The facts about R-32 and R-454B

R32

Many people are unaware of the upcoming shift to low-GWP refrigerants. Daikin is committed to providing stakeholders the facts about low-GWP R-32, so you can make the right choice when replacing existing residential and commercial R-410A systems in the future.

SPECS

	R-410A Benchmark	R-32	R-454B
Global Warming Potential (GWP) [1]	2,088	675	466
Total Emissions (kg CO_2-eq.) [14]	17,263	14,916 (13.6% lower)	15,008 (13.1% lower)
Composition	R-32 50% R-125 50%	R-32 100%	R-32 68.9% R-1234yf 31.1%
Refrigerant Safety Classification [3]	A1	A2L	A2L
Temperature Glide [5]	Yes	No	Yes
System Capacity [*,+]	100%	>110% [7]	>97% [8]
System Efficiency [*,+]	100%	>107% [7]	>102% [8]
Refrigerant Charge Size [*]	-	Up to 40% smaller [10]	Up to 10% smaller [11]
Proprietary	No	No	Yes

[*, +, 1, 3, 5, 7, 8, 10, 11, 14] Please see supporting information for these items on page 4.

EXTENDED CONTEXT

Both R-32 and R-454B are classified as A2Ls and meet the less than 750 GWP requirement in published CARB regulations and granted EPA petitions. Experts measure Life Cycle Climate Performance (LCCP) to understand refrigerant impacts to the environment. When using LCCP analysis, (which considers charge size, efficiency and capacity), our test results show R-32 has a slight advantage over R-454B.

Regulatory - There are no published regulations or granted EPA petitions that state R-32 will be prohibited in the U.S. after 2029.

In fact, R-32 is a single component refrigerant, while R-454B is a blend that consists of nearly 70% R-32.

PROVEN

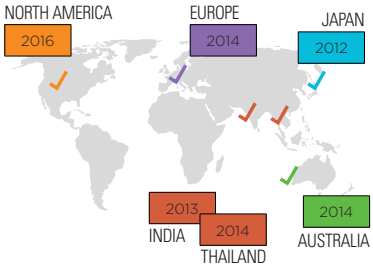
R32

R-32 has been safely used in over 160 million units in the US and around the world by more than 40 OEMs. In more than 100 countries. R-32 has become the global de facto to replace R-410A.

R-454B

R-454B has limited use compared to R-32 globally. There have been limited residential trials with products using R-454B as they are currently not for sale in the US.

MATURITY - USED SINCE 2012



R-32 is actively promoted and adopted by multiple OEMs of rooftops, chillers, window AC, mini-splits and *VRV*/VRF equipment worldwide. Major mini-split OEMs are expected to bring their R-32 designs into NA before 2025. Daikin contractors have been installing commercially available R-32 mini-splits since 2021 in the US.

EASY

R32

As a pure, single component refrigerant, R-32 can be added or recharged in the field in both liquid and gas phases, without changes in composition. It is easy to clean, reuse on-site, and easy to reclaim off-site with a simple cleaning process.

R-454B

R-454B is a blend and it must be charged like R-410A. The components of R-454B leak at different rates, while R-32 is a single component refrigerant and can be added in the field without concern of composition change.

Since R-32 is not a blend, it can be reused with less effort and has fewer steps to be reclaimed in the market.

EFFICIENT

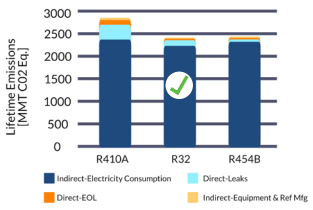
R32

Test data in Daikin's labs of inverter-driven compressors for rooftop units and water-cooled chillers found that full-load and partial-load efficiency rated metrics can be improved by up to 12% using R-32 instead of R-410A.

R-454B

There are several references promoting R-454B as being "Similar to R-410A." Unlike R-454B, R-32 has improved capacity over R-410A that can result in lower operating costs and lower environmental impacts for the product lifecycle.

R32 has lower LCCP vs. R454B



Daikin has proven global experience designing and optimizing systems using R-32 to deliver compact, energy saving systems.

