TRANE LET'S GO BEYOND™

Refrigerant Update: The New Transition Has Begun

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Learning Objectives

After viewing the presentation, attendees will be able to:

- Discuss the science behind why and how HVAC refrigerants are evolving.
- Summarize the drivers behind the new regulations & legislation for HVAC refrigerants.
- Discuss the actions being taken globally (*via the Kigali Amendment to the Montreal Protocol*) Compare & contrast current & next-generation refrigerant options, in terms of environmental impact, efficiency & safety.

Understand the facts today; plan for tomorrow

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Where were we and where are we going?

Past (CFCs)
R-12, R-11, R-113, & more…

⇨ **ODP**

Low-ODP or no ODP

Current (HCFCs & HFCs)
R-22, R-134a, R-410A, R-407C
R-123, R-404A R-245fa, & more…

⇨ **GWP**

Reduced GWP & De Minimis ODP

Transitional & Next-Gen
(HFOs & blends)
R-1234yf, R-1234ze, R-1233zd, R-513A,
R-1336mzz, R-514A, R-452B, R-454B, & more…

Discussions on balancing ozone depletion, global warming, and energy efficiency as all being equally important.

- As stated in 1991 Trane Article for HPAC Magazine.

Balanced approach minimizes overall environmental impact:

- Ozone depletion
- Energy efficiency
- Refrigerant emissions
- Climate Change (GWP)
- Atmospheric life

Refrigerant selection focused on minimizing overall impacts

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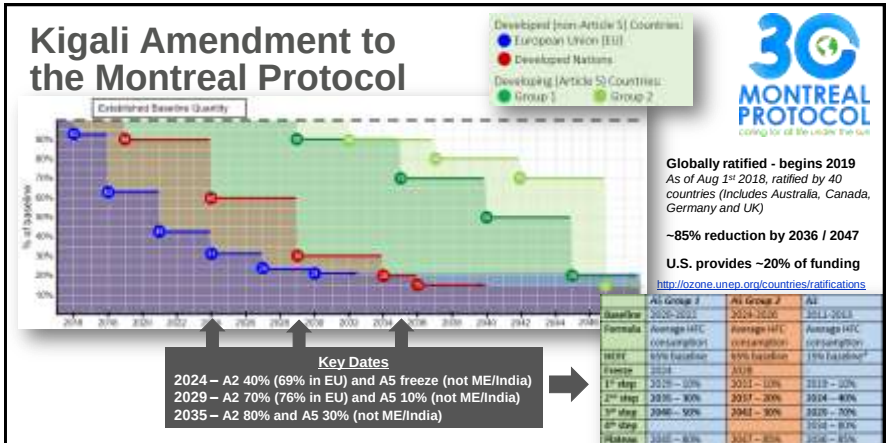
Kigali Amendment to the Montreal Protocol



MONTREAL PROTOCOL

Globally ratified - begins 2019
As of Aug 1st 2018, ratified by 40 countries (Includes Australia, Canada, Germany and UK)

~85% reduction by 2036 / 2047

U.S. provides ~20% of funding

http://ozone.unep.org/countries/ratifications

Key Dates
2024 – A2 40% (69% in EU) and A5 freeze (not ME/India)
2029 – A2 70% (76% in EU) and A5 10% (not ME/India)
2035 – A2 80% and A5 30% (not ME/India)

Cap-and-phase-down of HFCs starting in 2019 for developed nations

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United States Future

Direction not clear; plans evolving

- **Compliance with Kigali is expected.**
  - *International trade regulations dictate compliance*
- **HFCs will be phased-down.**
  - *Timing is clear; process is not*
- **A federal standard is desirable.**
  - *State-by-state is the alternative*
  - *California (CARB*) proposing HFC regulations*
  - *Other states looking to follow California*
- **Federal action possible.**
  - *Legislation that directs EPA to regulate in accordance with Kigali*
  - *Kigali ratification being considered*

**California Air Resources Board*

The future is known… the *how* and *when* is unclear

California Air Resources Board (CARB)

CARB exploring new HFC phase-out proposals

June 2018

HFC Reduction Measures

Hydrofluorocarbons (HFCs) are among the most potent and widespread climate pollutants in the world, and their use is growing rapidly.

