Preparing for the Safe Use of A2L Refrigerants in Commercial Refrigeration

May 27, 2021

EMERSON

Disclaimer

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Refrigeration system designs, regardless of refrigerant of choice, should be planned and implemented by appropriately trained, qualified, and licensed professionals with the skills, knowledge, and experience with the specific technology being utilized. All engineered systems and refrigerants of choice come with a variety of risks, performance limitations, and benefits. Information presented herein does not relieve the system designers and other refrigerant users from conducting its own research to confirm that designs and systems will work as intended. Statements or suggestions about the use of certain materials or processes are made without claim or warranty that such use may not involve a patented concept. For any questions involving regulatory compliance, environmental compliance, and/or intellectual property concerns, among other topics, you should always consult an attorney about your situation and specific facts.

Panelist Introductions

EMERSON

Panelist Introductions

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Agenda

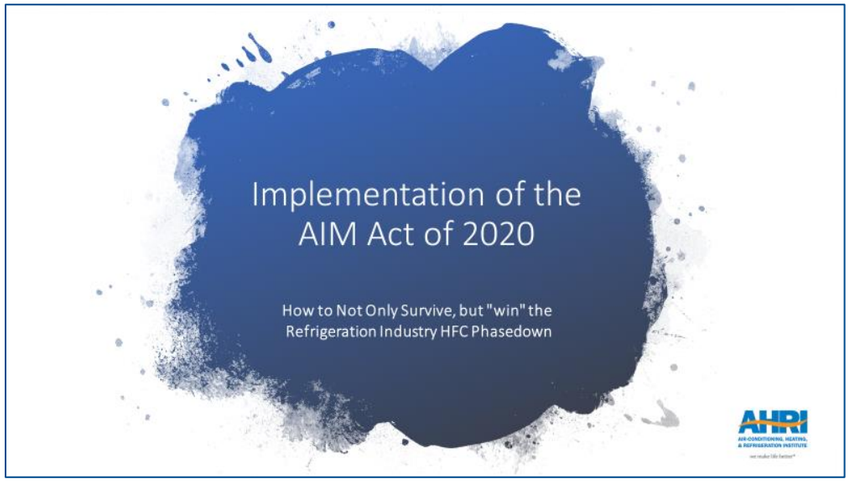
1	Webinar Overview
2	A European Retailer’s Refrigeration Journey — ASDA
3	Roundtable Discussion
4	Appendix
5	Question and Answer Session

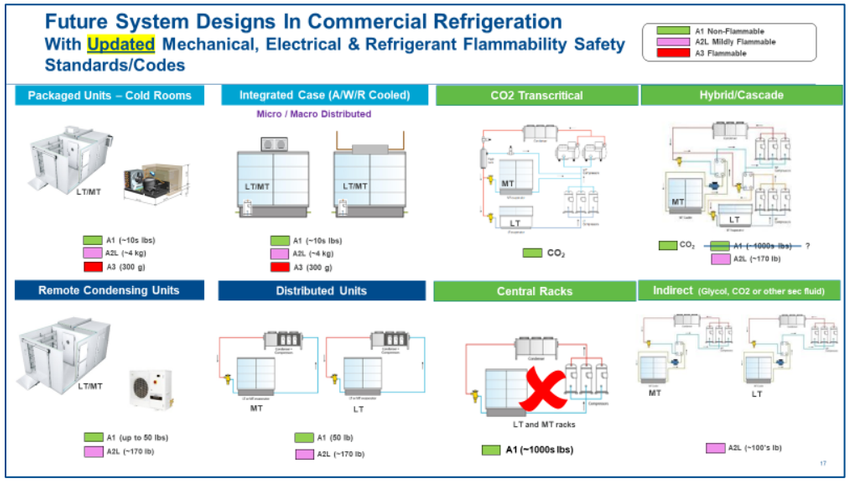
Overview

AHRI Webinar for Commercial Refrigeration

How to Not Only Survive, but "Win" the Refrigeration Industry HFC Phasedown

April 20, 2021





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Objectives

- What can we learn from a European retailer’s journey towards lower-GWP refrigerants?
- Specifically, for A2L refrigerants, how can we safely and effectively use them in a retail application?
- How do the safety standards for equipment and application being developed in the US enable safe and successful use of low-GWP A2L refrigerants in commercial refrigeration?
- To gain a deeper understanding of the holistic approach to making refrigerant choices in existing and new stores, including **use of all the tools in the toolbox.**

Toolbox

In order to reduce direct environmental impact:

- New Equipment
  - Use “lower or as low as possible” GWP refrigerant
  - Consider smaller refrigerant charge sizes in design and selection
- Existing Equipment
  - Maintain well to detect, fix, and reduce or eliminate refrigerant leaks
  - Retrofit (A1 for A1) to a lower-GWP refrigerant
  - Recover and reclaim refrigerant for use in service

Reduce indirect environmental impact of the refrigerants (10X or more of direct):

- Install, commission, maintain all components, equipment and systems to design conditions at all times

A European Retailer's Refrigeration Journey

ASDA

ASDA at a Glance

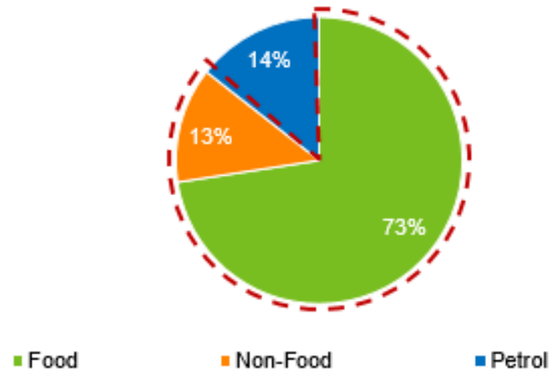
A Customer-Centric, Omnichannel European Retailer

ASDA | Who We Are

Business of Scale which is highly cash generative

~£22.9bn	FY19[1] Revenue (inc. Petrol & Other)
~£745m	Capex invested over the last two years[4]

2019A Revenue Breakdown (Inc. Petrol): £22.9bn[6]



UK's Third-Largest Supermarket

Large-scale UK business

Multi-format omni-channel offering

Every Day Low Price foundations

George.