AVAILABLE

R32

R-32 is a commodity manufactured by numerous refrigerant producers and distributed globally. There are no active patents on the basic molecule. Some alternative low-GWP blends can be proprietary, potentially limiting access and supply, potentially driving cost up.

R-454B

R-454B is a blend available from fewer suppliers. Production capacities are not widely understood to support industry volumes. The nature of blends indicate further processing and thus potential added cost may be passed on to the end users.

Refrigerants | HVAC Breaking News

Daikin Offers Free Access to Patents for Equipment Using HFC-32 Refrigerant

Move facilitates global conversion to HFC-32 for HVAC applications

September 11, 2015

KEYWORDS alternative refrigerants / GWP (Global Warming Potential) refrigerants / HFC refrigerants

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WASHINGTON — Daikin Industries Ltd. announced it is offering companies worldwide free access to 93 patents to encourage them to develop and commercialize air conditioning, cooling, and heat pump equipment that uses HFC-32 as a single-component refrigerant.

Daikin's action is aimed at encouraging manufacturers worldwide to adopt comfort cooling and heating technologies that use HFC-32, a refrigerant with a lower global warming potential (GWP) than commonly used refrigerants.

R-32 IS ENDORSED BY DAIKIN Amana Heating & Air Conditioning Goodman Air Conditioning & Heating

Low GWP Alternate Refrigerants for HVAC Systems

FREQUENTLY ASKED QUESTIONS:

R32

WHAT ARE REFRIGERANT CLASSIFICATIONS?

- Refrigerants are categorized based on toxicity and flammability and assigned respective refrigerant concentration limits by ASHRAE® Standard 34. This is an alphanumeric system, where letters A and B denote lower toxicity and higher toxicity respectively, and the numeral 1 denotes no flame propagation, 2L denotes lower flammability, 2 denotes flammable and 3 denotes higher flammability.

WHAT IS LOW GLOBAL WARMING POTENTIAL (GWP) CLASSIFICATION?

- GWP numbers for a refrigerant are calculated and published by the United Nations Intergovernmental Panel on Climate Change (IPCC). The GWP number is based on the refrigerant's properties, such as lifetime, radiative forcing effect, and current atmospheric conditions such as abundance of CO_2 gas. Consequently, GWP numbers have changed over time. However, most notable regulations such as the Kigali Amendment of the Montreal Protocol, CARB Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Stationary Air-conditioning and Other End-Uses, and the AIM act, are based on the IPCC's 4th Assessment Report (IPCC AR4) values. Regulatory bodies have used the IPCC AR4 values to develop policies and identified refrigerants with a GWP of <750 as lower GWP candidates.

WHAT ARE SINGLE COMPONENT AND BLEND REFRIGERANTS?

- Single component refrigerants are comprised of only one type of molecule, so they have a constant evaporation and condensation temperature at a given pressure. On the contrary, blend refrigerants are a combination of two or more single component refrigerants that are carefully formulated and composed to strengthen or compensate for certain properties.

WHAT ARE THE BENEFITS OF A SINGLE COMPONENT REFRIGERANT COMPARED TO BLENDS?

- Single component refrigerants are simpler to handle than most blends. Single component refrigerants do not have a temperature glide; refrigerant charging can be performed in liquid or gas phase even with an upright cylinder; there is no negative performance impact due to composition change; it can be easily reclaimed, recycled, and after reused and its production cannot be restricted by patents, as is the case for many newer low GWP blends.

WHAT IS TEMPERATURE GLIDE?

- Temperature glide is variability in boiling temperature of a refrigerant fluid due to the fraction of liquid and vapor at a given pressure condition. This is an undesirable characteristic that can compromise optimal performance of an HVAC system.

WHAT IS CRITICAL TEMPERATURE (T_c)?

- Critical temperature is the temperature above which a pressure change cannot liquify the refrigerant, no matter how much pressure is applied. Higher critical temperatures allow for greater heat transfer at a constant temperature and is thus desirable for better efficiency.

WHAT IS LOWER FLAMMABILITY LIMIT (LFL)?

- LFL is the minimum concentration of a refrigerant that is capable of propagating a flame under specific test conditions. A higher LFL is desired because it means a higher concentration is required to create flammable conditions. LFL for lighter fluid – butane is 1.7% (%vol), compared to R-32's 14.4% (%vol).

