REFRIGERANTS TRENDS

NATURAL REFRIGERANTS PROJECTS TIMELINE

Nidec Global Appliance

1993 — First R600a Table Top

1994 — First R290 Portable Air Conditioner

1996 — R600a Compressor Supply To Haier And Kelon

1996 — Commercial Freezer with R1270

2008 — R744 Hermetic Compressor

2008 — First R290 Compressor for Ben & Jerry Ice Cream Freezer in US market

2015 — First Variable Capacity Ultralow Freezer Using R290 and R170

2019 — 50 % of Compressors Sold by Embraco Are For Natural Refrigerants

GLOBAL CONTEXT: CLIMATE CHANGE

Nidec Global Appliance

GLOBAL AGREEMENTS AND GOALS TO MITIGATE THE RISKS OF CLIMATE CHANGE

- Paris Agreement
- UN' Sustainable Development Goals
- Kigali Amendment to Montreal Protocol

REFRIGERATION, REPRESENTS 10% OF GLOBAL CO_2 EMISSIONS, MUST BE AN INTEGRAL PART OF THE SOLUTION.

20% OF EMISSIONS COME FROM REFRIGERANTS (HFCs)

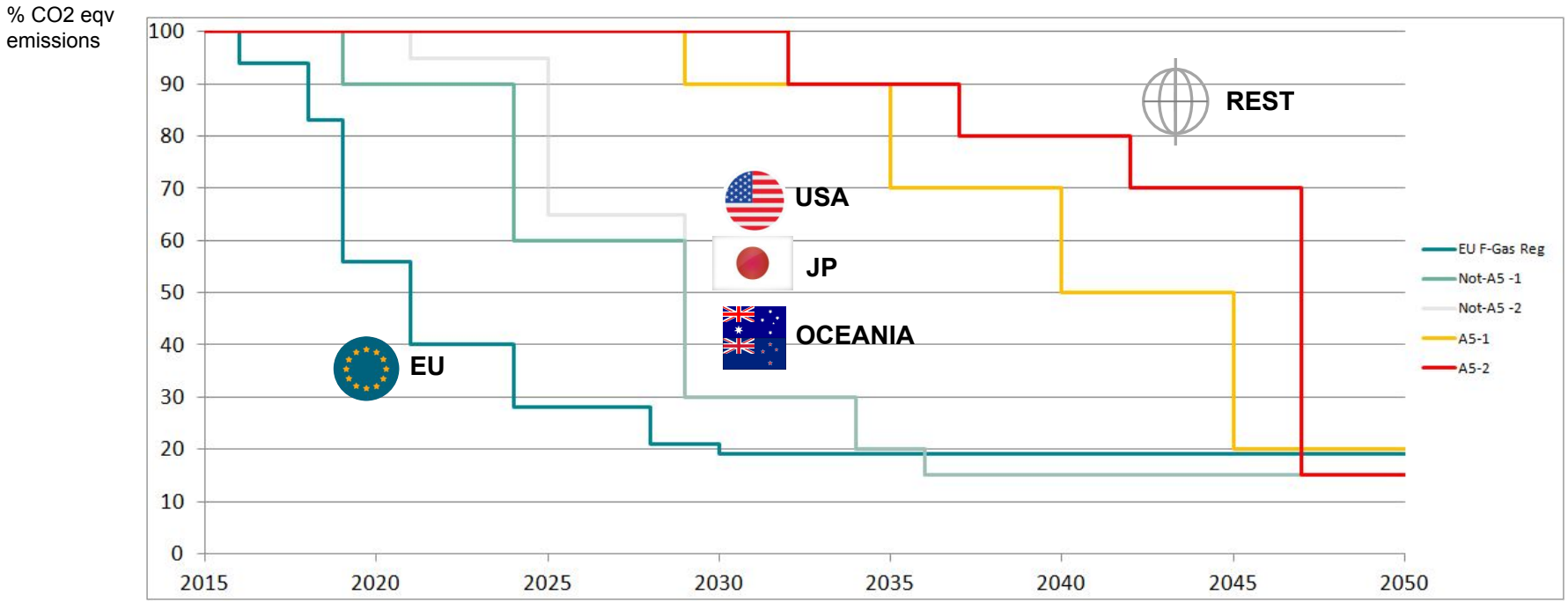
80% FROM PRODUCTS ENERGY USE

REGULATIONS PHASE DOWN OF HIGH GWP REFRIGERANTS

REGULATIONS TO IMPROVE PRODUCTS ENERGY EFFICIENCY

Source: Birmingham Energy Institute (UK) / CDP Cooling Executive Summary

F-GAS REGULATIONS – KIGALI AMENDMENT



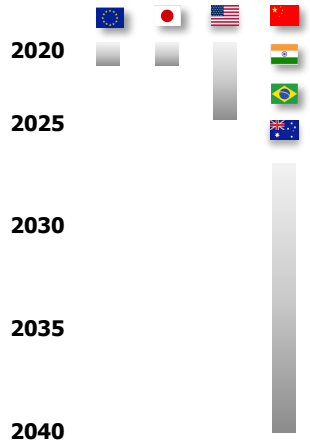
121 Countries Ratified Kigali Agreement , EU is Leading In F-Gas Regulations Effort, US Is Following With AIM Act

