Lessons Learned: Successfully Using Hydrofluoroolefin (HFO) Refrigerant Blends for Retrofits in Cold Chain Applications

August 24, 2021

Today's Host

Kersey Manliclic, PhD
U.S. Environmental Protection Agency
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Kersey has worked in various sectors before coming to U.S. EPA. Most recently, he worked for 3.5 years at the California Air Resources Board implementing an incentive program for cleaner agricultural equipment and ensuring that Cap-and-Trade incentive programs benefitted disadvantaged communities. Prior to that, he worked with state agencies to plan hydrogen fueling infrastructure for fuel cell electric vehicles. He holds engineering degrees all from the University of California, Irvine.

Today's Host

Kirsten Cappel
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Kirsten has worked for more than fifteen years at the U.S. EPA in the Office of Air and Radiation, managing both regulatory and voluntary programs. Most recently, she managed a voluntary EPA program that worked cooperatively with the solid waste industry to encourage the beneficial use biogas from landfills. She began her tenure at the Agency in the Stratospheric Protection Division, and is excited to return to the Division and work with the supermarket industry.

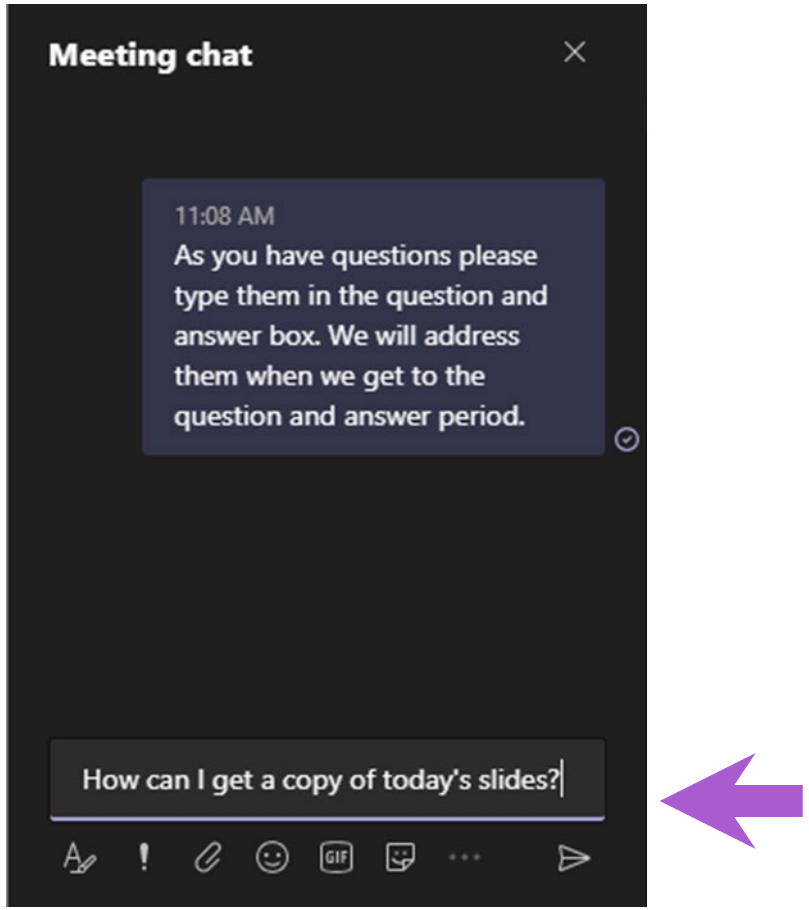
Questions and Webinar Feedback

Question and Answer Session

- Participants are muted
- Questions will be moderated at the end
- To ask a question, enter your comment into the chat box

Feedback Form

- We value your input!
- The link to a feedback form will appear in the chat window



Webinar Materials

Recording and Slides

- Webinar is being recorded
- Materials will be posted on the GreenChill website under Events and Webinars: www.epa.gov/greenchill
- To receive notification when materials are posted email: EPA-GreenChill@abtassoc.com

