HVAC&R INDUSTRY REFRIGERANT CHANGE OVERVIEW

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SFPE Fire Service Webinar

Richard Lord (Dick)
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Richard Lord is a Senior Fellow with 54 years of experience in the design and application of commercial air conditioning equipment and controls with expertise in systems, fluids, refrigerants, heat transfer, heat exchanger design, software, controls, diagnostics, commercial efficiency, HVAC safety and building standards and codes. He is also an ASHRAE Fellow.

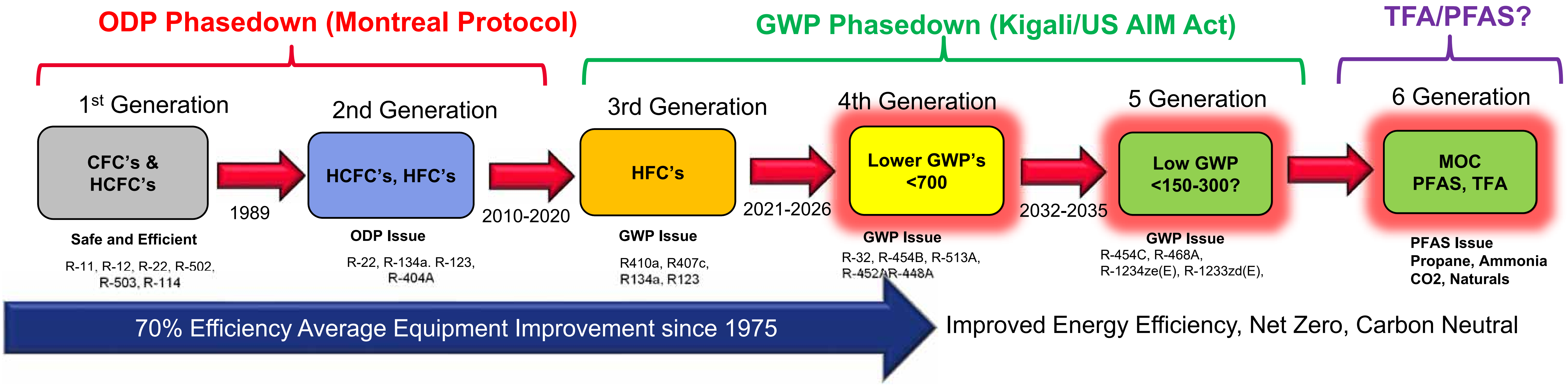
He is located in Monteagle, Tennessee, and is member of Research and Development Electromechanical Organization working on refrigerants, commercial equipment advanced technology, systems innovation and is also involved industry standard, regulations and research and is the Chair of ASHRAE 90.1, a member of ASHRAE 189.1, ASHRAE 196, ASHRAE 205, ASHRAE 207, CSA 424, chair of Canada CSA 401, CSA 424, member of CSA Scooper, UL60335-2-40, AHRI 340/360, Canada B52, AHRI 550/590, AHRI System Steering committee and AHRI Safe Transition Task Force and several other industry committees.

Over his career, Lord has worked on the design of commercial HVAC equipment including heat exchanger design, air- and water-cooled chillers, rooftops, splits systems, air handlers, advanced controls and systems, and refrigerants. For the past several years, he has led industry initiatives to expand the systems approach to include not only the equipment but the full application in a building. He also has been involved in the multiple refrigerant transitions that have occurred over the past 30 years and is conducting many technical studies and research for new refrigerant selections for the new global warming potential (GWP) phasedown regulations as well as involvement is Carrier and global environmental initiatives.

Carrier

Refrigerant Change Overview

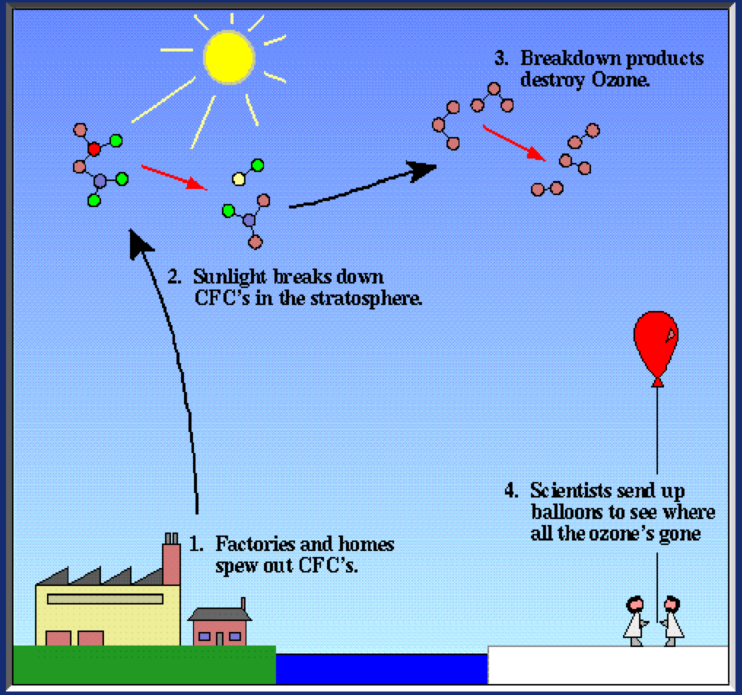
Once again, the industry finds itself faced with **phasedown/elimination of the refrigerants** that are used in the HVAC&R

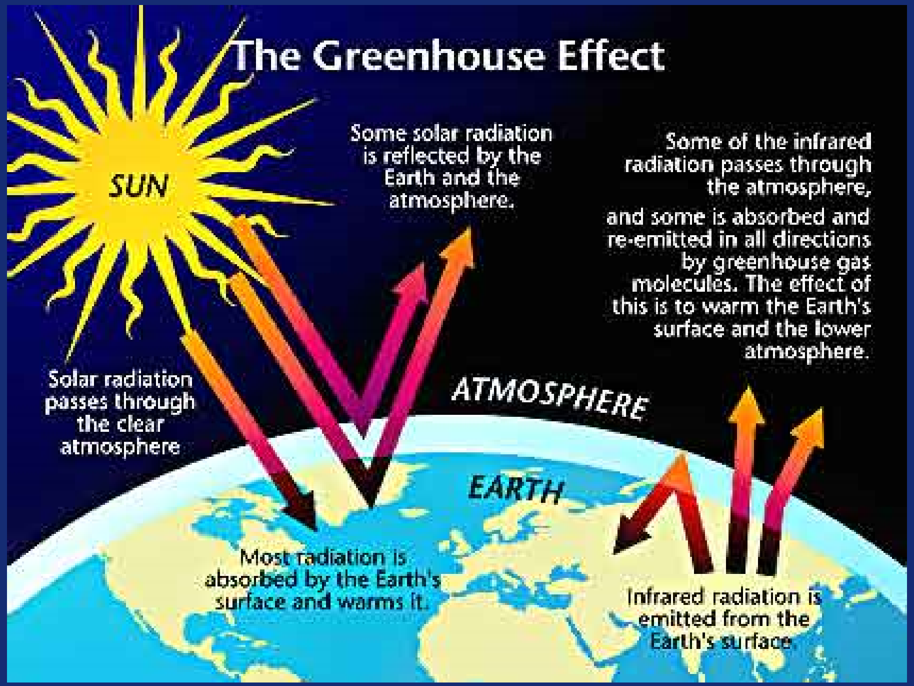


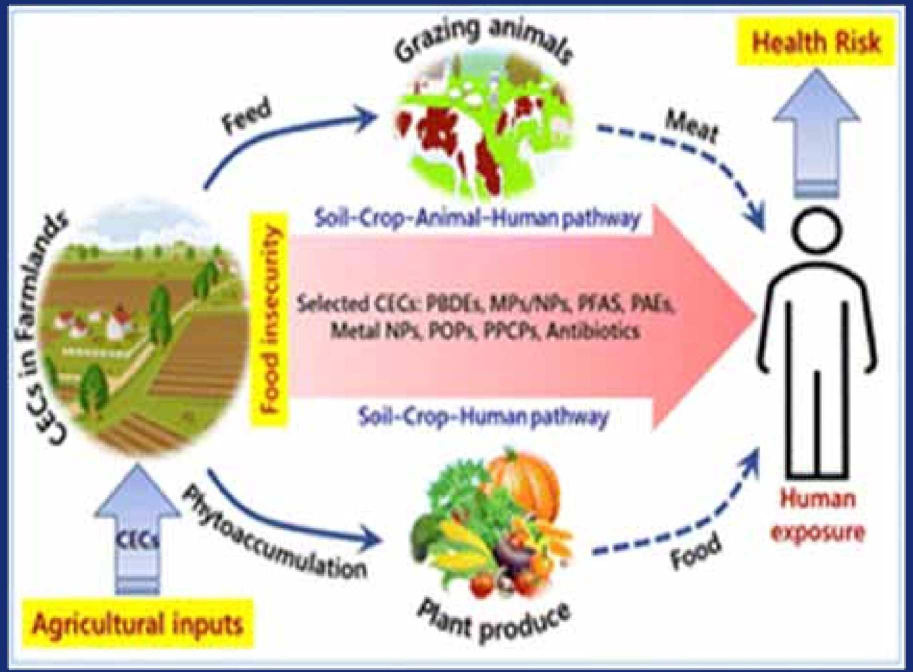
- The landscape for regulations and phasedown control are **complex and still evolving and changing**
- As we move to the next generation refrigerants the options are limited and refrigerant selections will be product specific
- Developed countries are now in the transition to <700 GWP and the use of HFO's, but it will not end there
- In **2032 GWP levels are going to decrease again** for developed countries, but some want to skip and move directly 6th generation and naturals, but there are new issues with natural (toxicity and flammability)
- But natural refrigerants are limited and use of A3 (propane) will require significant system changes and use of indirect systems

ENVIRONMENTAL ISSUES

Why are HVAC&R Refrigerants Changing







1- Ozone Depletion
(past regulations)

Montreal Protocol
1987

2- Global Warming
(current regulation)

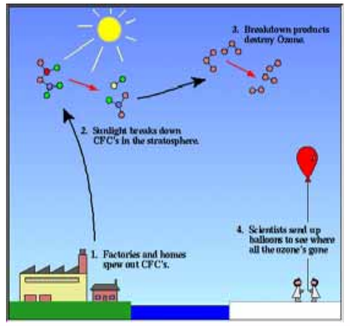
Kigali Agreement
2016

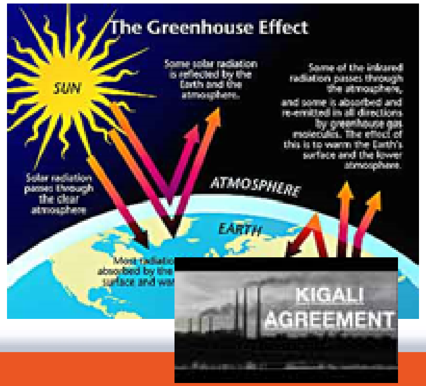
3- Materials of Concern
(future)

In discussion
?

Refrigerant Change (Past and Current)

Issue 1





Issue 2

Environment
Ozone Deletion
Issue and Regulations

HVAC&R
Refrigerant Change

Environment
Global Warming
Issue and Regulations

Efficiency

Montreal Protocol
1989

Kigali Agreement
2016

US Clean Air Act

Europe F-Gas
2016, 2024

US AIM Act
2022, 2023,
2024, 2025

US States
i.e. CARB, 2021

Refrigerant Change Driver - Environmental Issues

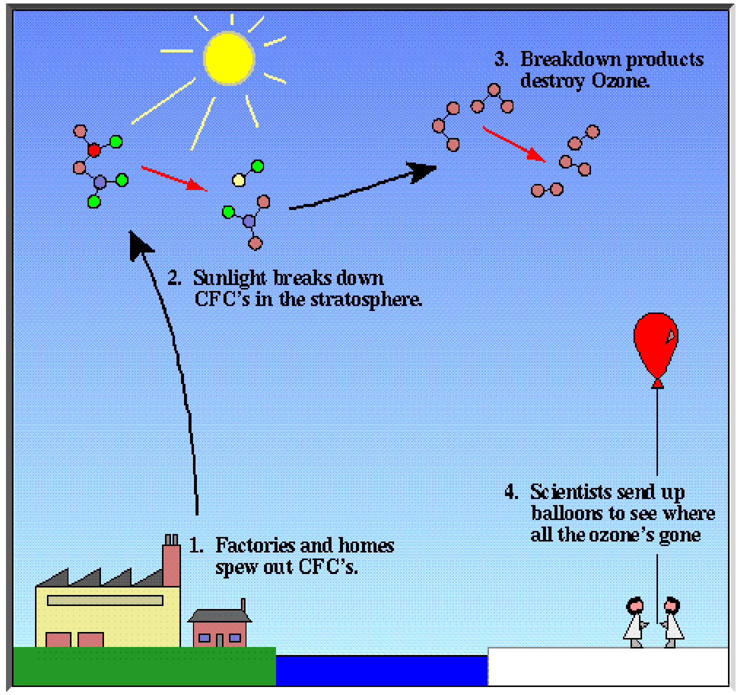
- Since the 1980's the HVAC&R industry and other industries have been under pressure to change the refrigerants that are used in HVAC&R, automobiles, foams, and other industrial processes due to environmental issues
- There are two main drivers for refrigerant change and one possible new driver;

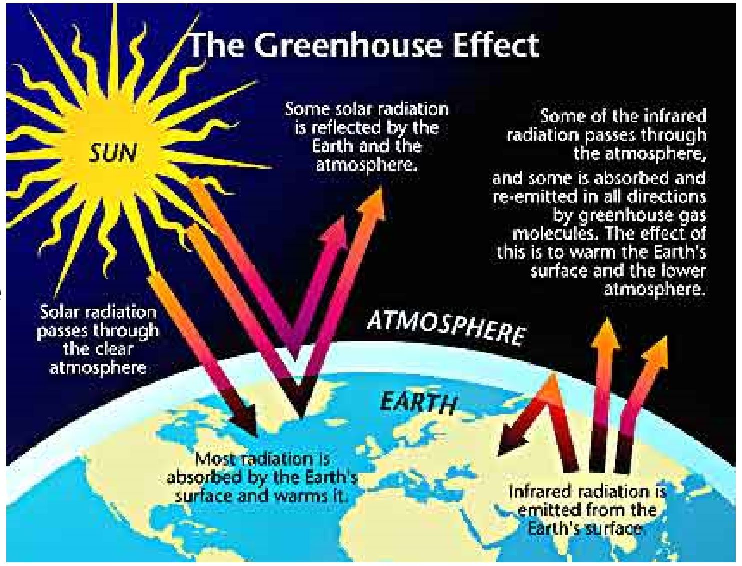
Issue 1 - Ozone Deletion (ODP) (base metric is based on R-11 = 1)

- Refrigerants have a detrimental impact atmospheric ozone layer which provides protected against detrimental solar radiation
- This was addressed by the original **Montreal Protocol** approved in 09/16/1987
- It resulted in the first refrigerant change with a phaseout of CFC refrigerants (R-11, R-12, R-113, R-114, R-500, R-502, R-503 starting in 2004
- It was followed by further elimination of HCFC refrigerants in from 2010-2020 (R22, R123) in the US

Issue 2 – Global Warming (base metric is CO_2 = 1)

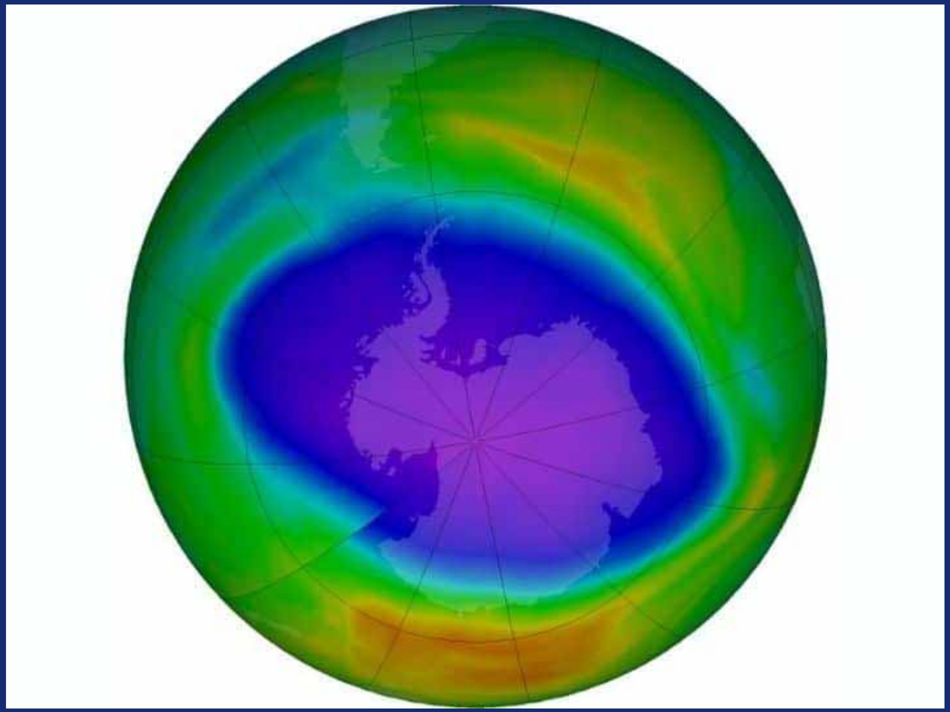
- Global warming is the result of emissions of greenhouse gases into the atmosphere that results in trapping of solar radiation resulting in global warming
- **Refrigerants are one of the greenhouse gases**, but they are not the only greenhouse but relative to CO_2 base they can have average of times the potential impact
- The **Montreal Kigali agreement was developed to** addressed the reduction in **direct global warming** gases and was approved on 10/15/2016





Refrigerant Change Drivers (new)

- **Issue 3a (New) – Refrigerant Breakdown Products - PFAS**
  - Concerns have been raised with breakdown products and resulting and the formation of PFAS (Perfluoroalkyl and Polyfluoroalkyl Substances)
  - PFAS are a common material that is contained in packaging, cookware, clothes, carpets, foam, and has been reported to be a breakdown product of the new low GWP HFO refrigerants
  - Concern is that PFAS does not breakdown and can stay in the ground and water for very long periods
  - There is concerns about the impact on people and studies are currently in progress
  - But in **Europe 5 Nordic countries are trying to ban all refrigerants** that result in PFAS which would limit options to just natural refrigerants (i.e.. Propane, Nitrogen, Water, CO2, Ammonia) all of which have additional issues with flammability, toxicity and efficiency
- **Issue 3b (New) Refrigerant Breakdown Products – TFA**
  - Another breakdown product of some refrigerants is TFA (Trifluoroacetic acid)
  - There are concern with buildup in ground water and the impact human health
  - Not all the new HFO's refrigerants breakdown and form TFA but some like R-1234yf used on automobiles is of concern
  - Studies are still underway, and the problem again seems to be a **major area of concern in Europe**.



Ozone Hole

Global Regulations

ISSUE 1 - OZONE DEPLETION

Ozone Depletion Potential

- The metric used for ozone depletion is compared to refrigerant R-11which has an ozone depletion potential (ODP) of 1.0.
- R-11 was the primary refrigerant used in centrifugal chillers thru the early 1980's
  - There are still about 15,000 R-11 centrifugals operating in the US
- In the USA the last Ozone deleting refrigerant was phase out in 2020 which was R-123 which was a replacement for R-11

Refrigerant	Class	Formula	Lifetime (yrs.)	ODP Montreal Protocol	ODP1 WMO 2011
R-11	CFC	CCl_3F	45	1.00	1.00
R-12	CFC	CCl_2F_2	100	1.00	0.82
R-113	CFC	CCl_2FCClF_2	85	0.80	0.85
R-114	CFC	$CClF_2CClF_2$	190	1.00	0.58
R-115	CFC	CF_3CClF_2	1020	0.60	0.50
Halon -1301	Bromocarbons	CF_3Br	65	10.0	15.9
Halon-1211	Bromocarbons	CF_2ClB	16	3.00	7.9
Halon 2402	Bromocarbons	C_2F4Br_2	20	6.00	13.0
R-22	HCFC	$CHClF_2$	11.9	0.055	0.04
R-123	HCFC	CF_3CHCl_2	1.3	0.02	0.01
R-124	HCFC	CF_3CHClF	5.9	0.022	
R-141b	HCFC	CH_3CCl_2F	9.2	0.11	0.12
R-142b	HCFC	CH_3CClF_2	17.2	0.065	0.06
R-225ca	HCFC	$CF_3CF_2CHCl_2$	1.9	0.025	0.02
R-225cb	HCFC	$CClF_2CF_2CHClF$	5.9	0.033	0.03
Carbon tetrachloride	Other	CCl_4	26	1.1	0.82
Methyl chloroform	Other	CH_3CCl_3	5	0.01	0.16
Methyl Bromide	Other	CH_3Br	0.8	0.70	0.66

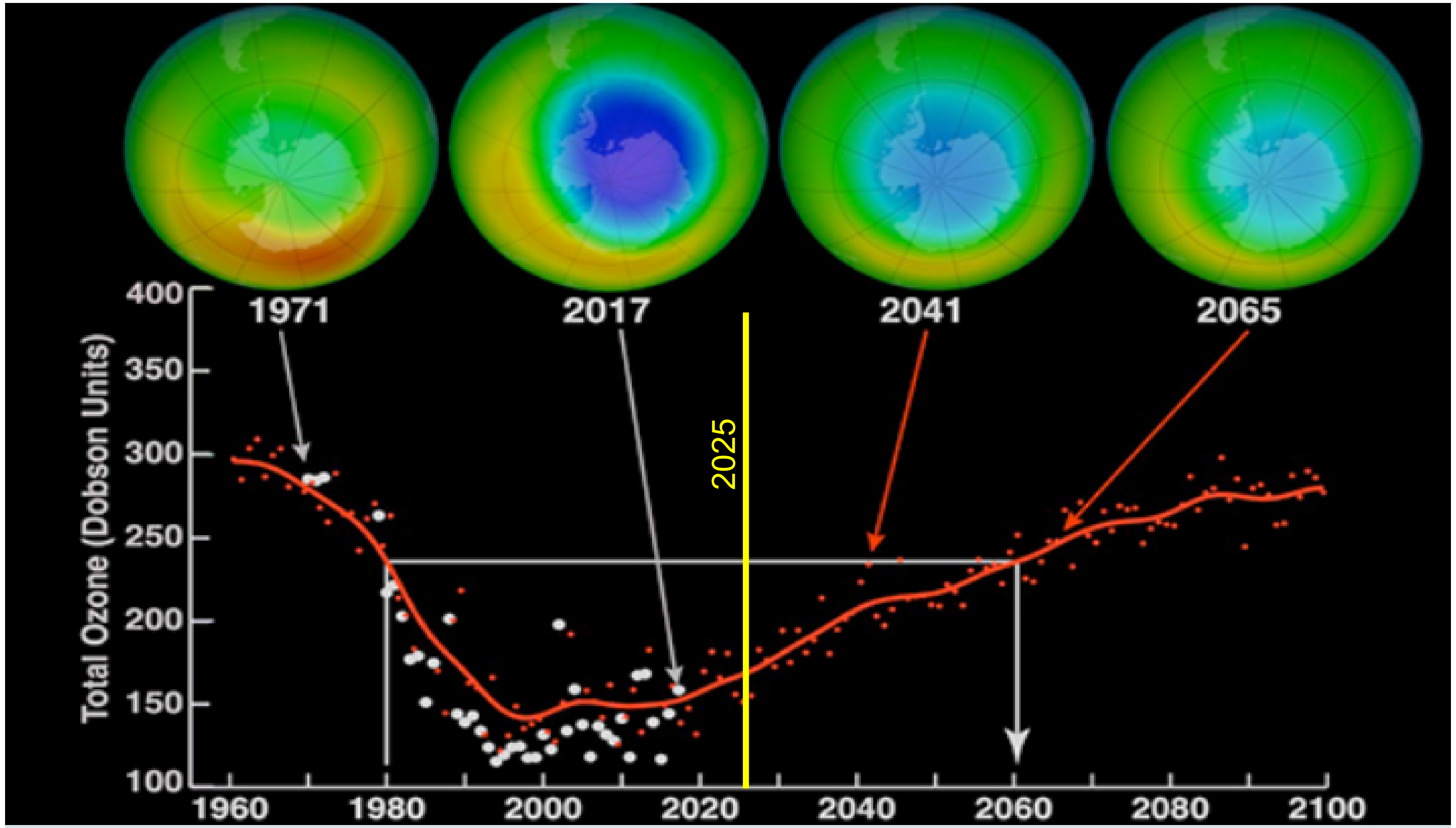
Regulations - Montreal Protocol

- International agreement to protect the stratospheric ozone layer developed at the Vienna Conference in 1985
- On **September 16, 1987, the Montreal protocol** was approved and entered into force on **August 26, 1989** to phase out the use of ozone depleting refrigerants which included CFC’s and HCFC’s.
- The agreement has been very successful, and **197 countries** have approved.
- Final Agreed to phase down was divided into **developed (non article 5)** and **developing countries (article 5)**
- The Montreal agreement included a phasedown of **CFC** and **HCFC** refrigerants with separate regulator phasedown requirements for developed and developing countries.
- Some non article 5 developed countries and regions including Europe and the US further accelerated the phasedown of ozone depleting refrigerants.
- The phasedown for article 5 countries, is still underway and is schedule to be complete by 2030.
- Annual meetings to update articles are held
- Recently the Montreal Protocol has also taken on **GWP phasedown with the Kigali Agreement** and more recently **energy efficiency** because of the emissions of power plants generating electricity

Continue to meet and track progress every year

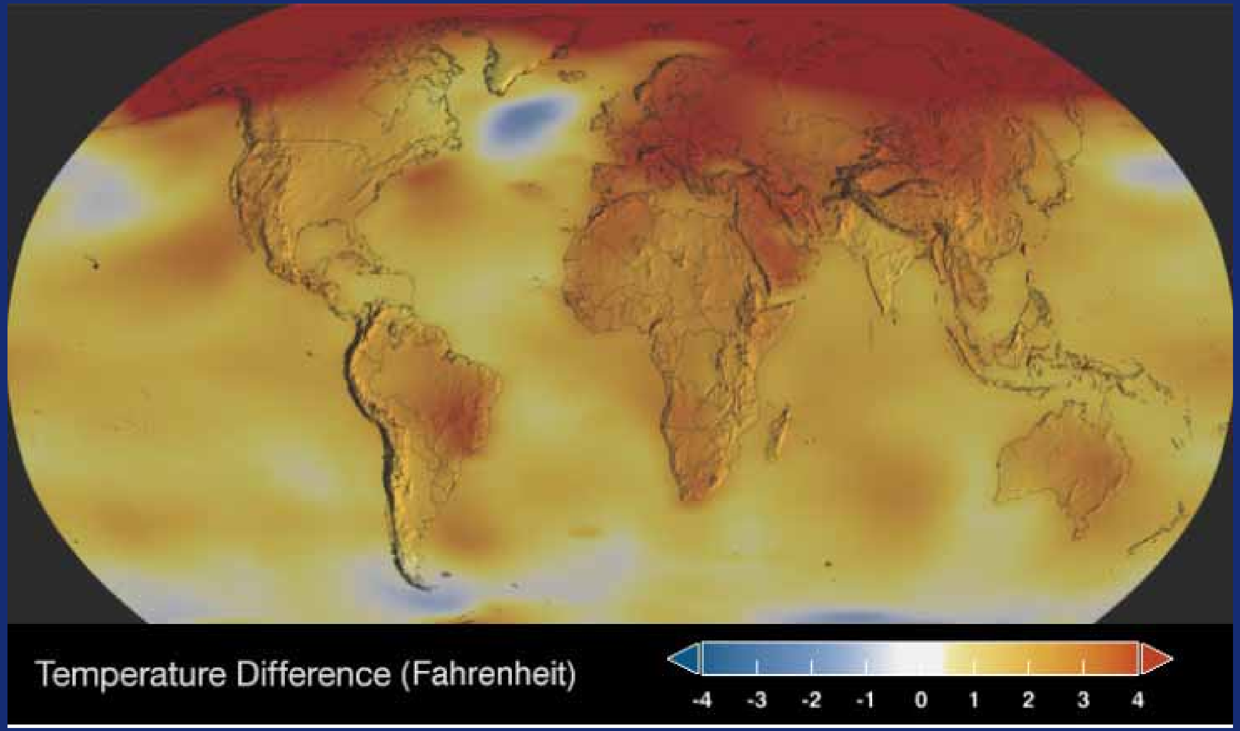
Current Status – Ozone Deletion

- The Montreal protocol has been very successful, and we are seeing positive improvement trends in the ozone layer as shown in the following forecast.