#2 clothing[1] brand by volume[2] in the UK through George

Strong own-brands

Food sourcing competitive advantage via IPL

~140k flexible and engaged colleagues

ASDA Walmart

Supported by Walmart

ASDA's Refrigeration Journey | Measuring Success

BEFORE

Centralized Plant

1) Custom design
2) Supplier dominant
3) Limited flexibility
4) Limited consistency
5) Large refrigerant charge
6) Single points of failure

Who Are We Kidding?

The 90s and 2000s

1) Reliability issues
2) Unknown expenses
3) Unknown causes
4) High gas leakage
5) High energy
6) Environmental impacts

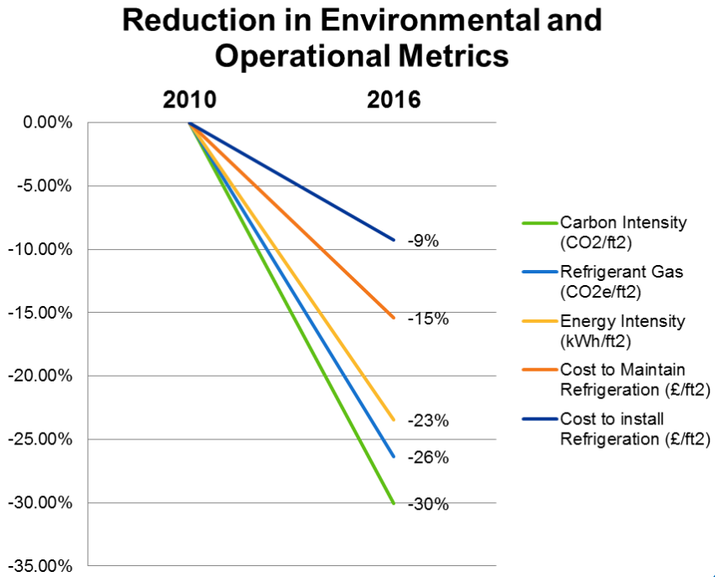
Distributed Systems

1) Customer first
2) Quality control
3) Retrofit design
4) Distributed systems
5) Service simplicity
6) Trading risk mitigated
7) Standardization to leverage
8) Flexible
9) Less disruption

NOW

Distributed Systems Benefits Since 2008

EXAMPLE



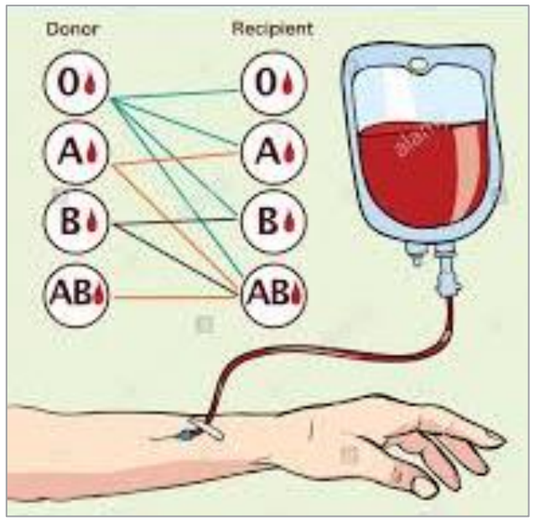
A2L refrigerants, as well as other refrigerants, may exhibit certain levels of toxicity and/or flammability. Always use reasonable care, hire trained professionals, and be sure to follow any applicable guidelines, rules, laws and regulations for the safe and proper use, storage, disposal and transport of any refrigerants.