GLOBAL REGULATION FOR LIGHT COMMERCIAL REFRIGERATION

REGULATIONS AND PROGRESSIVE COUNTRIES DRIVING CHANGES IN MEDIUM AND LONG TERM

	CFCs	HCFCs	HFCs	Mixtures	Natural
	ODP: **High** GWP: **High** R11, R12	ODP: **Mid** GWP: **Mid-High** R22, R408, R409	ODP: **0** GWP: **High** R404A, R507	ODP: **0** GWP: **Mid** R448A, R449A	ODP: **0** GWP: **Low** R744, R290, R6O0a
USA	Phased Out		Phasing Out	Growing Demand	**Ramp up**
EU			Phasing Out 2020	Partial adoption (Remote)	**Default Solution**
CHINA			Default Solution	Being Tested	**Ramp up**
AUSTRALIA			Default Solution	Under Evaluation	Being Tested

HFC Refrigerants Ban
Migration to Mixtures & Natural Gases



Concentration of Installed Base

EMBRACO PORTFOLIO FOR COMMERCIAL REFRIGERATION

Nidec Global Appliance







Merchandiser | **Food service | food retail** | **Medical**

Fixed Speed

Merchandiser				Food service | food retail							Medical		
EM	EH	F	NE	EM	EH	F	NE	NT	NJ	SCROLL	NE	NT	NJ

Variable Speed

Merchandiser		Food service | food retail					Medical		
VEM	FMF	FMX	VEM	VES	FMF	VNE	FMX	VNE	FMF

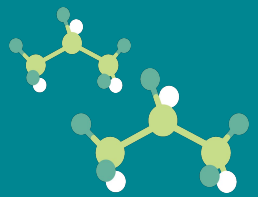
Condensing Units / systems

Merchandiser	Food service | food retail			Medical
Cond. Unit	Cond. Unit	Plug n' cool	Falcon	Bioma	Cond. Unit

RECIPROCATING: 2-38CC | **SCROLL:** 2-13HP **AVAILABLE FOR LBP, MBP, HBP APPLICATIONS**

WHY NATURAL REFRIGERANTS?

