FUTURE GENERATION REFRIGERANT FROM ENVIRONMENTAL PERSPECTIVE

By
Mr Manoj Chakravorty
Date: 06.11.17
Venue: Monotel, Saltlake
Montreal Protocol targets new global agreements on greenhouse gases (GHGs)

November 6, 2015

http://www.achrnews.com/articles/131056-montreal-protocol-sets-global-hfc-phasedown

Montreal Protocol Global HFC Phase

The 197 Parties to the Montreal Protocol agreed to begin work on an amendment that will reduce the global production and consumption of HFCs at the 27th Meeting of the Parties (MOP), held Nov. 1-5 in Dubai, United Arab Emirates. The amendment, deemed the “Dubai Pathway,” is expected to be completed in 2016 and put an end to ongoing discussions regarding HFC usage that’s persisted among Montreal Protocol parties for more than five years.

Global agreement to include HFCs in global phase-down expected

Montreal Protocol: October 2016 at Rwanda, Africa
What is Driving Action in the USA?

**Dramatic global growth of high-GWP HFCs**

**Recent HFC Growth Dramatic and Increasing**

**HFCs: Potential Growth If Unmitigated**

- HFC growth directly linked to Montreal Protocol's ODS phaseout and expanding availability of refrigeration & air conditioning
- HFC emissions could reach 19% of projected global CO₂ emissions by 2050 if left unchecked

Alignment with support to sign Montreal Protocol Amendment
Global Consumption of HFCs

Source: UNEP Ozone Secretariat Fact Sheet 2 “Overview of HFC Market Sectors” (Oct 2015)

Markets Using HFCs

- RACHP
- Foam
- Aerosols
- Fire Protection
- Solvents

Percent of Tons of CO₂

- 86%
- 7%
- 4%
- 3%
- 0.0%

Total Metric Tons

- 79%
- 12%
- 7%
- 2%
- 0.3%

FACT SHEET 2 Overview of HFC Market Sectors

Facts and figures related to the consumption and market sectors of HFCs.
Kigali Amendment

Pathway for a global phase down of HFCs

October 15, 2016

Established Baseline Quantity

% of baseline

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

Developed (non-Article 5) Countries:
- European Union (EU)
- Developed Nations

Developing (Article 5) Countries:
- Group 1
- Group 2

2016 2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038 2040 2042 2044 2046 2048

10% 20% 30% 40% 50% 60% 70% 80% 90%
AHRI and NRDC have engaged in discussions on the importance of responsibly moving beyond high-GWP refrigerants used in chillers. Considerations have included the safety of alternatives, the continued improvement of system energy efficiency, reasonable product development timelines, and the avoidance of market migration. With these factors in mind, AHRI and NRDC support EPA finalizing the following changes of status:

- Remove R-134a, R-410A, and R-407C from the list of acceptable substitutes in all new air-cooled and water-cooled chillers using centrifugal, screw, scroll, and all other compressor types effective January 1, 2025

This proposal allows eight years from the publication of the final rule for industry to finish designing and transitioning to new equipment addressed in the rule. It is important to note that these actions are necessary to ensure the continued implementation of climate change mitigation initiatives.
February 1, 2016

Cindy Newberg
Chief, Alternatives and Emission Office of Atmospheric Programs
U.S. Environmental Protection Agency
1200 Pennsylvania Ave.
Washington, DC
20460

Dear Mr. Newberg,

Recent Update from AHRI & NRDC

The Air Conditioning, Heating & Refrigeration Institute (AHRI) and the Natural Resources Defense Council (NRDC) are pleased to report that the Environmental Protection Agency (EPA) has removed R-134a, R-410A, and R-407C from the list of acceptable substitutes in all new air-cooled and water-cooled chillers using centrifugal, screw, scroll, and all other compressor types effective January 1, 2025.

