, there is no obligation to recover R290. However, it is recommended to recover R290 with suitable equipment.**
- ✓ **After recovery, purge the system with dry-nitrogen at least for 10 seconds to displace any trapped R290 in the system.**
 - Recovery device/cylinder should be suitable for use with hydro-carbons!
 - Recovery device/cylinder should be explosion proof!
 - Recovered refrigerant should be delivered to disposal-companies.



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Flammable Refrigerants Service Tools

What are the standard refrigeration service tools when working with R290?



Brazing
Set



Dry-Nitrogen,
Regulator,
Hoses



Vacuum
Pump



All equipment should be
Explosion-proof
equipment



Lokring
Unions



Lokring
Wrench



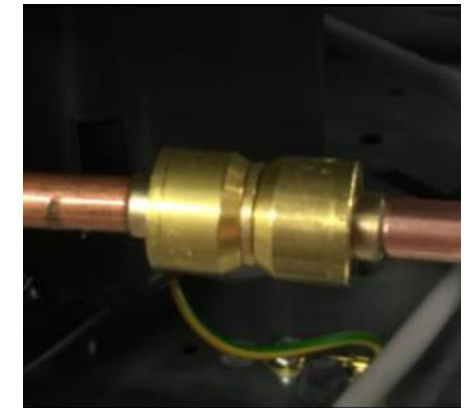
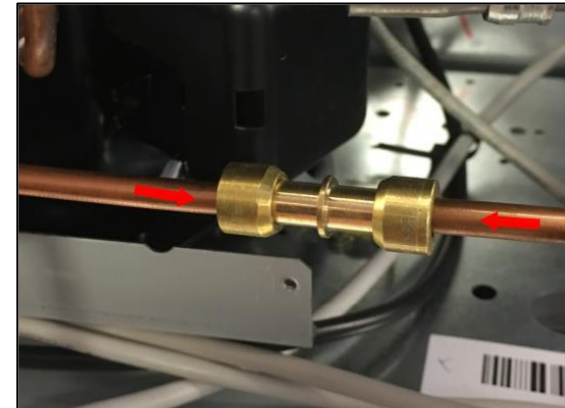
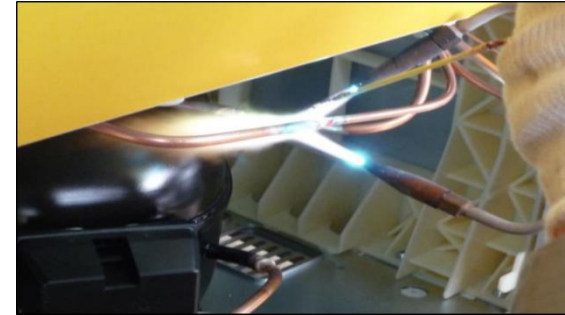
Thread Adapter
All flammable refrigerant cylinders are left-threaded!

Alternative for brazing. This is not
a standard refrigeration tool.
Check if can be used!

Repair Of Flammable Refrigerant Units

Extreme caution is required at the beginning and throughout the repairs to hydrocarbon systems!

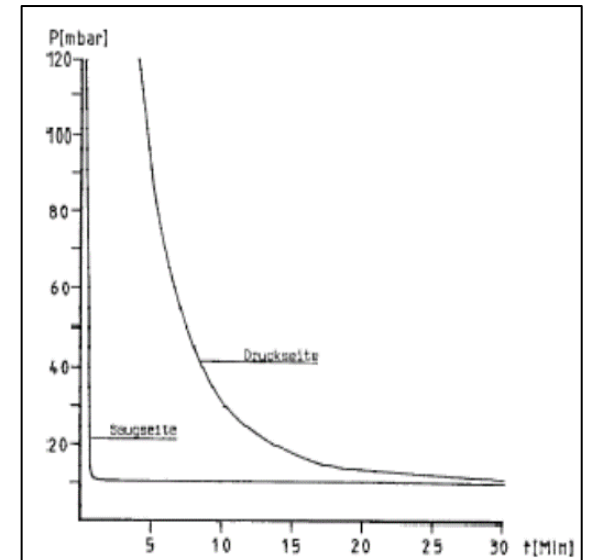
- An **estimated 80%** of the **errors** in refrigerant systems are **not in the cooling circuit.**
- Exchange of components, only with certified and specified components.
- Never use torches when removing system components. Use a pipe cutter instead.
- Electrical components should be spark-free and are certified for being a non-sparking component..
- After disposal of the refrigerant, residual gas is to be expected (even after flushing with nitrogen), because it can bond with oil, which can then liberate the gas.
- Open pipelines carefully; pay attention to floor drains (seal them if necessary).
- If soldering is necessary, dispose of the protective gas filling; evacuate the unit with a vacuum pump. Afterwards solder in the replacement part while flushing with nitrogen.
- Suggestion: instead of brazing use Lokring- connectors. With this connectors you can manufacture a hermetic bond without flame.
- Ensure adequate ventilation during the work, especially during the start-up