Images above the graph show a view of the South Pole in October over time including measurements taken in the past in 1971 and 2017 and model projections of ozone over the area for 2041 and 2065. The graph shows the average minimum ozone over Antarctica in October. Credit: NASA GSFC

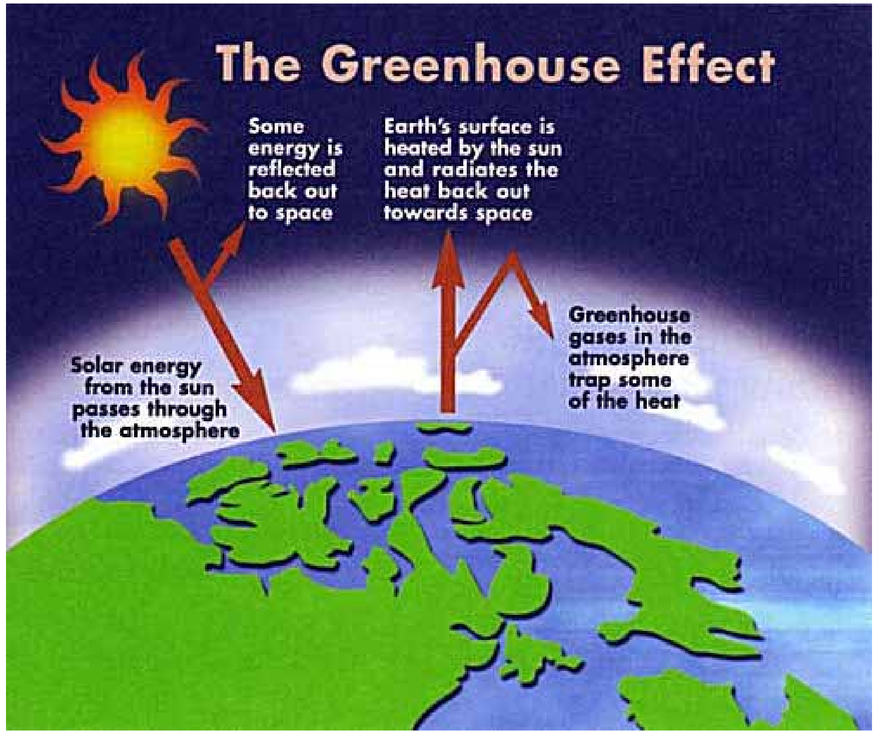
But continued management and monitoring is required, and the UN and Montreal protocol routinely review atmospheric data



ISSUE 2 - GLOBAL WARMING REFRIGERANT CHANGE

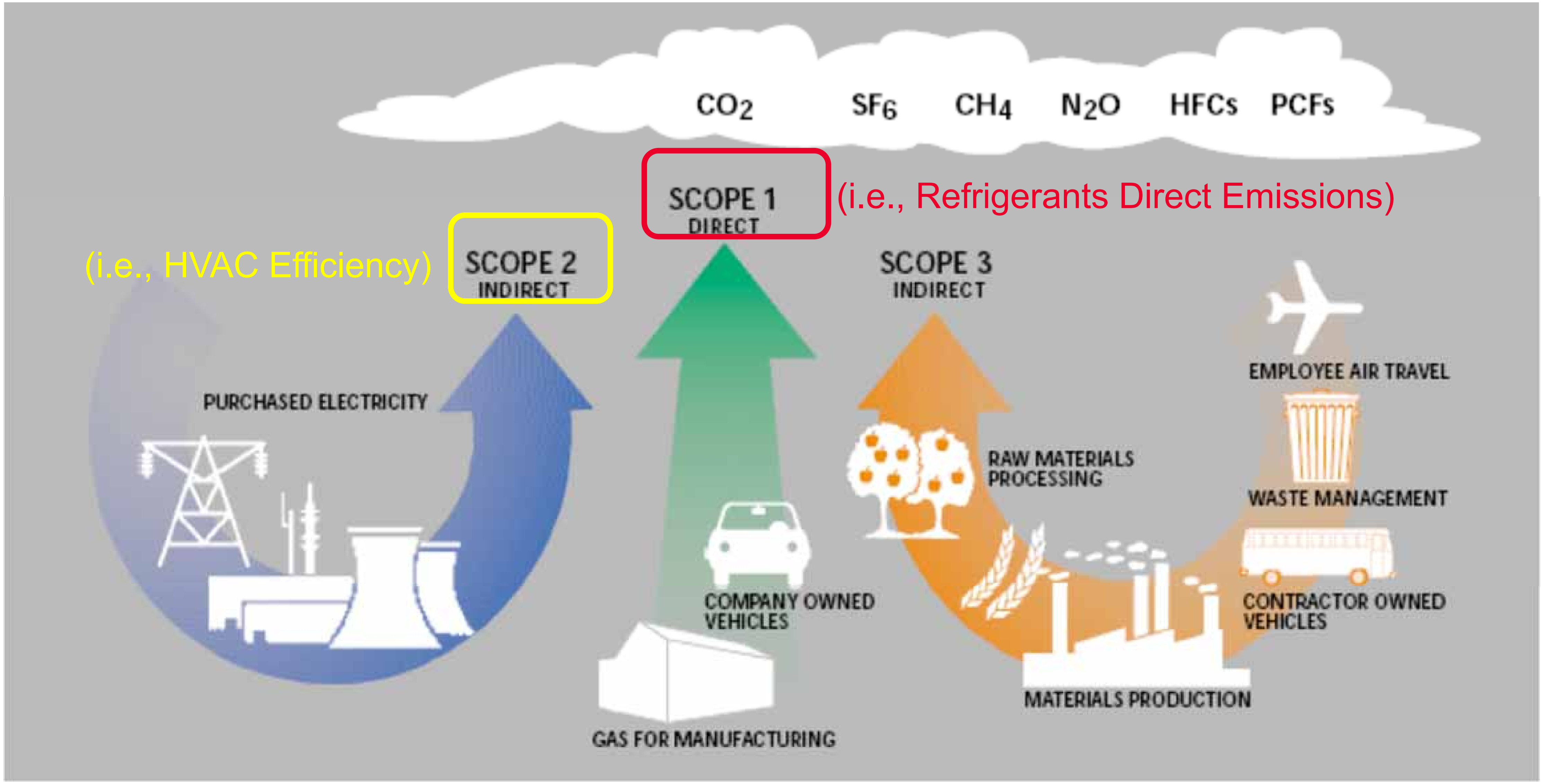
Issue 2 – Global Warming

- The second major environmental regulatory initiative concerns **global warming**.
- Global warming is the long-term warming of the planet's overall temperature
- Greenhouse gases rise to the upper atmosphere where solar radiation from the sun hits the surface of the earth and that normally radiates back to space is trapped due to increased global warming gas in the upper atmosphere.
- The trapped radiation then causes the temperature of the earth to gradual increase.
- HVAC&R is strong contributor to global warming due to the **direct emissions of refrigerants** which are high global warming gases, and due to the **indirect emission due to power** use of our equipment and the emissions from fossil fuel fired power plants which is why there is increased focus on efficiency
- Greenhouse gas concentrations are projected to reach double pre-industrial levels by about 2060



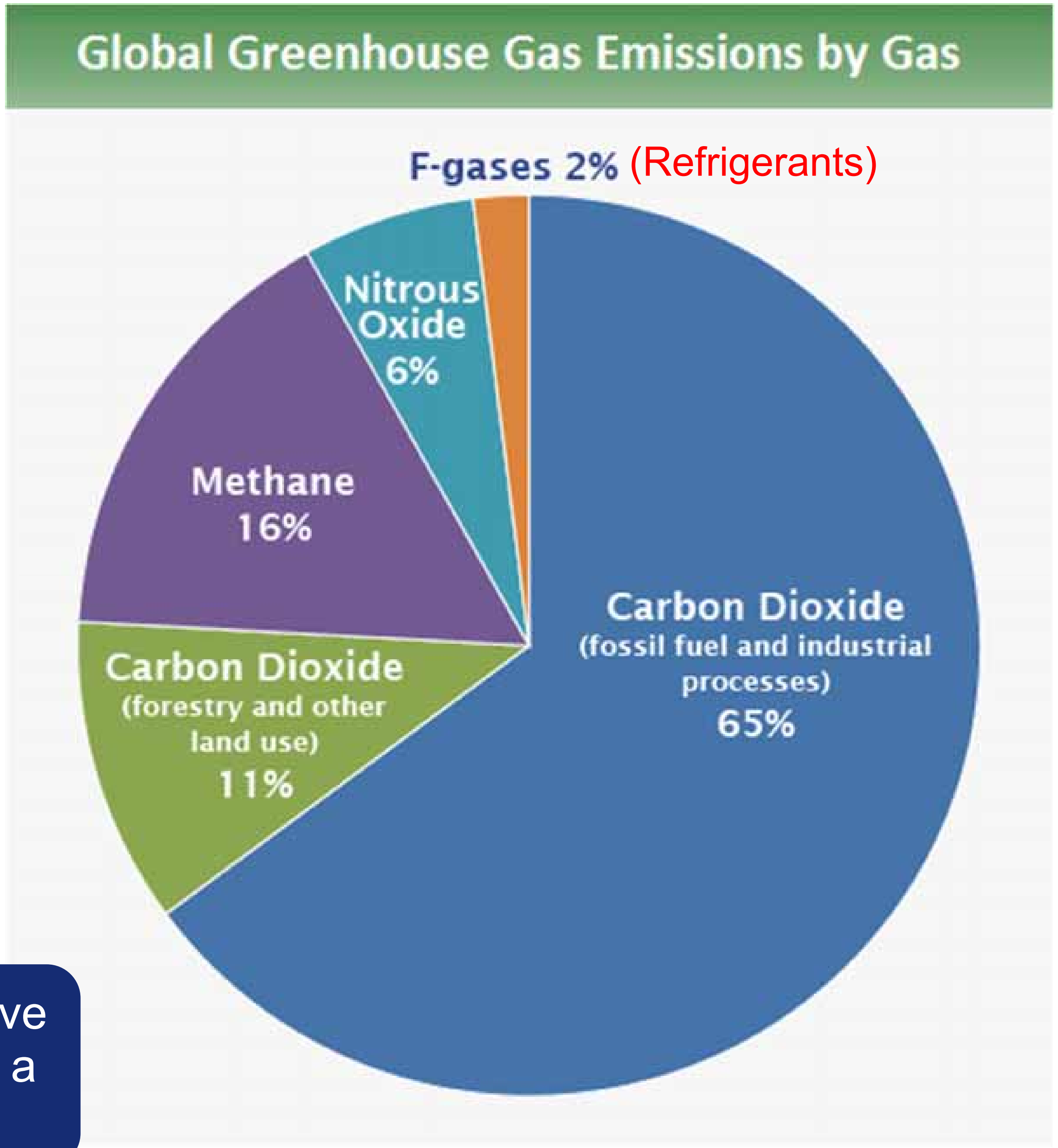
GWP Emissions Regulations

- **Carbon Dioxide** (CO_2): *Emitted mainly from the burning of fossil fuels (US uses 86% fossil fuel fired power plants)*
- **Methane** (CH_4), **Nitrous Oxide** (N_20), **Hydrofluorocarbons** (HFCs), **Perfluorocarbons** (PFCs), and **Sulphur Hexafluoride** (SF_6): *Emitted mainly from waste disposal, air conditioning and refrigeration, and specific industrial processes.*



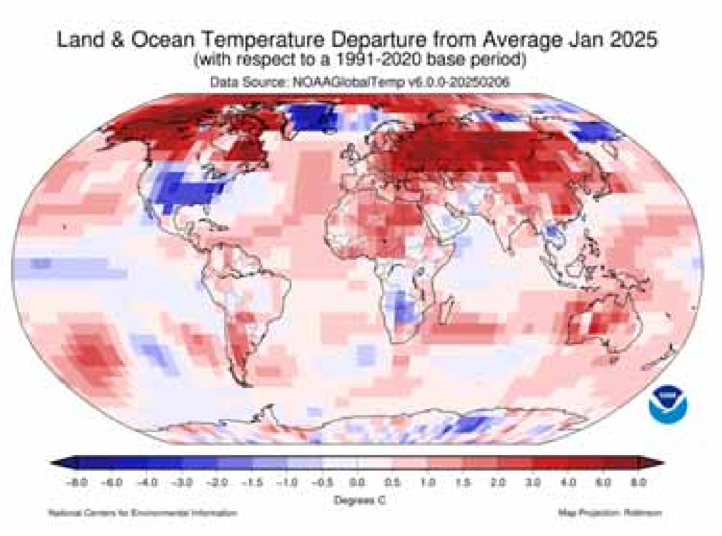
Greenhouse Gas Emissions

- **Carbon Dioxide (CO_2) (Scope 3):** Fossil fuel use is the primary source of CO2. CO2 can also be emitted from direct human-induced impacts on forestry and other land use, such as through deforestation, land clearing for agriculture, and degradation of soils. Likewise, land can also remove CO2 from the atmosphere through reforestation, improvement of soils, and other activities.
- **Methane (CH4) (Scope 3):** Agricultural activities, waste management, energy use, and biomass burning all contribute to CH4 emissions.
- **Nitrous oxide (N2O) (Scope 3):** Agricultural activities, such as fertilizer use, are the primary source of N2O emissions. Fossil fuel combustion also generates N2O.
- **Fluorinated gases (F-gases) (Scope 1):** Industrial processes, refrigeration, and the use of a variety of consumer products contribute to emissions of F-gases, which include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6).
- **Black carbon (Scope 3)** is a solid particle or aerosol, not a gas, but it also contributes to warming of the atmosphere.

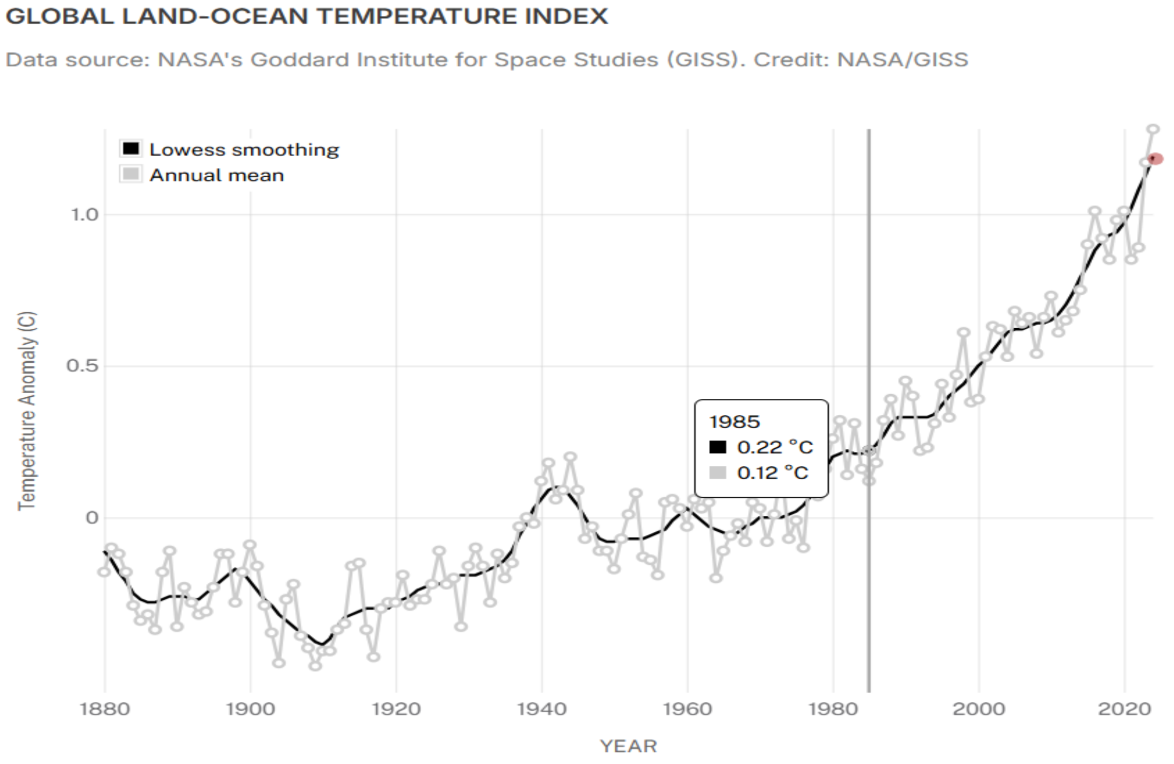


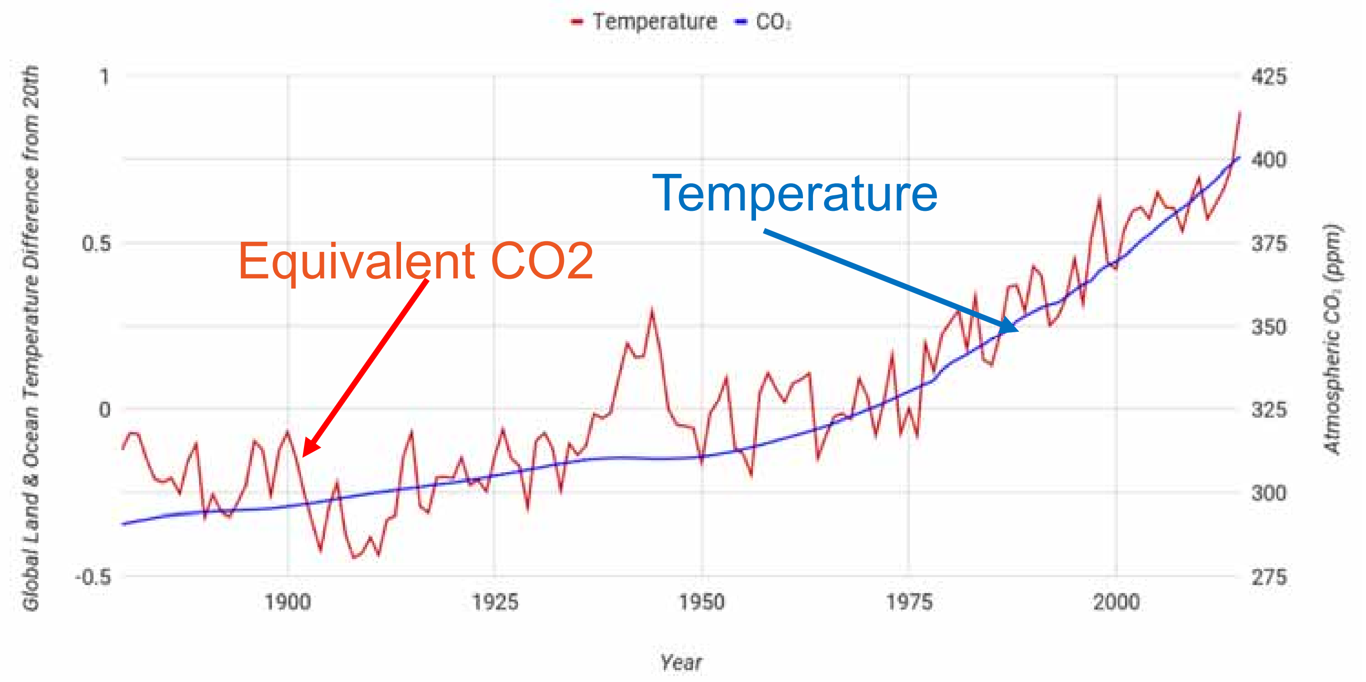
Note that refrigerants emissions are small but because they have a very high GWP (average of 2421 times that of CO_2) they are a strong focus of regulations

Impact of Greenhouse Gases on Temperature



Earth's global temperature in 2024 was 2.3 °F (1.28 °C) warmer than the 20th century baseline of 1951 - 1980.

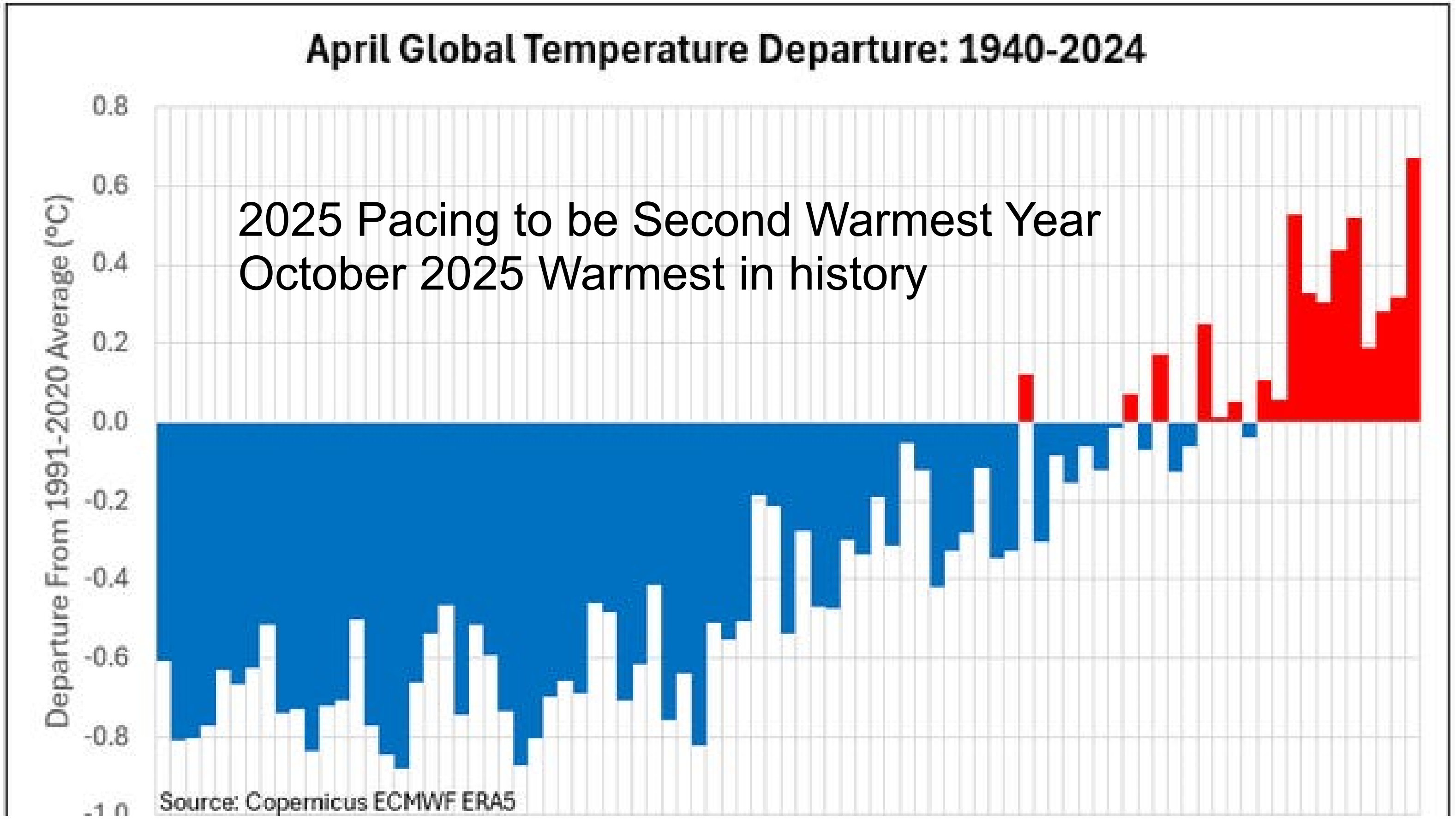




Goal is to limit temperature rise to 1.5 °C per the Paris Agreement

Global Temperature Rise

- Earth's temperature has risen by an average of 0.11° Fahrenheit (0.06° Celsius) per decade since 1850, or about 2.3° F in total.
  - The rate of warming since 1982 is more than three times as fast: 0.36° F (0.20° C) per decade.
- 2024 was the warmest year since global records began in 1850 by a wide margin.
  - It was 2.12 °F (1.18 °C) above the 20th-century average of 57.0°F (13.9°C).
  - It was 2.43 °F (1.35 °C) above the pre-industrial average (1850-1900).
- The 11 warmest years in the historical record have all occurred in the past decade (2014-2025).



Impact of Global Warming

- Increased temperatures 2.3 °F (1.28 °C) since 1901
- Glaciers are shrinking: average thickness of 30 well-studied glaciers has decreased more than 60 feet since 1980.
- Snow is melting earlier compared to long-term averages.
- Sea level rise has accelerated from 1.7 mm/year throughout most of the twentieth century to 3.2 mm/year since 1993.
- The area covered by sea ice in the Arctic at the end of summer has shrunk by about 40% since 1979.
- More storms, hurricanes and tornados, Forest Fires
- Droughts are also becoming more common, particularly in the Western United States. Humans are using more water, especially for agriculture.

Refrigerant ODP and GWP Values

GWP values are defined relative to CO2.

The values are routinely updated but all regulations use AR4 which is defined by Montreal Protocol, but there is AR5 and AR6

Typical 100 yr periods are used, but recently NY State switched to GWP 20 yr

- R-454B (100yr), AR4 - 465
- R-454B (100yr), AR6 - 531
- R-454B (20 yr), AR6 - 1,854

The table shows a list of some of the common refrigerants used today and being considered.

As you can see the GWP value is closely tied to the atmospheric life of the refrigerant

Regulations are being implemented in a phase approach, but likely we will have to be below a GWP_{100}, AR4 of 150

Refrigerant	Type	Chemical	Safety Rating	Lifetime yrs.	ODP	GWP (AR4)
R-11	CFC	CCl_3F	A1	45	1.0000	4750
R-12	CFC	CCl_2F_2	A1	100	1.0000	10900
R-113	CFC	$C2F_3Cl_3$	A1	85	0.8000	6130
R-114	CFC	$C2F_4Cl_2$	A1	190	1.00000	10000
R-115	CFC	$C2F_5Cl$	A1	1020	0.6000	7370
R-22	HCFC	$CHFCl_2$	A1	11.9	0.0550	1810
R-123	HCFC	$C_2HF_3Cl_2$	A1	1.3	0.0200	77
R-134a	HFC	CH_2FCF_3	A1	13.4	0.0000	1430
R-404A	HFC	CH_2F_2	A1	'–	0.0000	3922
R-407C	HFC	mixture	A1	'–	0.0000	1744
R-32	HFC	CH_2F_2	A1	5.2	0.0000	675
R-290	HC	C_3H_8	A3	'–	0.0000	3
R-410A	HFC	mixture	A1	'–	0.0000	2088
R-448A	HFC/HFO	mixture	A1	'–	0.0000	1386
R-449A	HFC/HFO	mixture	A1	'–	0.0000	1396
R-452A	HFC/HFO	mixture	A1	'–	0.0000	2139
R-454A	HFC/HFO	mixture	A2L	'–	0.0000	236
R-454B	HFC/HFO	mixture	A2L	'–	0.0000	465
R-454C	HFC/HFO	mixture	A2L	'–	0.0000	145
R-466A	HFC/HFO	mixture	A2L	'–	0.0000	733
R-468A	HFC/HFO	mixture	A2L	'–	0.0000	145
R-513A	HFC/HFO	mixture	A1	'–	0.0000	629
R-514A	HFC/HFO	mixture	B1	'–	0.0000	3.71
R-515B	HFC/HFO	mixture	A1	'–	0.0000	287
R-516A	HFC/HFO	mixture	A1	'–	0.0000	139
R-600	HC	C_4H_{10}	A3	.02	0.0000	4
R-600a	HC	$CH(CH_3)_2CH_3$	A3	.02	0.0000	3
R-717	HC	NH_3	B2L	0.27	0.0000	0.00
R-744	Natural	CO_2	A1	5	0.0000	1
R-1234yf	HFO	CF_3-CF=CH_2	A2L	0.029	0.0000	0.31
R-1234ze(E)	HFO	CF_3-CH=CHF	A2L	0.045	0.0000	0.97
R-1233zd(E)	HFO	CLCH=HC=CF_3	A1	0.027	0.0003	1.34
R-1224yd(Z)	HFO	(Z)-CF_2CF=CHCL	A1	0.058	0.0000	1
R-1270	HC	C_3H_6	A3	.02	0.0000	3

Refrigerant Leak Rates

- Refrigerants are only an **issue if they leak** but the industry statics are not good on refrigerant loss
- There are further studies underway as well as new test procedures to evaluate leaks with the development of ASHRAE 196
- Overall industry needs to pay more attention to leaks and end of life recovery

ASHRAE 228P Standard

	Equipment Type	Typical Annual Leakage Rate of Refrigerant Mass Charge Per Year
1.	Supermarket refrigeration	30%
3.	Commercial condensing units	15%
4.	Water chillers	5%
5.	Hermetic units with no field installed refrigerant piping	1%
6.	Rooftop unit air conditioner	6%
7.	Residential heat pump and air conditioner	2%
8.	Variable refrigerant flow air conditioner	10%
9.	Other refrigeration	2%
10.	Other air conditioning	2%

CEC CARB Table 6 and Table 2

System Type	Annual Leak Rate	End of Life Loss
Room AC-window/wall	2.00%	98.50%
Room AC - portable	1.00%	98.50%
Room AC - PTAC/PTHP	2.00%	98.50%
Room AC-dehumidifiers	1.00%	98.50%
Residential AC	5.30%	80%
Residential HP	5.00%	80%
Non-residential AC 65-135	10.00%	56%
Non-residential AC>135	7.00%	20%
AC Large Chillers>2000 lbs	2.30%	20%
AC Medium Centrifugal Chillers 200-2000 lbs	1.40%	20%
AC Chillers Packaged 200-2000 lbs	6.90%	20%

Australia Table 1

Equipment class/application	Annual leak rates (% p.a.)		
	Lower	Typical	Upper
Refrigeration applications			
Centralised system (i.e. supermarket rack)	5%	Maintained = 12.5%, otherwise 15%	23%
Chillers (i.e. cold storage facilities, process refrigeration)	5%	7%	16%
Condensing units (i.e. Walk-in coolrooms)	5%	Maintained = 12.5%, otherwise 15%	23%
Self-contained refrigeration system	—	2%	—
Road transport	15%	20%	23%
Marine	20%	30%	40%
Air conditioning applications			
Chillers	5%	7%	9%
Chillers (HCFC-123)	—	2%	—
Roof top packaged systems	4%	5%	9%
Split systems (single and multi)	3%	4%	9%
Window/wall units and portable	—	2%	—

Best_Practice_Tewi_June2012.pdf (airah.org.au)

Refrigerant Leak Rates

- Refrigerants ar
- There are furth 196
- Overall industr

ASHRAE

Equipment Typ
1. Supermarket re
3. Commercial cond
4. Water chi
5. Hermetic units with no field ins
6. Rooftop unit air
7. Residential heat pump a
8. Variable refrigerant flo
9. Other refrige
10. Other air cond

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Residential HP	5.00%	80%
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Roof top packaged systems	4%	5%	9%
Split systems (single and multi)	3%	4%	9%
Window/wall units and portable	—	2%	—

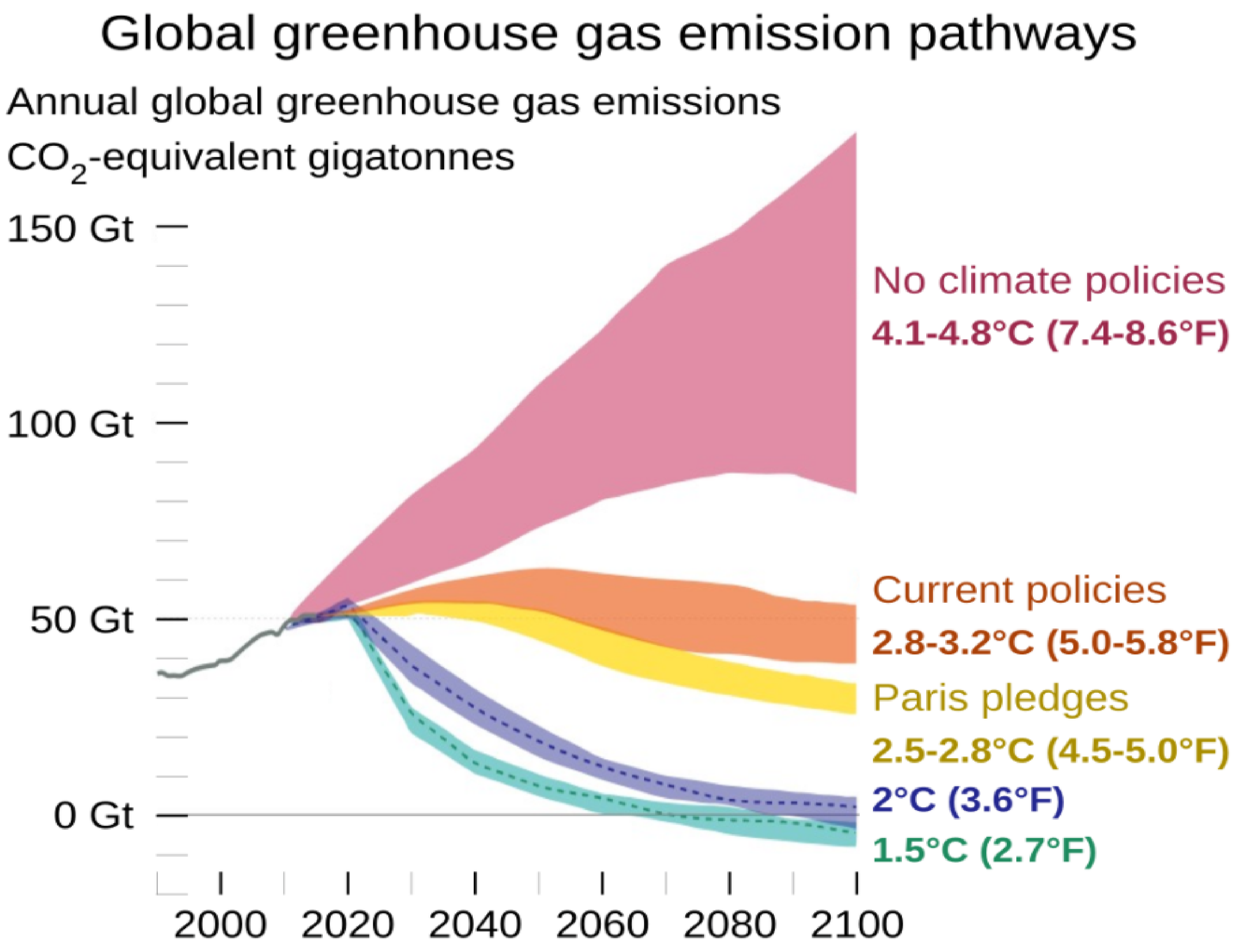
Recovery at end of life is a significant opportunity to reduce the impact of refrigerant emissions

Best_Practice_Tewi_June2012.pdf (airah.org.au)

GLOBAL WARMING
REFRIGERANT REGULATIONS

Legislative Action Plans

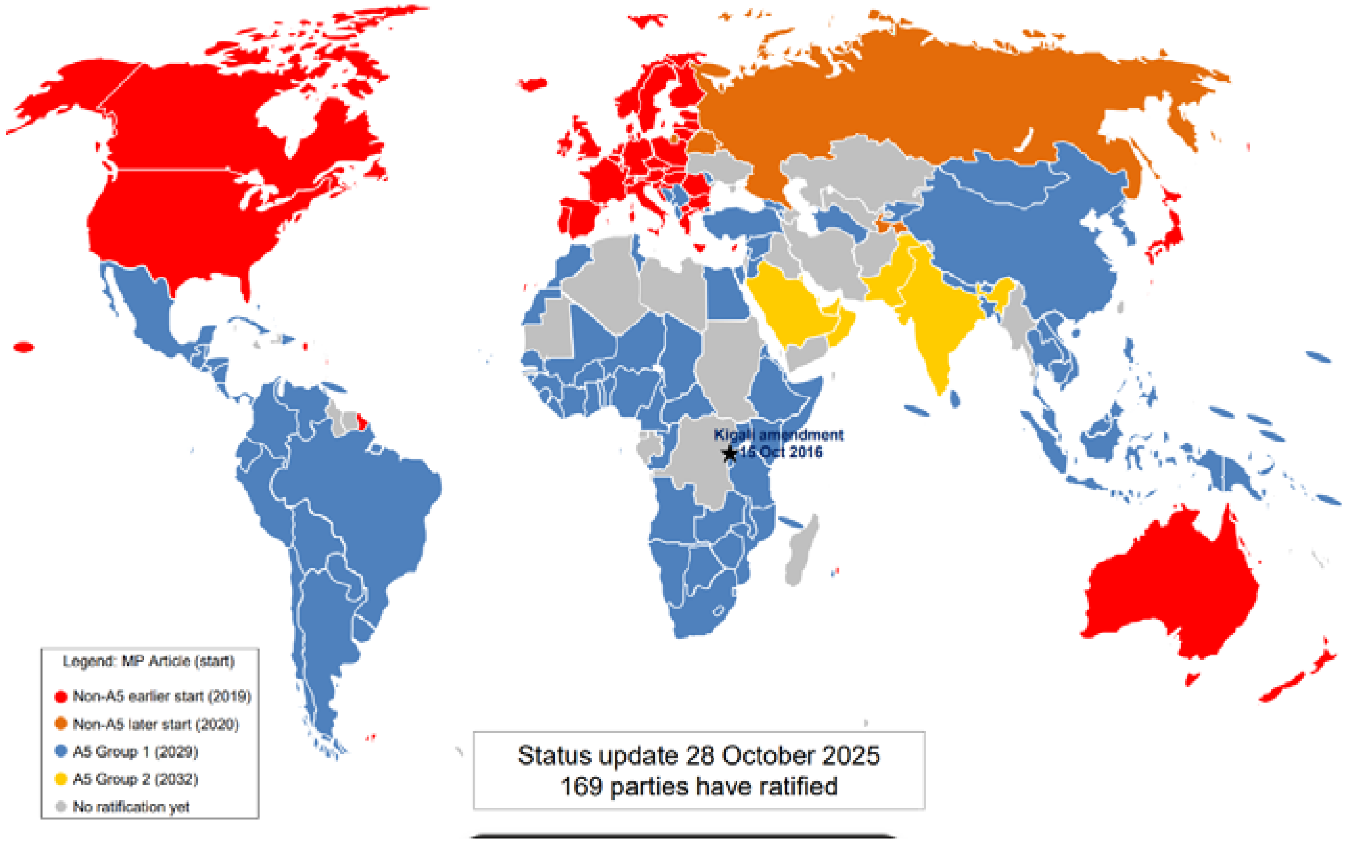
- The Montreal Protocol, Kigali agreement, Paris agreement, COP26, Europe F-Gas ,US AIM Act, and California CARB regulations are trying to address the global warming
- Note Trump, dropped out of Paris agreement and does not support environmental policies
- "Taken as a whole," the IPCC states, "the range of published evidence indicates that the net damage costs of climate change are likely to be significant and to increase over time.
  - Changes in global Precipitation
  - Increased Summer temperatures
  - The intensity, frequency, of storms
  - Global sea level 1 to 8 feet by 2100.
  - Increase forest fires