Consider Everything, Because Technology Will Keep Changing

Montreal Protocol – Kyoto Protocol - F-Gas – Kigali Agreement – Net Zero

F-Gas 2020
Remove, Replace, Reuse

Existing Systems *(refrigerant retrofit; do not dispose!)*



Blood Transfusion

F-Gas 2022
Transition

New Systems *(system retrofit)*

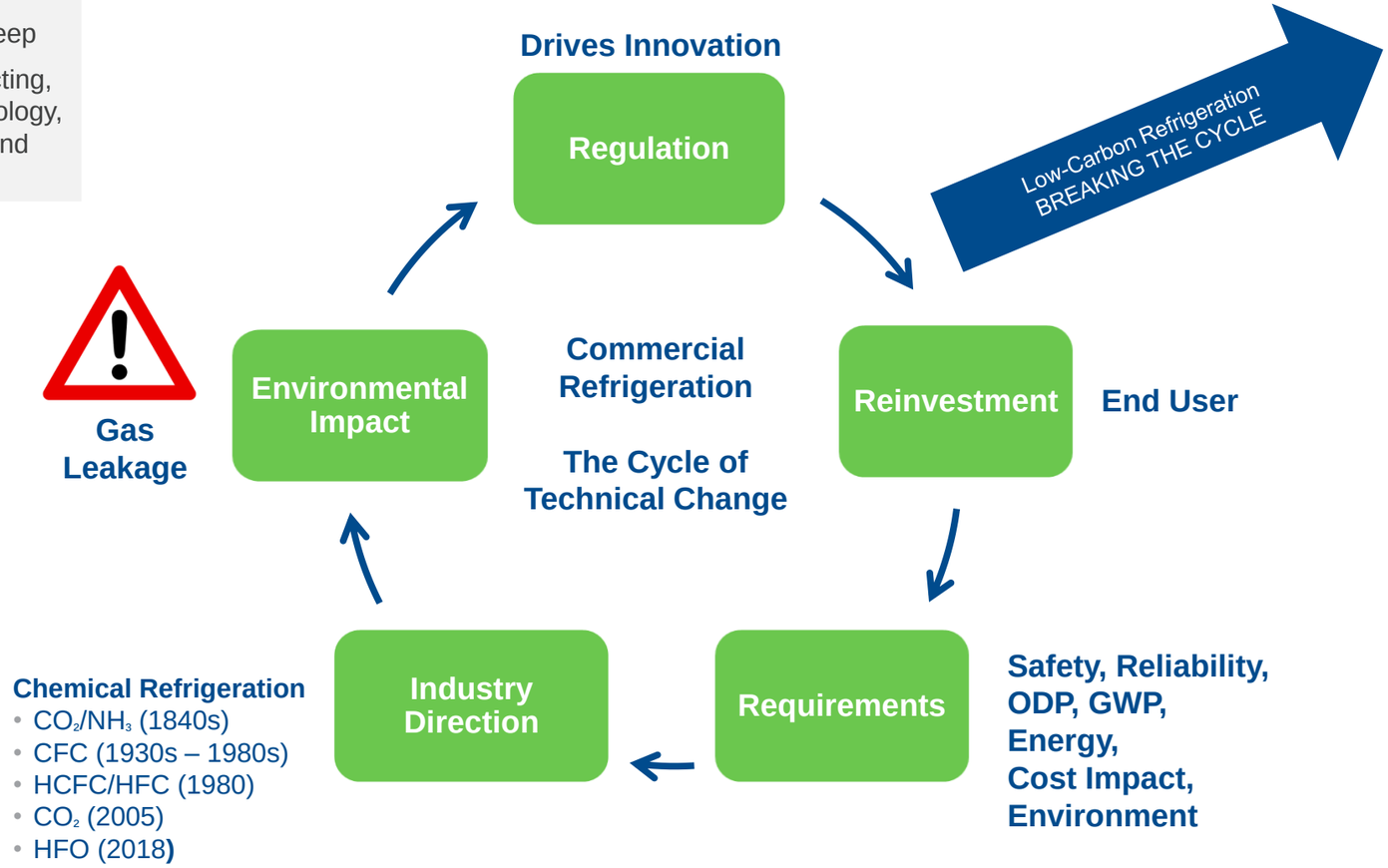
Organ Replacement

Whack-a-Mole

Strategy | Reduction Prevention Transition

Objectives

- Reduce leakage and energy
- Prevent leakage and energy creep
- Transition to simple, low- impacting, safe, reliable, repeatable technology, which is both environmentally and financially sustainable



BEST PRACTICE

Strategy: Land the Basics Well

Reduction, Prevention, Transition

Reduction in leakage, energy, system failure, reactive maintenance

Prevent leakage, energy creep and risk of failure

Transition to next-gen design:

- Customer first
- Agnostic approach
- Toolbox of solutions
- Safe systems
- Trial, not error
- Like-for-like evaluation

Simple
Measurable
Accountable
Reliable
Repeatable
Time-Sensitive

F-Gas: Over a Decade of Savings

Get It Right and Save

Revenue

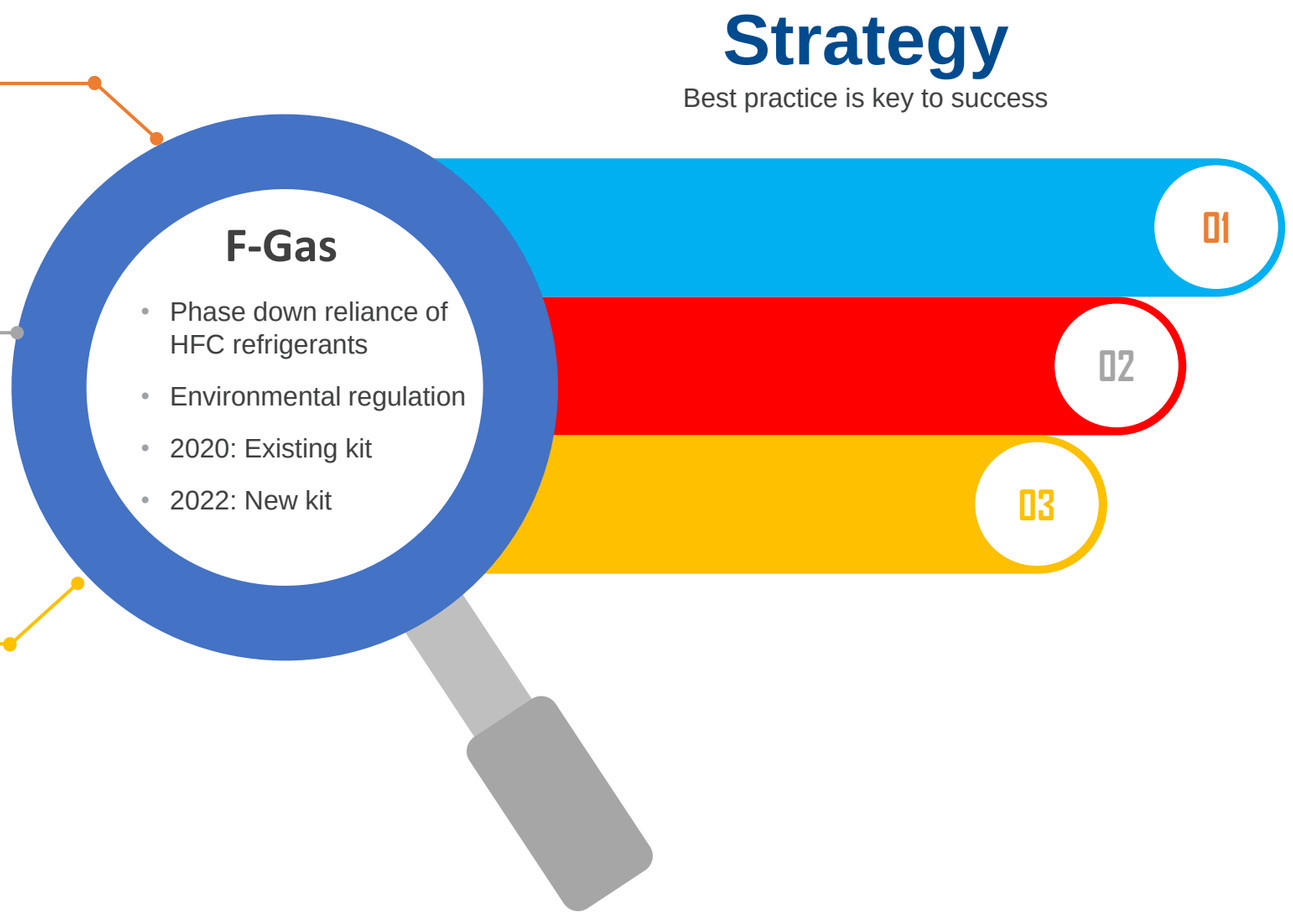
- Mitigate costs
- Simple, reliable, safe, repeatable
- Cost-effective maintenance

Capital

- Deferred asset investment
- Limiting the risk of destroying refrigerants prematurely (remove, replace, reuse)
- Trials to identify alternatives

Carbon

- Over 2.5TM CO_{2e} mitigated carbon through TEWI
  1. Carbon production energy 80%
  2. Carbon production leakage 20%