AHRI’s members include the leading manufacturers producing a significant majority of the global market share of water-cooled and air-cooled chillers, and its research program on alternative refrigerants is helping industry transition to lower global warming potential (GWP) substitutes. NRDC has a strong history of advocating for changes of status for high GWP refrigerants on the SNAP list, including a recent petition covering the equipment addressed in this letter.
US places bans on R404A and R134a

Monday, September 26, 2016, the U.S. EPA (Environmental Protection Agency) announced the much anticipated SNAP (Significant New Alternatives Policy) final ruling for chillers that use HFC refrigerants.

The U.S. EPA (Environmental Protection Agency) announced the much anticipated SNAP (Significant New Alternatives Policy) final ruling for chillers that use HFC refrigerants.

The EPA Administrator, Gina McCarthy, signed the following document on 9/26/2016, and the Agency is submitting it for publication in the Federal Register (FR). While we have taken steps to ensure the accuracy of this Internet version of the document, it is not the official version. Please refer to the official version in a forthcoming FR publication, which will appear on the Government Printing Office's FDsys website (http://fdsys.access.gpo.gov/fdsys/search/home.action) and on Regulations.gov (www.regulations.gov) in Docket No. EPA-HQ-OAR-2015-0663. Once the official version of this document is published in the FR, this version will be removed from the Internet and replaced with a link to the official version.

ENVIRONMENTAL PROTECTION AGENCY
40 CFR Part 82
[ EPA-HQ-OAR-2015-0663; FR-9952-18-OAR ]

Protection of Stratospheric Ozone: New Listings of Substitutes; Changes of Listing Status; and Reinterpretation of Unacceptability for Closed Cell Foam Products under the Significant New Alternatives Policy Program; and Revision of Clean Air Act Section 608 Venting Prohibition for Propane

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final Rule.

SUMMARY: Pursuant to the U.S. Environmental Protection Agency’s (EPA) Significant New Alternatives Policy program, this action lists certain substances as acceptable, subject to use conditions, lists several substances as unacceptable, and changes the listing status for certain substances from acceptable to unacceptable, subject to narrowed use limits, or to unacceptable.

This action also exempts propane in certain refrigeration end-uses from the Clean Air Act section 608 prohibition on venting, release, or disposal. In addition, this action applies unacceptability determinations for foam blowing agents to closed cell foam products and products containing closed cell foam that are manufactured or imported using these foam blowing agents.

US: The US EPA is to ban a host of high GWP refrigerants including R404A, R134a, R407C and R410A in certain new products from as early as January 1, 2021.

The bans are part of wide ranging new rules finalised by the US Environmental Protection Agency yesterday, that will see bans on a number of existing refrigerants and a tightening of leak rate rules to reduce HFC emissions.

Commonly-used high GWP refrigerants R404A and R607A are among a number of refrigerants to be banned in new retail food refrigeration from as early as January 1, 2021, with both also being banned in new cold storage warehouses from January 1, 2023. Also included in the bans are many of the so-called retrofit blends including R407A and R407B.

R134a is one of a number of common refrigerants that will be banned from use in new centrifugal and positive displacement chillers as of January 1, 2024. Others include R407C and R410A, as well as a number of interim “drop-in” blends.

The new rules will also see R134a being banned in new domestic fridges and freezers from January 1, 2021.
Final Ruling on HFC Acceptability in Chillers

September 26th 2016  https://www.epa.gov/snap/snap-regulations

“These two rules demonstrate the United States’ continued leadership in protecting public health and the environment,” said EPA Administrator Gina McCarthy. “We are reducing emissions of HFCs that are harmful to the climate system and showing the world that we can do this responsibly and thoughtfully by working with businesses and environmental groups. I’m especially excited that we have taken these actions ahead of next month’s Montreal Protocol negotiations.”