- Poised to adopt provisions from U.S. EPA SNAP Rules 20 & 21, delisting high-GWP HFCs, potentially:
  - Phase-out of high GWP HFCs in new chillers by 2024
  - Phase-out of HFCs with high GWP in new stationary AC by 2023
- Proposal expected to evolve based on industry comments
- CARB anticipates a final rule prior to the end of 2019

https://ww2.arb.ca.gov/our-work/programs/hfc-reduction-measures

California being more aggressive than U.S. EPA on HFC phase down

Canada Actions Taken

HFC phase-out dates established

Effective: April 16th 2018

Year	Reduction from Baseline (%)
2019	10
2024	40
2030	70
2034	80
2036	85

Restrictions:

- Industrial Refrigeration:
  Phase-out of GWP > 2200 by 2020
- Transport Refrigeration:
  Phase-out of GWP > 2200 by 2025
- HVAC Chillers:
  Phase-out of GWP > 750 by 2025

Note: The overall phase down aligns with Kigali. There is no production in Canada, so consumption allocations are imports.

http://www.ammonia21.com/articles/8284/canada_puts_hfc_phase_down_plan_in_force

Product	GWP of refrigerant in product	Date
Stand-alone medium-temperature refrigeration system	1,400	Jan. 1, 2020
Stand-alone low-temperature refrigeration system	1,500	Jan. 1, 2020
Centralized refrigeration system	2,200	Jan. 1, 2020
Condensing unit	2,200	Jan. 1, 2020
Chillers	750	Jan. 1, 2025
Mobile refrigeration system	2,200	Jan. 1, 2025
Motor vehicle air-conditioning (MVAC)	150	Jan. 1, 2021 model year of vehicles
Domestic refrigeration	150	Jan. 1, 2025

Canada Committed: Ratified and Restrictions in Place

What refrigerant do I buy?

- There are no perfect refrigerants.
- Take a balanced approach:
  Safety, Environmental Impact, Efficiency
- R-123, R-134a, R-410A, R-404A, R-407C are all responsible HVAC refrigerant choices… *today*.
  …but planning for tomorrow begins now.
- Leak tightness is key!
  Safety, Environmental Impact, Efficiency
- Next-generation alternatives are available; only A1/B1 refrigerants offer clear and immediate solutions.

Use the facts to plan for tomorrow

HVAC Industry Investigation & Action

Next-generation refrigerants bring more variables

Some next-generation refrigerants offer new challenges

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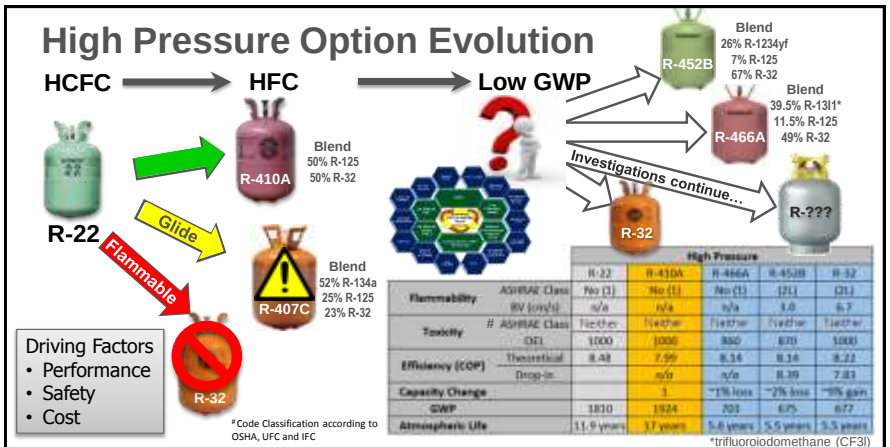
High Pressure Option Evolution