Strategy

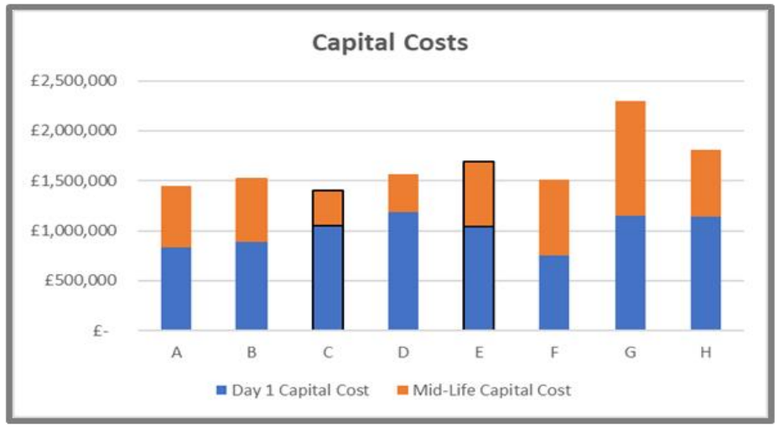
Best practice is key to success

Design Ownership

Lifecycle and Emissions Impact No HFC-Based Tech

Trial, Not Error

Based on 20 years - *Model store*



Glossary

A Non-compliant tech post 2022

B HFO – Mildly flammable (Model Option)

C Mistral / HFO (Model)

D Mistral / CO_2 option

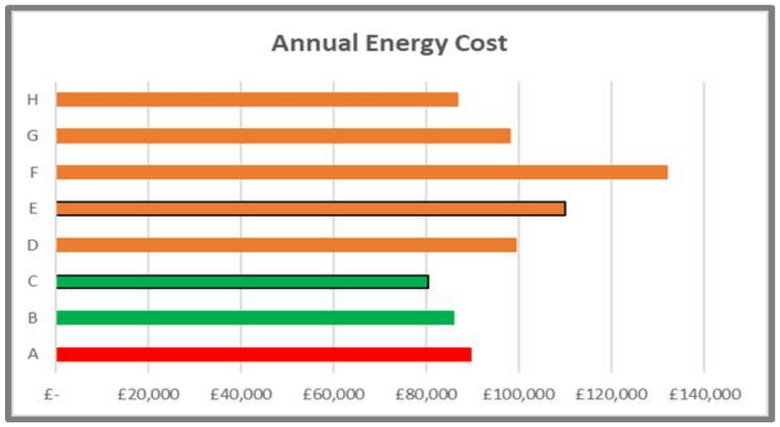
E CO_2 (Industry Driven Option)

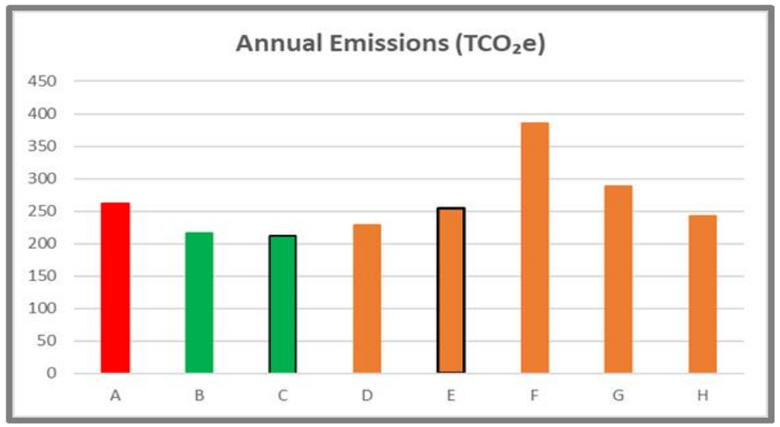
F Plug-in fridge tech option (air-cooled)

G Plug-in fridge tech option (water-cooled)