	HIGH GWP HFC's	LOW GWP HFC's	HC's
SAFETY CLASS	A1 Not flammable	A2L Mildly flammable	A3 Highly flammable
ENVIRONMENTAL IMPACT	Bad	Good	Excellent
REFRIGERANT COST	Ref	Very high*	Normal
COMPRESSOR THERMAL REGIME	Ref	Higher	Lower
INVESTMENTS FOR SAFETY	Ref	Yes	Yes
SYSTEM EFFICIENCY	Ref	Higher	Much higher
CHARGE LIMIT (IEC, EN60335-2-89)	No	150 g**	150 g**



Hydrocarbons Are a final solution to meet F-Gas regulations

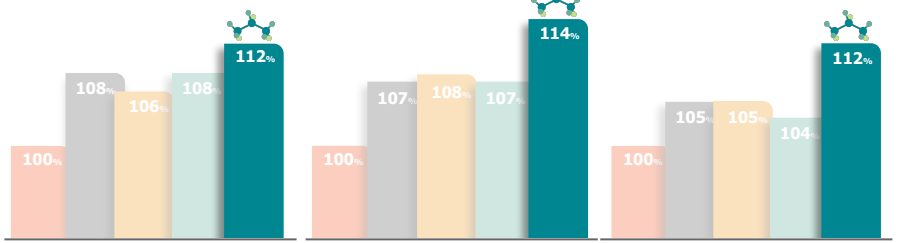
* Not yet in mass production

** Pending adoption of higher charge with local agencies

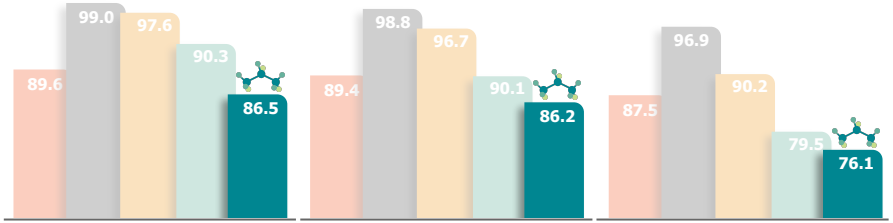
WHY NATURAL REFRIGERANTS?

Nidec Global Appliance

EFFICIENCY COMPARISON
% / Superheating 22.2 ºC / Middle point based



THERMAL REGIME EVALUATION
ºC / Superheating 22.2 ºC / Dew point based



R404A A2L #1 A2L #2 A2L #3 R290

Propane (R290) is the best in efficiency and lower TCO

Lower operating temperatures lead to longer compressor life

WHY NATURAL REFRIGERANTS?

Nidec Global Appliance

The main advantages of R290 vs A2L alternatives:

Excellent thermodynamic efficiency	= Higher COP, lower indirect impact
Low discharge temperature	= Higher reliability, larger envelope
No temperature glide	= Simple heat exchanger design
Low refrigerant charge	= Higher resistance to liquid return
Natural refrigerant with low price	= Lower production and service cost
Extremely low GWP	= Very low direct impact, future proof
Lower operating pressures	= In EU easier PED compliance

Except CO_2, All Low GWP alternatives are flammable (A2L, A2, A3), Code and Standards Requires An Urgent Revision

REFRIGERANT TRENDS

1. F-Gas

EPA federal **regulation on HFCs**: Following AIM Act updated regulation suppose to follow California ruling based on SNAP 20-21.

SNAP 20-21 (state level): R448A/R449A/R513A (relevant for FR and walk-in coolers) are in compliance - 8 states approved and 7 on going

CARB: 2019 - New Equip. (plug-in, distributed) <50lbs -> GWP <1400;
2022 - New Equip. (plug-in, distributed) >50lbs -> GWP <150;

1. Safety

UL/CSA 60335-2-89 - ref. charge increase (date TBD):
R290 -> 300g w/ doors / 500g w/o doors;
A2L – approx 2.3kg w/ doors / approx 3.8kg w/o doors

Ashrae 15 to be updated to allow flammables – in progress. Building Codes to follow in 2022 to be allowed in US

1. F-Gas

Under Kigali amendment. HFC ban by 2040

1. Safety

IEC 60335-2-89: charge increase. R290 < 500g; A2L < 1.2kg. Already in force in BR

There are a significant number of regulations taking place in different regions, with a focus on increasing the charge of flammable refrigerants (R290 and A2L's), GWP reduction.