- **Centrifugal Chillers** (Jan 1, 2024)
  R-134a, R-410A, R-407C, R-245fa…
- **Positive Displacement Chillers** (Jan 1, 2024)
  R-134a, R-410A, R-407C, R-245fa…
- **Cold Storage Warehouses** (Jan 1, 2023)
- **Retail Food Refrigeration** (Jan 1, 2021)
- **Household Refrigerators/Freezeers** (Jan 1, 2021)

http://www.coolingpost.com/world-news/us-places-bans-on-r404a-and-r134a/

US phase-out of HFCs in chillers 1/1/2024

FOR IMMEDIATE RELEASE: December 1, 2016

[Image of EPA logo]

FACT SHEET

CHANGE OF LISTING STATUS

<table>
<thead>
<tr>
<th>End-Uses</th>
<th>Substitutes</th>
<th>Date of Change of Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Conditioning</td>
<td>FOR12A, FOR12B, HFC-134a, HFC-227ea, HFC-236fa, HFC-245fa, R-125/134a/600a (28.1/70/1.9), R-125/290/134a/600a (55.0/1.0/42.5/1.5), R-404A, R-407C, R-410A, R-410B, R-417A, R-421A, R-422B, R-422B, R-422C, R-423A, R-424A, R-434A, R-438A, R-507A, RS-44 (2003 composition), and THR-03</td>
<td>Unacceptable, except as otherwise allowed under a narrowed use limit, as of January 1, 2024</td>
</tr>
</tbody>
</table>


EPA mechanism for managing regulations
Where were we and where are we going?

Past (CFCs)
- R-12, R-11, R-113 more...

⇒ ODP

Low-ODP or no ODP

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

⇒ GWP

Reduced GWP & De Minimis ODP

Future (HFO & Blends)
- R-1234yf, R-1234ze, R-1233zd, R-513A,
- R-1336mzz, R-514A, R-452B, more...

Balanced approach minimizes overall environmental impact:
- Ozone depletion
- Energy efficiency
- Refrigerant emissions
- Global warming
- Atmospheric life

Refrigerant selection focused on minimizing overall impacts
Regulatory Requirements Driving Change

Montreal Protocol / Ozone Depletion Concerns

CFC Phase-out

CFCs

HCFCs

HCFC Phase-out

EU F-Gas Regulation

HFCs

HFOs

Ozone

Global warming

Simple Chemistry

Enhanced Chemistry

New Molecule Development

Advanced Molecules Development + Complex Chemistry

R12

R134a

R1234yf
HVAC Industry Next Transition Begins

Next-Generation Refrigerants now available...

Industry available choices offer high efficiency options
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*
- Leak tightness is key! Means lower emissions, higher efficiencies, lower cost, safer

Understand the facts today; plan for tomorrow
All refrigerants used today are and will be available for the life of the equipment.

Focus on reliable, efficient designs!

And, let us worry about the refrigerant!

How Can I Protect My Investment?

Total cost of ownership encompasses total carbon footprint

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>“First Cost” (chiller + refrigerant)</td>
<td>4.92%</td>
</tr>
<tr>
<td>Lifetime Refrigerant Supply</td>
<td>0.04%</td>
</tr>
<tr>
<td>Lifetime Service Costs</td>
<td>6.53%</td>
</tr>
<tr>
<td>Lifetime Electrical Costs</td>
<td>88.51%</td>
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</table>

A balanced approach, with a focus on efficiency
## Next Gen Refrigerant Offerings