GWP Phasedown Regulations

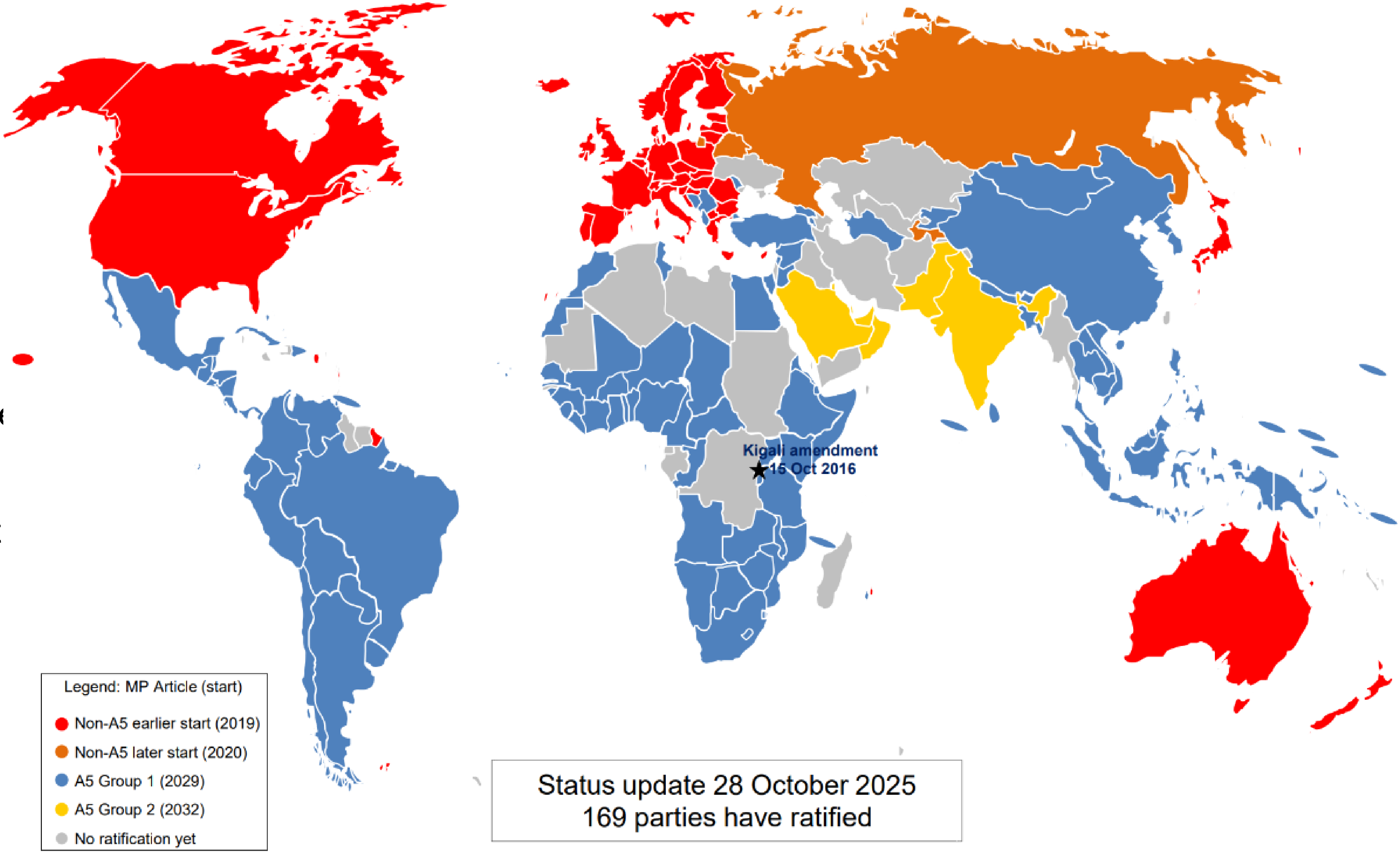
- In 2012 the **Paris Climate Agreement** committed to limit global temperature rise to 2ºC,
- The **Kigali Agreement**, developed by the Parties to the **Montreal Protocol** was approved on 10/25/2018.
  - As of 10/25/2025 169 countries have ratified the Kigali agreement (20 were required for the phasedown to go into effect on 1/2019), (70 are required for trade sanctions to go into effect in 2030).
- For the US approval of the Kigali Agreement is considered a treaty and required 2/3 approval of the Senate
- The US Senate approved the Agreement on 10/31/2025

Kigali Agreement



Kigali and F-Gas Phasedown Regulations

- 197 countries **approved the agreement**
- It goes into effect when
  - Ratifications by 20 countries
  - When 70 countries have ratified trade sanctions for non-approval countries can be used in 2030
- As of 10/25/2025 169, countries have **ratified the agreement**
- The US ratified the Kigali agreement treaty on October 31, 2023
- EPA is proceeding using the AIM Act



Montreal Protocol Kigali Agreement

Kigali agreement calls for the phasedown of high GWP refrigerants

	A5 Group 1	A5 Group 2	A2
Baseline	2020-2022	2024-2026	2011-2013
Formula	Average HFC consumption	Average HFC consumption	Average HFC consumption
HCFC	65% baseline	65% baseline	15% baseline*
Freeze	2024	2028	–
1st step	2029 – 10%	2032 – 10%	2019 – 10%
2nd step	2035 – 30%	2037 – 20%	2024 – 40%
3rd step	2040 – 50%	2042 – 30%	2029 – 70%
4th step	–	–	2034 – 80%
Plateau	2045 – 80%	2045 – 85%	2036 – 85%

* For Belarus, Russian Federation, Kazakhstan, Tajikistan, Uzbekistan 25% HCFC component of baseline and different initial two steps (1) 5% reduction in 2020 and (2) 35% reduction in 2025

Notes:

Group 1: Article 5 parties not part of Group 2

Group 2: GCC (Saudi Arabia, Kuwait, United Arab Emirates, Qatar, Bahrain, Oman), India, Iran, Iraq, Pakistan

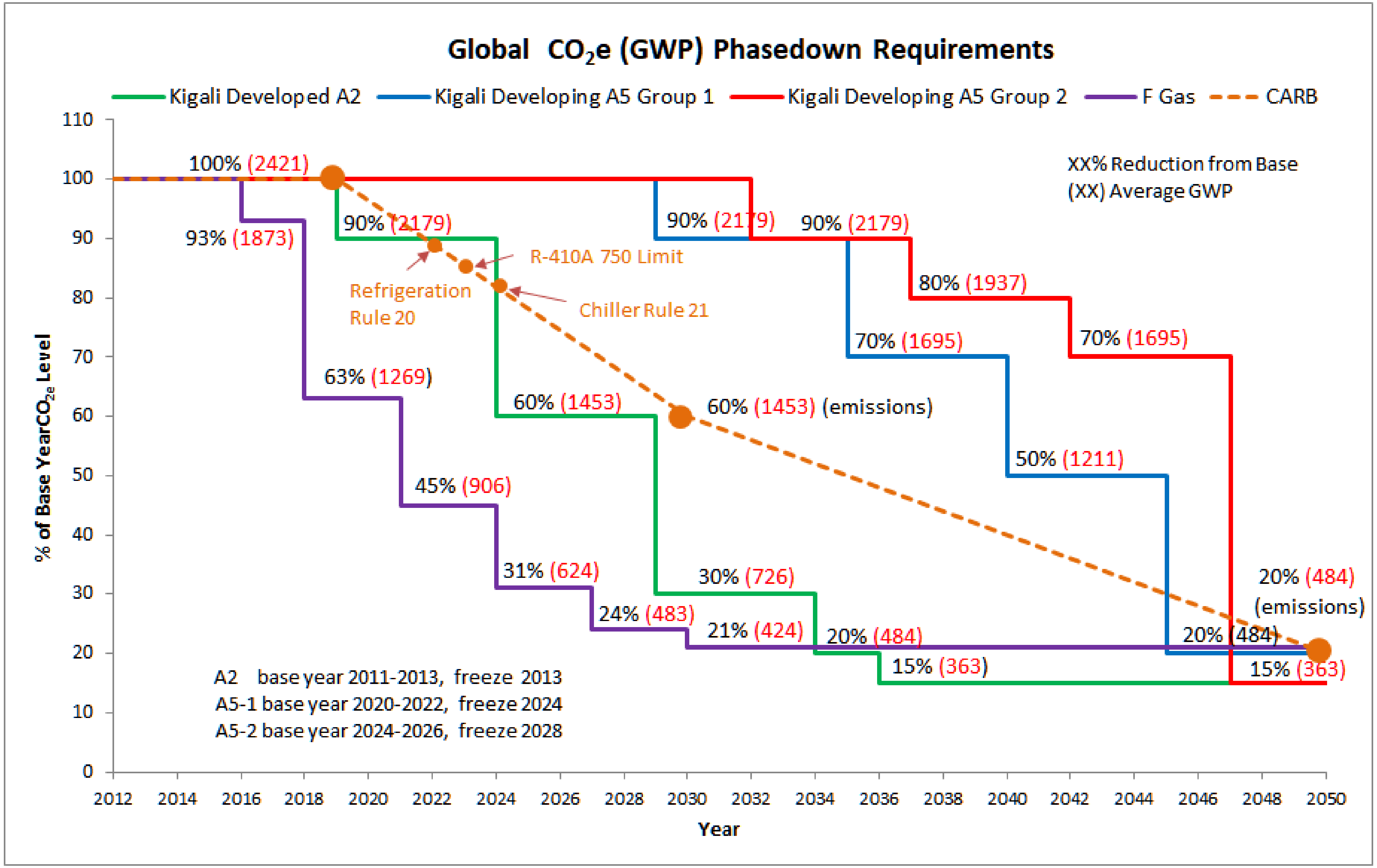
Technology review in 2022 and every 5 years

Technology review 4-5 years before 2028 to consider the compliance deferral of 2 years from the freeze of 2028 of Article 5 Group 2 to address growth in relevant sectors above certain threshold.

Global HFC Phasedown Regulations

XX % is the reduction from base year including compensation for volume increases

(XXXX) Is the average industry GWP assuming not change in reclaim and recovery

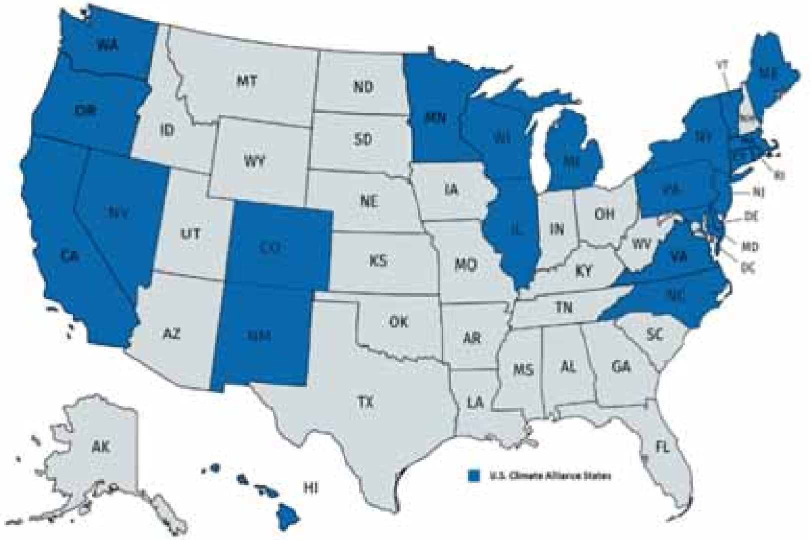


YS GWP Phasedown Regulations

- The **EPA** tried to regulate GWP refrigerant emissions with **Rule 20 (refrigeration)** and **Rule 21 (chillers)** but was vacated in federal courts because EPA was not approved to regulate GWP refrigerants
- On Dec 27 2020, **The American Innovation and Manufacturing Act**, (AIM Act) was approved
  - AIM gives authority to **the EPA** to establish a national phase down schedule for high GWP refrigerants
  - Legislative response to the court vacating SNAP rule 20 for refrigeration and SNAP rule 21 , 22, 23, 24, 25, 26 and proposed rule 27 have been released
- **Concerned US states** have also taken up the phasedown regulations thru the **US Climate Alliance** with a goal to reduce **emissions below 2005 levels by 26-28%** by 2025. There are 24 member states, 392-member city mayors and 18 states with active legislation
  - Approved – California, Washington, New York (regulation 6 NY Part 494)
  - Proposed - Connecticut, Vermont, Maryland, New Jersey, Rhode Island, Massachusetts, Maine, Virginia, and Rhode Island

HFc
PHASEDOWN
American Innovation & Manufacturing (AIM) Act
A U.S. Environmental Protection Agency Program

US Climate Alliance States



Accounts for 54% of the US population

NA Equipment Transition Dates (AIM Act)

Transition date	Equipment	Requirement	Where[1]?
January 1, 2023	Refrigeration	GWP ≤ 2,200	California, National[2] – July, 2024 (LE)
January 1, 2024	Chillers[3]	SNAP Rule 21 Refrigerants ban GWP ≤ 750	12 States - CA, CO, DE, MA, MD, ME, NJ, NY, VA, VT, WA, RI National [2] – July, 2024 (LE)
January 1, 2025	Res and Light CML Stationary A/C	GWP ≤ 750	California, Washington National[2]
January 1, 2026	VRF	GWP ≤ 750	California, Washington National[2]

[1] Situation as of December 2021. Several States at an early stage of the rulemaking process are not listed.

[2] Regulation in progress - NOT approved yet

[3] EPA proposed date is for >35 F setpoint chillers

North America Regulatory 2025 Change

Focus Shift from Federal to State Activity with new Administration

Focus Area	Action	Goal	Responsibility
US Federal Activity	**Monitor and Report on Federal Regulatory Action including EPA and DOE activity**	Update as Needed, Update at Regulatory Summit November 2025	Jason Thomas
State Activity	**NY Part 494:** Monitor approach to implementation.	Update at Regulatory Summit November 2025	Jason Thomas
	US State Activity: Monitor and report as needed	Update at Regulatory Summit November 2025	Jason Thomas
Carrier Strategy	Revise refrigerant and supporting technology strategy / roadmaps	Strategy Update June 5 & December 2025	Larry Burns
Canada	**Rulemaking:** Monitor start of rulemaking (delayed, timing unknown)	Report at Summit April 2025	Jason Thomas

NY State 6 NYCRR Part 494 Final Rule Prohibitions

Subsector	Prohibited Substances	Prohibition Date
(i) Centrifugal chillers	FOR12A, FOR12B, HFC-134a, HFC-227ea, HFC-236fa, HFC-245fa, R-125/13Centrifugal chillers4a/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-422C, R-422D, R-423A, R-424A, R-434A, R-438A, R-507A, RS-44 (2003 composition), THR-03	January 1, 2024
(ii) Positive displacement chillers	FOR12A, FOR12B, HFC-134a, HFC-227ea, KDD6, 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-422C, R-422D, R-424A, R-434A, R-437A, R-438A, R-507A, RS-44 (2003 composition), SP34E, THR-03	January 1, 2024
(iii) Chillers	Regulated substances pursuant to requirements in 40 CFR section 84.54(a)(10)(i) and 40 CFR section 84.54(c)(3)	Effective date of this Part
	Regulated substances with a **GWP20 greater than 20**	January 1, 2030
(iv) Heat pump chillers	Regulated substances pursuant to requirements in 40 CFR section 84.54(a)(10)(i) and 40 CFR section 84.54(c)(3)	Effective date of this Part
	Regulated substances with a **GWP20 greater than 20**	January 1, 2034
(v) Residential and light commercial air conditioning and heat pumps	Regulated substances pursuant to requirements in 40 CFR section 84.54(a)(1) and 40 CFR section 84.54(c)(1)	January 1, 2026
	Regulated substances with a **GWP20 greater than 10**	January 1, 2034
(vi) VRF systems	Regulated substances pursuant to requirements in 40 CFR section 84.54(c)(2)	January 1, 2026
	Regulated substances with a **GWP20 greater than 10**	January 1, 2030
(vii) Other residential HVAC	Regulated substances with a **GWP20 greater than 10**	January 1, 2027
(viii) Other commercial HVAC	Regulated substances with a **GWP20 greater than 10**	January 1, 2034
(ix) Data centers	Regulated substances with a **GWP20 greater than 2690**	January 1, 2026
	Regulated substances with a **GWP20 greater than 10**	January 1, 2030

AHRI and HARDI have jointly filed the lawsuit challenging 6 NYCRR Part 494, which took effect earlier this year.

The Phase Down Can Be Chaotic

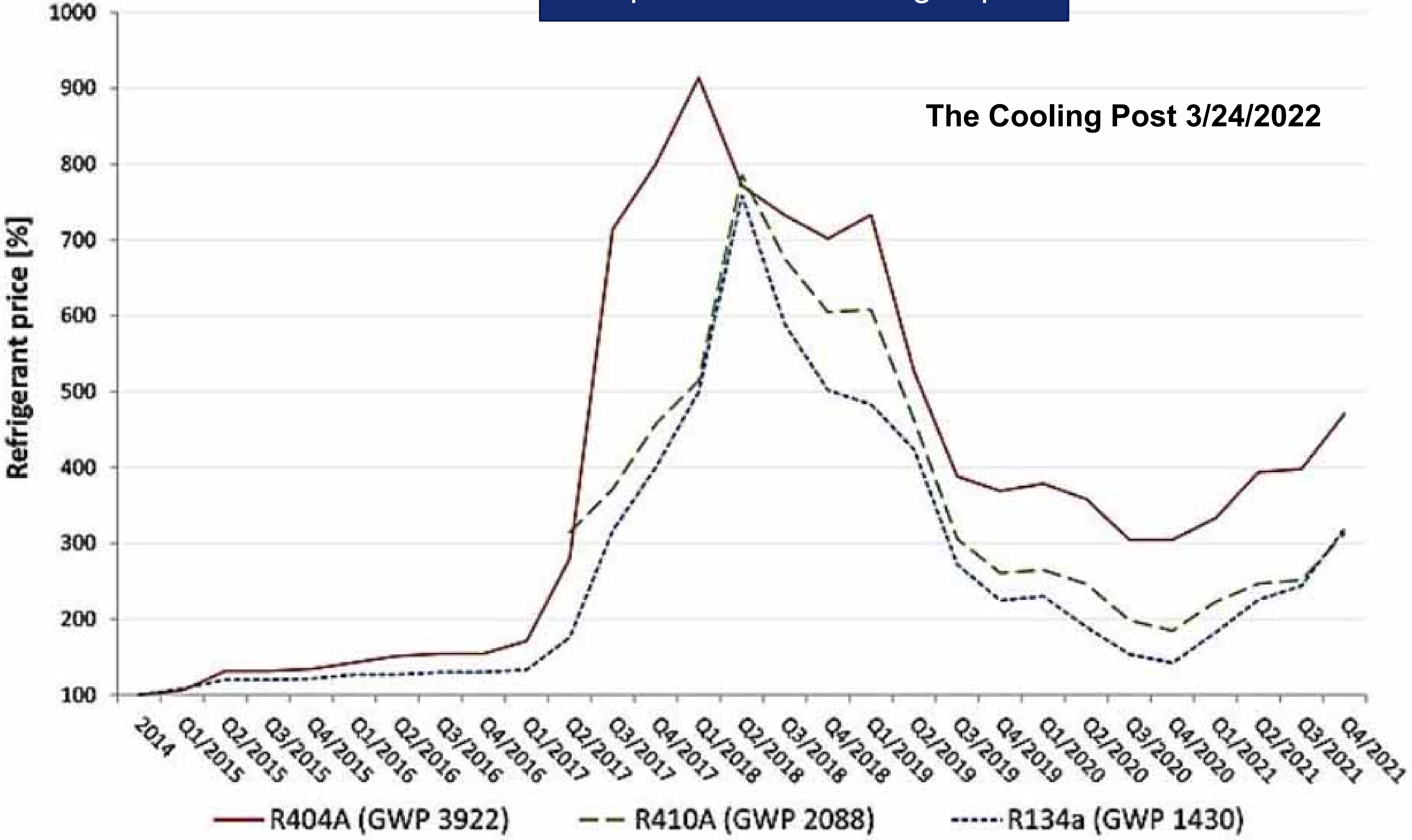
Phase down = Reduced Supply
Economics → Scarcity ≈
Increased Prices

Shown in the chart is the price increases in Europe resulting from the F-GAS phase down

We have seen similar changes in US

In 2025, the HVAC industry is facing a significant shortage of R-454B refrigerant, driven by supply chain issues, increased demand, and regulatory changes.

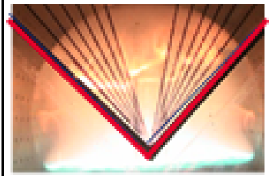
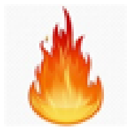
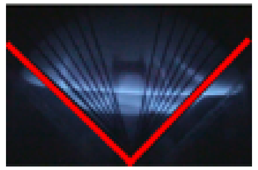
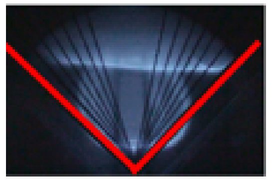
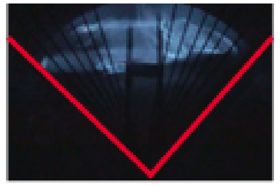
European F-Gas Pricing Impact



NEW REFRIGERANT OPTIONS

Refrigerant Classifications

ASHRAE 34 and EN 378

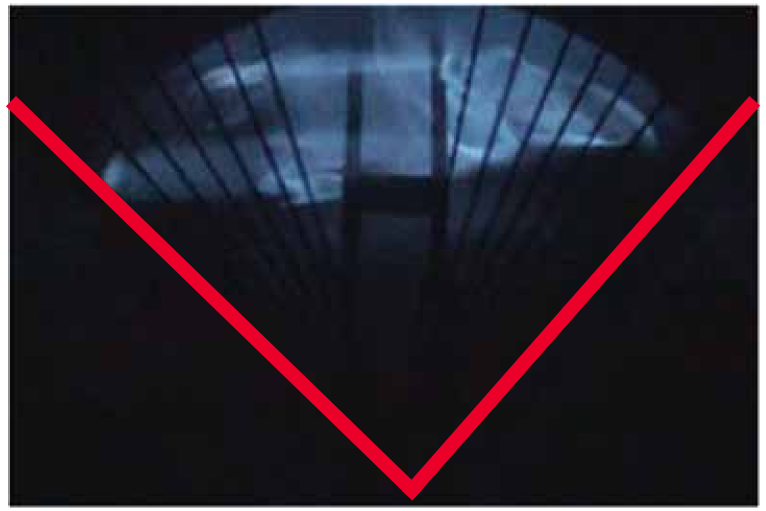
		E681 Test				
Higher Flammability (explosive) 			Ignites very easily Potentially **Explosive**	**A3** R-429A, R-430A, R-431A, R-435A, R-290 (Propane), Butane, Butene, Butyne,	**B3**	**Clase 3 Requirements** 1. Flame propagation when tested at 60 C 2. and LFL < 0.10 kg/m^3 3. or heat of combustion<19,000 kJ/kg
				High Flammability		
Low Flammability 			**Ignites Easily** Relatively High Energy Release	**A2** R-152a, R-413A, R-439A, R-440A	**B2** R40 Methyl Chloride	**Clase 2 Requirements** 1. Flame propagation when tested at 60 C 2. and LFL > 0.10 kg/m^3 3. and heat of combustion<19,000 kJ/kg
				Flammable		
Lower Flammability 	 Low Grade Coal		"Mildly Flammable" **Difficult to Ignite** Relatively Low Energy Release Low Flame Speed	**maximum burning velocity of ≤10 cm/sec** **A2L** R-1234yf, R-1234ze(E), R-32, R-452B, R-454B, R-454A	**New** **B2L** R717 (Amonnia)	**Clase 2L Requirements** 1. Flame propagation when tested at 60 C 2. and LFL > 0.10 kg/m^3 3. and heat of combustion<19,000 kJ/kg 4. and **burning velocity ≤ 10 cm/s @ 23 C**
				Lower Flammability		
No Flame Proprogation 			No flame propogation Ignition at ≤60 C	**A1** R-22, R-410A, R-407C, R-404A, R-134a, R-448A, R-449A, R-513A, R-452A R-1233zd(E), R-448A, R-450A, R-466A	**B1** R-123, R-514A	**Clase 1 Requirements** 1. **No flame propagation** @ 60 C
				No Flame Proprogation		
				Lower Toxicity [OEL of 400 ppm or greater.]	**400 ppm** **Higher Toxicity** [OEL of less than 400 ppm.]	**Flammability Criteria**

Decreased Toxicity

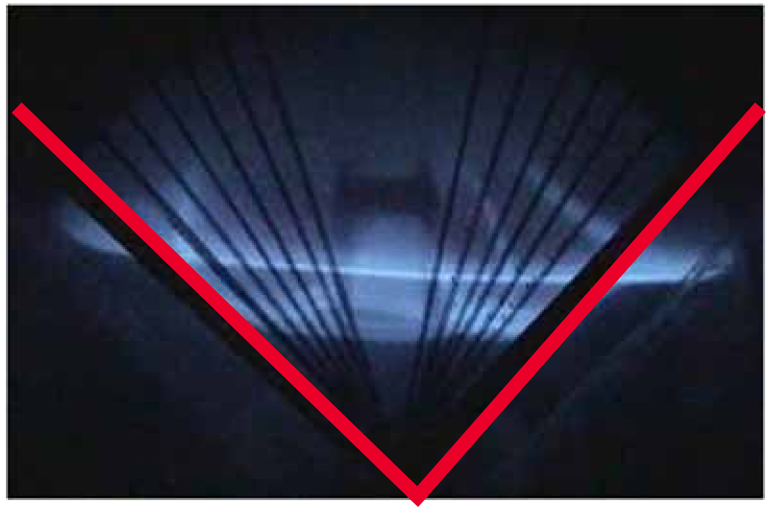
Burning Velocity and Heat of Combustion

Increase Flammability

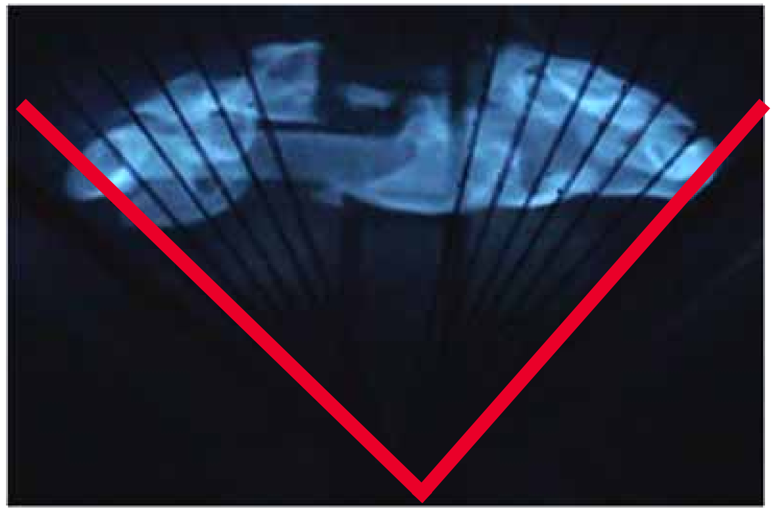
ASHRAE Classification ASTM E-681 Tes Procedure



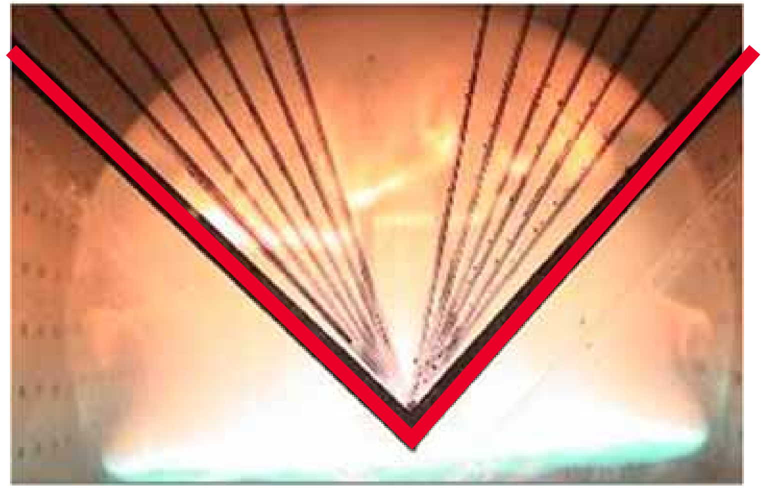
R-410A
Class 1 Does not propagate a flame but can burn



R-152a
Class 2
LFL>0.1kg/m3 and
HOC <19,000kJ/kg



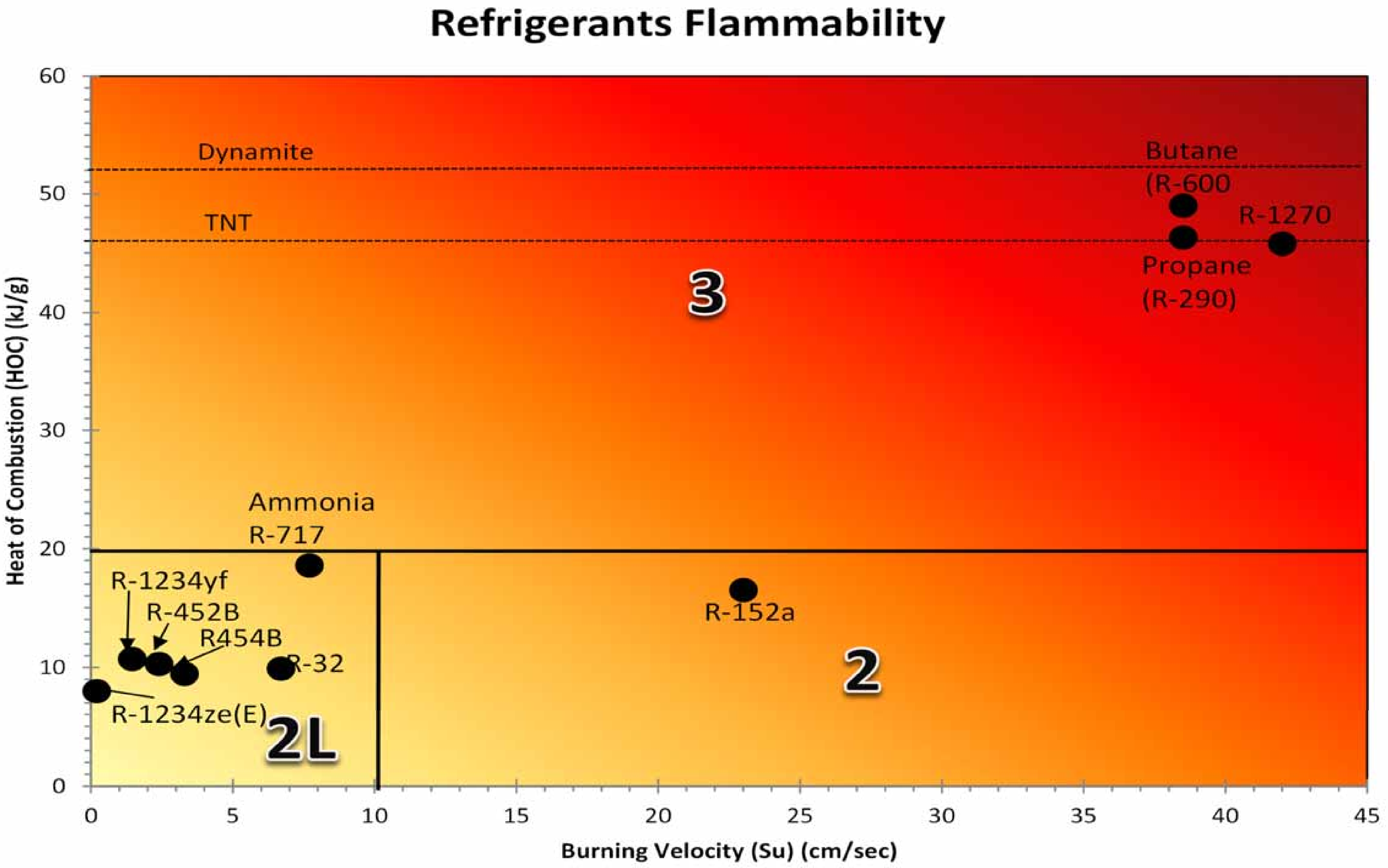
R-32
Class 2L
BV<10cm/sec,
LFL>0.1kg/m3 and
HOC 19,000kJ/kg