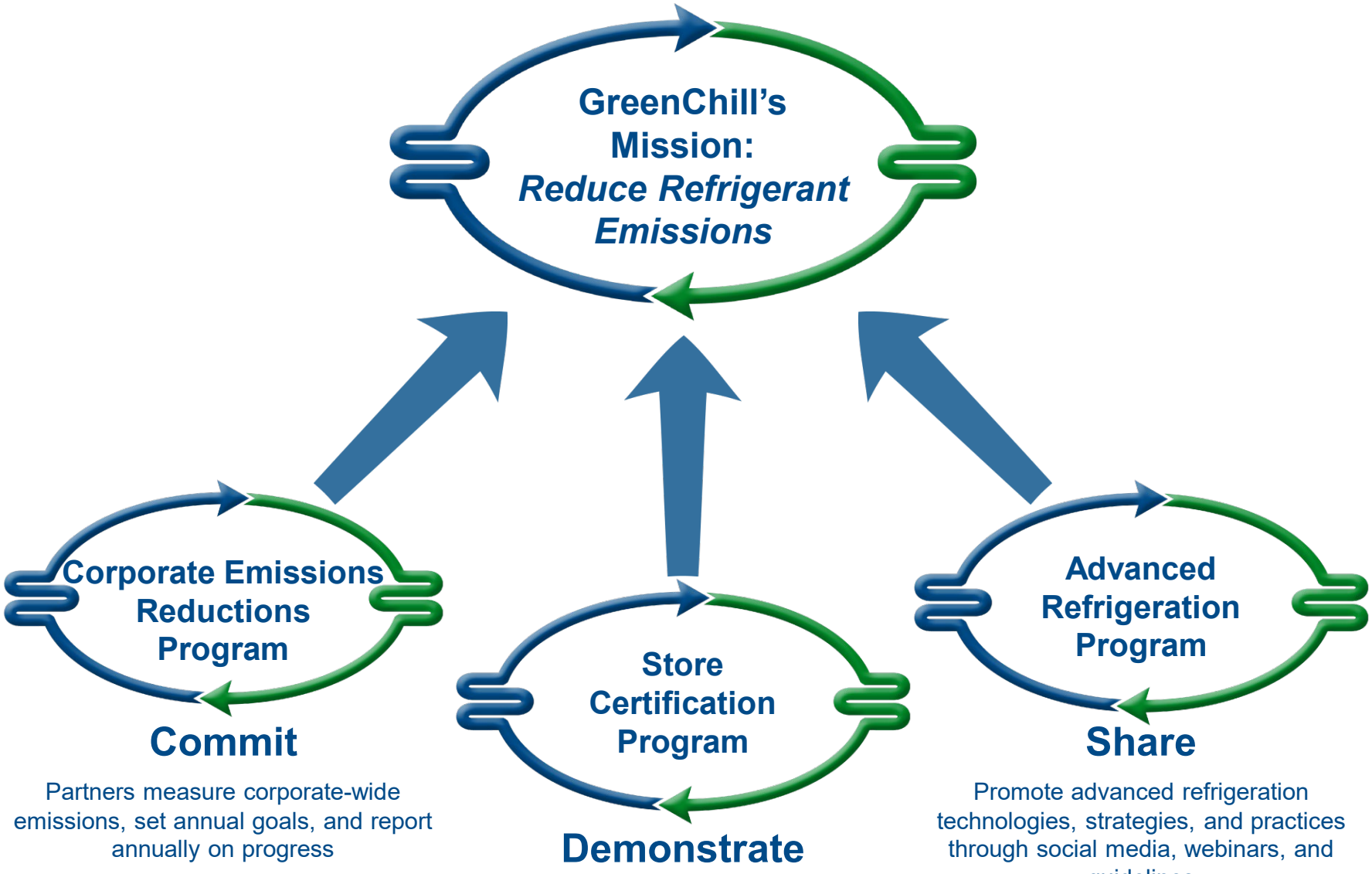
Program Overview

www.epa.gov/greenchill

GreenChill is a voluntary partnership program that works collaboratively with the food retail industry to reduce refrigerant emission and decrease stores' impact on the ozone layer and climate system

GreenChill works to help food retailers:

- Lower refrigerant charge sizes and eliminate leaks
- Transition to environmentally friendlier refrigerants
- Adopt green refrigeration technologies and best environmental practices


GreenChill's Mission: *Reduce Refrigerant Emissions*
Corporate Emissions Reductions Program
Commit
Partners measure corporate-wide emissions, set annual goals, and report annually on progress
Store Certification Program
Demonstrate
Individual stores earn GreenChill certification for meeting highest standards: low charge size, use of less harmful refrigerants, and low leak rates
Advanced Refrigeration Program
Share
Promote advanced refrigeration technologies, strategies, and practices through social media, webinars, and guidelines