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Manufacturers</th>
<th>Refrigerant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrifugal Chillers</td>
<td>Trane/IR</td>
<td>R-1233zd</td>
</tr>
<tr>
<td></td>
<td>MHI</td>
<td>R-1233zd</td>
</tr>
<tr>
<td></td>
<td>Carrier</td>
<td>R-1233zd</td>
</tr>
<tr>
<td></td>
<td>Star</td>
<td>R-1234ze</td>
</tr>
<tr>
<td></td>
<td>Klima Therm</td>
<td>R-1234ze</td>
</tr>
<tr>
<td></td>
<td>Airedale</td>
<td>R-1234ze</td>
</tr>
<tr>
<td></td>
<td>Geoclima</td>
<td>R-1234ze</td>
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<tr>
<td></td>
<td>MHI</td>
<td>R-1234ze</td>
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<tr>
<td></td>
<td>Smardt</td>
<td>R-1234ze</td>
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<tr>
<td></td>
<td>RC-Group</td>
<td>R-1234ze</td>
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<tr>
<td></td>
<td>Cofely</td>
<td>R-1234ze</td>
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<tr>
<td></td>
<td>Smardt</td>
<td>R-513A</td>
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<tr>
<td></td>
<td>JCI</td>
<td>R-513A</td>
</tr>
<tr>
<td>Screw Chillers</td>
<td>Trane/IR</td>
<td>R-1234ze</td>
</tr>
<tr>
<td></td>
<td>Carrier</td>
<td>R-1234ze</td>
</tr>
<tr>
<td></td>
<td>Blue Box Kappa</td>
<td>R-1234ze</td>
</tr>
<tr>
<td></td>
<td>JCI</td>
<td>R-513A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R-513A / 1234ze</td>
</tr>
</tbody>
</table>

| Product Type       | Manufacturers            | Refrigerant | |
|--------------------|--------------------------|-------------|
| Unitary (Scroll)   | Trane                    | DR-55       |
|                    | Daikin                   | R-32        |
|                    | Fujitsu                  | R-32        |
|                    | Hitachi                  | R-32        |
|                    | Panasonic               | R-32        |
|                    | Haier                    | R-32        |
|                    | MultiAqua                | DR-55       |
|                    | Mitsubishi               | R-32        |
| Transport Refrigeration | Thermo King/IR       | R-452A      |
|                    | Carrier/Transicold       | R-452A      |
|                    | Tecumseh                 | R-452A      |
Current Trends Shift from HFC to HFO.....

Carrier at the forefront of innovative technology

Air-cooled screw chillers

- 30K and 30KW platform
- Complete range: 400 to 900 kW
- With fixed and variable-speed compressors
  - EER* up to 3.4
  - ESEER* up to 5.2

Water-sourced screw chillers and heat pumps

- 30KW, 30KW-V and 30KW-HV platform
- Complete range: 450 to 1350 kW
- With fixed and variable-speed compressors
  - EER* up to 5.5
  - ESEER* up to 8.0

...combined with a new refrigerant: HFO-R1234ze

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>GWP</th>
<th>ODP</th>
<th>Ozone Depletion Potential</th>
<th>Toxicity</th>
<th>Flammability</th>
<th>Applications covering</th>
<th>Efficiency</th>
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</thead>
<tbody>
<tr>
<td>HFO-R1234ze</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>Class A*** (non toxic)</td>
<td>not flammable at room temperatures</td>
<td>++ Larger operating envelope</td>
<td>++</td>
</tr>
<tr>
<td>HFC-R134a</td>
<td>1430</td>
<td>0</td>
<td>0</td>
<td>Class A (non toxic)</td>
<td>not flammable</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
China: US manufacturer Carrier has become the latest chiller company to design a machine using low GWP refrigerant R1233zd(E).

The new AquaEdge 19DV two-stage, variable-speed centrifugal chiller is featured on the Carrier China stand at this week’s China Refrigeration Expo in Beijing. It features Carrier’s Greenspeed variable frequency drive motor controller and is said to achieve market-leading refrigeration efficiencies.

Produced by Honeywell as Solstice zd, R1233zd(E) is a single component, non-flammable A1, fourth generation HFO refrigerant. It was originally developed for use as a blowing agent but has also been found to be a high efficiency alternative to R123.

US rival Trane was the first to adopt the refrigerant when it launched its Series E CenTraVac water-cooled centrifugal chiller in 2014. It was followed last year by Mitsubishi Heavy Industries’ launch of the ETl-Z Series using the same refrigerant.
Current Trends Shift from HFC Alternate…..

January 20, 2016
USA: York centrifugal and screw chillers from 440 to 21,100kW are now compatible with R513A, the lower GWP alternative for R134a.

Johnson Controls says it will showcase its York’s AHR Expo.
THANK YOU