Propane
Class 3
LFL<0.1kg/m3 and
HOC> 19,000kJ/kg

Chemours

Flammability Classification

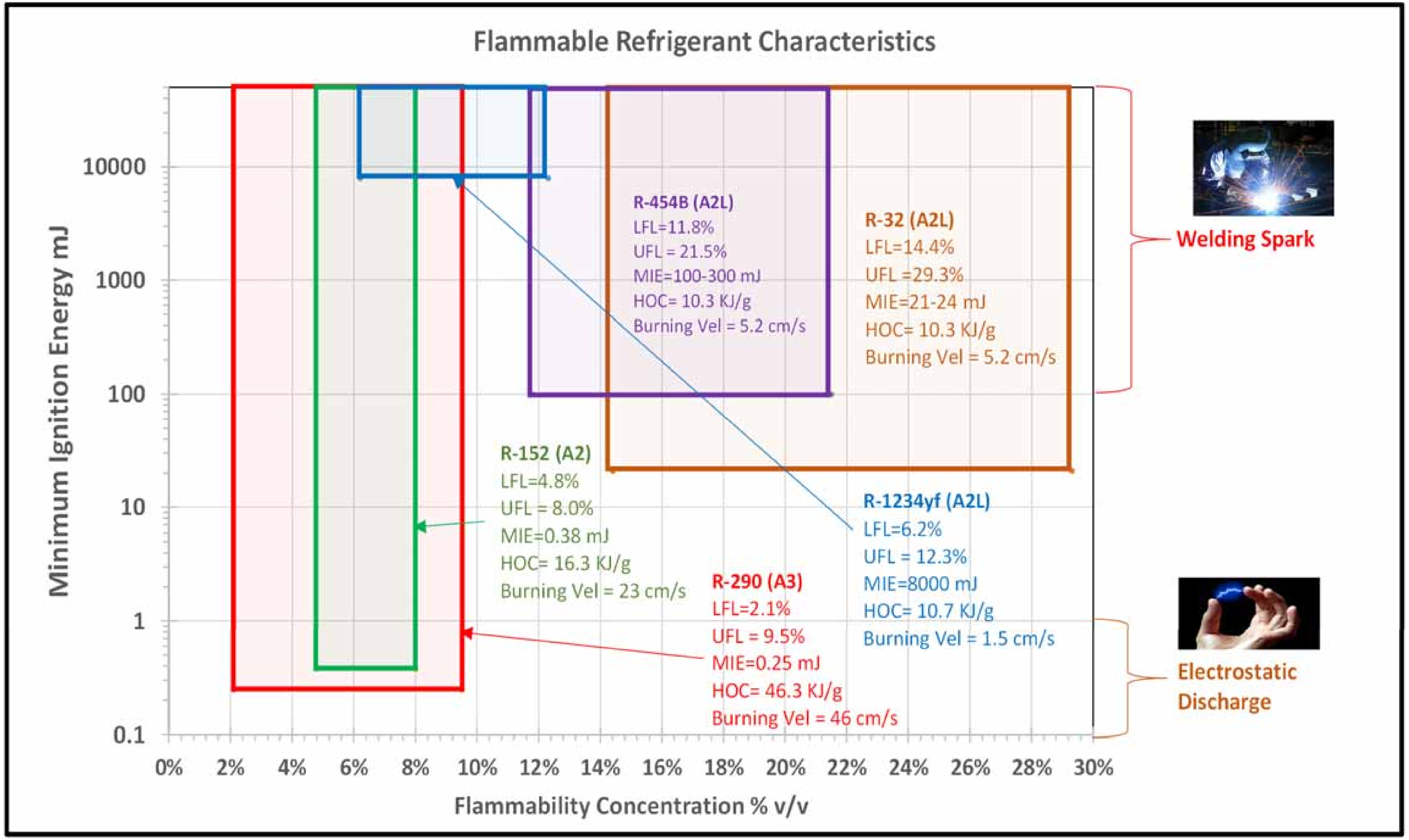


Flammable Refrigerant Properties

Research found the new category 2L refrigerant are difficult to ignite and high concentration levels are required

Research also found that minimum ignition energy are very high

Both these were then factored into modified standards and codes



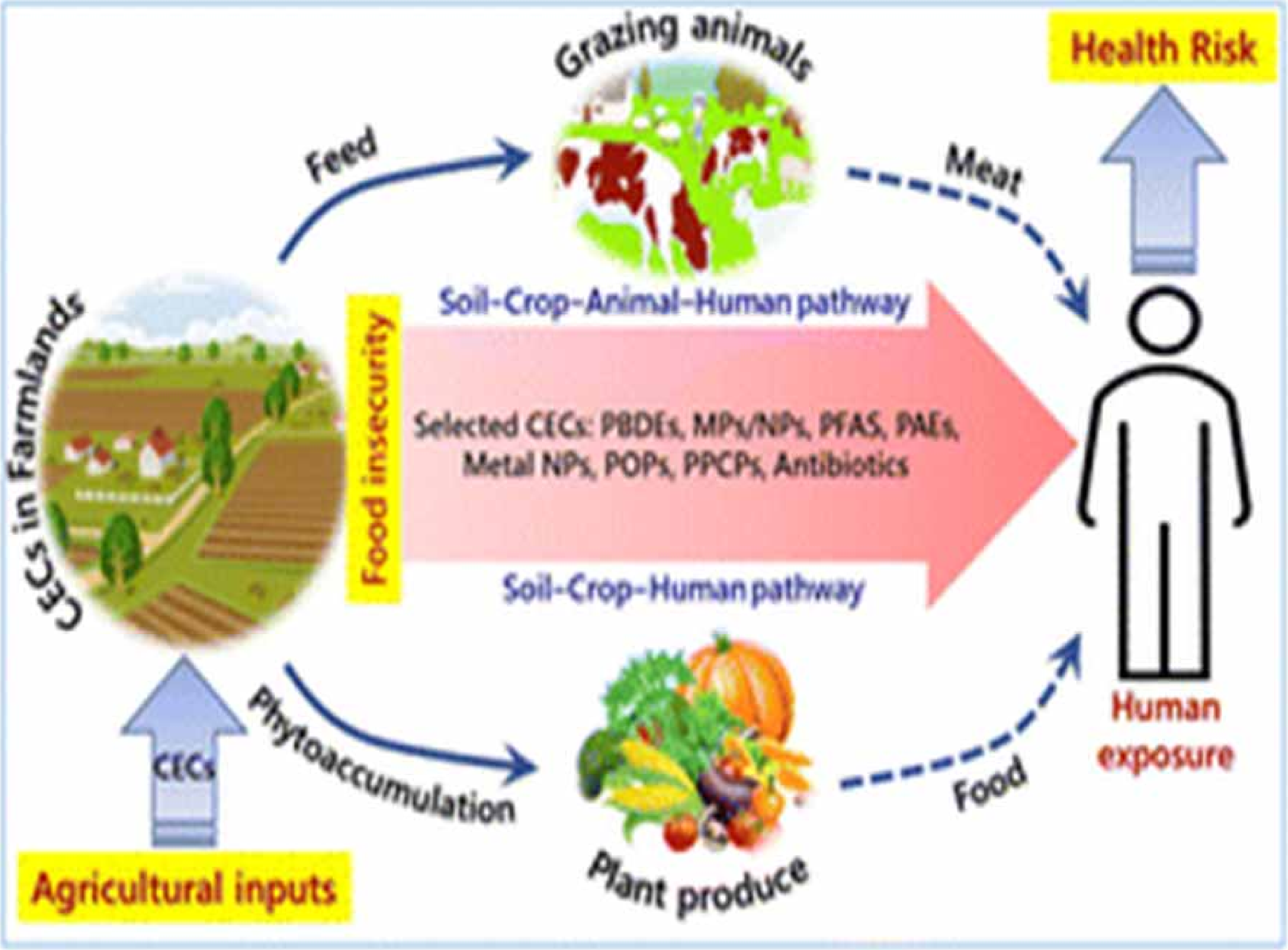
MATERIALS OF CONCERN

New

Carrier

Materials of Concern

- There is growing concerns and potential regulations concerning materials concern and the impact on human exposure.
- This concerns not just the refrigerants we use but all materials used in our products as well as our production processes and for other industries
- Right now, the focus appears to be more in Europe and US is on a somewhat different path for now just to track and report



Materials of Concern

- Materials of concern is an important concept for Environmental, Social, and Governance (ESG).
- However, many organizations struggle to understand what it means, how it relates to their business and how to act on it.
- In the last few years, ESG has moved from a nice-to-have element of CSR (Corporate Social Responsibility) programs to a critical component of corporate strategy.
- With mandatory requirements from the SEC (Securities and Exchange Commission) in the United States and CSRD (Corporate Sustainability Reporting Directive) in the EU either upcoming or currently in force, organizations around the world should be thinking about how to facilitate collecting, managing and reporting ESG data.
- The following six environmental topics that are common across most industries:
  - GHG Emissions
  - Air Quality
  - Energy Management
  - Water and Wastewater Management
  - Waste and Hazardous Materials Management
  - Ecological Impacts

What is PFAS

- Per- and polyfluoroalkyl substances (PFAS) are chemicals that have been used in a wide range of consumer and industrial products since the 1940's due to their resistance to grease, oil, water, and heat.
  - For example, PFAS are used in stain- and water-resistant fabrics and carpeting, cleaning products, paints, fire-fighting foams, some refrigerants, fire suppressants, common materials like Scotch tape, Gore-Tex, non-stick pans and many other compounds are in the class
- Per- and polyfluoroalkyl substances (PFAS) are a group of over 9,000 synthetic chemicals that have been used in industry and consumer products, worldwide, for over 70 years.
- PFAS also includes hexafluoropropylene oxide dimer acid and its ammonium salt (HFPO-DA – sometimes referred to as GenX chemicals), perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), perfluorononanoic acid (PFNA), and perfluorohexanesulfonic acid (PFHxS).
- There are also concerns about the breakdown products like **TFA Trifluoracetic Acid** which is also a class of PFAS and most refrigerants break down into TFA
- There are many studies still in process, but concerns about breakdown products and fluorinated replacement chemicals being used for lower GWP options have led some regulators to contemplate whether all PFAS should be considered problematic out of an abundance of caution until contrary information is available
- Some of the European proposals are based on preliminary, not Peer reviewed papers, that are being questioned
- **US has currently not consider refrigerants a PFAS** issue but discussions and regulations are underway
- Some have just concluded that we should move to all natural refrigerants like ammonia, CO2, water and propane but these have other significant issues

PFAS Restrictions

- **Europe (REACH Chemical Policy)**
  - **5 Countries in Europe, Denmark, Germany, Netherlands, Norway and Sweden**, have developed a proposal to ban all PFAS, but as they are cold climates have not considered all the ramifications and likely negative impact on global warming.
  - Other countries are expressing concerns that this will not allow green goals to be meet.
  - The Ricardo study found that the proposed restriction would generate increased costs and reduced efficiency, both in the performance of the product applications and in their energy consumption, leading to an increased burden on consumers, possibly limiting their choices and reducing incentives of technological change from the current equipment containing F-gases.
  - The 5-country proposal is only the proposal from 1 group of smaller colder countries.
  - Debate is still underway in Europe and any regulations have been delayed to 2030
- **US**
  - In the US, the efforts are underway thru EPA to gather data and scientific information on the issues and solutions.
  - There have been some legislation passed in Maine to start reporting and the EPA is currently evaluating the issues of PFAS

Refrigerant Impacted by the PFAS

PFAS in the scope of this restriction intention have the following structural formula:

X-(-CF2-)n-X' with n equal to or larger than 1 and X, X' not being H (thus including X-CF3), meaning fluorinated substances that contain at least one aliphatic carbon atom that is both, saturated and fully fluorinated, i.e. any chemical with at least one perfluorinated methyl group (-CF3) or at least one perfluorinated methylene group (-CF2-), –), including branched fluoroalkyl groups and substances containing ether linkages, fluoropolymers and side chain fluorinated polymers.

Single Component Refrigerants

Refrigerant	Class/GWP	Formula	($-CF_3$)	($-CF_2-$)
R-32	A2L/675	**CH2F2**	**no**	**no**
R-134a	A1/1430	CH2FCF3	yes	no
R-152	A2/124	**CH2FCH2F**	**no**	**no**
R-152a	A2/124	**CH3CHF2**	**no**	**no**
R-1132(E)	B1/10	**CHF=CHF**	**no**	**no**
R-1234yf	A2L/0.31	CF3CF=CH2	yes	no
R-1234ze(E)	A2L/0.97	CF3CH=CFH	yes	no
R-1233zd(E)	A1/1.34	CF3CH=CHCl	yes	no
R-1336mzz(Z)	A1/1.58	C 4 H 2 F 6	?	?

Blended Refrigerants

Refrigerant	Components	Class	Formula	($-CF_3$)	($-CF_2-$)
R-410A	**R-32**	A1/2088	**CH2F2**	**no**	**no**
	R-125		CHF2-CF3	yes	no
R-404A	R-125	A1/3922	CHF2-CF3	yes	no
	R-143a		CH3CF3	yes	no
	R-134a		CH2FCF3	yes	no
R452A	**R-32**	A1/2139	**CH2F2**	**no**	**no**
	R-125		CHF2-CF3	yes	no
	R-1234yf		CF3CF=CH2	yes	no
R-454A/B/C	**R-32**	A2L/236/465/145	**CH2F2**	**no**	**no**
	R-1234yf		CF3CF=CH2	yes	no

PFAS Definition Continues Under Review and Discussion
Final Definition and Restriction Could Eliminate all HFC and HFO

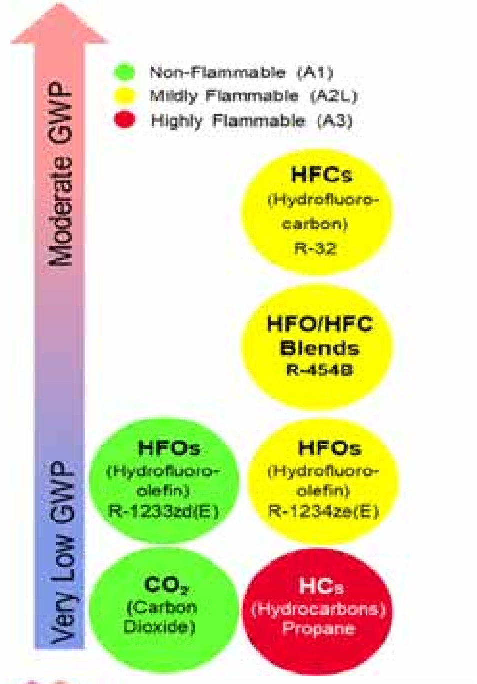
REFRIGERANT OPTIONS

Future Refrigerant Selection

- There are many issues that need to be considered for new refrigerant selections
  - Cycle Efficiency (major contributor to indirect power plant emissions)
  - Heat Transfer
  - ODP (no ozone deletion)
  - GWP (global warming regulations and timing)
  - PFAS. TFA and Materials of Concern (potential regulations)
  - Flammability (A1, A2L, A3, B2L)
  - Toxicity (A vs B)
  - Cost
  - Transport properties (pressure drop, viscosity)
  - Pressure and Density (determines size of compressors and heat exchangers)
  - Refrigerant Glide
  - Material compatibility
  - Standards and Codes

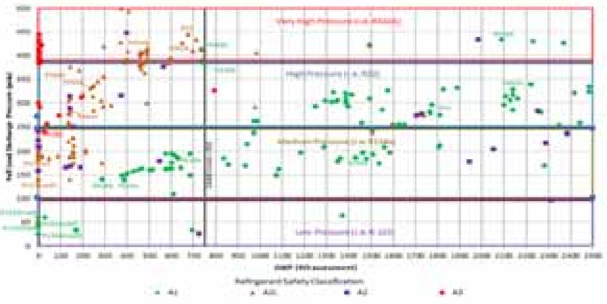
Refrigerant Selection Process

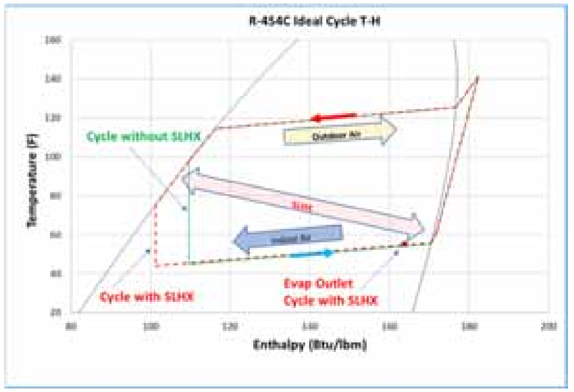
Identify Alternatives



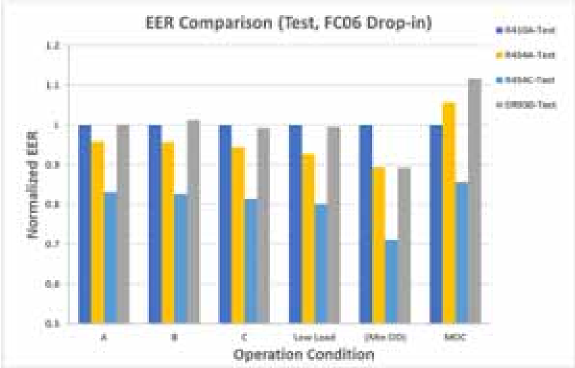
Chemours
Honeywell
ARKEMA
The world is our inspiration
Mexichem FLUOR

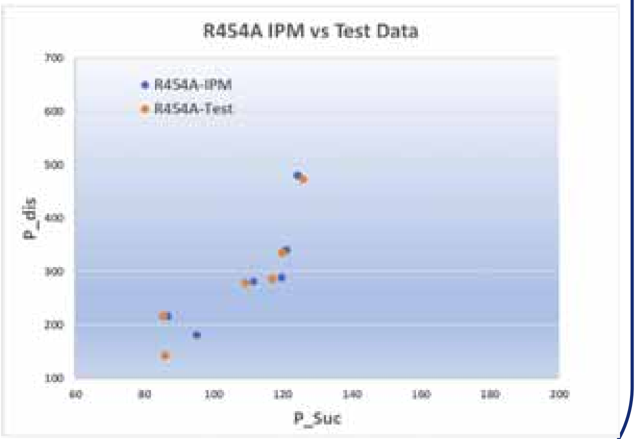
System Modeling





Validation Testing



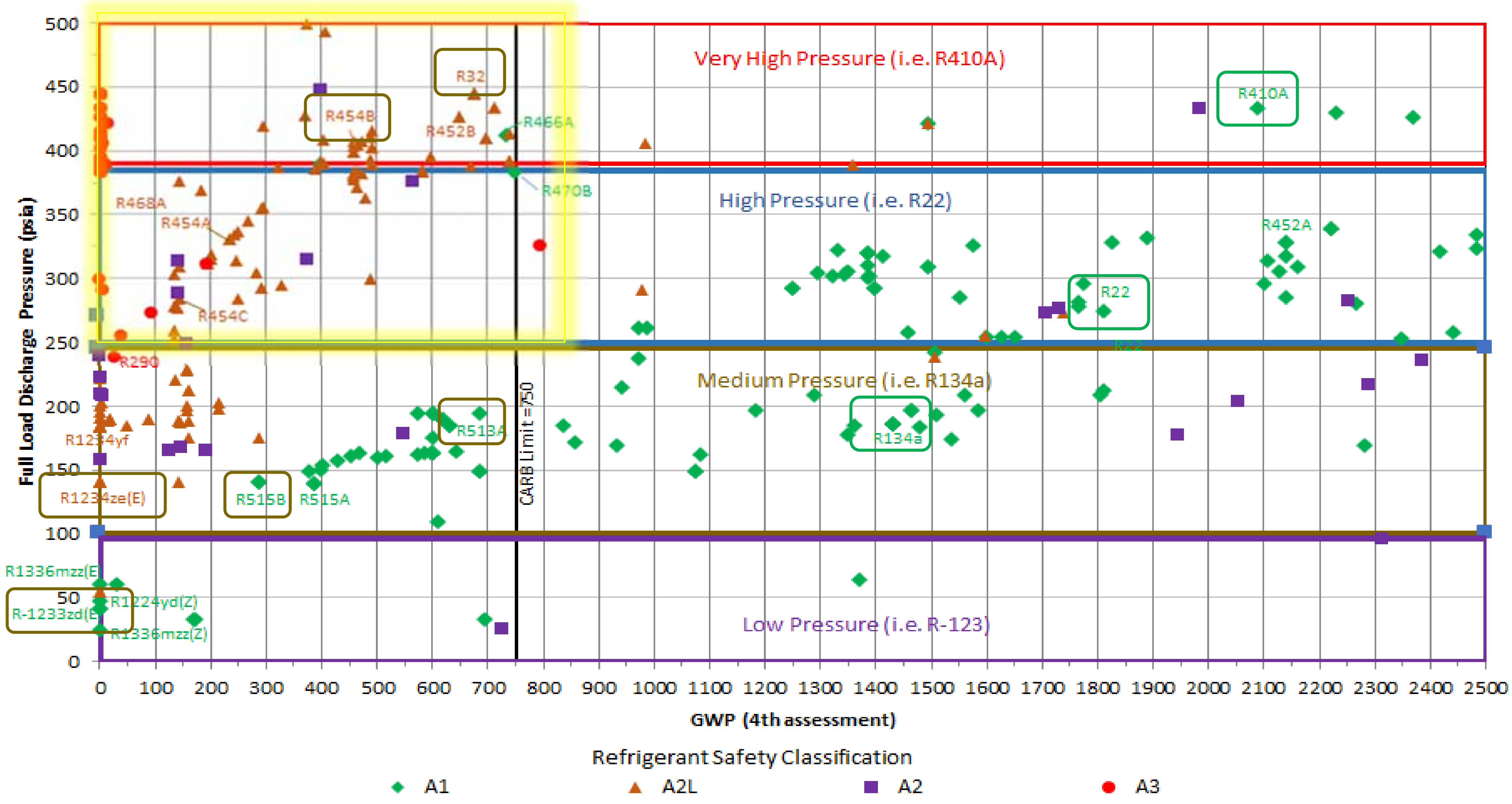


Refrigerant Down selection

	R-454B	R-452B	R-32	R-466A
GWP	465	697	675	733
Flammability	A2L	A2L	A2L	A1
Compressor size	+4%	+3%	-5%	+4%
Condensor size	Same	Same	Same	Same
Effective Glide	1.3C	1.1C	NA	1.2C
Performance	Same	Same	Same	Same
Dischg. Temperature	Same	Same	Mitigation Required	Same
Material Compatibility	Same	Oil/Bearing Concern	Same	CF_3I
System Cost (vs R410A)	+9%	+10%	+10%	+18%

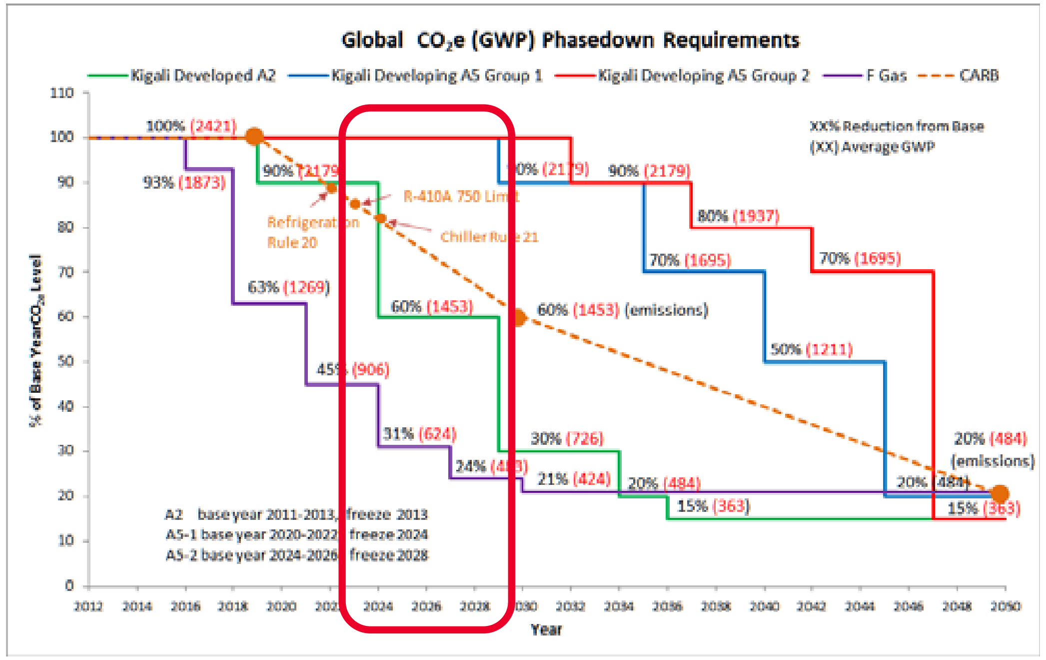
Depending on the classification, changes to codes and standards can be required

Future Refrigerant Options for R-410A Products



Recent Refrigerant Selections

- For the 2024-2026 Phasedown in the US the following refrigerants have been selected
  - **Residential and Light Commercial** – R-454B (A2L), R-32 (A2L)
  - **Commercial Scroll Air Cooled Chillers** – R-454B (A2L), R-32 (R-32)
  - **Commercial Screw Chillers** – R-513A (A1), R-515B (A1), R-1234ze(E) (A2L), R-1233zd(E) (A1), R-514A (B1)
  - **Transport Refrigeration** – R-448A (A1), R-452A (A1), R-454A (A1), R-513A (A1), R-744 (CO2) (A1)
  - **Commercial Refrigeration** –R448A (A1), R-448B (A1), R-452A (A1), R-1234yf (A2L), R-744 (CO2) (A1)
  - **Small Appliances** (<150 g charge) – R-32 (A2L), R-454B (A2L), Propane (A3), Butane (A3)



But this is only the first phase of Kigali and the US AIM act to get below 700 GWP and in 2030-2032 additional changes will be required to get below 300 and maybe even 150 GWP and there is growing focus on the use of natural refrigerants

Natural Options for HVAC&R

With the concerns on PFAS some are pushing for just the use of natural refrigerants.

- For refrigeration CO_2 is good option and for very small plug-in refrigeration propane can work.
- For low temperature refrigeration ammonia is also used (B2L), but is both flammable and very toxic
- For HVAC the options for use of natural refrigerants are much more complex
  - Propane can be used for chillers, but they must be indirect systems above 114g, and there are concerns about safety especially in service
  - For the more typical residential and light commercial rooftops propane is not a viable option and would require radical changes to indirect systems ie. chillers)
  - Although CO_2 has been effective for refrigeration it is not a good option for HVAC and even the best optimized system was 20% below current R-410A systems.
- Keep in mind 90% or more of the global warming gases come from **indirect power plant emissions**.
  - Yes, the grid will get greener, but projections are that about 35% of building energy will come from renewable energy and efficiency is still very important

Low GWP Refrigerants – Natural

Supplier	Refrigerant Name		GWP*	Composition	Class	Application
	ASHRAE	Supplier				
	R-717	Ammonia	0	NH_3	B2L	Natural option, potential PFAS response
	R-718	Water	0	H_2O	A1	Natural option, potential PFAS response
	R-744	Carbon Dioxide	1	CO_2	A1	Natural option, potential PFAS response
	R-728	Nitrogen	0	N	A1	Natural option, potential PFAS response, Stirling Cycle
	R-704	Helium	0	He	A1	Natural option, Stirling Cycle
	R-290	Propane	3.3	C_3H_8	A3	Natural option, potential PFAS response
	R-1270	Propene	1.8	$CH_3CH{=}CH_2$	A3	Natural option, potential PFAS response
	R-600	Butane	4	$H_3C - CH_3$	A3	Natural option, hydrocarbon
	R-600a	Isobutane	3	C_4H_{10}	A3	Natural option, hydrocarbon
	R-601	Pentane	5	C_5H_{12}	A3	Natural option, hydrocarbon
	R-601a	Isopentane	5	$CH_3CH_2CH(CH_3)_2$	A3	Natural option, hydrocarbon
	R-610	Perfluoro butane	4	$(CF_3)_2C{=}CF_2$	A3	Natural option, hydrocarbon
Huaxhong University	R-480A	Propene / Isobutane	2.5	84% R-1270 / 16% R-600a	A3	Natural Option, hydrogen blend
Huaxhong University	R-480B	Propene / Isobutane	2.5	38% R-1270 / 62 % R-600a	A3	Natural Option, hydrogen blend
	R-510A	Dimethyl ether / Isobutane	3.1	88% RE170 / 12% R-600a	A3	Natural Option, hydrogen blend
	R-511A	Propane / Dimethyl ether	3.3	95% R-290 / 5% RE170	A3	Natural Option, hydrogen blend

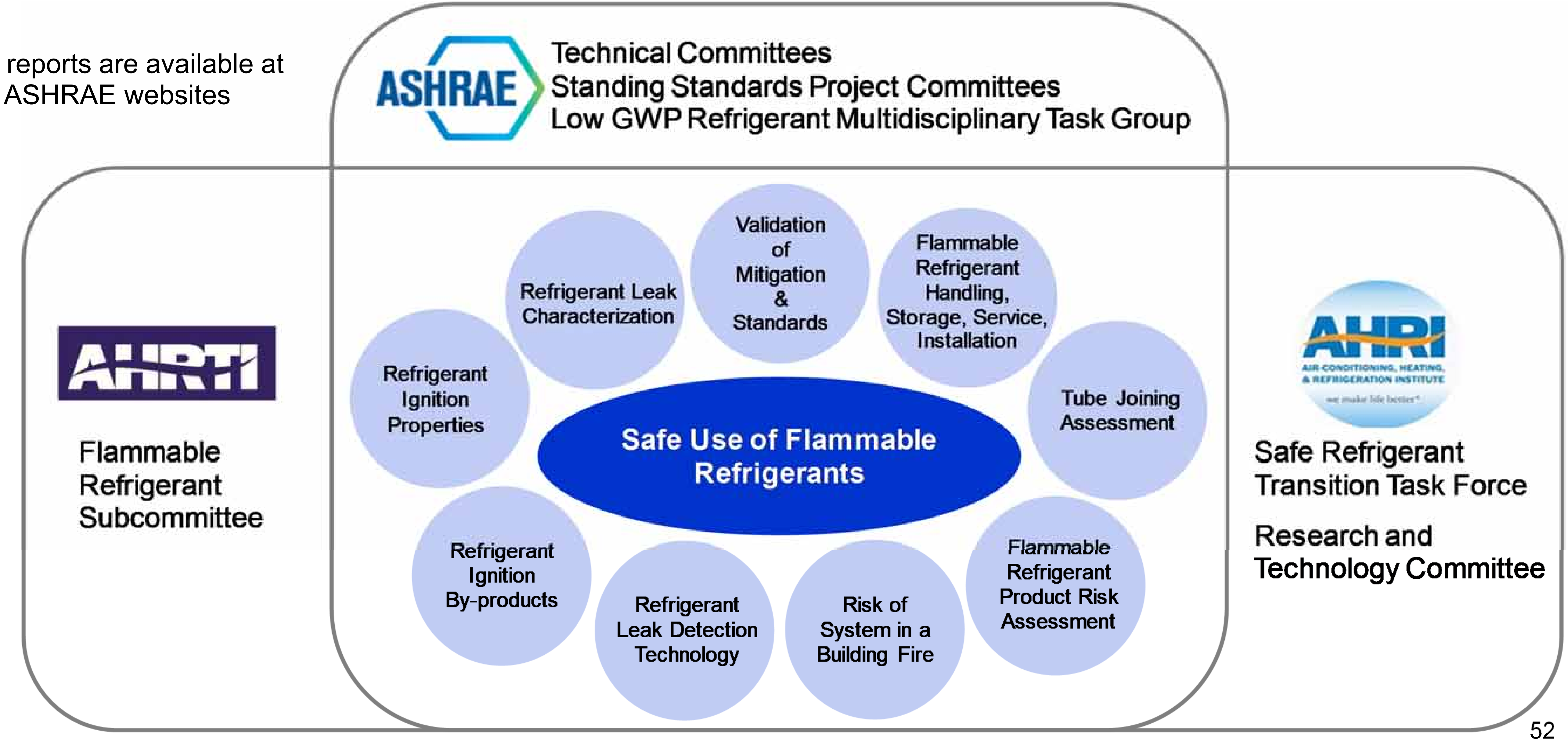
Most natural refrigerants are highly flammable A3, Except for CO2 which is very high pressure, but also has low efficiency for cooling

QUALIFICATION OF NEW FLAMMABLE REFRIGERANTS

Refrigerant Flammability

As shown, for some product we needed to use A2L refrigerants and we expected this and started research over 14 years ago to insure they could be safely applied.