REFRIGERANT TRENDS

1. ***F-gas***

F-Gas: 2020: >2500 GWP ban, in 2022
>150 GWP ban for refrigerators and freezers for storage, display or distribution of products in retail and food service for hermetically sealed systems. Regulation update expected in 2021.

1. ***Safety***

EN 60335-2-89: expected final vte by July 2021, ref. charge increase under European harmonization process by mid 2022. R290 < 500g; A2L < 1.2kg.

1. ***F-Gas***

HFC regulation: Ozone Protection Law, From 1st of January 2019, manufacturers and importers of HFC's must receive permission and obtain a quota in advance from the Ministry of Economy, Trade and Industries (METI).

1. ***Safety***

IEC 60335-2-89: charge increase not yet published (date tbc) . R290 < 500g; A2L < 1.2kg.

1. ***F-Gas***

Under Kigali amendment. HFC ban by 2040

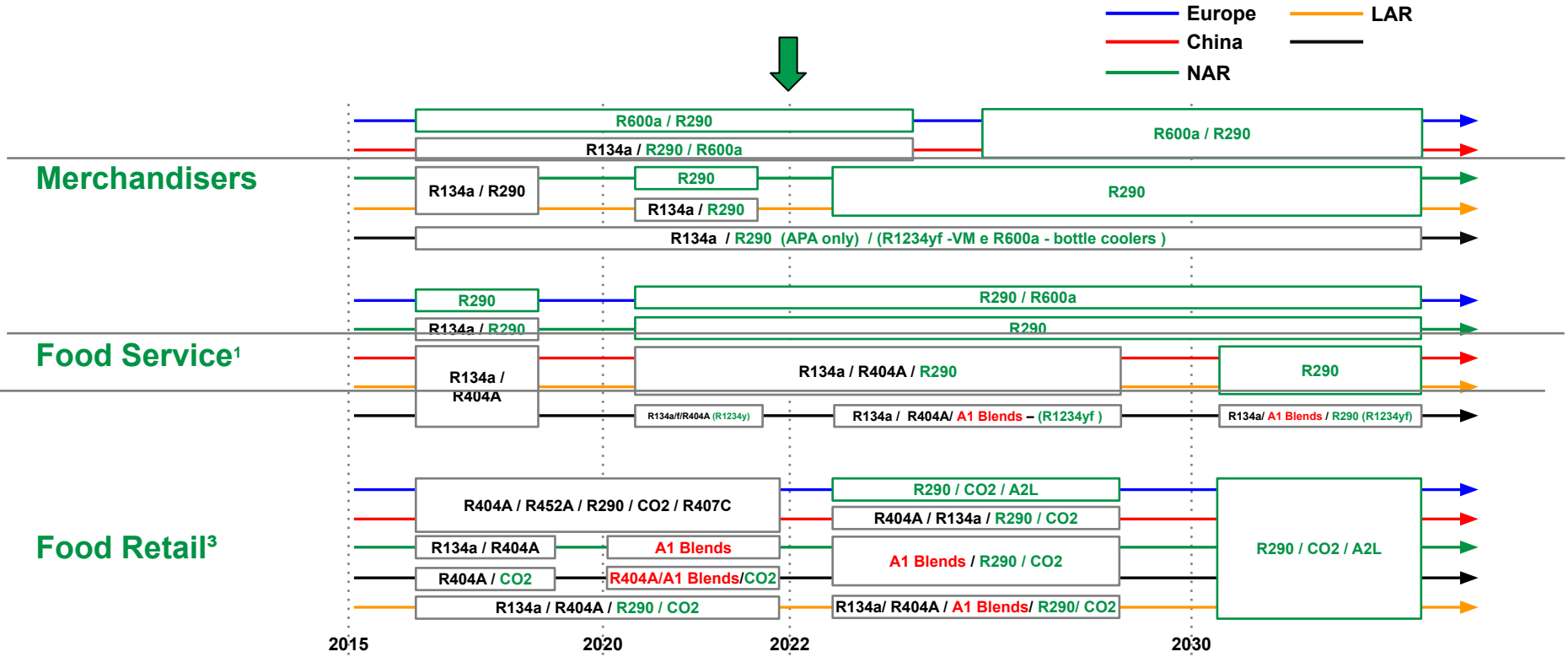
1. ***Safety***

Australia and New Zealand the AS/NZS 60335.2.89 already in force: R290 < 500g; A2L < 1.2kg.