WHAT ARE LIFETIME EMISSIONS? WHY IS IT IMPORTANT TO CONSIDER LIFETIME EMISSIONS OVER DIRECT EMISSIONS?

- *Lifetime Emissions* (kg CO_2.eq) from a system are a sum total of its *Direct* and *Indirect Emissions*.
- Simply stated, *Direct Emissions* relate to the refrigerant type and its GWP whereas *Indirect Emissions* relate to equipment manufacturing and use in its lifetime.
- *Direct Emissions* will be lower for a lower GWP refrigerant because it is calculated as $kg_{refrigerant\ leaked}$ * GWP. However, an HVAC system is designed to reduce leakage and not release refrigerant to the atmosphere. But, *Direct Emissions* typically contribute up to 11% of a systems total *Lifetime Emissions*.
- *Indirect Emissions* make up more than 89% of a systems *Lifetime Emissions*.
- Thus, efficiency of the system is a very important criteria in choosing a refrigerant for effective reduction of GHG emissions. R-32 refrigerant's increased efficiency helps OEM engineers design systems with low electricity consumption over the system's life, compensating for *Direct Emissions*, and resulting in lower *Lifetime Emissions* than other lower GWP blends.

Direct Effects from Refrigerant

- Refrigerant GWP
- Atmospheric reaction products
- End-of-life impact

+

Indirect Effects from Lifetime Use

- Construction materials
- Energy generation and use
- End-of-life impact

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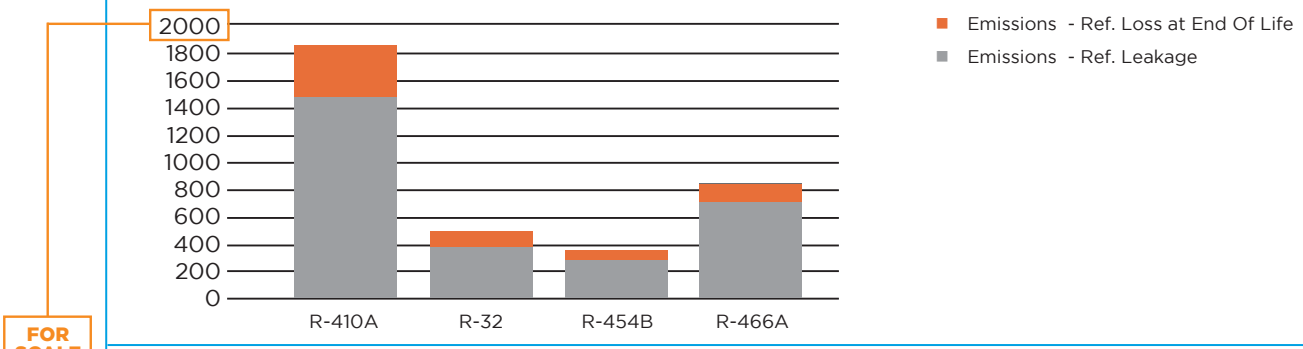
Life Cycle Climate Performance (LCCP)