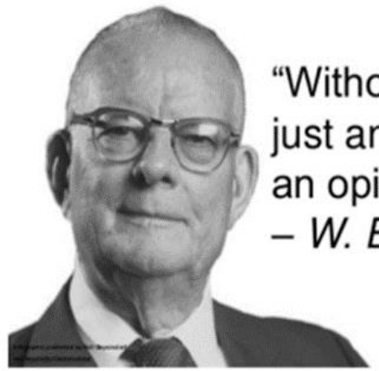
H Secondary Glycol

Annual Energy & Emissions – *per store*



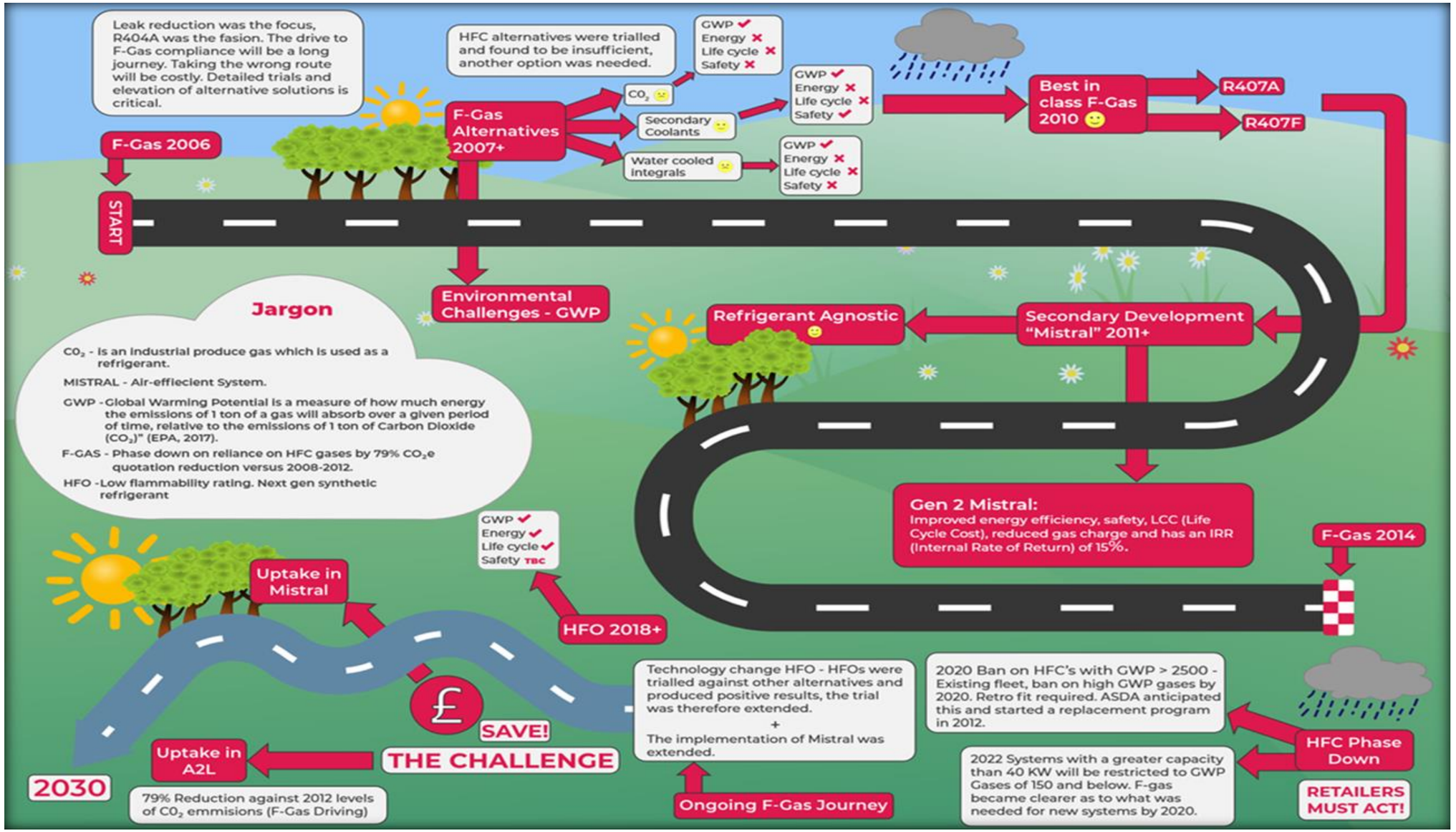


Why?



"Without data you're just another person with an opinion."
– *W. Edwards Deming*

The F-Gas Journey So Far



Collaborative Working Group Creating an A2L

Design Standard

Multi-Award Winning Since 2008

Safety First

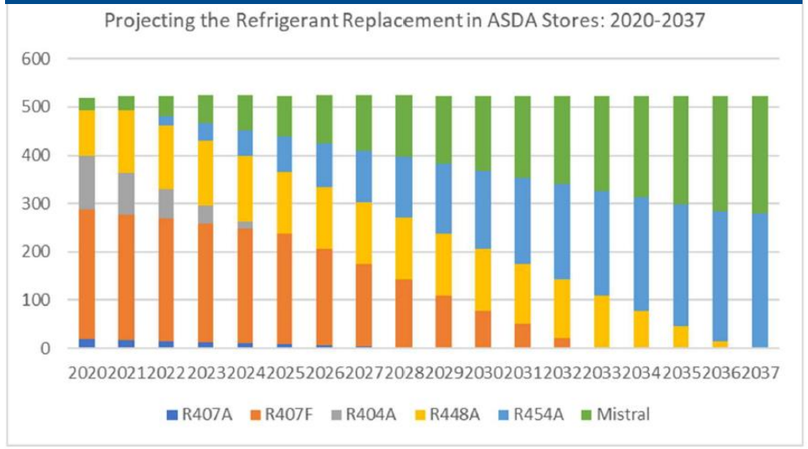
- DSEAR assessment completed across all areas with a compendium of information capturing learnings through ongoing developments
- Robust technical direction, documented requirements providing safety through standards and design

“We’re not reinventing the wheel. We’re just making it work better for us.”

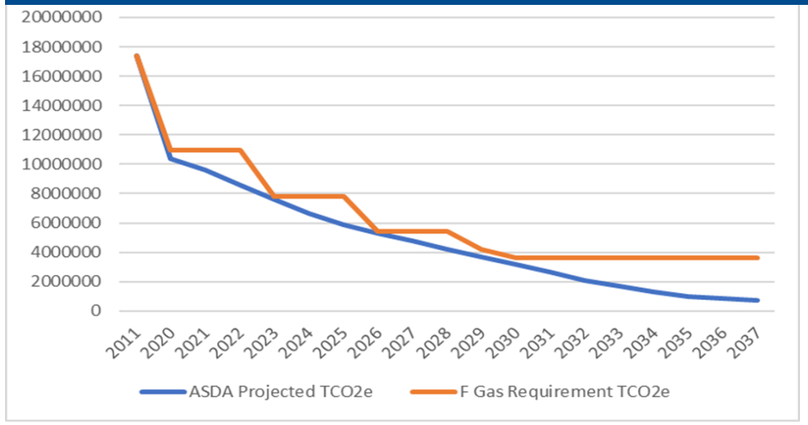
- TRIAL, NOT ERROR
- Agnostic approach
- Keep it simple and aligned with existing architecture. Regulation has limited choice. Safety now a key concern. Refrigerant chemicals will be either flammable, toxic or explosive.
- Of our many trials, A2Ls best align our operation and architecture
- Lower flammability rating is managed through robust design standards
- We have taken a "belts and braces" approach, knowing we will strip back as we learn
- All of our learnings are shared – *International Institute of Refrigeration*
- Documented compendium of information across all areas
- Value engineering to maintain and create repeatable solutions
- Accept you will never finish the journey
- A2L-ready approach will spread the cost of change and is affordable
- It allows us to impact more systems quicker through affordability and flexibility

Our Proven Approach in Deployment of Distributed Systems

Projected HFC Phasedown



Projected HFC Phasedown vs. F-Gas Quota Reduction



First HFO Trial: 2018
Model Standards: 2021

Findings to Date

- Aligned with existing architecture
- Engineering skill base familiarity
- 94% direct emissions reduction
- 20% energy saved
- Enhanced performance in high ambient
- Hybrid plant and display case design
- Lowest overall TEWI
- Lowest TCO
- Safe through design

Roundtable Discussion

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AHRI Webinar for Commercial Refrigeration