There are a significant number of regulations taking place in different regions, with a focus on increasing the charge of flammable refrigerants (R290 and A2L's), GWP reduction.

REFRIGERANTS LANDSCAPE

Nidec Global Appliance



¹A2Ls can be an alternative for larger sizes blast chillers . Cold rooms will be divided between A2L and R290 and few with CO2.
²R290 also R600a will be present for small applications
³Above 2HP A2L will have more relevance.
A1Blends: R448A, R449A, R452A, R513A
A2L: R454C, R455A

Future proof solution

ALTERNATIVE REFRIGERANTS

		Properties			Embraco	
BASE	ALT.	Saf. Class	GWP	Glide	MBP	LBP
R404A (HFC)	R452A	A1	2140	3K	Approved - same envelope	Approved - same envelope
	R448A		1386	4K	Conditional approval NEU/NT/NJ (-15 to 0°C)	Conditional approval NEU/NT/NJ (-30 to -10°C)
	R449A		1397	4K	Conditional approval NEU/NT/NJ (-15 to 0°C)	Conditional approval NEU/NT/NJ (-30 to -10°C)
R134a (HFC)	R513A		631	0.5K	Approved - same envelope	Approved - same envelope
	R450A		597	0.5K	Approved - same envelope	Approved - same envelope
R404A (HFC)	R454C	A2L	146	8K	Planned approval	
	R455A		146	11K	Planned approval	
R134a (HFC)	R1234yf		<1	0K	Approved - Same envelope	Approved - Same envelope
HC	R290	A3	3	0K	Approved - Same envelope	Approved - Same envelope
	R744	A1	1	0K		

Same envelope
Restricted envelope
Planned approval

2018: A3 and A2L = Maximum refrigerant charge 150gr
2019: A3=0.5kg and A2L=1.2kg - Proposal under final IEC vote

NEW IEC CHARGE – Updated LIMIT FOR FLAMMABLES – IEC 60335-2-89 (2021)

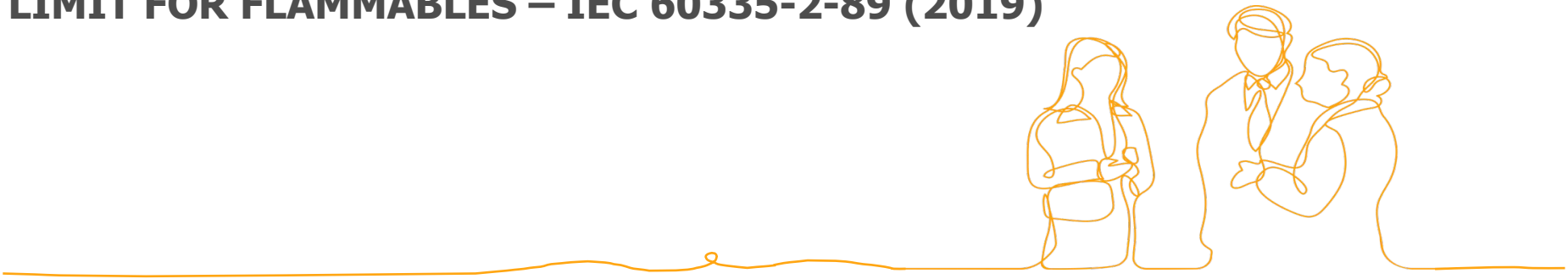
•UL (Underwriters Laboratories) has approved a second edition of the **UL 60335-2-89** standard, including higher charge limits for hydrocarbon and A2L (less flammable) refrigerants.