Learn More

www.linkedin.com/groups/1426947/

www.epa.gov/greenchill

GreenChill@epa.gov

Celebrating 30 Years of Climate Partnership

This year, EPA is celebrating the **30th Anniversary** of the founding of Green Lights, the **Agency's first climate partnership program**. As a **Friend of GreenChill**, we invite you to join in the celebration, and help us spread the word about our impacts! **We wanted to thank and celebrate you!** We're excited to share these results with the world to **show how businesses and organizations like yours are tackling the climate crisis and leading the way to a clean energy economy.**

www.epa.gov/30climate

GreenChill Annual Recognition

- Join us virtually on September 9 at 2:00 pm EST as we recognize achievements by GreenChill Partners and Certified Stores

- Learn more: www.epa.gov/greenchill/events-and-webinars

Today's speakers…

Disclaimer from Presenters

"This presentation will provide technical and engineering information to commercial refrigeration operators to enable safe and efficient refrigerant retrofits of existing systems from legacy refrigerants to lower global warming potential (GWP) options. In compliance with anti-trust laws, this presentation WILL NOT address topics or questions of a commercial nature, including but not limited to, pricing, product quantities, distribution channels, markets or specific product comparisons. We will only address questions and comments of a technical nature. Thank you for your cooperation."

Chuck Allgood, PhD

Chuck Allgood, PhD
Chemours
Refrigerant Technology Leader
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Chuck has over 30 years in the heating, ventilation, air-conditioning, and refrigeration (HVACR) industry, having held a variety of research, development, business, and technical service positions with Chemours. He holds a PhD in Chemistry and prior to joining DuPont worked for the National Institute of Standards and Technology. A frequent speaker at many industry events, Chuck currently leads the technical service, training, and applications development activities for the Freon™ and Opteon™ brand refrigerants.

Andrew Pansulla

Andrew Pansulla
Chemours
Technical Service Engineer
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Andrew has been working on next generation refrigerant development at Chemours for the last 8 years. His primary areas of focus includes refrigerant retrofit implementation/training, energy optimization, and the development of refrigerant management plans.

Doug Starasinic

Doug Starasinic
Honeywell
Senior Applications Engineer
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Doug has over 30 years of experience in commercial refrigeration. His experience includes refrigeration design, construction, maintenance, energy management, and technical marketing.

Agenda

1. **Brief Regulatory Overview**
2. **Focus on Existing Stores**
   - Regulatory Baselines, Calculations and Goals
3. **Setting up for Success**
   - Converting R-404A, R-507, and R-22 to R-448A/449A
4. **What Success Looks Like – Learnings from the Last ~ 5 years**
   - R-448A/449A performance post conversion
   - Optimizing Set-Points, Controls, Subcooling, Thermostatic Expansion Values (TXVs), Discharge Temp
5. **Looking Ahead**
   - New Architectures, New refrigerants, New Regulations
6. **Question and Answer Session**

Environmental Challenges Driving Industry Transitions

Global Warming Potential (GWP):
The potential for a gas to trap heat in the atmosphere, resulting in climate change.

Ozone Depletion Potential (ODP):
The potential for substances to reduce the amount of ozone in the atmosphere that blocks harmful radiation from the sun.

Kigali Amendment [Hydrofluorocarbon (HFC)]
Phase ***Down***

Montreal Protocol [Chlorofluorocarbons (CFC)/ Hydrochlorofluorocarbons/(HCFC)]
Phase ***Out***

Regulatory Landscape

International Level

Montreal Protocol
Phaseouts, like R-22
Kigali Amendment
Phasedowns, like R-410A

US State Level

California Air Resources Board (CARB)
2025 timeline for air conditioning (A/C)
Avg GWP requirements Food Retail
Climate Alliance
24 states following similar plans

US Federal Level

American Innovation and Manufacturing (AIM) Act
Passed late 2020
Significant New Alternatives Policy (SNAP) Rule 23
A2L refrigerants in certain A/C applications

The international community has been operating under Kigali

In the absence of Federal activity, the states began regulating

New Federal regulations should re-align the industry

Federal regulations will offer guidance to the market

AIM Act – HFC Refrigerant Phase Down

The AIM Act

WHAT TO KNOW

port, the goal is to initiate the phasedown of the production and consumption of hydrofluorocarbons (HFCs) over the next 16 years.