Most of these reports are available at the AHRI and ASHRAE websites

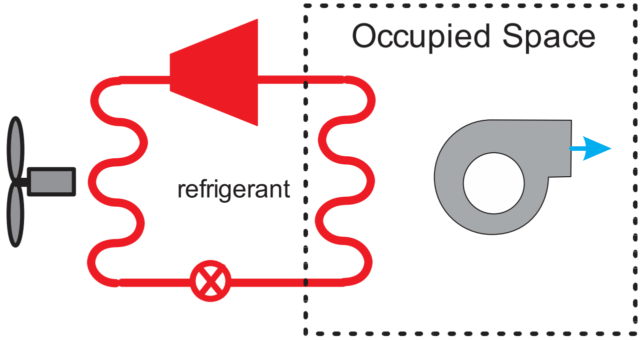


System Classification

Direct System

Refrigerant can leak into the occupied space

(Residential & Light Commercial)



Ductless

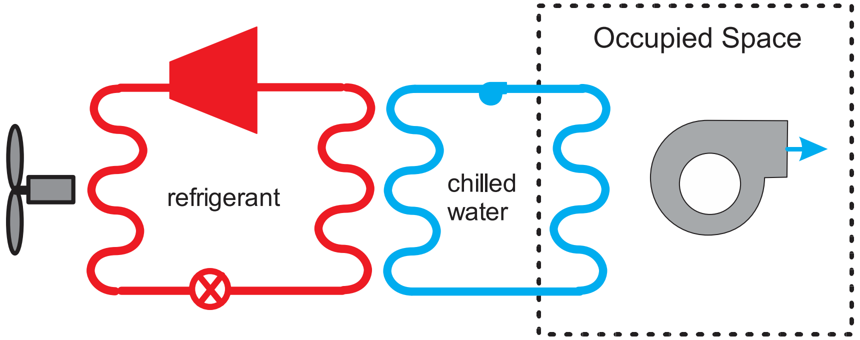
Ducted

Small Chiller

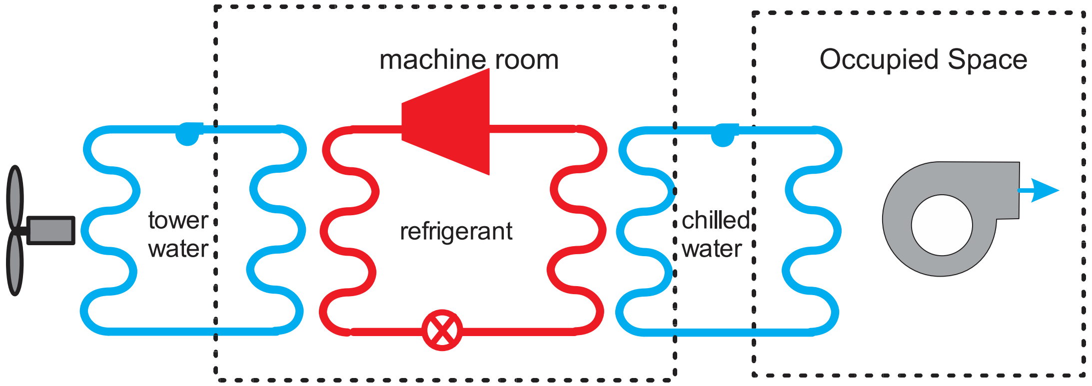
Indirect Systems

Refrigerant Leak Isolated by secondary loop Equipment outdoors or in a machine room

(Chillers)



Outdoor Chillers



Indoor Chillers

Hot Surface Ignition

- One area of concern for flammable refrigerants was **hot surface temperatures**.
- Typically, in the past for flammable gases the regulations have limited hot surfaces to the **auto-ignition temperature** of the gas with an additional 100 K safety factor and temperatures
- For A2L refrigerants this would limit hot surfaces to 300-400 C which for A2L refrigerants would cause issues with electric heat and gas heat
- The industry as part AHRTI Project 9008 they explore what really happens with hot surfaces
- Testing was done using a hot surface where refrigerant is exposed to the hot surface and then temperature of the hot surface was gradually increased until ignition was observed
- What they found was there was no ignition of pure R-32, R-1234ze(E) and R-452B occurred up to 850 C and with addition of 3% POE there was no ignition up to 800 C
- IEC60335-2-40 and UL60335-2-40 have added this to the standard in annex KK. They also have defined a default hot surface temperature of **700 C** where testing is not done which is sufficient for most HVAC&R applications
- Although there is some discussion of determining the hot surface for A2 and A3 but it will require the development of a new test procedure
- Carrier took the lead to evaluate the electric heat when there is airflow with some actual equipment testing at Southwest Research

2L Refrigerant Flammability with Electric Heat

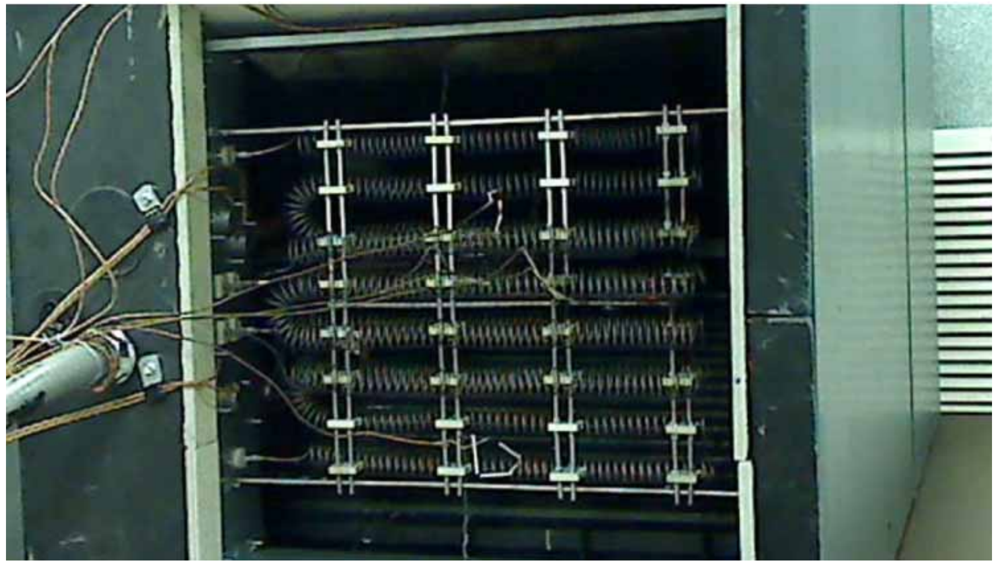
Fan Failure Test with Electric Heat and R-32

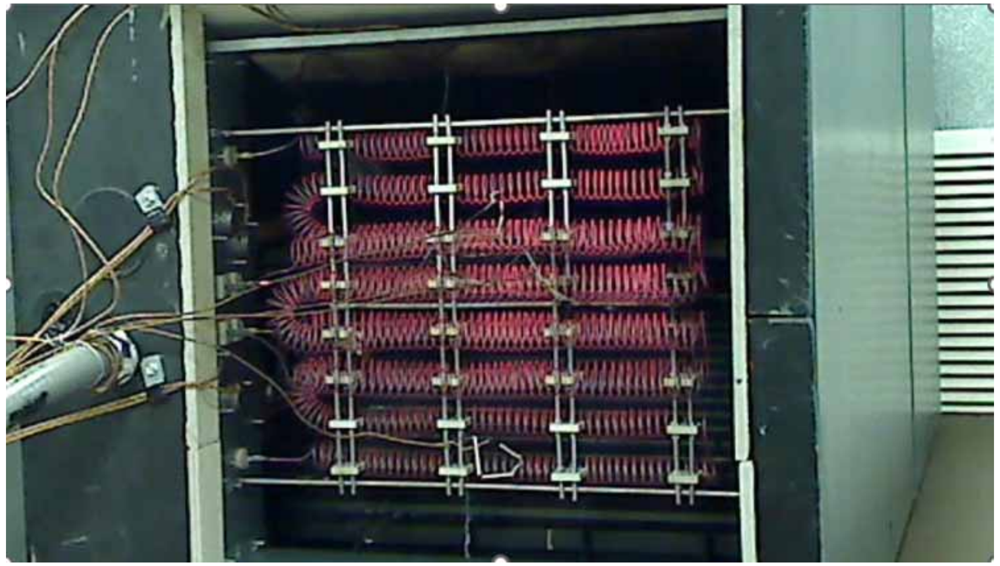
This a test of electric heat with the fan off and a leak of R-32 (A2L)

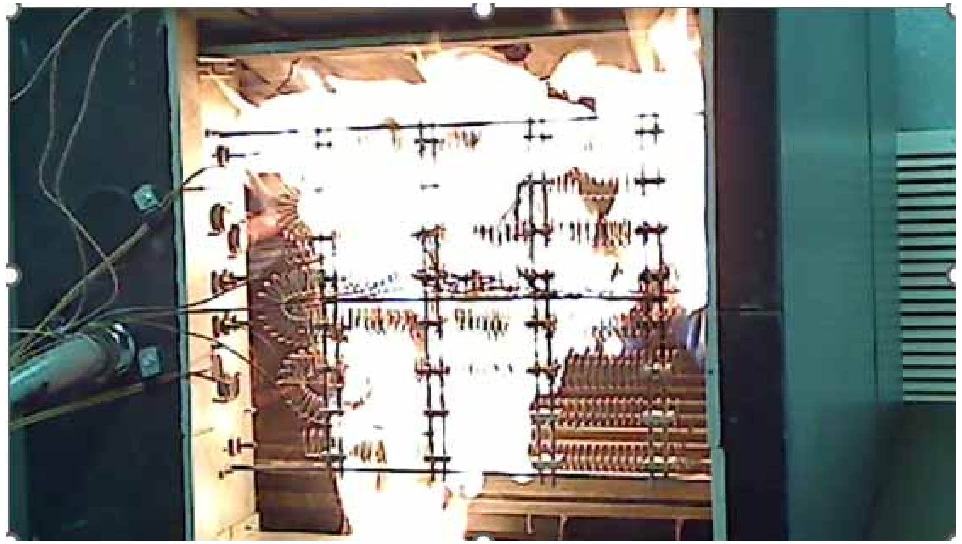
Leak was initiated with the fan off and safety switch jumped so that the electric heat gets very hot and then require catastrophic leak was initiated with no fan operation

Test confirmed that electric heat with no airflow will be an issue.

Standards we developed to detect refrigerant leaks and insure fan is on.



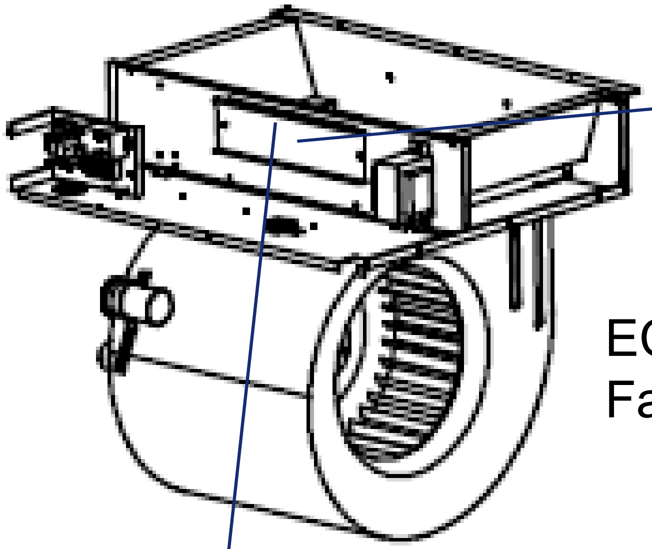




Carrier Fan Coil Electric Heat

1.5 Ton Fan Coil
(600 Nominal CFM)

11 x 12 7/16 Outlet



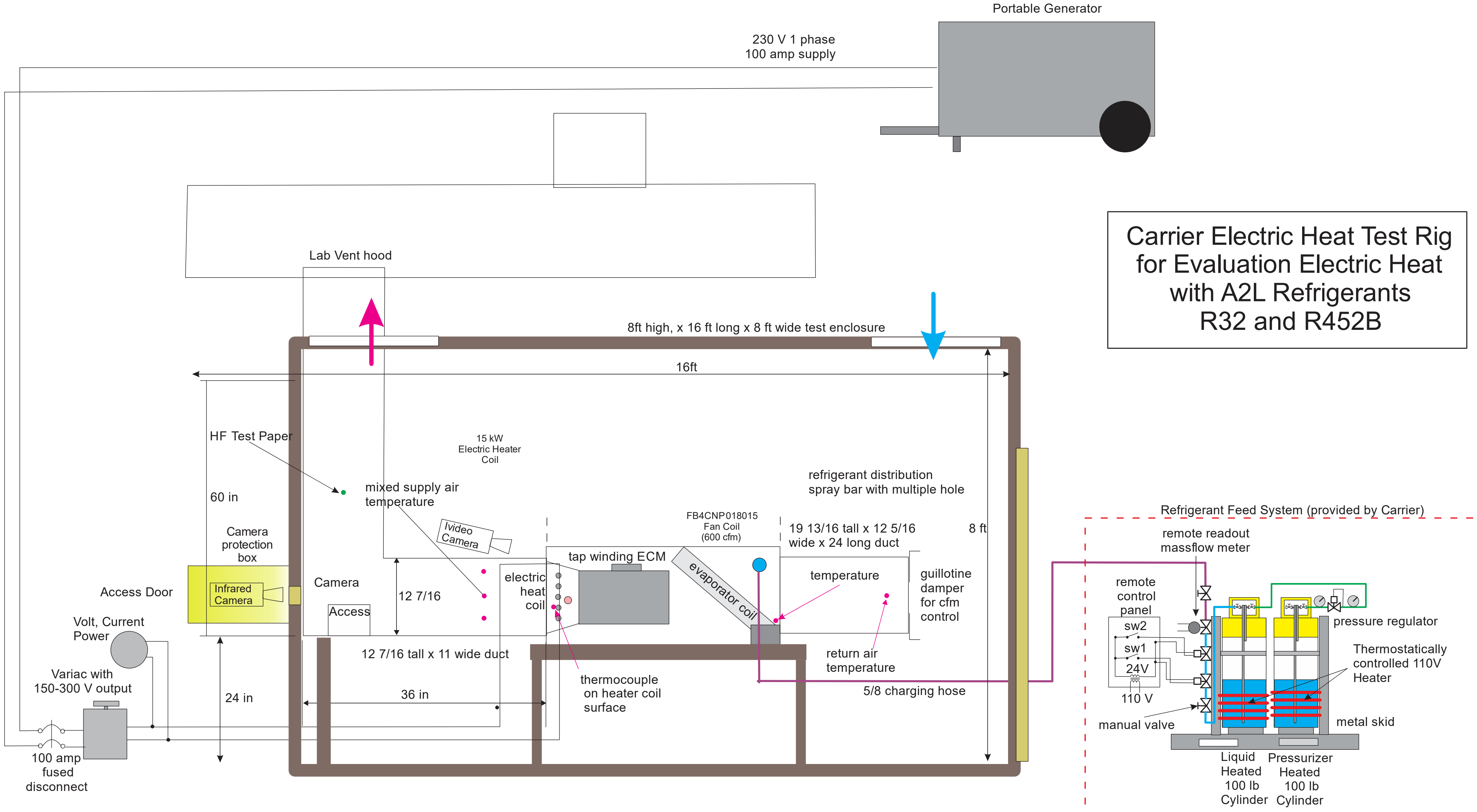
ECM
Fan

15 kW

Fan Outlet

<u>Each coil</u> = 4931w 240v, 20.5 amps, 10.27 +/-3% cold ohms, **61.2 watt density**, #16 (.051” dia.) ga. ‘NXT’ resistance wire, wound on a .688” arbor, stretched to 24” length.

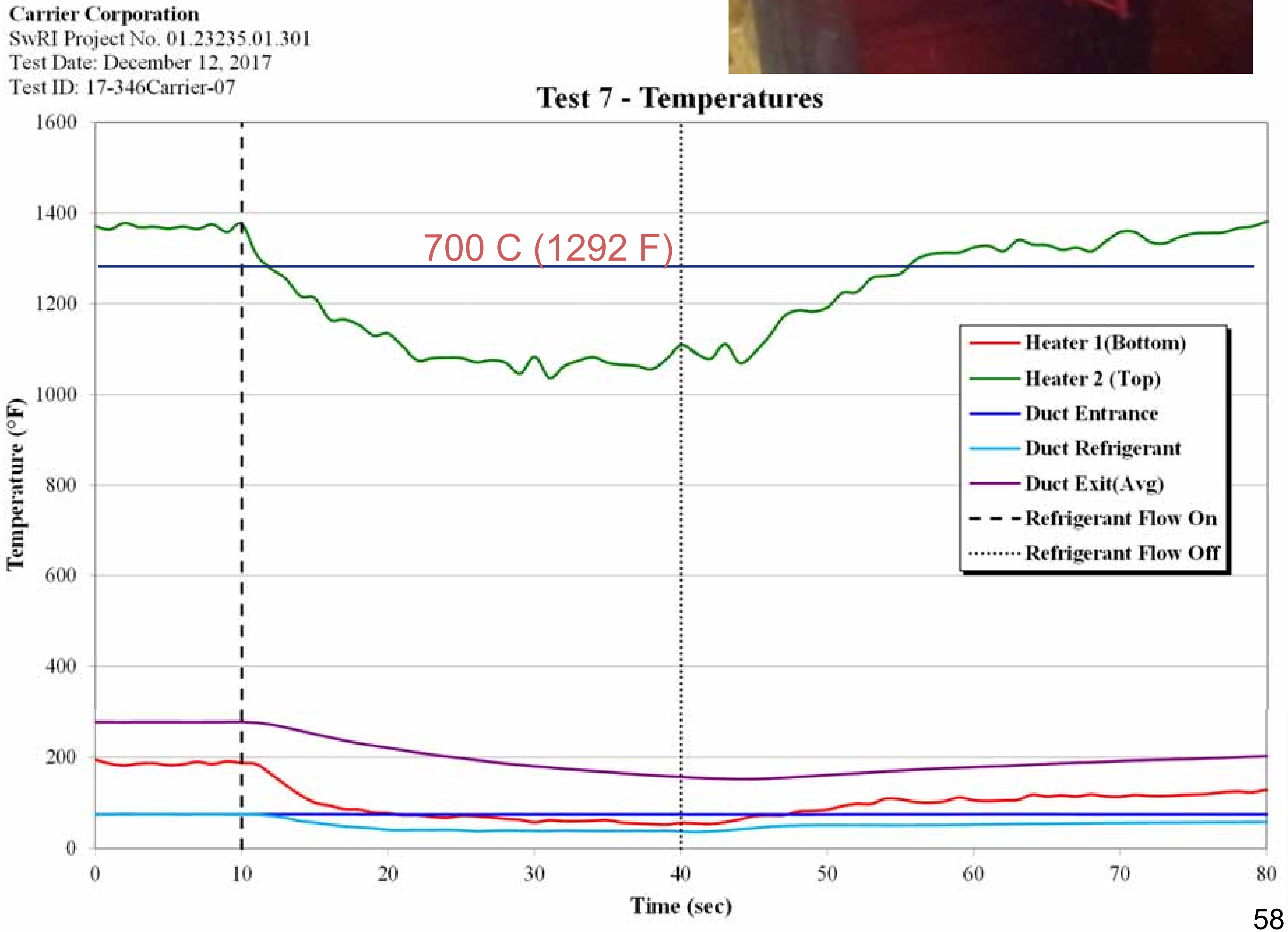
Test Setup



Carrier Electric Heat Test Rig for Evaluation Electric Heat with A2L Refrigerants R32 and R452B

Test 7 Analysis

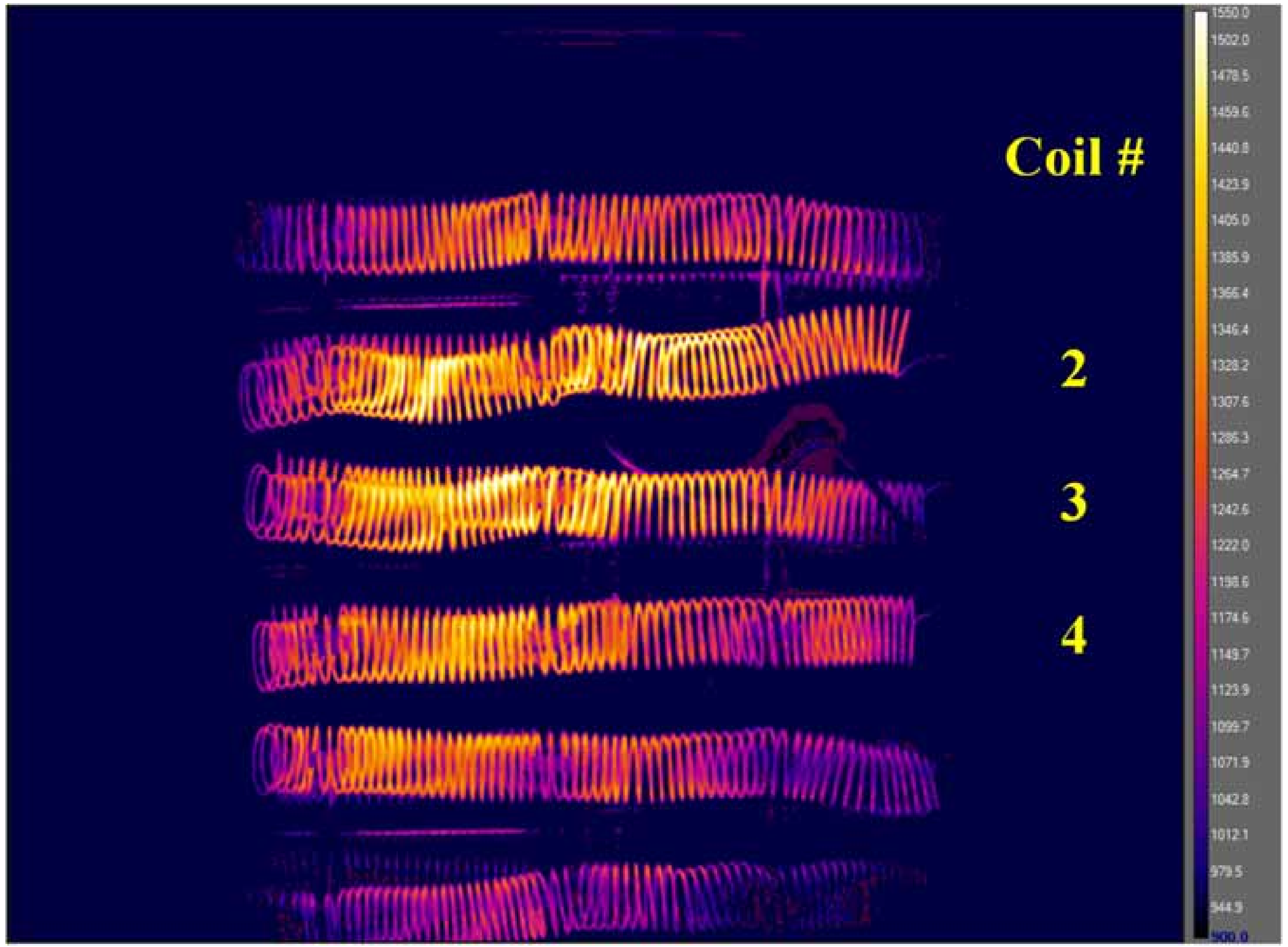
- Refrigerant = R-32
- Heater Voltage = 223.7 V
- Heater Current = 56.4 amps
- Heat Power = 14.5 kW
- Airflow = 198.4 CFM (below limits)
- Specific Airflow = 164.1 CFM/ton
- Leaving air temp = 200.8 F (at UL limit)
- Heater max temp = 1553 F
- Leak Rate Start = 10 second
- Leak Duration = 30 seconds
- Leak Amount = 7 lbs.
- Leak Rate = 14 lb./min
- Average Concentration = 20.1%
- FTIR Peak Concentration = 24.1%
- LFL = 14.4%
- UFL = 29.3%
- **No refrigerant ignition**
- **No HF measured**

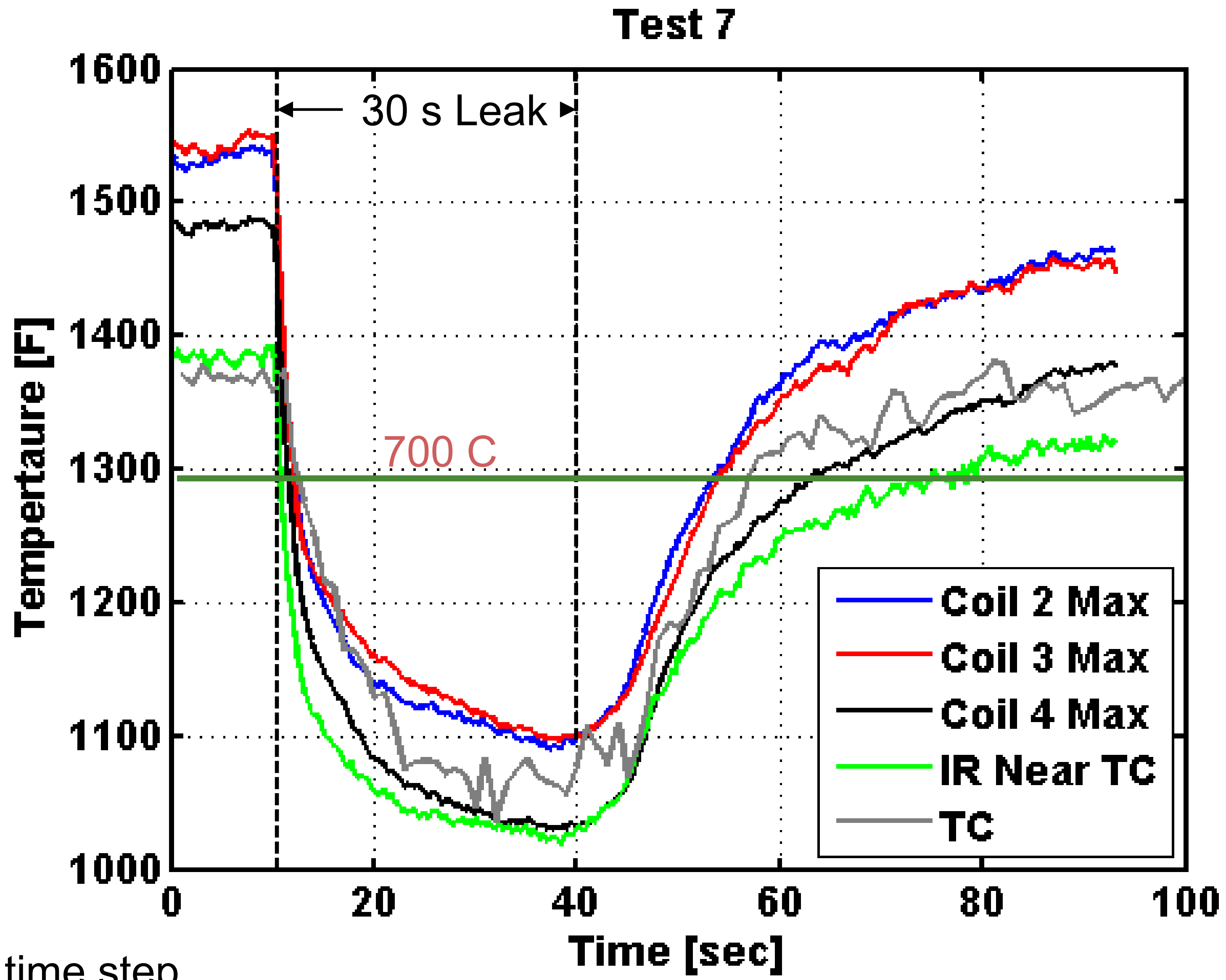


Test 7 Infrared Camera Analysis

Data represents maximum coil temperature with time

Assumed emissivity=0.98 because of coil oxidation with extended times at high temperature.





Determined maximum temperature of heater coils 2-4 for each time step.

AHRTI Project 8028 Fire Exposure Testing

- One significant area of concern with the use of A2L refrigerants raised by industry codes and fire services was the impact A2L refrigerants could have on building fires both inside and outside the building and the safety of people and fire personnel
- The fire service requested that data be developed to identify hazards to the fire service personnel when responding to fire events in occupancies with the new refrigerants.
- Specifically, they have identified the following areas where performance data of A2L refrigerants would assist them in their tactical considerations.
  - Comparison and contribution of A1 and A2L refrigerants in a fire relative to heat and gases generated;
  - Potential for flash fire, deflagration, or explosion hazards in residential and commercial applications; and
  - Influence on fire dynamics from refrigerant leakage during fire service suppression and overhaul activities.

A2L Refrigerants and Firefighter Tactical Considerations

February 2021

AHRTI Project. 8028

Prepared by

UL LLC

333 Pfingsten Road,

Northbrook, Illinois 60062 USA

Prepared for

AIR-CONDITIONING, HEATING AND REFRIGERATION TECHNOLOGY INSTITUTE, INC

2311 Wilson Boulevard, Suite 400, Arlington, Virginia 22201-3001

Based on this AHRI and Fire Services commissions a project to evaluate the impact of A1 and A2L refrigerants in building fires

There details on the test results can be found in the AHRTI Project report and there is also a detailed Fellows Technical talk

UL FSRI Background

- The testing was done by the UL Firefighter Safety Research Institute at their facilities in Northbrook Chicago https://ulfirefightersafety.org
- FSRI is a separate organization within UL and is separate from the UL that we work with for equipment safety qualification.
- UL Firefighter Safety Research Institute (FSRI) advances fire research knowledge and develops cutting edge, practical fire service education aimed at helping firefighters stay safe while more effectively protecting people and property.   They have a very strong link to the US Fire Marshals
- Working in partnership with the fire service, research departments, and agencies, UL FSRI executes firefighter research and makes the results widely available to the global fire community.
- With a team of pioneering experts and access to UL's leading infrastructure, equipment, and vast knowledge and insights, UL FSRI conducts and disseminates research and training programs focused on the changing dynamics of residential, commercial, and industrial fires and the impact they have on strategies and tactics throughout the fire service.

If you every need fire testing UL is a good source and there is also Southwest Research which we have found to be lower cost than UL and is where Carrier testing has been conducted

Test Scenario's

- It took over 3-4 months to define the testing to meet the requirements of the Fire Service Organizations but to be something that could happen in a real-life building
- Test plans were finalized in June of 2020 and occurred in Nov-Dec 2020
- A lot of the testing done to date by AHRI, and others have been extreme testing to understand the flammability characteristics of A2L refrigerant in order to develop mitigation requirements for standards like UL/IEC60335-2-40, ASHRAE 15, ASHRAE 15.2, ISO 5149, EN-378 and others
- The following 5 test scenarios were defined;

1. Comparison and contribution of A1 and A2L refrigerants relative to heat and gases generated in an open flame.
2. Hazards during suppression activity from change in fire dynamics in the hallway where firefighters may be advancing towards the fire room with a forced refrigerant release in ventilation-controlled conditions.
3. This scenario was planned as optional pending a review of Scenario 2. The difference between Scenario 2 and Scenario 3 is that the leak would not be forced as in Scenario 2.
4. Hazards in fire room during overhaul activity if firefighters action results in a refrigerant line break.
5. Fire conditions in a below grade closed room without any air movement, having an excessive amount of refrigerant pooling, well above the allowable limits of refrigerant to demonstrate how refrigerant burns when ignited with a flame.