Next transition with high pressure refrigerants offers challenges & trade-offs

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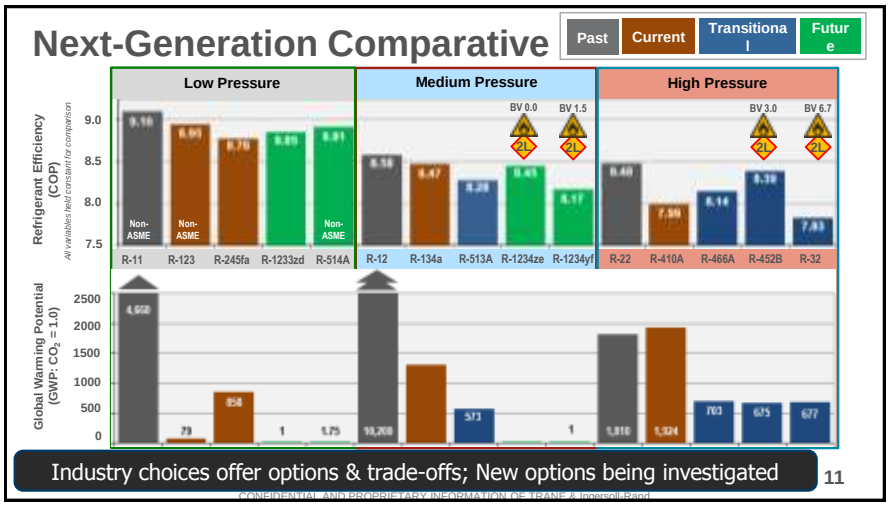
Next-Generation Comparative



Industry choices offer options & trade-offs; New options being investigated

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Choices Continue to Emerg

Research continues to find A1/B1 options

"The key third component, and the main reason for the blend's non-flammability, is trifluoroiodomethane (CF3I), a relatively new gas which has not previously been used in refrigerant blends.

A fire suppressant, CF3I is thought to be considered as a replacement for halon 1301. Significantly, CF3I is also a major contributor to Solstice N41's low GWP. The new gas makes up 39.5% of the new blend (R32 is 49% and R125 11.5%) but its 100-year GWP is less than 1 (in fact, 0.4).

Those blend proportions would give the new refrigerant a GWP of around 733, just slightly more than R32's GWP of 675, but with zero flammability."

https://www.coolingpost.com/world-news/secret-of-honeywells-new-refrigerant/

New refrigerants offer increased confidence for future of R-410A products

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Choices & Comparison

Past | Current | Transitional | Future

Screw & Centrifugal Technology Options

*Code Classification according to OSHA, UFC and IFC

	Low Pressure			Medium Pressure			
	R-123	R-1233zd	R-514A	R-134a	R-513A	R-1234yf	R-1234ze
Flammability	Non (1)	Non (1)	Non (1)	Non (1)	Non (1)	Slight (2L)	Slight (2L)
Toxicity #	Neither	Neither	Neither	Neither	Neither	Neither	Neither
Fluid Efficiency	9.4 COP	9.3 COP	9.4 COP	8.5 COP	8.3 COP	8.2 COP	8.5 COP
Capacity Change	1	35% Gain	Same	1	Same	5% Loss	25% Loss
GWP	79	1	< 2	1300	573	1	1

Chiller efficiency impacted by refrigerant choice – growing customer options

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How Can I Protect My Investment?

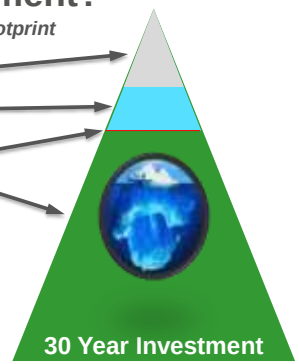
Total cost of ownership encompasses total carbon footprint

"First Cost" (chiller + refrigerant)	4.92%
Lifetime Service Costs*	6.53%
Lifetime Refrigerant Supply*	0.04%
Lifetime Electrical Costs	88.51%

All refrigerants used today are and will be – available for the life of the equipment.

Focus on reliable, efficient designs!

And let the manufacturer worry about the refrigerant!



* Based on low-pressure, hermetic design

A balanced approach, with a focus on efficiency

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Thank you for your time and attention!

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