Authorizes the Environmental Protection Agency (EPA) to develop regulations for the phasedown of HFCs by establishing:

- ☑ A national CO_2-eq baseline
- ☑ Production and consumption allowances
- ☑ Sector-specific controls (e.g., global warming potential limits)
- ☑ HFC refrigerant management practices

How it works

The EPA will use an allowance system to meet the phasedown schedule.

Rulemaking begins in Q1 2021 and is expected to end in Q4.

The rule will:

- **DEFINE** the CO_2-eq baseline for the U.S. market
- **OUTLINE** distribution of allowances
- **PROVIDE** details on the phasedown schedule

CO_2: Carbon dioxide

AIM Act Regulations

AIM Act Supports the Transition in 3 primary ways:

1. HFC Production/Consumption
   Baseline, Allowances, Phasedown, Trading, etc.

2. HFC Management
   Standards for servicing, repair, recovery, reclaim

3. Sector Based Controls

California Air Resource Board Regulations

In September 2018, the California Cooling Act (Senate Bill 1013) passed SNAP Rules 20 and 21

Stationary Refrigerant limits – New Systems	Year	GWP Limit
Commercial Refrigeration containing >50 pounds (lbs.)	2022	150
New Chillers (AC & Refrigeration)	2024	150
AC systems containing >2lbs	2025	750

Companies owning or operating retail food facilities with refrigeration systems charged with > 50lbs must collectively meet a **1,400 GWP average or 55% reduction** in greenhouse gas emission potential (GHGp) reduction over 2018 levels by **Jan 1, 2030**.

Additionally, companies owning or operating > 20 retail food facilities with refrigeration systems charged with > 50lbs must collectively meet a **2,500 GWP average or 25% reduction** in greenhouse gas emission potential (GHGp) reduction over 2018 levels by **Jan 1, 2026**.

Regulatory Compliance: Define your Store Footprint

Baseline WAGWP	Target GWP*	Calculated WAGWP
2,394	1,400	⊗ 2,394
Baseline GHGp	**Target GHGp***	**Calculated GHGp**
35,904,450	16,157,003	⊗ 35,904,450

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*Target WAGWP and GHGp are based on the CARB regulation to reach GWP <1400 or 55% reduction in GHGp by Jan 1st 2030. End users with >20 retail food facilities need to achieve an WAGWP of <2500 or a 25% reduction in GHGp by 2025.

Breakdown +

Refrigerant Fleet Totals	Initial Fleet Charge	Final Fleet Charge
R-404A	5,000	5,000
R-22	3,500	3,500
R-407A	2,000	2,000
R-134a	1,500	1,500
R-408A	500	500
R-507A	500	500
CO2	2,000	2,000

"Green House Gas Potential" or **"GHGp"**
GHGp = ∑ (Charge x GWP) where ∑ is the sum of the products of charged multiplied by the GWP for each separate type of refrigerant

"Weighted Average GWP (WAGWP)" means ∑ (charge x GWP)/ ∑ charge. Where the charge equals the pounds of each separate type of refrigerant, refrigerant blend, or heat transfer fluid used in refrigeration equipment and systems.

GHGp and WAGWP Example

Store #	R-404A (lbs.)	R-22 (lbs.)	R-407A (lbs.)	R-134a (lbs.)
Store 1	0	3000	0	0
Store 2	3000	0	0	0
Store 3	3000	0	0	0
Store 4	0	0	2000	1000
Store 5	0	0	3000	0

Refrigerant	AR4 GWP
R-404A	3900
R-22	1810
R-407A	2107
R-134a	1430

$$GHGp = (3000 * 1810) + (3000 * 3900) + (3000 * 3900) + (2000 * 2107) + (1000 * 1430) + (3000 * 2107) = \mathbf{4.08\ X\ 10^7\ lbs\ CO_2eq}$$

$$WAGWP = \frac{4.08\ \mathrm{X}\ 10^7}{15000} = \mathbf{2720}$$

AR4: Fourth Assessment Report of the United Nations Intergovernmental Panel on Climate Change
CO_2eq: Carbon dioxide equivalent

GHGp and WAGWP Example

Store #	R-404A (lbs.)	R-22 (lbs.)	R-407A (lbs.)	R-134a (lbs.)	R-448A (lbs.)	R-449A (lbs.)	CO_2 (lbs.)
Store 1	0	-3000	0	0		+3000	
Store 2	-3000	0	0	0	+3000		
Store 3	-3000	0	0	0			+3000
Store 4	0	0	2000	1000			
Store 5	0	0	3000	0			