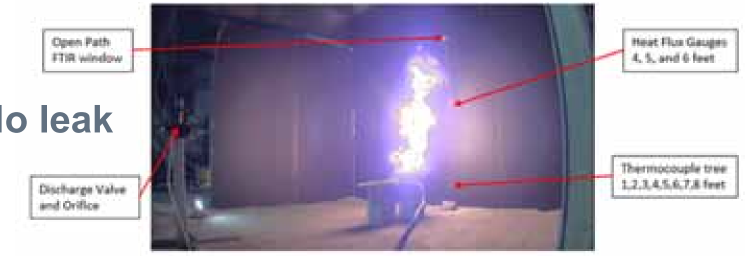
In the end scenario 3 was not run but scenario 5 was added during the testing of scenario 1 and 2

UL Fire Research Testing Highlights

Refrigerant exposure to open flames

(refrigerant injected into a 120 kW open flame)

No leak



R-410A (A1)

R-454B (A2L)

R-466A (A1)

Results

Suppressed flame

Generation of equivalent amounts of **hydrofluoric acid (HF) for both R410A and A2L**

Minimum increase in incremental energy release

R-466A emissions of iodine

Building Fire Test

Results

No visible difference for A1 vs A2L

Small increase in fire energy increase +40 kW vs 2200 kW

Temperature (+1530 F) high enough to melt coil and release refrigerant (safe failure)

Note: Aluminum melts at 1221 F

Test Facility

- Testing was done in one of the UL fire test room as shown in the first picture
- For test series 2 thru 5 a custom designed test house consisting of two rooms that were 14 ft x 14 ft
- The rooms were designed to simulate and oxygen deprived fire in a room where the fire personnel would access the fire thru a hallway where the fire is deprived from oxygen
- The temperature in the hallway would be higher at the top of the hallway
- Approach was to run baseline tests with A1 and then with various A2L options

UL Test Room

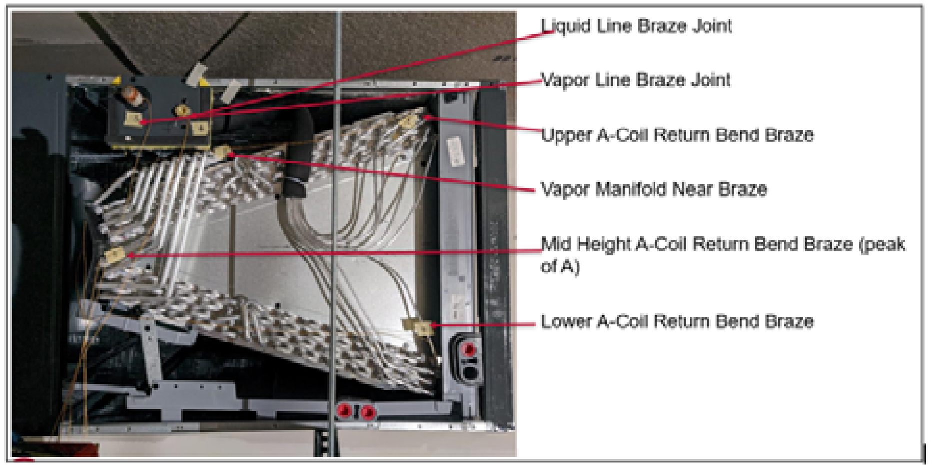
Special Test House

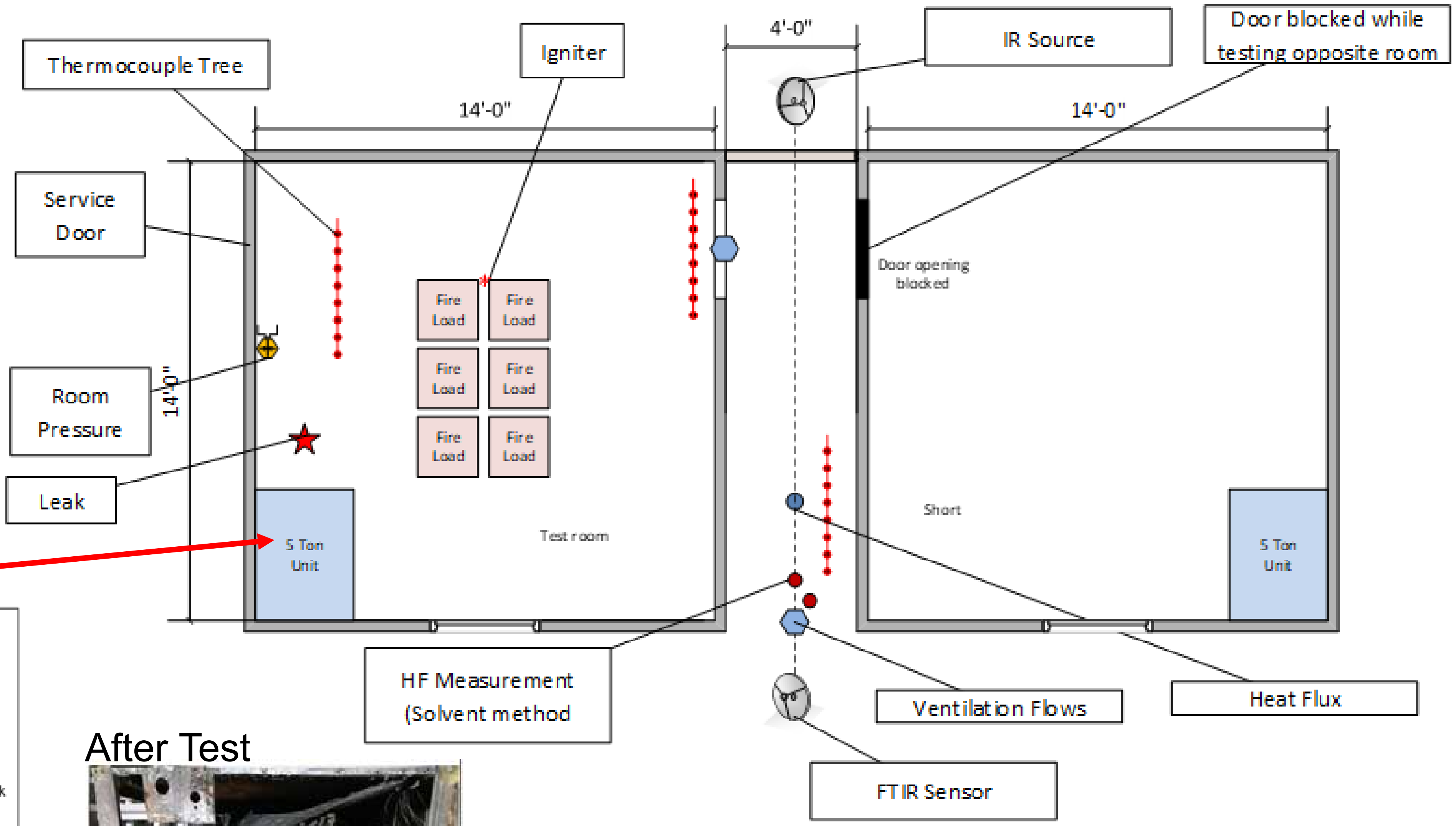
Test Room Configuration

Test consisted of a room fire simulating a couch fire with about 2,3000-2500 kW with a peak 6500 kw Energy Release

After the fire was established the fan coil was allowed to heat to a point where the refrigerant was vented into the room and the fire

The incremental temperatures in the room and the hallway were measured





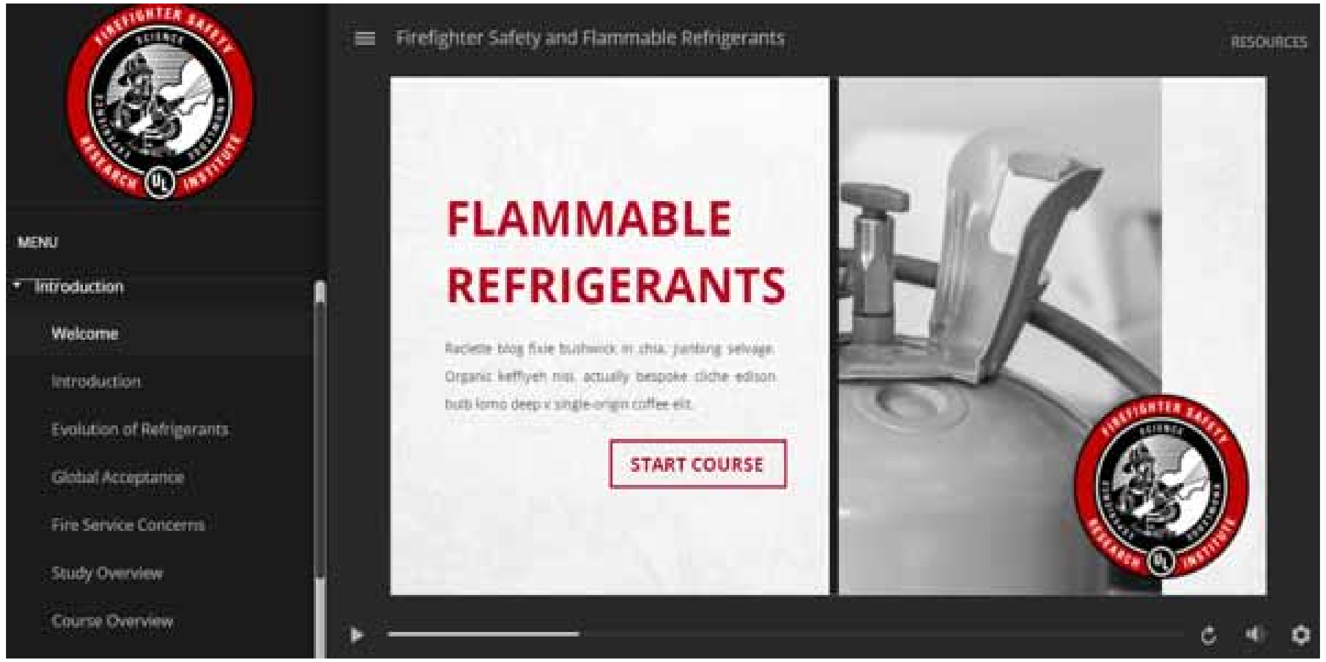
After Test

Summary Results

- The compartment fires were ventilation limited when compared to the free burn of the same fuel load. The compartment fires peaked in the range of 2,300-2,500 kW, while the free burn peaked at 6,500 kW.
- There were **no significant differences in the heat release rates** (comparing baseline to refrigerant release tests) as the differences were within the measurement uncertainty at this level of HRR. A value of an incremental energy release of 20 kW was measure.
- There was no significant difference in heat flux in the hallway when comparing the release tests with the baseline test without any refrigerant released.
- Temperatures at the floor level in the hallway entrance remained at ambient conditions due to the influx of air caused by ventilation limited conditions.
- Temperatures at the air handler were sufficient to melt aluminum which would have resulted in a catastrophic leak so it was concluded that test 3 need not be run
- **Hydrogen fluoride (HF)** measurements for the outside release were about the same when comparing R-410A to R-32. The measurements for the R-32 inside release were 5 to 40 times larger than either of the two outside release tests.

Communications and Training

Building fire training



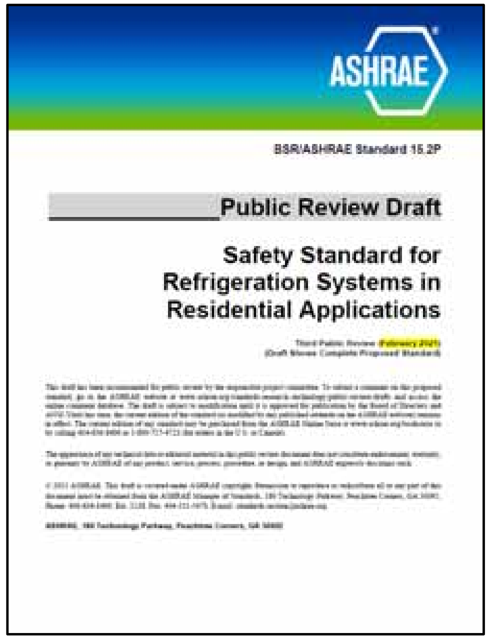
- Industry webinars
- UL FSRI training
- CAL fire outreach
- AHRI NATE training
- Service outreach
- ASHRAE webinars
- Code approvals (IBC, IRC, IAPMO)

Industry education initiatives

Future Refrigerant Changes

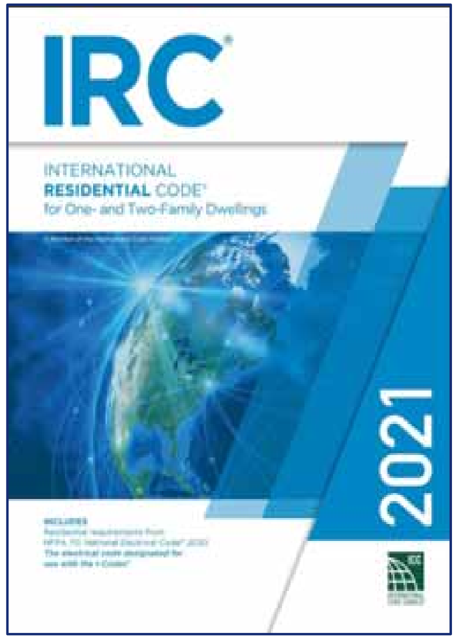
- The next phase down in 2030-2032 is going to be even more challenging as we are required to move to lower GWP refrigerants
  - Even more use of A2L refrigerants, and likely some A3 refrigerants like propane
  - Refrigerant mixtures with higher glide (challenge for equipment design and service)
- This will require similar research as we did for A2L's
- AHRI, DOE and Industry have started work on evaluation of the use of Natural A3 refrigerants are are routinely having workshops
  - Likely will require change to indirect systems (ie. chilled water)
  - New risk assessments and mitigation
  - New flammability testing
  - New technology
  - Working closely with fire service organizations

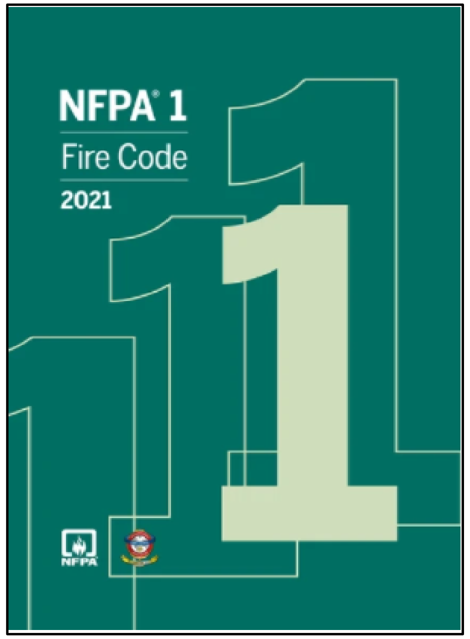
Standards



SAFETY STANDARDS AND CODES

Building Codes





Codes and Standards

- Unlike in the past refrigerant changes, we had to address flammability, but with a focus on A2L lower flammability
- This required extensive research and development of new modified standards and codes
- Knowing that we had to switch to A2L refrigerants as the options for A1 would not allow GWP selections for R-410A below 700.
- This also impacts shipping and extensive work has been done with DOT and shipping permits
- In addition, significant training is underway for service and installation training
- This has taken over 15 years of work and regulatory changes.
- Some standards like ASHRAE 15 have been revised, but other new standards like UL60335-2-40 are new to the US and ASHRAE 15.2 has been created as a simplified version of ASHRAE 15

If we changes to A3 (i.e. Propane) additional changes will be required to codes and standards

NAO HVACR Standards and Codes Dashboard

Revisions to Support **2L,** 2 & 3 Refrigerants

Complete | Under revision | No Activity | Under revision | ★ Will cover in this report

Refrigerant Phasedown Standards/Regulations

US Specific

- Kigali Agreement (GWP) — 163 Countries approved Kigali US AIM ACT
- ASHRAE 34 Designation and Safety Classification of Refrigerants — 2024 Published New refrigerants
- EPA SNAP Significant New Alternatives Policy Program (20,21,23, 608) — Kigali AIM ACT Rule 22, 23, 25, 26
- States State HFC Regulations — Rule 21, 22 NY State

on-going

Canada/Mexico

- Kigali Agreement (GWP) (CA & Mexico have approved) — Approved Canada and Mexico, but no regulations
- ASHRAE 34 Designation and Safety Classification of Refrigerants — 2022 Published New refrigerants
- ★ Country & Provincial Regulations — Environment Canada regs in development Mexico Developing Country?

on-going

Safety Standards

Equipment

US:

- ★ UL 60335-2-40 3rd, 4th, Adm 1 Heating and Cooling Equipment — 4th Amend-ment 1
- UL 60335-2-89 Commercial Refrigerators & Freezers — Published
- UL 60335-2-24 Ice Cream Makers — Published
- ★ ASME Section VIII Pressure Vessels — Eliminating exceptions <6 in & waterside on hold

2018-2022

Canada/Mexico:

- CSA 22.2 No 236-19 (binational) Heating and Cooling Equipment — Tied to 2-40
- UL 60335-2-89 (binational) Commercial Refrigerators & Freezers — Published
- ★ IEC60335-2-40 7th Heating and Cooling Equipment — Mexico using IECC

2014-2018

Application

US:

- ★ ASHRAE 15 Safety for Commercial Refrigeration Systems — 2024 Published
- ★ ASHRAE 15.2 Safety for Residential Refrigeration Systems — 2024 Published
- ★ DOT Transportation Standards — US Special Permits Approved
- NFPA 55, NFPA 85 Cylinder Storage — Completed

2018 -2022

Canada/Mexico:

- ★ B52 Safety for Commercial Refrigeration — Approved\ 12/2023
- Transport Canada — Equivalency permits but issues
- Transport Mexico — Hazmat >12 kg

2018-2019

Building & Other Codes

US:

- IMC - International Mechanical Code
- IRC - International Residential Code
- IBC - International Building Codes
- IFC – International Fire Code
- UMC - International Mechanical Code
- NFPA 1 - Fire Code
- NFPA 90A, 90B – Installation of HVAC

2024 Published 2027 Cycle Started

2024

Canada/Mexico:

- National Building Codes of Canada (NRC) — Last revised in 2015
- Mexico Building Codes (appear to use US codes) — Appear to using IEC but not clear

2022-2024

Local Codes

US:

- ★ State, County & City Building Codes (i.e. CBC California) — A2L modifications (training
- Insurance Company Rules (likely no revisions required) — Likely not an issue for A2L but could be an issue for A3

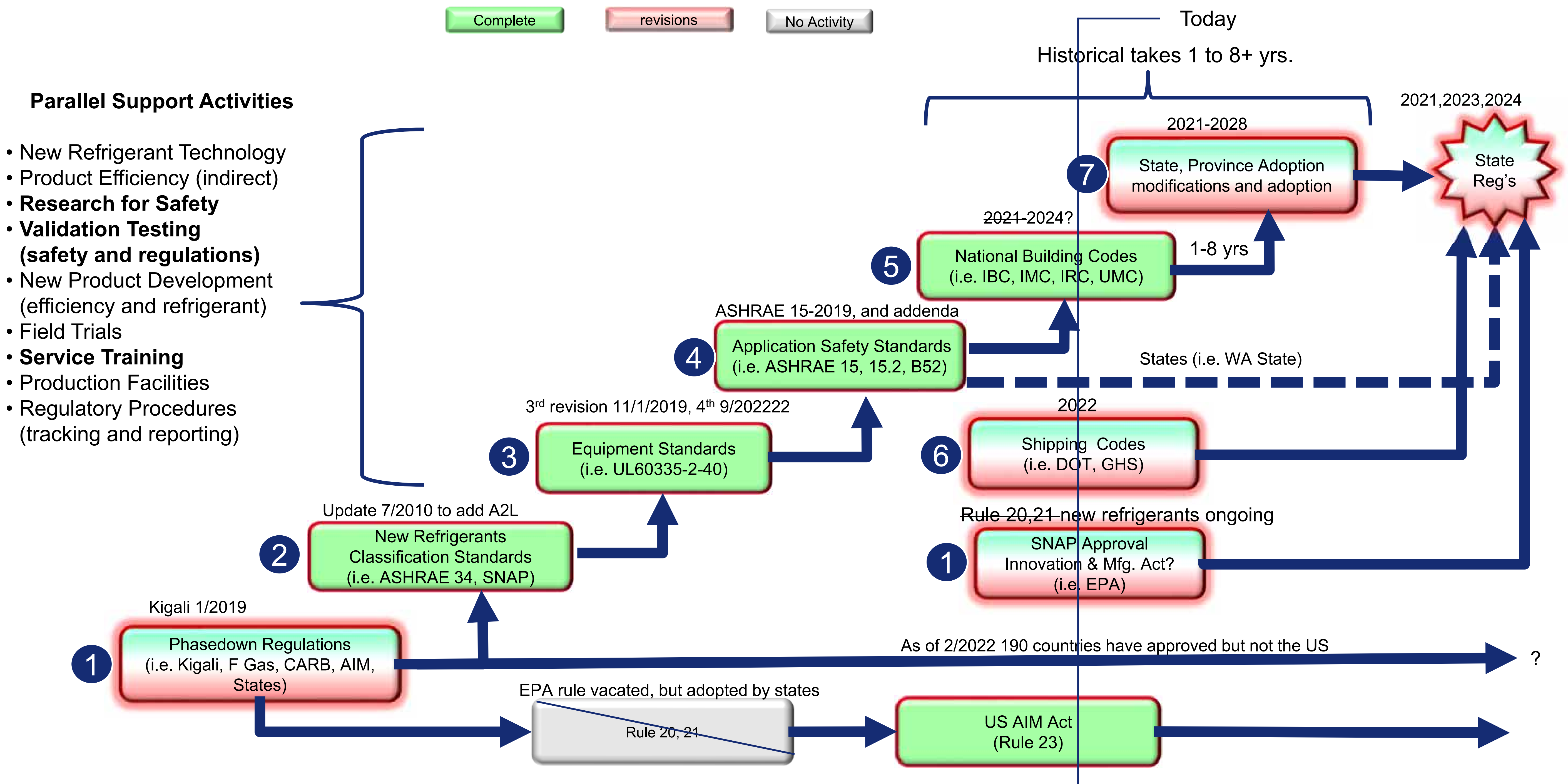
2020-2025?

Canada/Mexico:

- Local Building Codes? — AHRI working to help implement B52
- Insurance Company Rules Likely no revisions required — Likely not an issue for A2L but could be an issue for A3

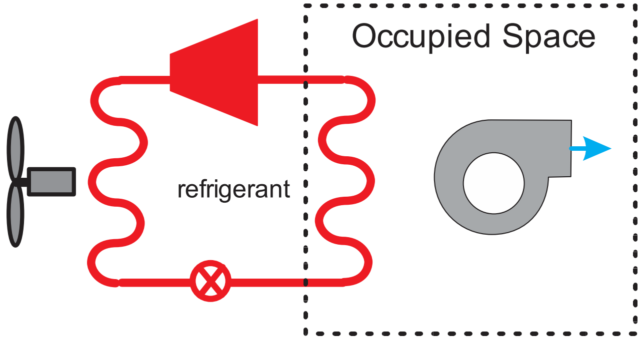
2022-2028?

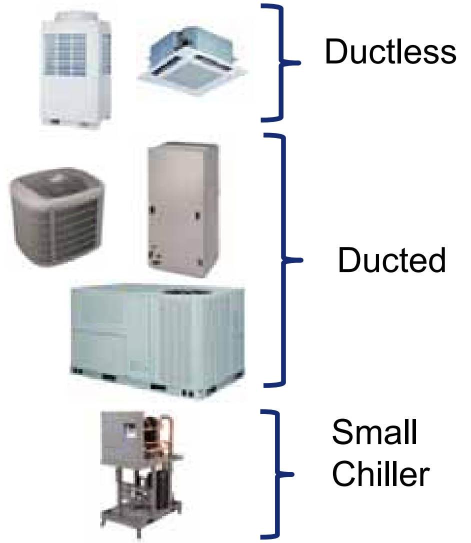
US A2L Standards and Codes Revision Process



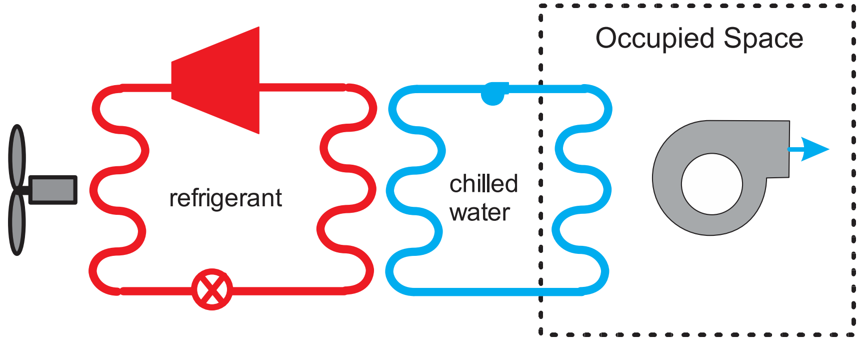
Safety Standard Application Classifications

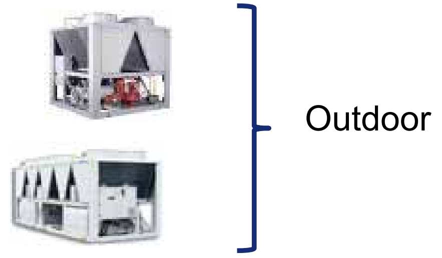
Direct System
Refrigerant can leak into the occupied space
(Residential & Light Commercial)

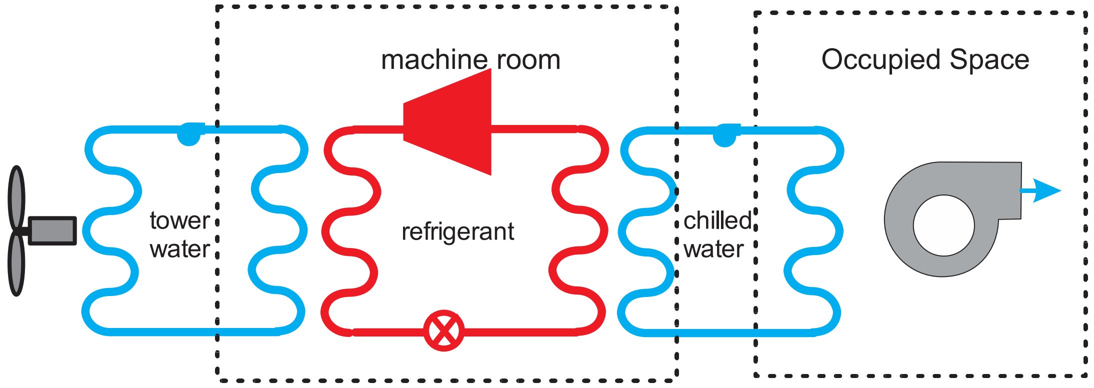


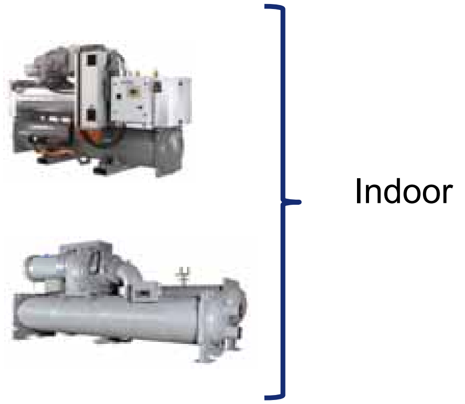


Indirect Systems
Refrigerant Leak Isolated by secondary loop Equipment outdoors or in a machine room
(Chillers)









Standards and Codes Interactions

3

Model Building Codes

US - IAPMO, ICC (IBC, IRC) and NFPA Codes US

Canada – NBC

Mexico - ? Only 7% of municipalities have building codes

4

State, Province and City Adoption

sometimes locally modified

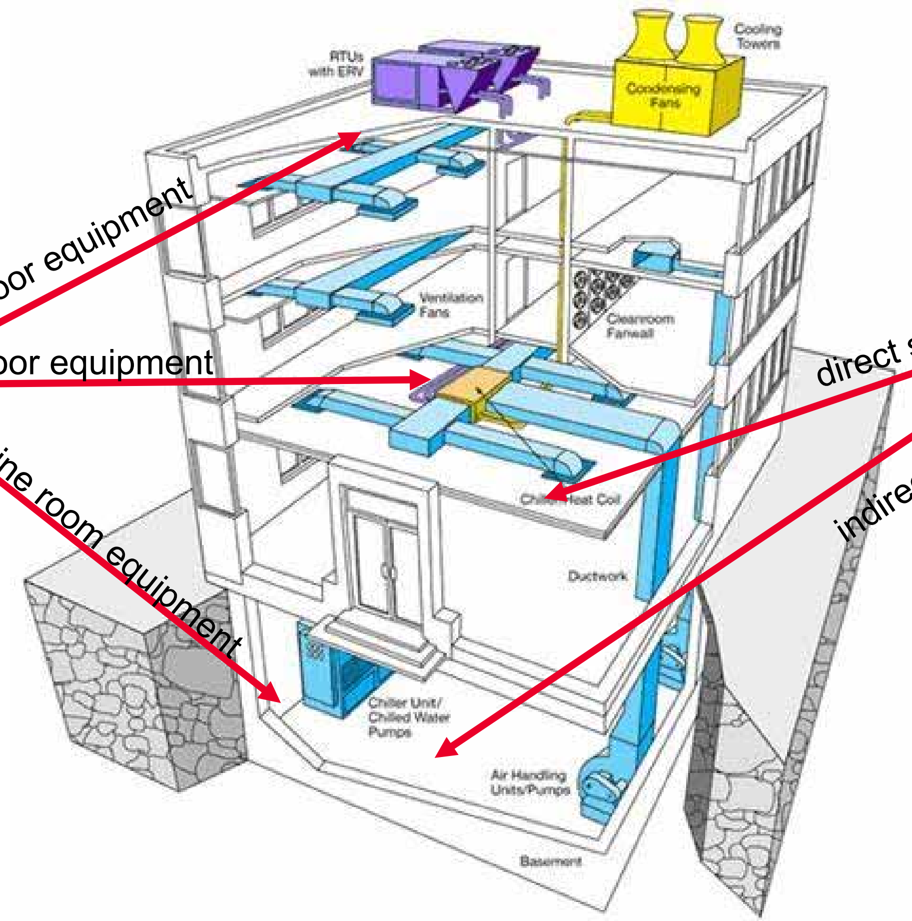
1

Equipment Standard

UL 60335-2-40/C22.2 (HVAC)

UL60335-2-89/C22.2 (Refrigeration)

ASME



outdoor equipment

indoor equipment

machine room equipment

direct system

indirect system

2

Application Standards

ASHRAE 15 (US commercial)

ASHRAE 15.2 (US residential)*

B52 (Canada – All)**

Mexico??