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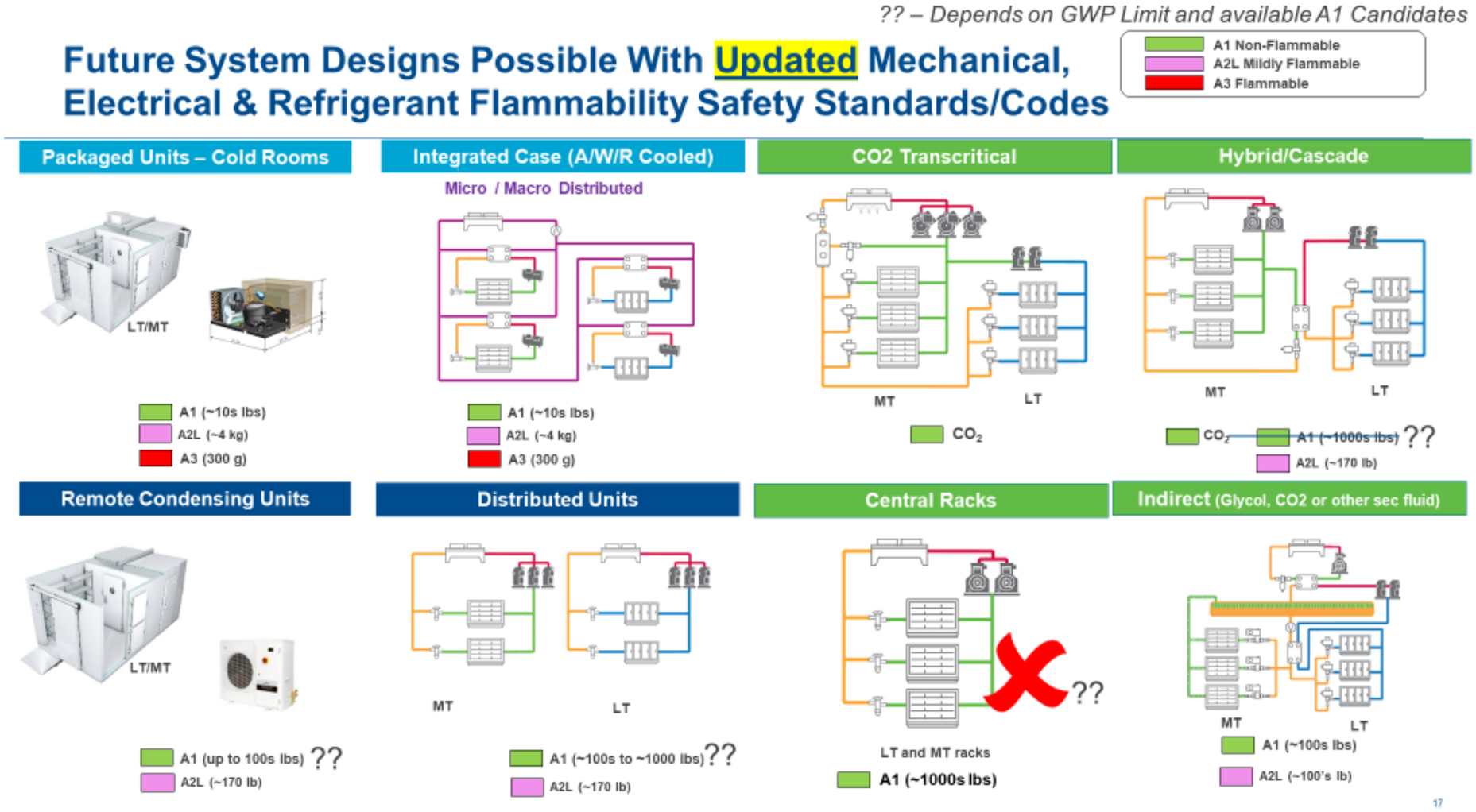

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Reduce indirect environmental impact of the refrigerants (10X or more of direct):

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ASHRAE 15 (2019) – Addendum I Overview

Proposes to expand the use of flammable refrigerants in Com Ref:

- Updates would apply to refrigerant Safety Groups A2L, A2, and A3
- Covers self-contained and field-erected (A2L only) systems
- All systems must be listed to UL/CSA 60335-2-89
  - Charge limits consistent with UL/CSA 60335-2-89 draft
- Prohibits installing systems with > 4*LFL charge within 20’ of an open flame
- Compliance path for installing doors on open cases with flammables
- A2L specific requirements for field-erected systems

Refrigerants Charge Limits

A2L Charge Sizes:

8 x LFL ~ 2.4 kg [5.3 lb.]

13 x LFL ~ 4 kg [8.8 lb.]

52 x LFL ~ 16 kg [35 lb.]

260 x LFL ~ 78 kg [172 lb.]

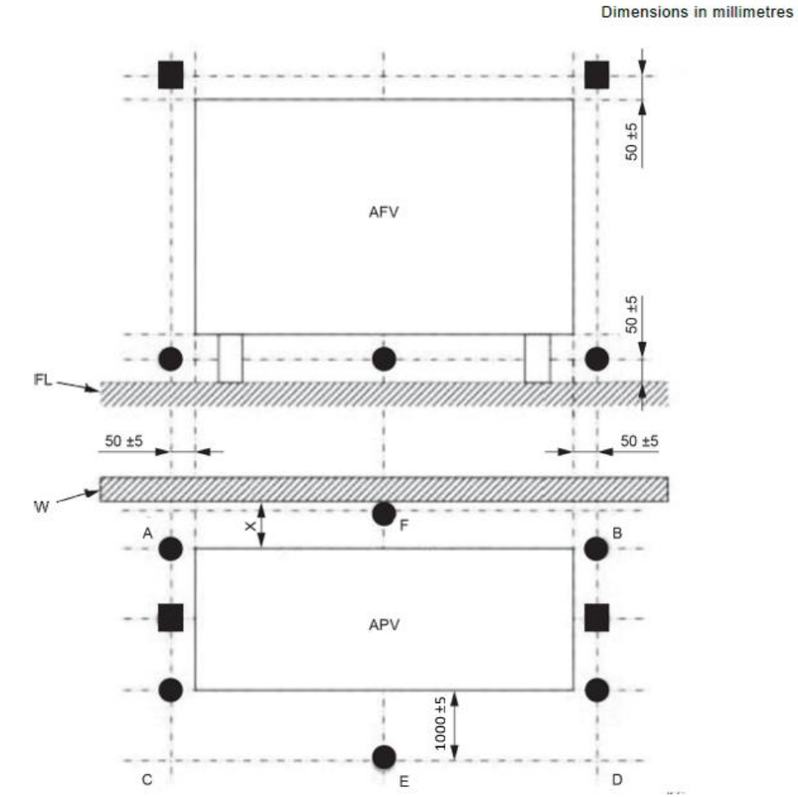
A3 Charge Sizes:

8 x LFL ~ 300 g [0.67 lb.]