•The new UL standard raises the charge limit in commercial plug-in display cases to **13 times the LFL (lower flammability limit) of a refrigerant – or 500g for propane (R290)** – but only for open appliances (without doors)

• It raises the charge limit for closed appliances with doors and/or drawers to **eight times the LFL of the flammable refrigerant (300g for R290)**. The prior limit for flammable refrigerants in commercial cases – used in millions of installed cases globally – was 150g.

•A higher charge limit for R290 in commercial cases has long been considered necessary for wider adoption of the equipment in U.S. supermarkets. It will allow fewer compressors and condensing units to be used in cases, lowering costs and increasing energy efficiency, observers say.

NEW IEC CHARGE LIMIT FOR FLAMMABLES – IEC 60335-2-89 (2019)

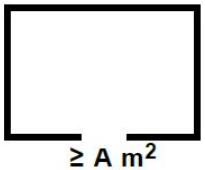


- **Max** refrigerant **charge** for each circuit **13*LFL**, but not more than **1,2kg**, (eg.500g of R290, 1,2kg R32).
- **Requirements** for systems **up to 150 g are not changing**. They are the same as with previous standard.
- **Cold Rooms** are **not part of the scope** with any refrigerante.
- **Remote Systems** with more then 150 g of flammables **are excluded** from the scope of this new edition
- **Commercial Ice Makers** are now part of the standard **scope.**

NEW IEC CHARGE LIMIT FOR FLAMMABLES – IEC 60335-2-89 (2019)

Main new requirements above 150g of charge:

- Refrigeration circuit has to be **hermetically sealed** Refrigerant-containing parts shall be **protected** and **not** be an **accessible** part
- Appliance shall be constructed to **not cause excessive vibration or resonance,**
- Appliance shall be **marked** with the **minimum room floor area** in which the appliance is permitted to be installed (With some exceptions),



[symbol IEC 60417-6415 2 (2019-03)][3] minimum room floor area

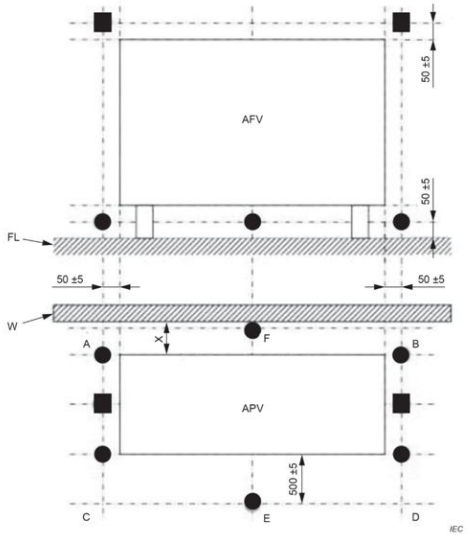
NEW IEC CHARGE LIMIT FOR FLAMMABLES – IEC 60335-2-89 (2019)

Main new requirements above 150g of charge:

- The main factor used to minimize the creation of a flammable mixture arround the appliance is the **air-flow or/and specific design features.**

- Appliance shall be constructed such that a leak of refrigerant shall not result in a flammable refrigerant concentration **surrounding the appliance** , by passing the test of **Annex CC.**

- Testing includes **doors**/drawers **opening** test after full charge release inside closed cabinet.



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

CONCLUSIONS

Nidec Global Appliance

•New Edition of **IEC 60335-2-89 was published in 2019.** It **was** a huge achievement on the path to meet **Kigali Amendment** and becomes a **reference standard** for all regional and national legislation to **mitigate global warming**.

• In **US** approved IEC standard will be the base for equivalent **UL** standard with some modification based on **AHRI** recent studies on A3 and A2L safety class refrigerants probably with different charge limits then IEC standard.