- ASHRAE 15.2 not being used by 2024 Building codes

** B52 include residential, commercial and ammonia

not totally harmonized and some overlap

1

NAO EQUIPMENT STANDARDS

(UL60335-2-40, 4TH EDITION)

UL 60335-2-40

STANDARD FOR SAFETY

Household and Similar Electrical Appliances – Safety – Part 2-40: Particular Requirements for Electrical Heat Pumps, Air-Conditioners and Dehumidifiers

HVAC Equipment Safety Standards – UL60335-2-40

- In the US and Canada, the primary standard for equipment is the **by-national UL60335-2-40 4th edition (C22.2 in Canada**)
- As of 1/1/2024 it replaced UL1995 which has been sunset except for existing units (any change to an existing unit will require changing to UL60335-2-40)
- **UL60335-2-40 is based on the IEC60335-2-40** but there are significant US and Canada regional deviations including an expanded scope to cover voltages up to 13 KVA vs IEC which is limited to 300 volt.
- UL60335-2-40 is now required for products and recently was updated to the 4th edition which was published in Dec 2023
- There were significant changes to the 4th edition from the 3rd edition to support results of research and further changes to support **A2L refrigerants especially for sensors and mitigation requirements**
  - The UL60335-2-40 committee has completed amendment 1 to the 4th edition which will be published later this year
  - The primary focus is on Annex LL for sensors, but the amendment also addressing other miscellaneous changes
- UL60335-1, 2016 version has been under revision and was released for comment review. Comments are now being addressed.
- The revision to UL60335-1 and other issues will likely result in a 5th addition UL60335-2-40 effort starting in 2025-2026

Key Concepts in HVAC Standard UL 60335-2-40

UL60335-2-40 is a complex standard for the design and qualification of equipment

Limit Refrigerant Charge

Refrigerant Charge Limits
(UL60335-2-40 Annex GG 1.2)
m1, m2, m3
R32 m1=4.1 lbs., m2=26.8 lbs., m3=134.1 lbs.
R-454B m1= 4.0 lbs., m2= 26.0, m3=130.2 lbs.
Limit A2 and A3 to <m1 charge

Minimum Area Check (A_{min})
(UL60335-2-40 Annex GG)

- Safety factor of 0.50 (50%)
- Gravity equation or mixed equation

Reduce Refrigerant Leaks

Section 22 and 101.DVG Refrigerant Piping

- Protected lines
- Qualified joints (ISO 14903)
- Field pressure test
- Additional requirements for VRF

Eliminate Ignition Sources

Ignition Source Isolation

- Per Annex FF

No Competent Ignition

- Sources in unit and ducts
  Per 22.116, Annex KK, 22,117

Detect Leaks & Take Action

Factory Installed Refrigerant Detection System

- UL60335-2-40 Annex LL, Annex MM
- UL qualification testing
- UL approved
- Factory Calibrated
- Self Test Routine (1once/hr.)
- Fail safe mode with fan on
- Field inspection feature

Active mitigation for leaks
Detect, circulate and dilute
Annex GG

Install and Service

Service Training
Annex DD installation guidelines
Annex MM repair of leak detection system

Labeling and Literature
Per UL60335-2-40 Section 101, Annex DD

Will require new procedures and checks for installation

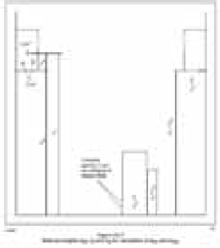
Also aligned with ASHRAE 15, and new ASHRAE 15.2

Safe Application of A2L Refrigerants Summary

UL60335-2-40 4th Edition Summary for a **<u>Ducted Unit</u>** A2L Refrigerant Requirements

Minimum Area Check (A_{min})
- Safety factor of 4
- Or safety factor of 2 with additional measures
- Per Annex GG

7



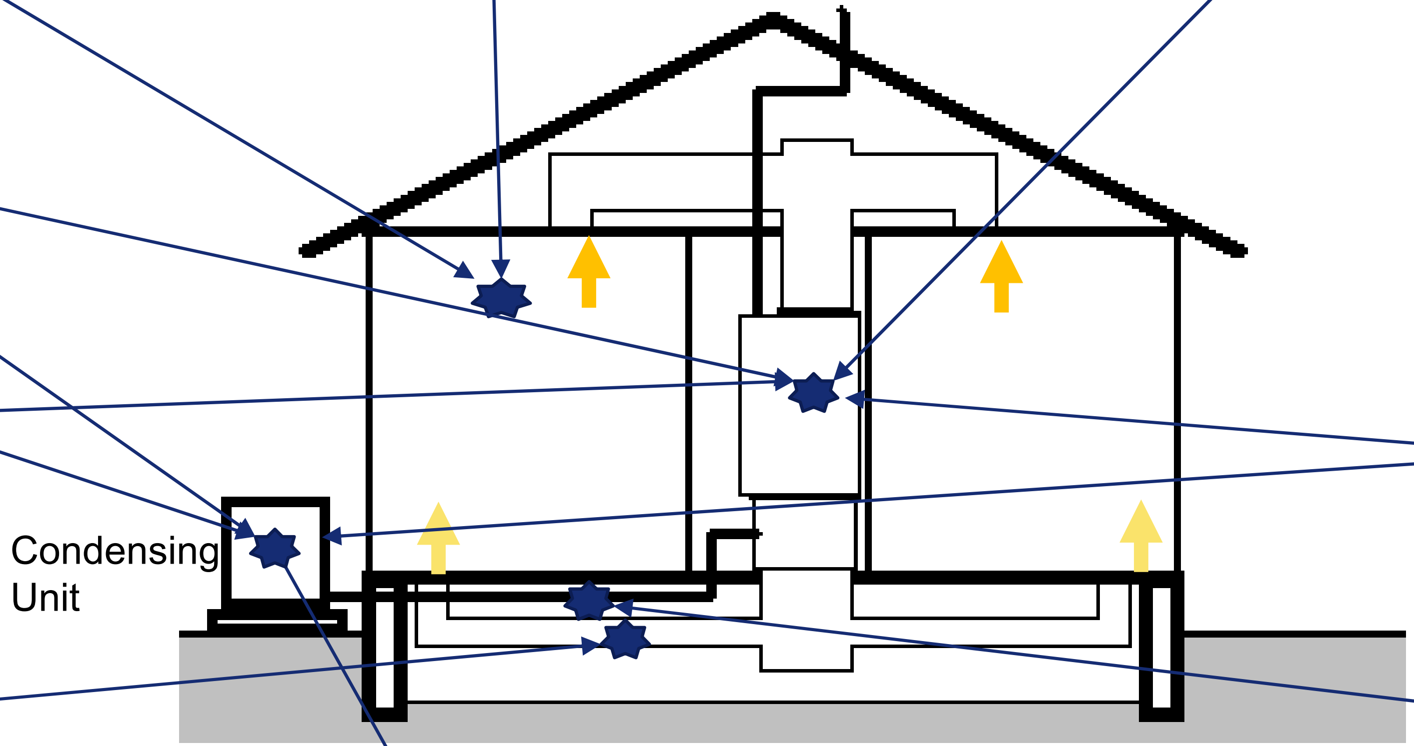
6

Active mitigation for leaks
detect, circulate and dilute
Annex GG

5

Factory Installed Refrigerant Detector <u>if required</u>
- UL60335-2-40, and Annex LL, Annex MM
- UL qualification testing
- UL approved
- Factory Calibrated
- Self Test Routine (1once/hr.)
- Fail safe mode with fan on
- Field inspection feature

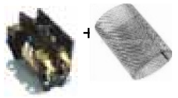
Residential Down Flow
Air Conditioners with Gas Heat



Service Training
and Education Annex DD

8

Ignition Source Isolation
Per UL 60335-2-40 1
Annex FF



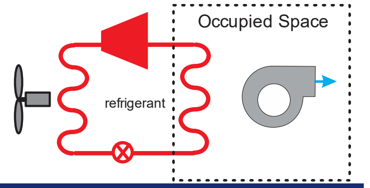
4 **Labeling and Literature**
Per UL60335-2-40
Per 101, Annex DD

No Competent Ignition 1
Sources in unit and ducts
Per 22.116, Annex KK, 22,117

2 **Refrigerant Charge Limits** (UL60335-2-40)
m1, m2, m3 per Annex GG1.2
R32 m1=4.1 lbs., m2=26.8 lbs., m3=134.1 lbs.
R-454B m1= 4.0 lbs., m2= 26.0, m3=130.2 lbs.

3 **Refrigerant Piping** (UL60335-2-40)
Per 22.116, 101.DVG
- Protected lines
- Qualified joints (ISO 14903)
- Field pressure test
- Additional requirements for VRF

A2L Refrigerant Requirements - Direct Systems



Product and Application Requirements (UL60335-2-40/CSA 22.2, ASHRAE 15.2, ASHRAE 15, B52, EPA)

Application Refrigerant Charge Limits/circuit

A3 limits to 114 g (m1)

Limit	Equation	R--32	R-452B
<m1	=3 or 6*LFL	2 or 4.1lb	2 or 4.0 lbs.
<m2	=52*LFL	35.1 lb.	34.7 lbs.
<2 x m2	=104*LFL	70.1	69.5 lbs.
>m3	=260*LFL	175.4	173.7 lbs.

- All Systems → No sensor requirements or area check, but other requirements still apply
- Appliances → A_{min} = (mc / (2.5 x (LFL)5/4 x ho)^2 , not less than A = mc / (SF x LFL x ho)
- Ductless → $A_{min} = m_c/(0.50 \times LFL \times h_0)$
- Ductless<35kW Multisplit → sensor and $A_{min} = m_c/(0.50 \times LFL \times h_{ra})$
- Ducted → sensor and $A_{min} = m_c/(0.50 \times LFL \times H)$
- Ducted/Ductless → Sensor External Mechanical ventilation

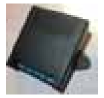
Check A_{min}
Validation Testing
Labeling of h_o
Room connection

(New Cylinder colors AHRI Guideline N and AHRI Guideline G for fittings left hand threads for flammable)

New Reclaim

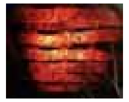
LH Threads

Refrigerant detector above m1 for ducted and circulation m2 or <Amin VRF in unit



Indoor airflow verification for electric heat (only if no refrigerant detector)

Hot surface limit of <700 C Except for heat with sensor or airflow verification



Tubing protection for exposed piping greater than 6.6 ft.

Red pantone service port (EPA Requirement)

Field Piping Design, (joints, protection) & Pressure proof test

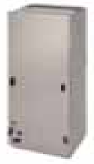
Direct System Product Type

Packaged Rooftop

Commercial Condensing Units

Indoor Packaged

Small Chiller



Fan coil/AHU

Residential Condensing Unit

VRF

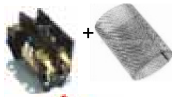
WSHP

Laboratory Upgrades (Manufacturers and Certification)

Production Processes

Warehouse and Shipping (DOT/GHS)

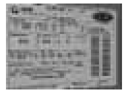
Safety / circulation control and unit interlock (UL Safety Circuit)



Ignition Source Flame arrestors or control box qualification

A2L

New Warming labels on units and packaging



Amin, h_o and charge tracking on unit nameplate

Isolation valves for multiple evaporator systems (VRF) Also additional requirements options per 101 DVG.2

Refrigerant Relief requirements

New service requirements and procedures

Training, Literature and Technician Certification? (Nate, HRAI, ACCA)

Refrigerant Sensors/Detectors

- **Refrigerant detectors/sensors** are a key part of the new standards requirements for A2L
- UL60335-2-40 as well as ASHRAE 15 have developed new comprehensive requirements for sensors and detectors which require new qualification and certification, but the basic sensor technology is the same as used in machine rooms and other industrial application and are being used in Japan and Europe
  - The **Sensor technology** is the basic sensor that is used to measure refrigerants and other gases like CO in homes
  - **Detector** is the new hardware containing the logic and controls that have been developed and defined as part of the new UL60335-2-40 requirements.

Refrigerant Sensor

Refrigerant Detector

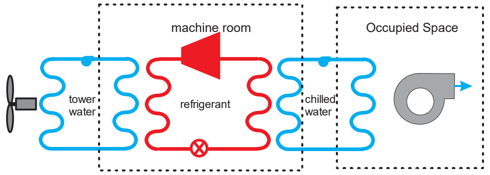
- Key features of the detector package are;
  1. Detectors must be **factory installed** on all direct system units with a charge above m_1
  2. Unlike a smoke detector that sound a passive alarm, the UL60335-2-40 standard requires detectors to have **active mitigation** by turning on the indoor fans, to mitigate refrigerant leaks via dilution and in some cases ventilation
  3. The standard requires, at a minimum, indicating sensors that detect and take action, but do not have to have readouts and alarms.
  4. The detector and mitigation will be **inspected and tested per the requirements annex LL and annex MM** for HVAC applications (IEC60079-29-1 is no longer being used).
  5. Refrigerant-specific setpoint is **factory set and sealed**, with no field adjustment permitted but internal calibration software routines are allowed.
  6. Setpoint and location are **validated by UL60335-2-40 testing (annex MM)**
  7. Must have alarm output

Refrigerant Sensors/Detectors

Key features of the detector systems (continued):

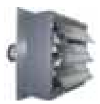
8. Must **respond in 30 second** when exposed to 25% of LFL per UL60335-2-40
9. Must comply with UL60335-2-40 annex MM simulated leak test for set point confirmation and demonstrate measured LFL below set point in less than 90 sec for the enabled mitigation system
10. **Self-test protocols** are requested that run every hour to ensure proper operation and function.
11. In the event of **detector failure, indoor fan activates** and maintain a required airflow to prevent flammable concentrations forming is initiated. As noted earlier once there is airflow it is not possible to get to a flammable concentration level. This fail-safe mode is maintained until the detector is replaced.
12. Routine factory inspections will be conducted by UL as part of the listing requirements.
13. Detector markings identify the manufacturer and refrigerants used.
14. Testing is required to determine sensor/detector accuracy vibration, range, setpoint verification, and response time
15. Sensors and detectors must pass **long term durability, stability and reliability requirements**,
16. Poisoning test exposure required for common fluids, as defined in UL60335-2-40 annex LL, seen in buildings.
17. Oil exposure testing
18. If the detector has a defined life and requires replacement after a given period, the detection system shall initiate an alarm or indication that replacement is required.

A2L Requirements Indoor Indirect Systems

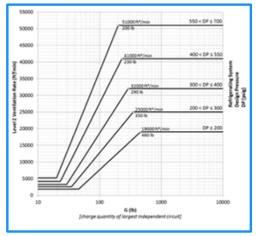


Product and Application Requirements (UL60335-2-40/CSA 22.2, ASHRAE 15, B52, EPA)

Revised/Increased machine Room Ventilation as a function of charge

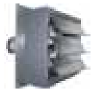


ASHRAE 15-2019



ASHRAE 15 addendum h increased ventilation as a function of charge, but being modified again by addendum Q

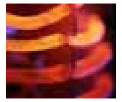
Safety / ventilation control interface and Inspection

Machine room requirements access controls, alarms, ventilation

Refrigerant sensor (already required for A1)

Hot surface limit of <700 C



New Warming labels on units and packaging

A2L

Flame arrestors or control box qualification for units and machine room

 + 

Machine Room Indoor Indirect Product Types

Routine inspection & Leak checking, CARB EPA Rule 608 >50 lbs.

Laboratory Upgrades

LH Threads New Reclaim

(New Cylinder colors AHRI Guideline N and AHRI Guideline G for fittings left hand threads for flammable)

Red pantone service port (EPA Requirement)

No open flame combustion

Machine Room Electrical Protection

Relief valves vented outdoors and refrigerant relief on waterside

Production Processes

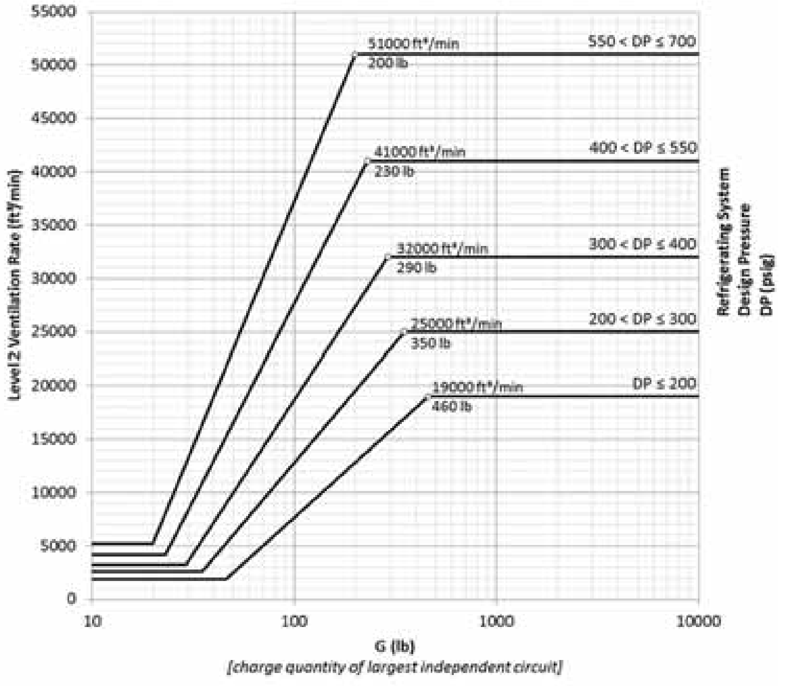
New service requirements and procedures

Training and Literature Machine Room Guidelines (NATE, HRAI)

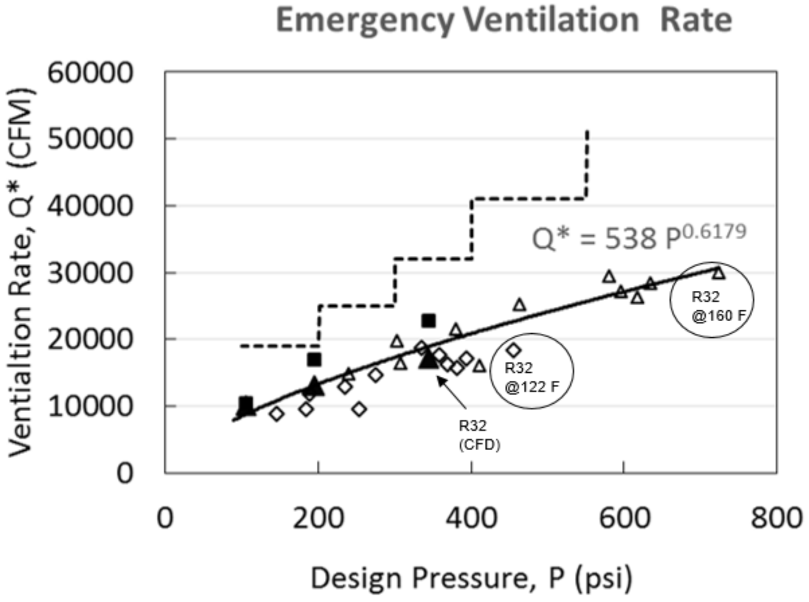
Machine Room Ventilation

- Sensors and ventilation are already required for all machine rooms even with A1 and following the requirements of ASHRAE 15 for US and EN 378 in Europe
- The requirements for ventilation in ASHRAE 15 are based on 100* $G^{0.5}$ which was developed many years ago but is not based on any testing or analytical studies
- UTRC/Carrier did considerable CFD work, which was validated by testing to develop a new correlation for use with A2L refrigerants
- This was submitted to ASHRAE 15 as a code change and they adopted the concept, but in implementation made some mistakes in section 8.11 and in the graphs that are in ASHRAE 15-2019
- We have found that the implemented requirements over-ventilate by as much as 3X
- We have developed a modified proposal and have submitted it as a CMP change proposal to ASHRAE 15 and they are currently evaluating making change and will release it
- At this point Europe, in the ISO 5149 standard has not modified the ventilation requirements but we continue to push them to make modifications to the current equation which is a function of $G^{2/3}$

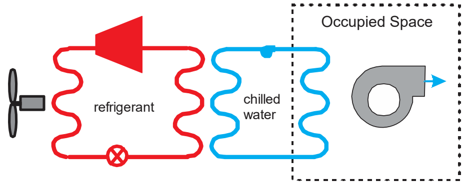
ASHRAE 15-2019 Requirements



Modified Proposal



A2L Requirements Outdoor Indirect Systems



Likely Product Impacts (UL60335-2-40/CSA 22.2, ASHRAE 15, B52, EPA)

No charge limits

(New Cylinder colors AHRI Guideline N and AHRI Guideline G for fittings left hand threads for flammable)

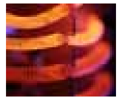
New Reclaim

LH Threads

No ventilation requirements

Refrigerant sensor (not required)

Hot surface limit of <700 C



New Warming labels on units and packaging

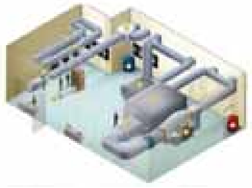
A2L

refrigerant relief sizing for waterside to be able to handle refrigerant

Outdoor Indirect Systems

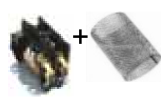
Routine Inspection & Leak checking Section 608 and CARB

Laboratory Upgrades



Located 20 ft from building intake (ASHRAE 15)

Red pantone service port (EPA Requirement)



Flame arrestors or control box qualification for units

Production Processes

New service requirements and procedures

Training and Literature & Machine Room Guidelines (NATE, ACCA, HRAI)

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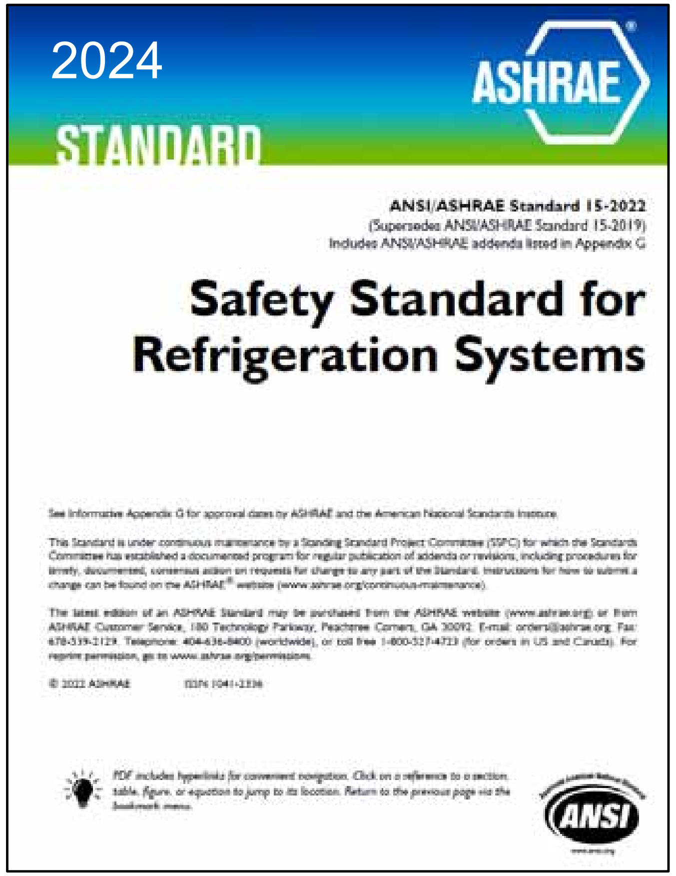
APPLICATION STANDARDS

(ASHRAE 15, ASHRAE 15.2 AND CSA B52)

Commercial HVAC, Refrigeration, and plug in residential equipment



2024

ASHRAE

STANDARD

ANSI/ASHRAE Standard 15-2022
(Supersedes ANSI/ASHRAE Standard 15-2019)
Includes ANSI/ASHRAE addenda listed in Appendix G

Safety Standard for Refrigeration Systems

See Informative Appendix G for approval dates by ASHRAE and the American National Standards Institute.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE® website (www.ashrae.org/continuous-maintenance).

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ANSI

2024

ASHRAE

STANDARD

ANSI/ASHRAE Standard 15.2-2022

Safety Standard for Refrigeration Systems in Residential Applications

Approved by ASHRAE and the American National Standards Institute on April 29, 2022.

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ANSI

New Standard for permanently installed residential equipment

ASHRAE 15 - Commercial Application Standard

- ASHRAE 15 specifies safe design, construction, installation, and operation of refrigeration systems
- It picks up the application side of installations where UL60335-2-40 leaves off with the equipment design, but the two standards do have some overlap and some conflicting requirements for the direct systems application when it comes to the minimum floor area requirements.
- This standard applies to
  - the design, construction, test, installation, operation, and inspection of mechanical and absorption refrigeration systems, including heat-pump systems used in stationary applications;
  - modifications, including replacement of parts or components if they are not identical in function and
  - capacity and substitutions of refrigerants having a different designation.
- The standard is updated every 3 years
- The 2022 edition of ASHRAE Standard 15 incorporates more updates than any other edition in the standard's history.
- These changes are intended to ensure continued improvement in the safe design, construction, installation, and operation of refrigeration systems with major changes focused on the safe use of the new A2L refrigerants.
- One major change (Addendum d) removes from the scope of Standard 15 applications covered by the newly published ANSI/ASHRAE Standard 15.2-2022, Safety Standard for Refrigeration Systems in Residential Applications, where one system serves one dwelling space
  - Residential applications where one system serves more than one dwelling space still lie within the scope of Standard 15.

ASHRAE 15.2 – Residential Application Standard

- ASHRAE 15.2 specifies the minimum requirements for the safe design and installation of refrigeration systems used in **residential applications**.
- This standard applies to listed direct refrigeration systems in the following residential applications that are limited to serving only a single dwelling unit or sleeping unit:
  - One- and two-family dwellings and townhouses
  - Detached outbuildings associated with a one- or two-family dwelling or townhouse and located on the same property included in Section 2.1(a)
  - Individual dwelling units and sleeping units located in a multifamily dwelling
- It only applies to permanently installed equipment and does not cover plug in equipment like window units
- The standard was first release in December 2022 and missed the window for inclusion in the building codes
- At this point it has not been adopted by the updated building codes that are being published at this time
- It likely will be included in the next update of the building codes in 2027
- It is a continuous maintenance standard

ASHRAE 15.2 – Residential Application Standard

- Historically, safety requirements were not applied as rigorously to residential HVAC systems as they were to commercial systems, primarily because
  - all direct systems were restricted to A1 refrigerants as classified by ANSI/ASHRAE Standard 34, Designation and Safety Classification of Refrigerants, and listed to safety design standards such as UL 1995 and UL 60335-2-40, and
  - the risk of reaching and exceeding a refrigerant’s acute toxicity exposure limit (ATEL) in the event of a complete release was very low.
- The need to reduce global warming potential (GWP) in residential applications has led to the use of mildly flammable refrigerants of the ASHRAE Standard 34 A2L classification and created a vacancy for an application safety standard that building code authors can depend on.
- Standard 15.2 was developed to fill this roll. It serves as a stakeholder document to accommodate the use of A2L refrigerants in model building codes and is intended for use by manufacturers, installers, contractors, service technicians, building code officials, and others.
- With the release in December 2019 of the third edition of UL/CSA 60335-2-40, North American product safety standards for residential products were modified to allow lower-flammability A2L refrigerants.

ASHRAE 15.2 – Residential Application Standard

- ASHRAE Standard 15.2 was developed in parallel and is more conservative than the UL standard in several places.
  - Standard 15.2 requires that all products be listed to a national product safety standard and installed per the manufacturer's installation instructions.
  - Particular attention is paid to ensure that, in the event of a full release of the refrigerant charge, the concentration in the space remains safely below the lower flammability limit of the refrigerant used.
  - Therefore, specific requirements are placed on which refrigerants can be used, the maximum allowable refrigerant charge, the accessories that can be used, and the interconnecting piping.
  - To streamline use, Standard 15.2 provides a flowchart showing how to apply the standard, as well as numerous tables eliminating the direct use of equations.

UL60335-2-40 vs ASHRAE 15

- UL60335-2-40 and ASHRAE 15 both have requirements for checking the occupied space for direct systems to insure there is enough area/volume to absorb a catastrophic leak and stay below 50% of the LFL
- But the standards are not completely aligned
  - UL60335-2-40 based on floor area **(Amin)** with an assumed maximum room high of **7.212 ft**.
  - ASHRAE 15 based on **effective dispersal volume (EVDC)** with a maximum room height of **8.2 ft** but also allows for inclusion of duct volume and plenum ceilings
  - The LFL values are not equivalent, and UL60335-2-40 uses WCF and ASHRAE 15 use WCFF and there are some differences in values result in different calculations
    - worst case of formulation for flammability (WCF): the nominal formulation, including the composition tolerances, that results in the most flammable concentration of components.
    - worst case of fractionation for flammability (WCFF): the composition produced during fractionation of the worst case of formulation for flammability that results in the highest concentration of flammable components as identified in this standard in the vapor or liquid phase.
- ASHRAE 15 reduces the EVDC by 50% for institutional occupancy classifications
- In most cases the UL60335-2-40 requirements will be more restrictive and the way codes are enforced is the most restrictive requirements apply
- We are currently working with the marketing teams to document this and explain this for installations

ASHRAE 15 vs UL60335-2-40 for R-454B

It always appears that UL60335-2-40 is more restrictive than ASHRAE 15 for R-454B even for institutional

R-454B Minimum Area and Effective Volume Comparison

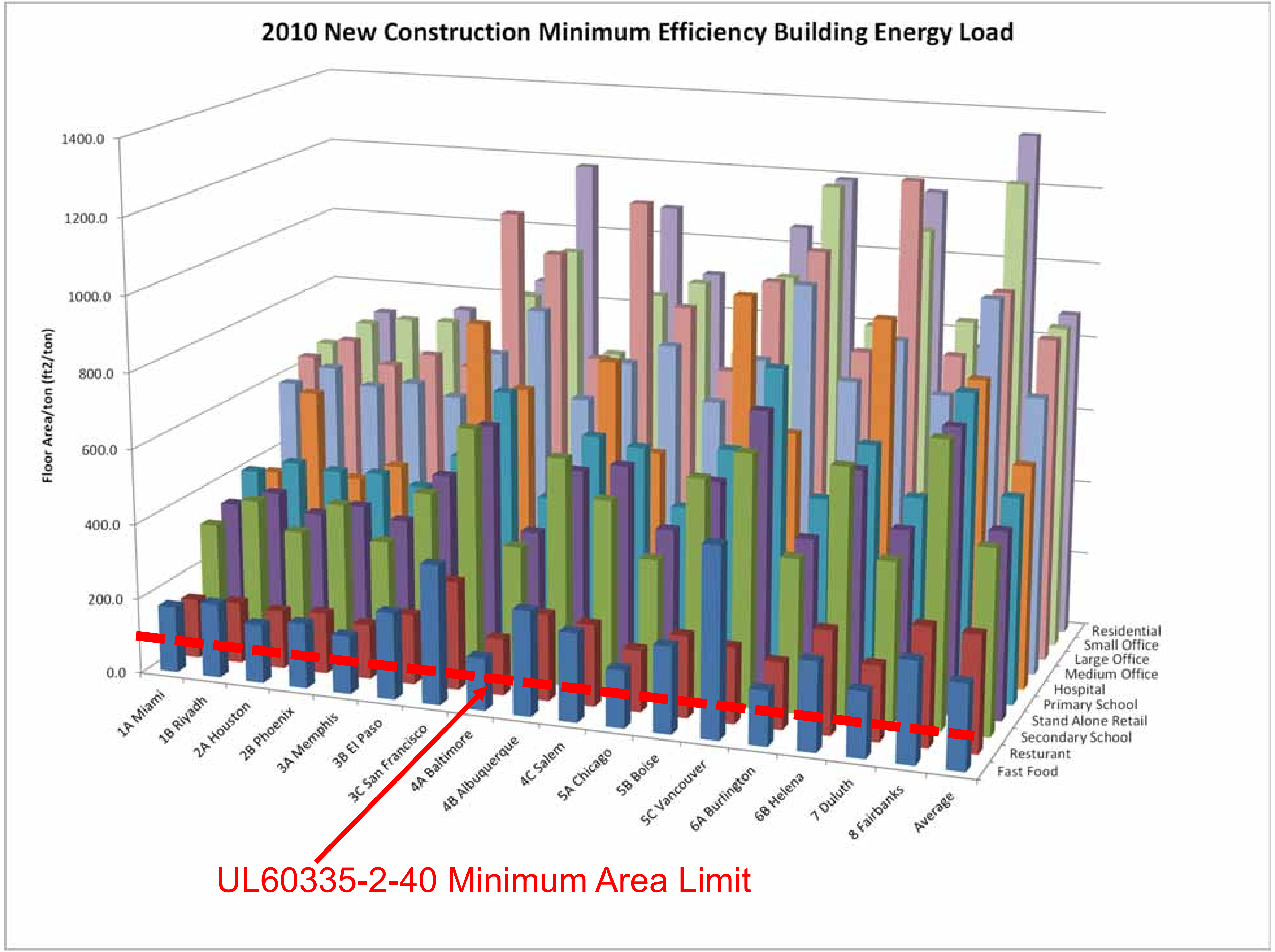
Charge		UL60335-2-40		ASHRE 15 - Base				ASHRE 15 - Institutional			
		Amin	Veff	Veff		Amin		Veff		Amin	
lb	kg	ft2	ft3	ft3	% UL	ft2	% UL	ft3	% UL	ft2	% UL
4.0	1.814	60.0	433	364	84%	44	74%	727	168%	89	148%
4.2	1.905	63.0	454	382	84%	47	74%	764	168%	93	148%
4.4	1.996	66.0	476	400	84%	49	74%	800	168%	98	148%
4.6	2.087	69.0	497	418	84%	51	74%	836	168%	102	148%
4.8	2.177	72.0	519	436	84%	53	74%	873	168%	106	148%
5.0	2.268	75.0	541	455	84%	55	74%	909	168%	111	148%
5.2	2.359	78.0	562	473	84%	58	74%	945	168%	115	148%
5.4	2.449	81.0	584	491	84%	60	74%	982	168%	120	148%
5.6	2.540	84.0	606	509	84%	62	74%	1018	168%	124	148%
5.8	2.631	87.0	627	527	84%	64	74%	1055	168%	129	148%
6.0	2.722	90.0	649	545	84%	67	74%	1091	168%	133	148%
6.2	2.812	93.0	671	564	84%	69	74%	1127	168%	137	148%
6.4	2.903	96.0	692	582	84%	71	74%	1164	168%	142	148%
6.6	2.994	99.0	714	600	84%	73	74%	1200	168%	146	148%
10.0	4.536	150.0	1081	909	84%	111	74%	1818	168%	222	148%
12.0	5.443	179.9	1298	1091	84%	133	74%	2182	168%	266	148%
14.0	6.350	209.9	1514	1273	84%	155	74%	2545	168%	310	148%
16.0	7.257	239.9	1730	1455	84%	177	74%	2909	168%	355	148%
18.0	8.165	269.9	1947	1636	84%	200	74%	3273	168%	399	148%
20.0	9.072	299.9	2163	1818	84%	222	74%	3636	168%	443	148%

The standards use different LFL's and different approaches for checking mitigation compliance

UL for standard applications requires more floor area and volume than ASHRAE 15

But for Institutional ASHRAE 15 with the 50% reduction requires more volume and area.