13 x LFL ~ 500 g [1.1 lb.]

- IEC Standard 60335-2-89 ed. 3.0 now allows charge limits for R-290 (an A3) in commercial refrigerators up to **494 g (1.10 lb.)** and for A2L refrigerants to **1.2 kg (2.6 lb.)** in self-contained equipment only.
- Recently, UL and CSA proposed charge limit changes to the North American version—UL/CSA 60335-2-89. This is currently in the public comment process.
- A3 refrigerants are limited to self-contained equipment only in the UL proposal, up to 494 g (1.10 lb.) in open appliances for R-290, but only up to 304 g (0.670 lb.) in closed equipment with doors
- In the UL proposal, A2L refrigerants can be used in field-erected “remote” systems with charge sizes up to about 78 kg (172 lb.), with additional safety measures required

Using Higher Charge Limits



Key

AFV	appliance front view
APV	appliance plan view
X	minimum separation distance from the wall specified in the instructions or allowed by the construction or 50 mm whichever is greater
FL	test room floor
W	test room wall

Figure CC.1 – Schematic illustration of the refrigerant concentration sampling points

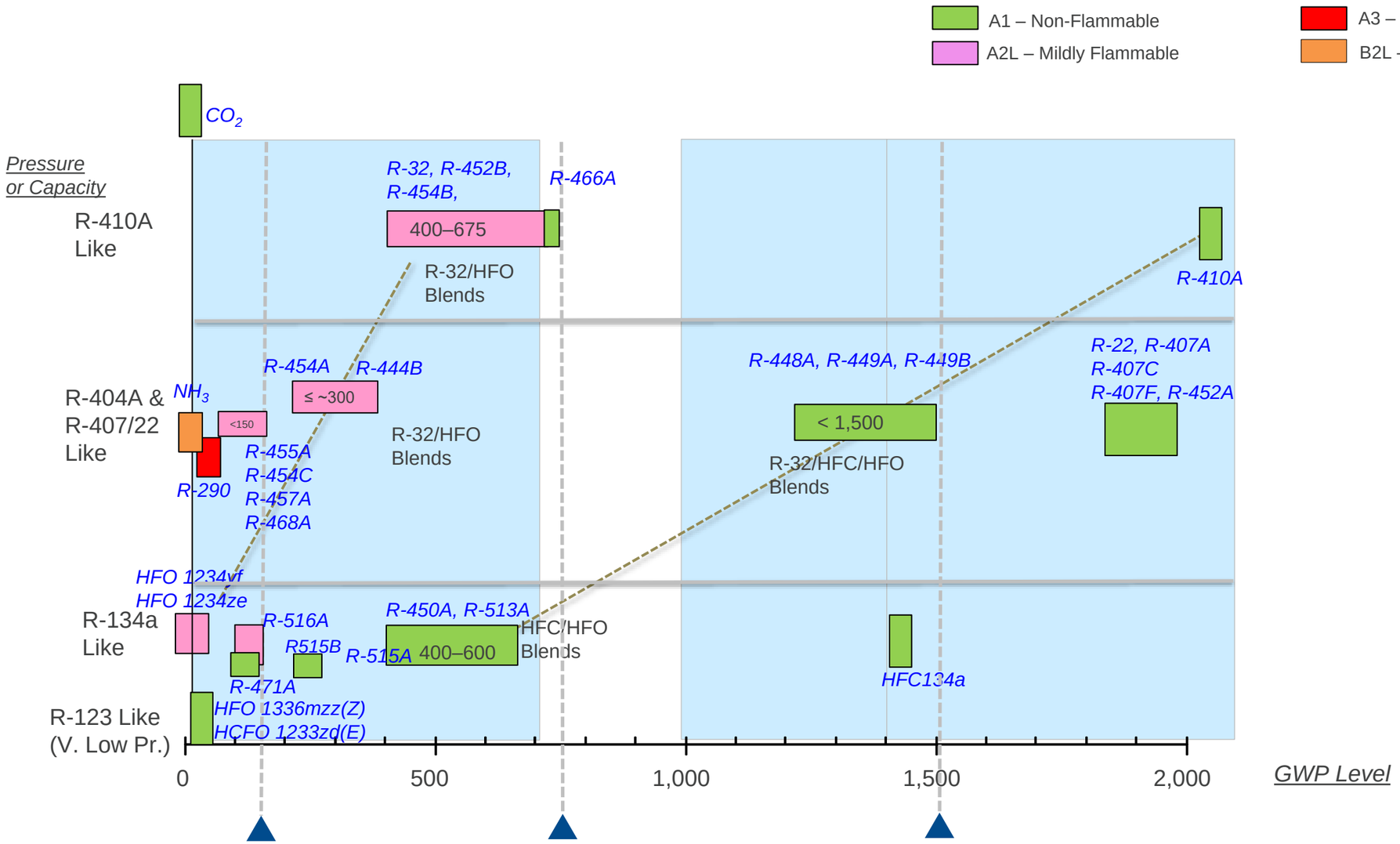
Diagram showing concentration sampling points, from UL 60335-2-89 proposed ed 2.0

- More stringent requirements for equipment with >150g of flammable refrigerant per circuit
  - Tubing protected from potential damage
  - System must be hermetically sealed
  - No low-temperature solders used
  - Test for excessive vibration
- Additional testing to ensure a flammable concentration does not form if a leak occurs:
  - Utilize condenser fan or auxiliary fan
  - Top-mounted condensing unit where possible
  - With A2Ls in a remote system, refrigerant detection system

Using Higher Charge Limits

- A2L refrigerants in remote systems – necessary mitigation
- Display and Storage Cases
  - Open: releasable charge less than 13 x LFL and comply with Annex CC
  - With doors/drawers: releasable charge less than 8 x LFL and comply with Annex CC
- Walk-in Cooler/Freezer Evaporators
  - If charge < 52 x LFL, air circulation constant or triggered by refrigerant detection
  - If 52 x LFL < charge ≤ 260 x LFL, ventilation triggered by refrigerant detection
- Indoor Compressor Units and Condensing Units
  - If 13 x LFL < charge ≤ 52 x LFL, safety shut-off valves triggered by refrigerant detection, and air circulation constant or triggered by refrigerant detection if room is smaller than certain threshold
  - If 52 x LFL < charge ≤ 260 x LFL, safety shut-off valves triggered by refrigerant detection, and ventilation triggered by refrigerant detection
- Outdoor Compressor Units and Condensing Units
  - Product installed according to requirements in ASHRAE 15