* One for one charge differences assumed for simplicity

Refrigerant	AR4 GWP
R-404A	3900
R-22	1810
R-407A	2107
R-134a	1430
R-448A	1387
R-449A	1397
CO_2	1

$$GHGp = (3000 * 1397) + (3000 * 1387) + (3000 * 1) + (2000 * 2107) + (1000 * 1430) + (3000 * 2107) = \mathbf{2.03\ X\ 10^7\ lbs\ CO_2eq}$$

$$WAGWP = \frac{2.03\ \mathrm{X}\ 10^7}{15000} = \mathbf{1355}$$

Tips for Compliance – Existing Stores

1. Maintenance and Leak Reduction

2. Retrofit to a lower GWP refrigerant → Extend the life of the existing equipment

3. Reduce Charge → Effective way to reduce store carbon footprint but will still be reliant on the incumbent gas

4. Remodel and Redesign → useful for equipment at end of life

Successful Retrofitting of HCFCs and HFCs

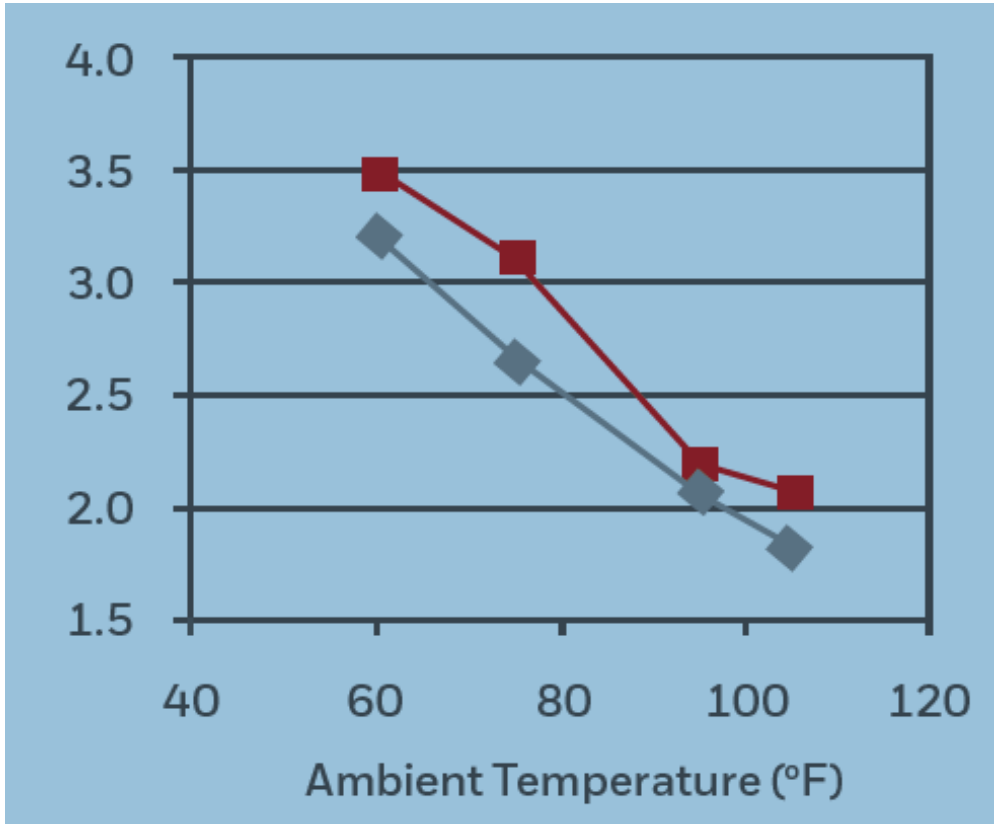
Key items
Energy impacts
Reasons to retrofit

Key Items for Retrofits

- Survey
- Compressor compatibility
- System review (upgrades & opportunities)
- Expansion valves
- Oil
- Leak prevention measures
- Line sizes
- Commissioning

Energy Results

- With R-404A retrofits a 5-10% energy efficiency gain is expected
- With R-22 retrofits energy reductions can be achieved when combined with simple commissioning measures



- COP R-448A/R-449A
- COP R-404A

COP: coefficient of performance

Retrofits - 3 Steps

Step 1 – Site Survey

- Compressors
- System issues & opportunities
- Review expansion valves
- Leak prevention
- Record baseline data
- Line sizes
- Test oil and refrigerant
- Forward completed survey form to the customer