Building Energy Intensity and Amin/EV



Unit Charge LB/Ton	ENERGY DENSITY AREA/TON
2	29.5
3	44.25
4	59
5	73.75
6	88.5

This shows that even extreme load buildings do not come close to the area limits. Any application above the values shown above would not have an issue with Amin for UL60335-2-40

For ASHRAE 15 institutional with the 50% derate it could be an issue

REFRIGERANT CYLINDER REQUIREMENTS

Refrigerant Cylinder Requirements

- For years, the industry has used color coded cylinders for each refrigerant
- With all the new refrigerants recently developed the industry has decided to abandon the use of color coded
- This was updated in AHRI Guideline N which defines colors for cylinders
  - All cylinders will change to **gray cylinders**
  - All flammable (A2L, A2, A3) cylinders will have a **red band**
  - Rupture disks on cylinders will change to relief valves for A2L
  - All flammable (A2L, A2, A3) cylinders will have left hand threads
- Cylinder service port fittings are covered by AHRI Standard M and flammable refrigerants use **left hand threads on cylinder**
- Service cylinders for recovery and reclaim are covered by Guideline K
- All cylinder must be in compliance with DOT requirements defined in 49 CFR 5124 and 49CFR specification 39
- A use of the color yellow as specified will identify the container as a recovery.
- Materials of trade DOT requirements allow for up to 200 lbs. to be exempt from special shipping requires for service trucks as defined in 49 CFR, Subpart C, Part 172

BUILDING CODES

U.S. Model Codes – Overview

- ***ICC & IAPMO*** are the main competing organizations developing Model Building Codes
- Complex Process – Beginning Current 3-year cycle, 2027 Publication by the end of 2026
- Change proposals were due Jan 12, 2024
- Majority of the overall modifications are discussed by Code Action Committees & Working Groups
- Industry has some influence and often helps with technical expertise - but final approval is by appointed, technical committee members, public safety and government officials only
- Local government can choose to adopt a model building code "as published, with modifications, and may adopt Model Codes at their own pace – between 1 and 8 years after publication
- Many states don't have a synchronized approach to adopt model codes (adopting 2021 IMC, and 2024 IFC)
- Some States follow a 6-year revision cycle vs. 3-year cycle for Model Codes – skipping versions
- Some States have no formal process / no fixed cycle for Code adoption – changes can be proposed anytime

Model Code Update – ICC & UMC

- All major code change proposals needed for the ***full acceptance of A2L refrigerants*** are approved by the Code Development Committees responsible for the
  - 2024 Edition of the International Residential Code (IRC);
  - 2024 International Mechanical Code (IMC);
  - 2024 Uniform Mechanical Code (UMC).
- The 2024 Edition of both UMC and IMC ***enable the safe use of A2L refrigerants***
- The 2024 Edition of the IMC references the 2022 Edition of ASHRAE 15, ASHRAE 34 and UL 60335-2-40
- The 2024 Supplement of the California Mechanical Code (based on UMC:2024), effective July1, 2024 reference the 2022 Edition of ASHRAE 15, ASHRAE 34 and UL60335-2-40
- **2024 Codes are Published, and available to read – online,** and on the GCS SharePoint here.
- State adoptions begin mid 2024, but could be delayed by 10/12 years depending on state and city
- IRC–M Technical Committee approves the inclusion of ASHRAE 15.2, *Safety Standard for Refrigeration Systems in Residential Applications,* in the 2027 Edition of the IRC-M

NORTH AMERICA ACTIVITY

State Code Adoption Status

U.S. State and Local Codes

2024 Model Codes published

Takeaway April 2024

- 2024 Edition of Model Codes published
- A2L acceptance enacted in 46 States + DC
- A2L effectively accepted in 45 States

All States on track for A2L acceptance before 1/1/2025

- 2024 Model Codes accept A2Ls for high probability systems for human comfort

Adoption at State/Local level – Extreme fragmentation, timing

- States and Local jurisdictions will adopt 2024 Model Codes at their own pace – between 2025 and ~2036
- Possibly with modifications
- No Statewide Code (CO, TX) and/or extreme fragmentation (TX, TN, AZ)
- No synchronization with Model Codes Cycle
- Some States follow a 6-year revision cycle vs. 3-year cycle for Model Codes (GA)
- Some (small) States have no formal process / no fixed cycle for Code adoption (DE)

U.S. Codes Strategy

Phase 1 – Advocacy A2L acceptance (2017-2024)

- Submit Code change proposals to States and Local jurisdictions

or

- Legislative approach - State Bill – Model language "*Code provisions shall not prohibit the use of refrigerants listed as acceptable under section 7671k of the federal Clean Air Act (42 U.S.C. 7671k), provided equipment is listed and installed in accordance with the use conditions imposed within section 7671k.*"

Phase 2 – Translate legislation into Code language (2023 onward)

Objective: Facilitate acceptance by AHJs in the field

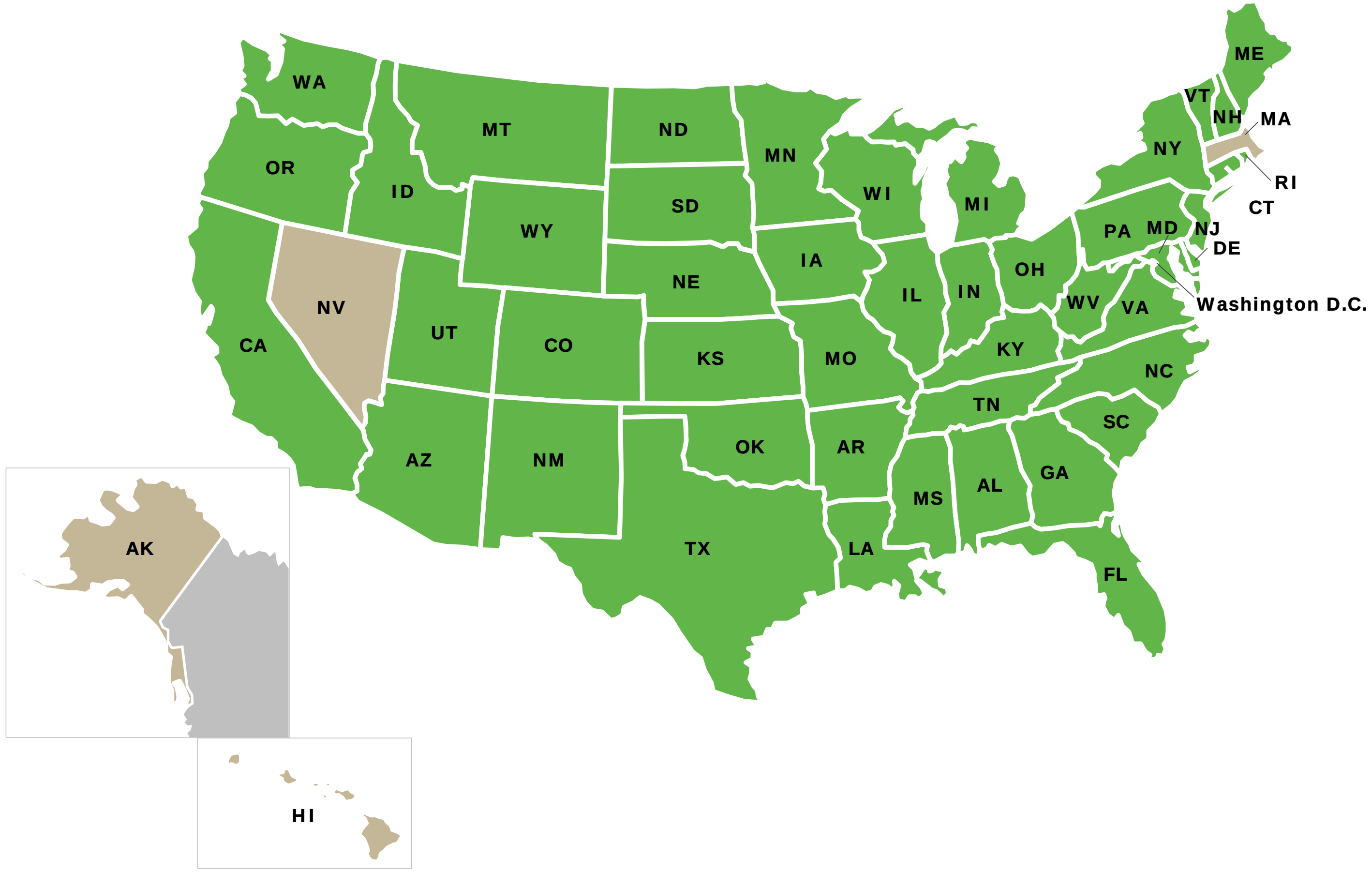
Strategy: Submit local code change proposals to anticipate 2024 requirements for A2L refrigerants (CA, AK, GA, …)

Actions:

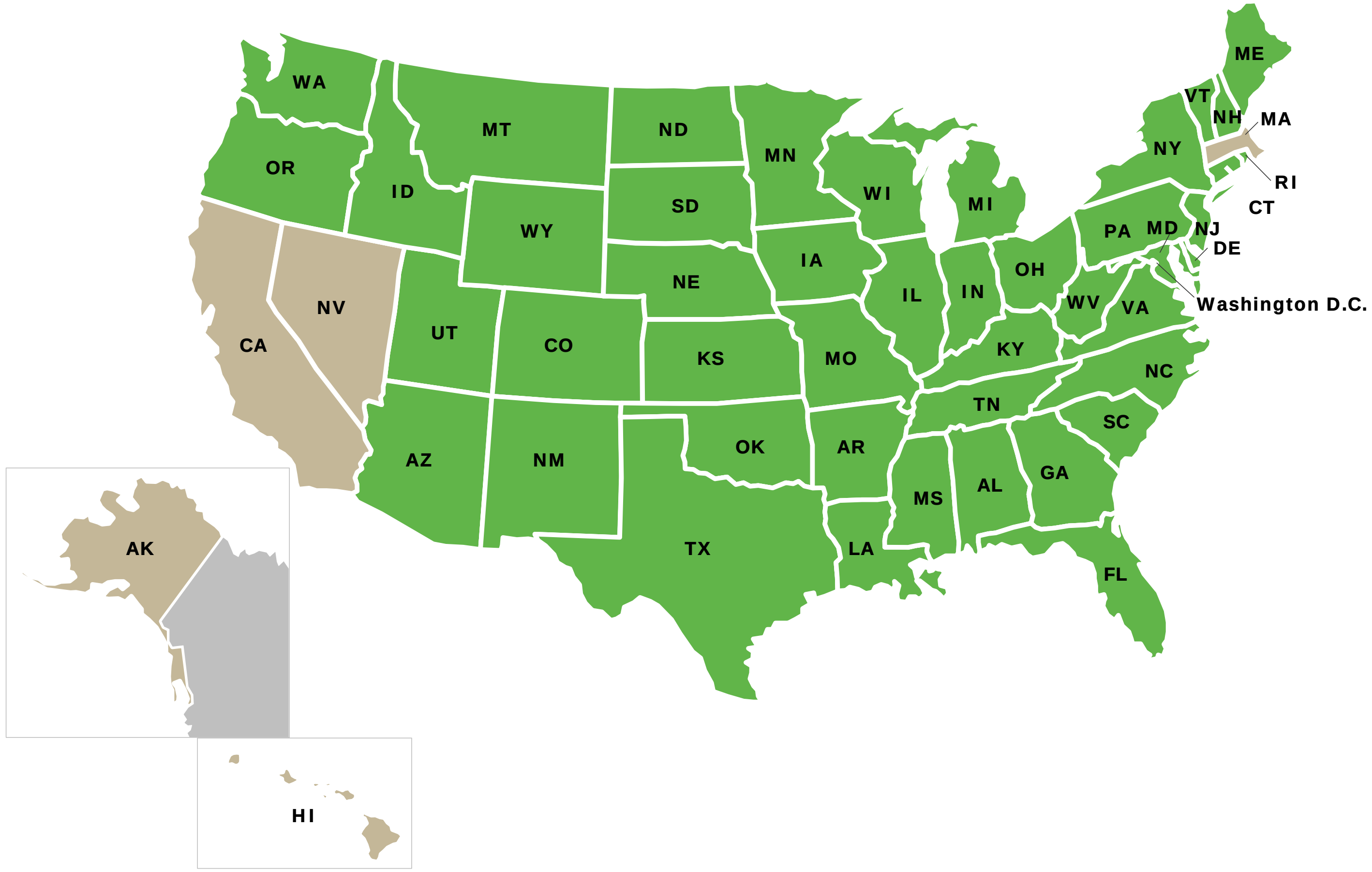
- AHRI + core group of OEM representatives (Carrier, Daikin, Trane) and Chemours
- ICC dedicated A2L webpage to educate AHJs and explain how to change local Codes based on old versions of I-Codes
- ICC/AHRI letter to AHJs in preparation asking for urgent code update
- New series of AHRI educational webinars for building inspectors, fire service starting May 2024
- HARDI active to change Code requirements for the storage of A2L refrigerants (IFC, IBC)

A2L Acceptance Status TODAY

A2L acceptance <u>ENACTED</u>
46 States + DC
98% Carrier revenues



A2L acceptance <u>EFFECTIVE</u>
45 States
88% Carrier revenues



This document is for informational purposes only and is not intended to constitute legal advice or be relied upon for compliance purposes. Information concerning State, local, and code requirements and various processes to promulgate such requirements is subject to change. Please consult your legal department for legal advice.

NORTH AMERICA SHIPPING STANDARDS

Transportation Requirements: GHS and DOT

NAO Shipping Standards Status

- Shipping standards for NAO are country defined and are not all aligned
  - U.S. Shipping is controlled by the Department of Transportation (DOT) and there are some requirements handle by OSHA
  - Canada requirements are defined by Transport Canada
  - Mexico requirements are defined by Secretariat of Infrastructure and Communications
- The current codes do not currently recognize the lower flammability A2L refrigerants and treat all flammable gases in one category (shipping category 2)
- In the Global Harmonized Shipping Standards (GHS-7 and 8) they added a new shipping category for A2L refrigerants called 1B for shipping standards
- We worked DOT to get the DOT codes modified for A2L
- The following actions have been taken by a joint AHRI task force of industry manufacturers working with DOR
  1. Interpretation request for A2L refrigerant charge ≤ 12 kg (26.4 lbs.) (approved)
  2. **Special shipping permit** for 12kg (26.4 lbs.) to 20 kg (44.1 lbs.) (approved per DOT-SP 21287 w/ Carrier party status)
  3. **Special shipping permit** for up to 5,000 lbs. (2268 kg) (approved per DOT-SP 21379 w/ Carrier party status)
  4. **Special shipping special permit** for shipping refrigerant cylinders in vertical position
- DOT has advised that they plan to implement the permits as standard requirements in 49 CFR this year which will eliminate the need for permits and renewal
- For Mexico full Hazmat shipping will be used for refrigerant charges above 12 kg
- For Canada we also spent considerable time working them and they have now harmonized with the DOT requirements and accept the 12 kg to 20 kg and and the 5,000 lb permit

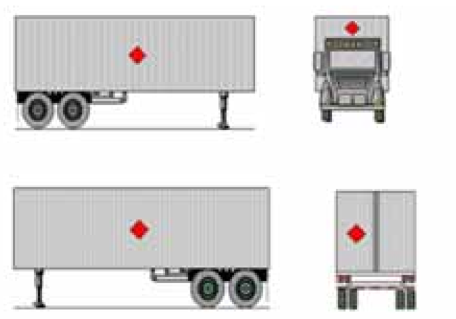
What we know for A2L Refrigerants

- US EPA categorizes the refrigerant into 3 weight classifications based on the amount of refrigerant in the unit; <12 KG / 12-20 KG / > 20 KG
  - Nothing changes for < 12 kg units intra-US; everything ships as it does today (RES units)
  - US DOT regulations apply to the largest unit refrigerant weight on the shipment
  - Collierville already shipping some units

US Unit placard above 20 kg

- Shipping papers must have the Chemtrec 800#

Mexico Truck placard above 12 kg (remove at boarder)



- MEXICO
  - Full hazmat regulations for units > 12 KGS (CMX-B & D)
    - Require RED diamond placard on trailer
    - Must be removed at US border
  - Our MX providers are compliant with MX regulations (Hector/Sylvia @ Ryder)
  - US DOT permit will need to be printed with the BOL at CMX-B & D

- All units with > 20 kgs must ship on ventilated trailers (i.e. flatbed) in NA
- and units must have service valves that are closed

What we know A2L Refrigerants

- Air freight strictly prohibited for charged units & accessories – all sizes
- US DOT permits cannot be used to export (allowed into Canada due to reciprocity)
- Rail transport is allowed, across all unit sizes, within US with the required permits (> 12 kgs)
- ITC readiness for Mexico to US and overseas import into US in process
- Canada has no transition plan from R-410A to R-454B, meaning:
  - Will need to direct ship R-410A from CMX to Canada, after the sell-through period
  - Reciprocity agreement between the US and Canada allows R-32 and R-454B charged units into Canada using the two US DOT permits for > 12 KG units but only to the first destination
- Ocean export only for < 12 KG charged units;
  - > 12 KG ocean export dry charged only
  - Including Puerto Rico and Hawaii
  - Still treated as hazmat and placards are required on the container

US Transport Regulations A2L

Regulation for Mexico Transport to US Border	Under 12 KGs	12-20 KGs	20 KGs or more
MSDS sheets included with BOL	YES	YES	YES
UL60335-2-40 A2L Label	YES A2L	YES A2L	YES A2L
Driver hazmat training	YES	YES	YES
UN3358 label on each unit Applied at the factory	NO	NO	3358 YES
Shipped on Flatbed/Ventilated trailer	NO	NO	YES
BOL has Chemtrec 1-800#	YES	YES	YES
US DOT Permit required Applies to CMX-B, CMX-D & Ryder DC	NO	YES DOT SP-21287	YES DOT SP-21379

Note for the >12 kg products can be reshipped as long as packaging or the unit has not been modified but if modified than party status is required

Mexico to US Transport Regulations A2L

Regulation for Mexico Transport to US Border	Under 12 KGs	12-20 KGs	20 KGs or more
MSDS sheets included with BOL	YES	YES	YES
UL60335-2-40 A2L Label	YES 	YES 	YES 
Red Diamond placard on trailer (remove at border) Applies to CMX-B, CMX-D & Ryder DC	NO	YES 	YES 
Driver license E for Mexican drivers	YES	YES	YES
Unit Labeling Applied at the factory	NO	YES 	YES  
Can cross at World Trade Bridge	YES	YES	YES
Shipped on Flatbed/Ventilated trailer	NO	NO	YES
BOL has Chemtrec 1-800#	YES	YES	YES
US DOT Permit required Applies to CMX-B, CMX-D & Ryder DC	NO	YES DOT SP-21287	YES DOT SP-21379

ADDITIONAL INFORMATION

Refrigerant Training Status

Industry

AHRI Refrigerant Webinar Series (recorded)

https://www.ahrinet.org/news-events/webinars/ahri-refrigerant-webinar-series

Webinar 1: Air Conditioning Applications – Ignition testing
Webinar 2: Commercial Refrigeration Applications
Webinar 3: Understanding of Refrigerant Sensor
Webinar 4: Predictive Tools for Refrigerant Behavior
Webinar 5: Refrigerant Ignition in Open Flame/Hot Surfaces:
Webinar 6: A2L Refrigerant Behavior in a Structure Fire
Webinar 7: Refrigerant Detection Systems 101
Webinar 8: Servicing A2L Refrigerant Systems
Webinar 9: A2L Refrigerants and Tactical Considerations for Firefighters
Webinar 10: Codes and Standards "Unlocked"
Webinar 11: Joint Types and A2L Refrigerants
Webinar 12: HVACR Equipment Needed for the Safe Refrigerant Transition
Webinar 13: The HFC Phasedown: Implementing the American Innovation & Manufacturing Act
Webinar 14: HFC Phasedown: Reirrigation Systems Leaks – Detection and reduction

ASHRAE

A2L Seminar at Winter Session (Jan 2022) (200+ attendance)
Safely Transitioning to Low GWP Refrigerants in Kuwait (Nov 2021)

NATE Refrigerant Exam

Training exam material completed, Exam release Pending
https://www.natex.org/

UL FSRI First Responder Training (recorded)

Online Training: Firefighter Safety and Flammable Refrigerants
UL FSRI Fire Safety Academy (ulfirefightersafety.org)

ACHR NEWS Webinar (recorded)

The Transition to Low-GWP (Flammable) Refrigerants in the Unitary Market
http://eblast.bnpmedia.com/EVENTS/webinars/confirmation/images/view-recording.png

Reducing HVAC GHG Emissions: Electrification & Decarbonization
https://www.achrnews.com/events/2786-reducing-hvac-ghg-emissions-electrification-decarbonization

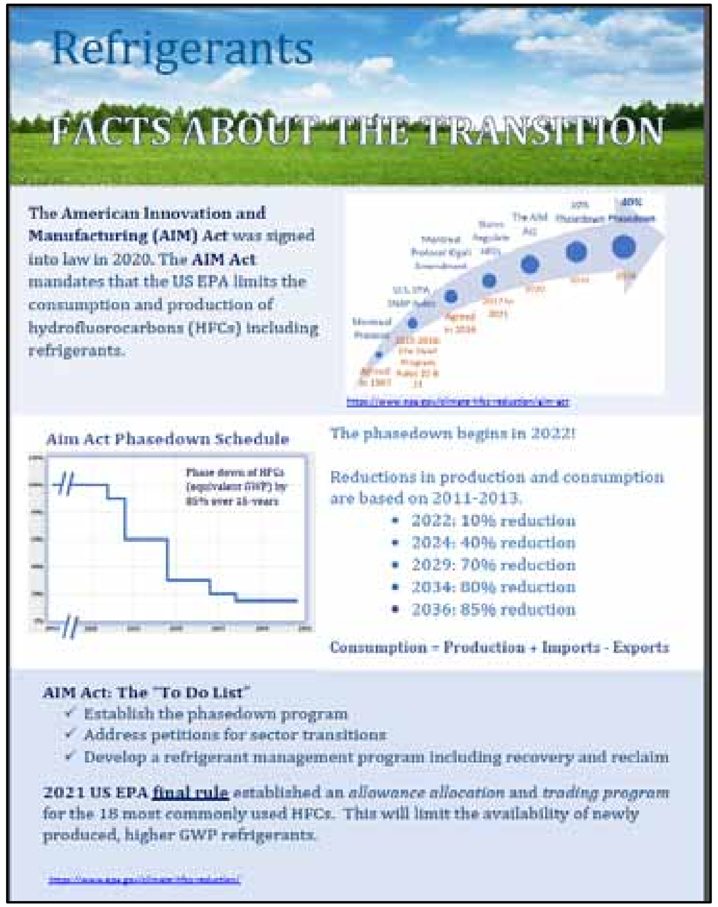
AHRI Safe Refrigerant Transition Task Force

Safe Refrigerant Transition Task Force (ahrinet.org)

Resources and Fact Sheets (see next page)
Relevant Articles
Presentations and Webinars
Safe Refrigerant Task Force Monthly Newsletter
HVAC Shop Talk Podcasts (Jason Obrzut), 2,100 views with goal of 100K

AHRI SRTF Transition Flyer

AHRI Safe Refrigerant Task Force has developed a fact sheet on Transition that was passed out at ASHRAE show



Refrigerants

FACTS ABOUT THE TRANSITION

The American Innovation and Manufacturing (AIM) Act was signed into law in 2020. The AIM Act mandates that the US EPA limits the consumption and production of hydrofluorocarbons (HFCs) including refrigerants.

Aim Act Phasedown Schedule

The phasedown begins in 2022!

Reductions in production and consumption are based on 2011-2013.

- 2022: 10% reduction
- 2024: 40% reduction
- 2029: 70% reduction
- 2034: 80% reduction
- 2036: 85% reduction

Consumption = Production + Imports - Exports

AIM Act: The "To Do List"

- ✓ Establish the phasedown program
- ✓ Address petitions for sector transitions
- ✓ Develop a refrigerant management program including recovery and reclaim

2021 US EPA final rule established an *allowance allocation* and *trading program* for the 18 most commonly used HFCs. This will limit the availability of newly produced, higher GWP refrigerants.

U.S. EPA HFC Allowance Allocation Final Rule

- HFC supply is reduced over time and *allocated* to importers and producers.
- Production and imports in 2022 are prohibited without allowances.
- Allowances were established for 2022 and 2023, similar to the quota process used for R-22.
- Allowance methodologies may change after 2024
- Currently, allocations currently do not apply to products that contain HFCs and are imported into the US

Some Other Details about the AIM Act

- Allowances* allocated for 90% of the baseline for 2022 and 2023.
- Next stepdown is significant: 60% of the baseline in 2024.
- Producers hold production and consumption allowances.
- Importers only need to hold consumption allowances.

*An allowance is based on an exchange value that is identical to CO2-equivalent, which is often seen as GWP (global warming potential) values in HFCs.

Reducing Demand to Balance Supply Options

- Stakeholders should take the HFC phasedown into consideration when installing new equipment (i.e., transition to lower GWP refrigerants when possible)
- Consider smaller charge sizes in new equipment
- Retrofit to lower GWP A1 refrigerant if approved by EPA and manufacturers.
- Reduce leaks
- Use recovered/reclaimed refrigerant

How will Equipment Manufacturers Meet the Transition?

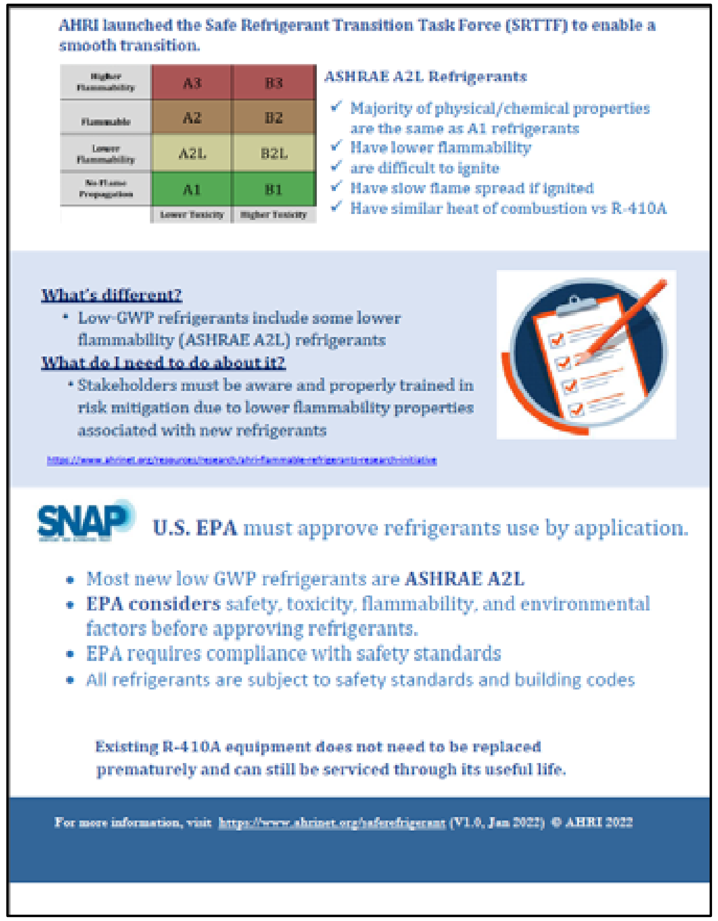
- Manufacturers will transition to lower global warming potential refrigerants.
- Many new, lower GWP refrigerants will have different safety classifications
- R-410A is ASHRAE A1 refrigerant and other lower GWP refrigerants may be ASHRAE A2L.

End-Use	Substitutes	Listing
Air-Conditioning (SNAP Rule 23)		
Residential and light commercial air conditioning and heat pumps (New)	R-32, R-452B, R-454A, R-454B, R-454C, R-457A	Acceptable Subject to Use Conditions
Air-Conditioning (SNAP Rule 19)		
Self-contained room air conditioners	R-32	Acceptable Subject to Use Conditions

AHRI, along with other industry stakeholders have been preparing for this transition for over a decade.

AHRI, ASHRAE, CARB and U.S. DOE have spent over $7 million in research evaluating the impacts relating to the transition.

Many new low GWP refrigerants are ASHRAE A2L.



AHRI launched the Safe Refrigerant Transition Task Force (SRTTF) to enable a smooth transition.

ASHRAE A2L Refrigerants

- ✓ Majority of physical/chemical properties are the same as A1 refrigerants
- ✓ Have lower flammability
- ✓ are difficult to ignite
- ✓ Have slow flame spread if ignited
- ✓ Have similar heat of combustion vs R-410A

What's different?

- Low-GWP refrigerants include some lower flammability (ASHRAE A2L) refrigerants

What do I need to do about it?

- Stakeholders must be aware and properly trained in risk mitigation due to lower flammability properties associated with new refrigerants

U.S. EPA must approve refrigerants use by application.

- Most new low GWP refrigerants are ASHRAE A2L
- EPA considers safety, toxicity, flammability, and environmental factors before approving refrigerants.
- EPA requires compliance with safety standards
- All refrigerants are subject to safety standards and building codes

Existing R-410A equipment does not need to be replaced prematurely and can still be serviced through its useful life.

For more information, visit https://www.ahrinet.org/saferefrigerant (V1.0, Jan 2022) © AHRI 2022

Safe Refrigerant Task Storage Force Flyer

AHRI SRTF has developed a trifold flyer that was shared at ASHRAE winter meeting

A2L Cylinder Storage Options

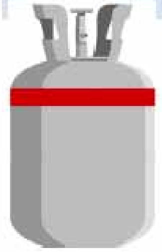
Characteristic	Shelf Storage	Rack Storage	Solid-pile
Storage design	Shelf cannot exceed 30" from front to back	Each level designed to hold pallet loads	Pallets stacked one upon another
Construction materials	Steel shelves	Steel rack	NA
Storage height	Maximum 6' to top of product	Can exceed 6' Limited by sprinkler design	Can exceed 6' Limited by sprinkler design
Sprinkler system design	Ordinary Hazard Group 2	Extra Hazard Group 1	Extra Hazard Group 1
Separation from flammable liquids	Required	Required	Required
Storage of other flammable or combustible products above A2L refrigerants	Prohibited	Prohibited	Prohibited
Storage of flammable liquids adjacent to A2L refrigerants	20' separation	20' separation	20' separation
Storage of flammable liquids with secondary containment adjacent to A2L refrigerants	10' separation to containment area	10' separation to containment area	10' separation to containment area

More information visit www.nfpa.org and www.iccsafe.org

For information purposes only. Always check with local and state building authorities regarding cylinder storage requirements.

A2L Refrigerant Indoor Storage

CYLINDERS



AHRI

Contact Information:
Mary Koban,
mkoban@ahrinet.org

For information purposes only. Always check with local and state building authorities regarding cylinder storage requirements.

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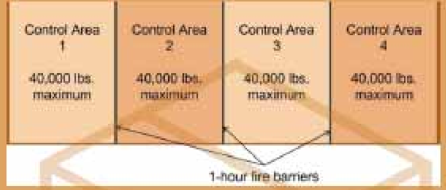
The 2024 International Fire Code (IFC) & the National Fire Protection Association (NFPA) codes & standards were recently updated to include A2L refrigerants. Model codes & standards are adopted by many states and localities. Fire marshals & building officials use the maximum allowable quantities (MAQ) contained in the IFC or NFPA 55 to provide A2L storage guidance.

International FIRE CODE

The MAQ for ASHRAE A2L refrigerant storage is based on the type of occupancy and the number of control areas in the building. Each building can have up to four control areas, increasing the total amount of refrigerant that can be stored in the building. 2024 Codes have been revised & the table shows maximum quantities in each control area for common occupancies.

A building protected with fire sprinklers can include 1-hour fire-resistance-rated walls to create 4 separate control areas. Each control area can store up to 40,000 lbs. of liquefied Group A2L refrigerants. See graphic for control areas.



Construction of a 1-hour fire barrier can be as simple as a wood stud wall covered with fire-resistant gypsum board. All entrances through the 1-hour fire barriers must be protected with a fire-rated device, such as roll-down shutters or fire doors.

Maximum Allowable Quantity (MAQ) in a Single Control Area

Occupancy Classification	Non-sprinklered	Sprinklered
	Liquefied gas in cylinders	Liquefied gas in cylinders
M – mercantile	20,000 lbs.	40,000 lbs.
S – storage/warehouse	20,000 lbs.	40,000 lbs.
F – factory/filling facility	10,000 lbs.	20,000 lbs.

More information visit www.nfpa.org and www.iccsafe.org

The code will classify the storage method as either:

1) Shelf Storage

2) Rack Storage

3) Solid Pile

AHRI Safe Refrigerant Task Force Flyers

A2L Equipment Best Practices

Before Installing or Servicing Equipment

- **SAFETY FIRST**
- Read SDS and OEM Equipment Manual
- Follow lockout/tagout procedures when needed.
- Verify no voltage present before working.
- Ensure area is well ventilated.
- Evaluate jobsite for a) ignition sources b) flammable vapors c) controlling area, d) confined spaces and e) clear exit points.

A2L Installation

- Follow OEM guidelines for minimum room area/refrigerant charge limits.
- Ensure mitigation components are installed and operating per OEM instructions.
- Use locking refrigerant caps to prevent unauthorized access to the system
- Ensure a filter drier is installed

A2L Evacuation and Pressure Test

- Consult the OEM instructions to determine proper evacuation targets/procedures
- Pressure test field erected components
- Evacuate the system before charging using an A2L rated vacuum pump
- Record a) *date*, b) *test pressure* c) *vacuum level on the label* (UL 60335-2-40).

A2L Charging (if required)

- Do NOT exceed the maximum allowable refrigerant charge per OEM instructions (charge amounts may vary due to line-sets.)
- Follow OEMs procedure for proper charging techniques. (Superheat/Subcooling)
- If refrigerant is a 400-series, the refrigerant must leave the cylinder in 'liquid form'.
- Record a) *date* b) *total refrigerant charge weight on the unit label* (UL 60335-2-40).

A2L System Repairs

- Leak check to verify no refrigerant is present.
- Ensure equipment is grounded before working.
- Use Proper capacitor discharge methods.
- Use only OEM approved replacement parts.
- Use nitrogen before and during all brazing.

A2L Recovery

- Do NOT vent
- Do NOT mix refrigerants
- Use recovery tools rated for use with A2L refrigerants
- Recover all refrigerant before opening system
- Recover into DOT approved recovery cylinder.
- Do not exceed cylinder fill weights.
- Label recovery cylinder contents

For more information visithttps://www.ahrinet.org/saferefrigerant V1.0_1/2022

Questions