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Flammable Refrigerants Pressure Test & Vacuum

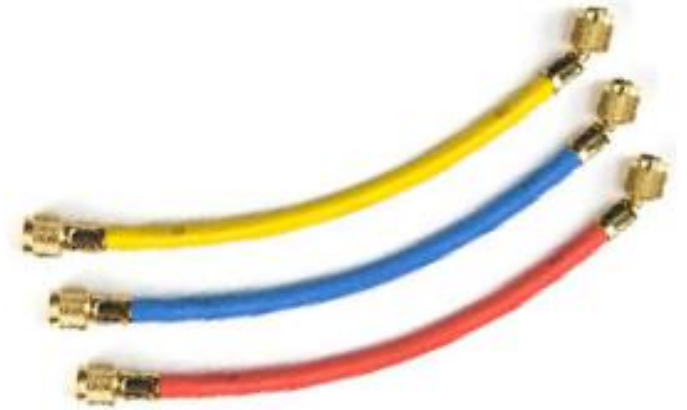
- ✓ Using the service port with the piercing valve, perform a pressure test with nitrogen.
- ✓ When no leaks have been found, vacuum the system until you reach 0,3 mbar vacuum level.
- ✓ R290 uses POE type oil which is very hygroscopic and absorbs moisture very quickly. It could be required to break the vacuum 3-4 times with dry-nitrogen before performing final evacuation to 0,3 mbar.
- ✓ Evacuate the cabinet long enough. No Refrigerant should left into the Tubes and into the Compressor. The time required for this process depends on the amount of refrigerant. This takes up to 15 minutes or more. The compressors must be shaken briefly at least once during draining so that as much refrigerant as possible, which is bound in the oil, is released.



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Flammable Refrigerants Charging

- ✓ Charge cylinders are not allowed with R290.
- ✓ Prior to charging, make sure there are no leaks. Check the vacuum level during evacuation.
- ✓ Hoses should be as short as possible to minimize the amount of refrigerant in them. Since the refrigerant amount in PLUG IN CABINETS are normally max 150 grams, ± 30 gram charge for instance would affect normal operation conditions drastically!
- ✓ Your scale should be a gram scale.



Safety First Aid Measures

General

- Contact with evaporating liquid may cause frostbite or freezing of skin.
- In case of frostbite spray with water for at least 15 minutes.
- Apply a sterile dressing. Get medical attention.

Skin contact

- High concentrations may cause asphyxiation. Symptoms may include loss of mobility/consciousness.
- Victim may not be aware of asphyxiation. Remove victim to uncontaminated area wearing self contained breathing apparatus.
- Keep victim warm and rested. Call a doctor. Apply artificial respiration if breathing stopped.

Eye contact

- Rinse the eye with water immediately.
- Remove contact lenses, if present and easy to do.
- Continue rinsing. Flush thoroughly with water for at least 15 minutes.
- Get immediate medical assistance. If medical assistance is not immediately available, flush an additional 15 minutes.



Safety Summary

Safety Summary:

- Switch off all electrical devices in the danger zone!
- Detection and removal of ignition sources (static discharge, capacitor, cell phones, hot surfaces, etc.)
- Separate the danger area and set up warning signs.
- Use a mobile gas extraction system (to not release refrigerant in the environment!)
- Use a gas detection system to identify the leak.
- Keep a fire extinguisher nearby.
- Use your personal protective equipment (PPE).

These procedures only take a short time!

As a service technician, you not only avoid injuries, but also avoid additional legal consequences!