• In **EU**, Ed.3 of IEC standard 60335-2-89 is going to become **EN60335-2-89:** not earlier than **2022.**

• In **Japan** IEC standard is going to be translated into Japanese with deviations based of JIRIA safety studies to become **JIS 9335-2-89**.

• Once the new edition of the standard is part of country/region standardization system to become applicable **has to be adopted by** country/region **legislation**, eg. EU harmonized standards list or in US by EPA.

US/Canada Product Safety Standards Status

Nidec Global Appliance

- **UL 60335-2-89** and **CSA C22.2 60335-2-89** update was prepared by CANENA Working Group 12

- **2nd Edition** of both standards will replace:

UL 1995 / CAN/CSA-C22.2 No. 236 Heating and Cooling Equipment
CSA C22.2 No.120 Refrigeration Equipment
UL 471 Commercial Refrigeration and Freezers
UL 427 Refrigerating Units
UL 412 Refrigeration Unit Coolers

- New **UL -89** Standard edition was published on **Oct,27 2021**

- To enter in force it has to be declared acceptable by EPA and then considered by Ashrae 15 Standard and Building Codes.

The major scope differences between IEC and UL/CSA 60335-2-89

	IEC -89 ed.3	UL -89 ed.2
refrigerated display and storage cabinets	YES	YES
refrigerated trolley cabinets	YES	YES
service counters and self-service counters	YES	YES
blast chillers and blast freezers	YES	YES
commercial ice-makers	YES	YES
factory assembled walk in coolers/freezers	out of scope	YES
split commercial refrigeration systems	YES**	YES
partial units used in field-erected systems	out of scope	YES
dispensing units	out of scope	YES
commercial refrigeration systems up to 15000 voltage	out of scope	YES
commercial refrigeratiors and freezers for use in fuel dispensing facilities	YES	YES

** up to 150g

Charge Limits For Class A2L and A3 (UL ed.2 vs IEC ed.3)

	Max Charge [IEC -89 ed.3]		Max Charge [UL -89 ed.2]			
			open cabinets		cabinets with doors	
	A2L (R454C)	A3 (R290)	A2L (R454C)	A3 (R290)	A2L (R454C)	A3 (R290)
refrigerated display and storage cabinets	1.2 kg	0.5 kg	3.8 kg	0.5 kg	2.3 kg	0.3 kg
refrigerated trolley cabinets	1.2 kg	0.5 kg			2.3 kg	0.3 kg
service counters and self-service counters	1.2 kg	0.5 kg	3.8 kg	0.5 kg	2.3 kg	0.3 kg
blast chillers and blast freezers	1.2 kg	0.5 kg			2.3 kg	0.3 kg
commercial ice-makers	1.2 kg	0.5 kg			2.3 kg	0.3 kg
factory assembled walk in coolers/freezers	out of scope				2.3 kg	0.3 kg
split commercial refrigeration systems	0.015 kg	0.015 kg	up to 76 kg	out of scope	up to 76 kg	out of scope
partial units used in field-erected systems	out of scope		up to 76 kg	out of scope	up to 76 kg	out of scope
dispensing units	out of scope				2.3 kg	0.3 kg
commercial refrigeration systems up to 15000 voltage	out of scope		3.8 kg	0.5 kg	2.3 kg	0.3 kg
commercial refrigeratiors and freezers for use in fuel dispensing facilities	1.2 kg	0.5 kg	3.8 kg	0.5 kg	2.3 kg	0.3 kg

embraco

Nidec

50 YEARS

1971-2021

REFRESHING THE FUTURE

PIONEER in solutions with natural refrigerants

Energy efficiency: robust portfolio with low energy consumption

Deep expertise: tailor-made solutions for the system needs.

Reliability: product life extension

High-quality and **high performance**

1 in 5 hermetic compressors used in the world are Embraco

40% in Light Commercial Equipments


Nidec
Global Appliance