Step 2 –Store coordination

- Order parts and refrigerant
- Technician training
- Perform system changes / upgrades
- Change oil from mineral to Poly Olester (POE)
- Change suction and liquid filters and driers
- Upgrade controller with Solstice® N40 (R-448A) pressure (PT) curves
- Leak check and repair

Three steps

Step 3 – The Retrofit

- Remind store personnel the day prior to retrofit
- Secure food safety (dry ice, plastic sheeting, signs on coolers, etc.)
- Recover existing refrigerant
- Record amount of refrigerant removed (including refrigerant previously removed)
- Break vacuum from recovery machine
- Replace seals, gaskets, and valves as needed
- Replace expansion valves and add adjustment kits as determined in survey
- Replace driers and filters
- Evacuate system
- Charge system
- Adjust expansion valves
- Adjust pressure controls
- Label components and systems

Years of energy efficiency and low maintenance realized

Success factors

With a well-executed retrofit the end-user can expect:

- Reduced leaks (<$)
- Reduced energy (<$)
- Upgraded system for long term
- Better food quality (depending on commissioning scope of work)

Why transition to R-448A / R-449A ?

1. Long-term replacement for R-404A, R-507, R-22, R-408A, R-402A
2. Non-flammable A1 refrigerant
3. Lowered GWP for regulatory compliance and for meeting sustainability goals *[R-448A (1287) vs R-404A (3922)]*
4. Lower energy usage than R-404A & R-507 
5. Simple retrofit and maintenance
6. Industry leading support and distribution

HFO 448A / 449A blends are non-toxic, non-flammable, non-corrosive, energy-efficient, has have lowered GWPs.

Learning from the Past

Key Learnings

Compressor Capacities

Key Learnings From the Field

- Save time that night
  - Do oil ahead of time
  - Replace valves ahead of time when possible
- Beware of overnight leaks
- Prevent flooding
- Setting TXV next day
- Food safety
- Adequate vacuum pumps
- Project Process management

	Oil	Leaks	Discharge temp	TXV's
R-22 retrofit	change	Med – High	Lower	Good
R-404A retrofit	Not likely	Low	Higher	Power head change to R-22 may be needed
R-402A/408A retrofit	change	Med - High	Higher	Power head change to R-22 may be needed

Train technicians on glide ahead of time!!

Control Optimization

Settings

- Evaporator Superheat = dewpoint
- Subcooling = bubble point
- Pressure settings and valves= mid point

USE PRESSURE BASED PT CHARTS TO MAKE GLIDE EASY!!

Pressure (psig)	Temperature °F		
	Avg	Bubble	Dew
35	6	1	11
40	11	6	16
45	**15**	10	20
50	19	14	24
55	23	23	28

Compressor Capacity Ratings Can Be Misleading

Compressor Heat transfer using different rating selections

	Dew and Comp. Heat transfer	Dew with Net Effect	Midpoint with Comp. Heat transfer	Midpoint with Net Effect
R-404A	26000	21700	26100	21800
R-448A / 449A HFO BLEND	~24500	~21600	~25400	~22600
				

COMPRESSOR INCREASES ARE NOT NEEDED!

Common Questions from the Industry

- Will fractionation cause any issues when using R-448A/R-449A?
  - No, the system effects of fractionation on refrigerants like R-448A/R-449A are insignificant
- What are the largest changes I will need to make to my system (R-22 and/or R-404A)?
  - R-22 → Oil/Elastomeric Seals
  - R-404A → TXVs/demand cooling needs
  - R-402A/R-408A →Oil/seals/TXVs/demand cooling needs
- How do I maximize energy efficiency using R-448A/R-449A?
  - Factor for glide, use proper superheats/subcooling measuring techniques, manage set points
- Since R-448A/R-449A are very similar can they be mixed?
  - No, although similar in performance, different refrigerants should not be mixed
- Will my current leak detection system be able to detect new refrigerants?
  - Any leak detector that can detect an HFC can be used with these refrigerants

Looking Ahead

New System Architectures

New Refrigerants

New Regulations

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Contacts and Upcoming Webinars

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Upcoming Events

Date	Webinar Topic
9/9/2021	Annual GreenChill Recognition Event (virtual)

Join our webinar invitation list or request today's slides: EPA-GreenChill@abtassoc.com

Access past webinar slides: www.epa.gov/greenchill/events-and-webinars