Direct Emissions from an HVAC System*

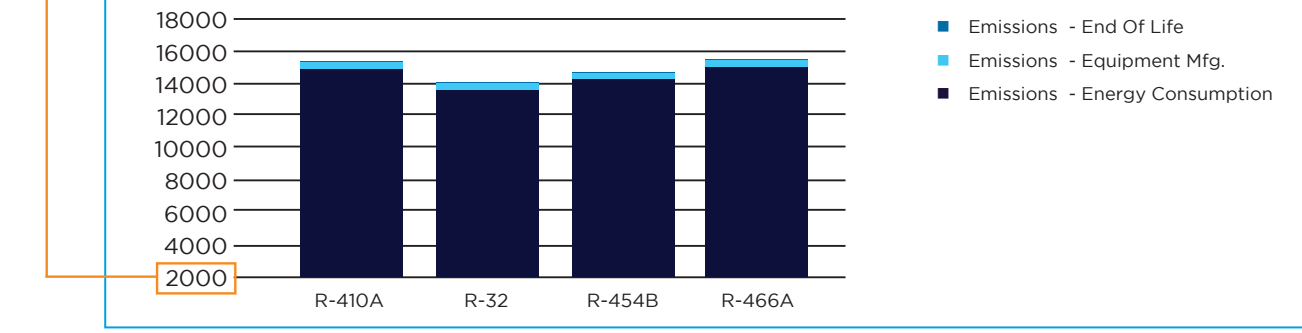
R-410A vs R-32 vs R-454B vs R-466A



FOR SCALE

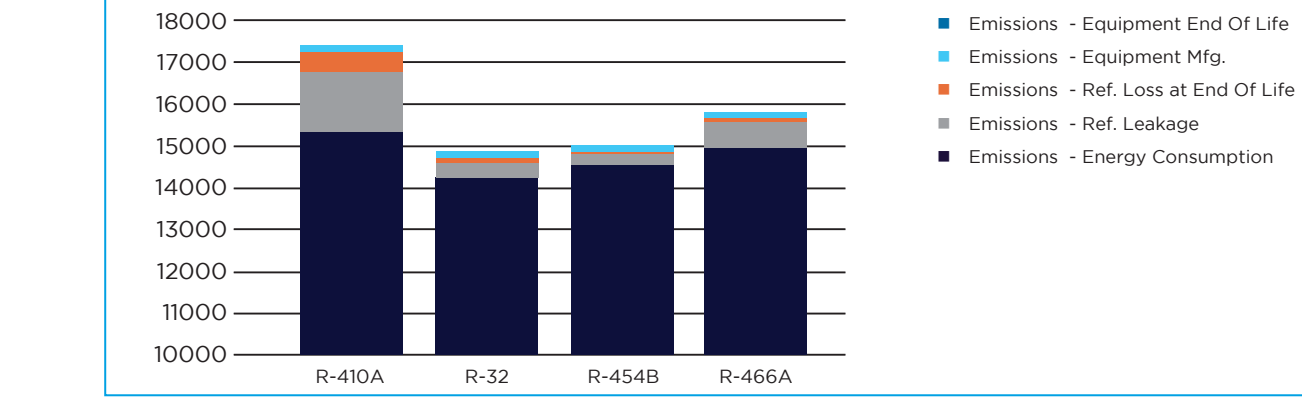
Indirect Emissions from an HVAC System*

R-410A vs R-32 vs R-454B vs R-466A



Lifetime Emissions from an HVAC System*

R-410A vs R-32 vs R-454B vs R-466A



* Comparison is made using the Life Cycle Climate Performance (LCCP) metric, measured in kg-CO_2.eq. LCCP analysis was performed using a high efficiency HP (24+ SEER), using performance gains claimed by respective refrigerant manufacturer, for a residential sized (9000 Btu/h cooling capacity), installed in Houston, TX climate zone, with an assumed annual leakage rate of 4% and end of life refrigerant leakage of 15% with a 15 year lifetime. The heating COP and SEER were adjusted based on refrigerant characteristics and performance. The physical system size, trim charge requirements and capacity were kept consistent to ensure a like-to-like comparison.

Low GWP Alternate Refrigerants for HVAC Systems

R32

As the U.S. HVAC industry transitions to low Global Warming Potential (GWP) refrigerants, there are three leading replacement options for R-410A today: R-32, R-454B, and R-466A. Here is how they compare:

	R-410A Benchmark	R-32	R-454B	R-466A
Global Warming Potential (GWP) [1]	2,088	675	466	733
Composition	R-32 50% R-125 50%	R-32 100%	R-32 68.9% R-1234yf 31.1%	R-32 49% R-125 11.5% R-1311 39.5%
Blend	Yes	No	Yes	Yes
Longevity in U.S.	Since 1996	Since 2016	Not in use yet	Not in use yet
Proprietary	No	No	Yes	Yes
Global System Install Base	Universal	>160 million [2]	No Data	No Data
Can be charged in both liquid and gas phase?	No	Yes	No	No
Is drop-in to existing R-410A units allowed?	-	No	No	No
Refrigerant Safety Classification [3]	A1	A2L	A2L	A1
Flame Propagation [3]	No	Yes - Lower flammability	Yes - Lower flammability	No
Anticipated to meet CARB/AIM Act Regulation (<750 GWP)	No	Yes	Yes	Yes
Lower Flammability Limit, LFL (g/m³) [3]	-	306	352.6 (296) [4]	-
Refrigerant Concentration Limit, RCL (g/m³) [3]	420	77	49 (74) [4]	99
Temperature Glide [5]	Yes	No	Yes	Yes
Temperature Glide amount (K) [5]	<0.1	0	1.0 to 1.3	1.5 [6]
Critical Temperature, T_c (°C) [5]	71.3	78.1	78.1	76.5 [6]
System Capacity *,*	100%	>110% [7]	>97% [8]	>95% [9]
System Efficiency *,*	100%	>107% [7]	>102% [8]	>100% [9]
Refrigerant Charge Size *	-	Up to 40% smaller [10]	Up to 10% smaller [11]	Up to 26% larger [12]
Direct Emissions (kg CO_2-eq.) [14]	1,879	496 (73.6% lower)	346 (81.6% lower)	660 (64.8% lower)
Indirect Emissions (kg CO_2-eq.) [14]	15,384	14,419 (6.3% lower)	14,662 (4.7% lower)	15,117 (1.7% lower)
Total Emissions (kg CO_2-eq.) [14]	17,263	14,916 (13.6% lower)	15,008 (13.1% lower)	15,776 (8.6% lower)

* When compared to a R-410A system with similar specifications.

* While R-32 products are widely available, there are no products readily available with other low GWP blends. Consequently, the comparative analysis was performed using calculations and simulation models and publicly available refrigerant data.

[1] IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

[2] https://www.daikin.com/csr/information/influence/hfc32

[3] ASHRAE Standard 34-2019, ISSN 1041-2336, with published errata and addenda (as of January 2022) ASHRAE, Atlanta, GA.

[4] Based on updated calculations from errata for ASHRAE 34-2019, the RCL may be closer to 74 g/m³. Daikin suggests that RCL values for R-454B, if needed, should be obtained from the refrigerant manufacturers.

[5] Lemmon, E.W., Bell, I.H., Huber, M.L., McLinden, M.O. NIST Standard Reference Database 23: Reference Fluid Thermodynamic and Transport Properties-REFPROP, Version 10.0, National Institute of Standards and Technology, Standard Reference Data Program, Gaithersburg, 2018. doi: https://doi.org/10.18434/T4/1502528

[6] https://sustainability.honeywell.com/us/en/products/refrigerants/hfo-blends/solstice-n41-r-466a

[7] Guo, Weihua; Ji, GaoFeng; Zhan, Honghong; and Wang, Dan, "R32 Compressor for Air conditioning and Refrigeration applications in China" (2012). International Compressor Engineering Conference. Paper 2098.

[8] https://www.opteon.com/en/products/refrigerants/xl41

[9] https://prod-edam.honeywell.com/content/dam/honeywell-edam/pmt/am/en-us/sustainability/refrigerants/documents/pmt-am-solsticen41-safety-compliance-brochure.pdf

[10] Based on Daikin's internal calculations: https://www.daikinapplied.com/news/news/R-32

[11] ACHR hosted Podcast - Refrigerants Transition from R-410A – Light commercial and Residential AC markets (participants: Chemours, Carrier, Danfoss, Emerson)

[12] ASHRAE Chapter Conference Paper 2020 (https://mnashrae.starchapter.com/images/Kujak_Minnesota_Chapter_Feb2020_Performance_of_R466A.pdf)

[13] Typical cost as described in EPA Affordability AIM Act Subsection i Factors October 2021 (https://www.regulations.gov/document/EPA-HQ-OAR-2021-0643-0032)

[14] Comparison is made using the Life Cycle Climate Performance (LCCP) metric, measured in kg-CO_2.eq. LCCP analysis was performed using a high efficiency HP (24+ SEER), using performance gains claimed by respective refrigerant manufacturer, for a residential sized (9000 Btu/h cooling capacity), installed in Houston, TX climate zone, with an assumed annual leakage rate of 4% and end of life refrigerant leakage of 15% with a 15 year lifetime. The heating COP and SEER were adjusted based on refrigerant characteristics and performance. The physical system size, trim charge requirements and capacity were kept consistent to ensure a like-to-like comparison.

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For more information, visit www.R32Reasons.com

R32