Refrigerant Alternatives – All Applications



Qualitative — Not to Scale

29

Appendix

A2L Safety Considerations

A2L refrigerants exhibit low toxicity and are mildly flammable. In terms of toxicity, like HFCs, A2Ls have a permissible exposure limit of >400 ppm and the related risk of accidents is low. In terms of an A2L's flammability, they typically require:

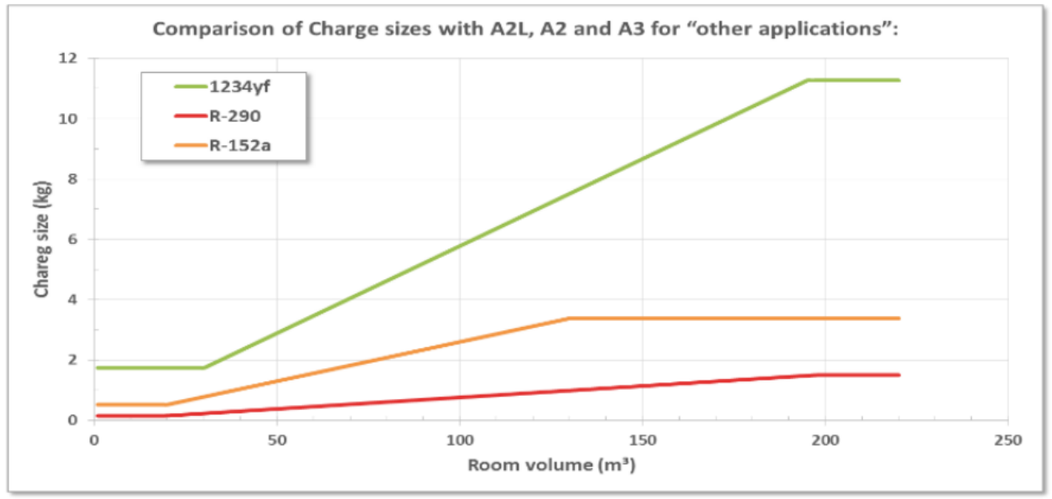
- Greater than 0.3 kg/m³ concentration in air to burn
- A heat of combustion of <19,000 kJ/kg
- A burning velocity of <10 cm/s
- The effect of ignition from A2Ls is low (when compared to hydrocarbons) and they are difficult to ignite. It is necessary that components with ignition sources are avoided, and appropriate ventilation is provided where necessary, as per guidance to relevant standards (EN-378: Refrigerating Systems and Heat Pumps).
- System Filling Charges for A2L Refrigerants: Charges are covered by the respective standards for refrigeration equipment – the general safety and use standard ISO 5149 and EN-378 "Refrigeration Systems and Heat Pumps". EN-378:2016 gives guidelines for ensuring that systems do not exceed the maximum amount of charge in a specific area, which is normally referred to as the *lower flammable limit.*

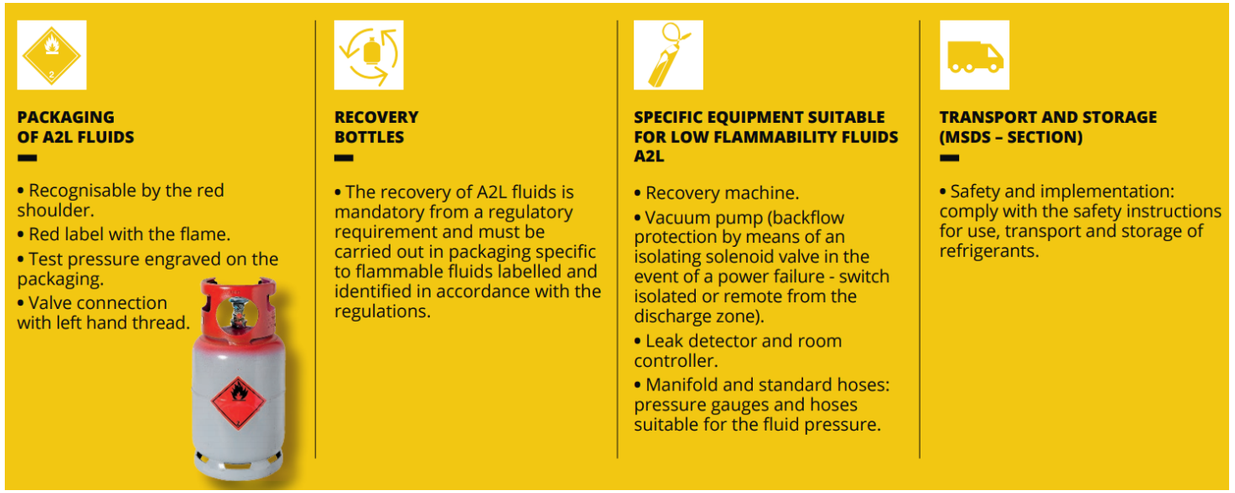
https://climalife.dehon.com/uploads/assets/Brochures/A2L%20guide/Guide_Fluides_A2L_210x150_FINAL_EN_BD.pdf

A2L Safety Considerations

- The graph below shows that you can typically use more than 10 times the charge of an A2L refrigerant compared to an A3 highly flammable refrigerant.

Charge size = 20 % x LFL x Room volume





Applications	Product safety norm	Norm EN 378	Refrigerants	GWP*	LFL kg/m³**	LFL %**	ELV***	PED
Commercial / Industrial Refrigeration	EN 60335-2-89	x	**R-455A** (Solstice® L40X)	146	0.431	11.8	0.414	Group 1
			R-454A (Opteon™ XL40)	239	0.278	8	0.461	Group 1
			R-454C (Opteon™ XL20)	146	0.293	7.7	0.371	Group 1
			R-1234ze (Solstice® ze)	< 1	0.303(2)	6.5(2)	0.28	Group 2

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Thank You!

Questions?

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