

Update on Codes and Standards Research

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Low-GWP AREP

- **Cooperative research & testing program to identify suitable alternatives to high GWP refrigerants**
- **Evaluation of candidates strongly desired by OEMs**
- **The program is NOT to prioritize refrigerants, rather test and present objective results in a consistent manner**
- **Phase I was completed at the end of 2013.**
 - 38 refrigerants were evaluated in Phase I
 - AHRI published 40 test reports
- **Phase II started in 2014, testing concluded in Dec.2015**
 - 17 new refrigerants, high ambient testing
 - 34 additional reports were published
- **Final reports available to the public**
- **<http://www.ahrinet.org/site/514/Resources/Research/AHRI-Alternative-Refrigerants-Evaluation>**



List of Low GWP Candidates in Phase I

Baseline	Refrigerant	Composition	(Mass%)	Classification (Note 1)	GWP ₁₀₀ (Note 2)
R22	ARM-32a	R-32/R-125/R-134a/R-1234yf	(25/30/25/20)	A1	1577
	LTR4X	R-32/R-125/R-134a/R-1234ze(E)	(28/25/16/31)	A1	1295
	N20	R-32/R-125/R-134a/R-1234yf/R-1234ze(E)	(12.5/12.5/31.5/1 3.5/30)	A1	975
	D52Y	R-32/R-125/R-1234yf	(15/25/60)	A2L	979
	L20	R-32/R-152a/R-1234ze(E)	(45/20/35)	A2L	331
	LTR6A	R-32/R-744/R-1234ze(E)	(30/7/63)	A2L	206
	R290	R290	100	A3	11
	R1270	R1270	100	A3	11
R-134a	AC5X	R-32/R-134a/R-1234ze(E)	(7/40/53)	A1	622
	ARM-41a	R-32/R-134a/R-1234yf	(6/63/31)	A1	943
	D-4Y	R-134a/R-1234yf	(40/60)	A1	574
	N13a	R-134a/R-1234yf/R-1234ze(E)	(42/18/40)	A1	604
	N13b	R-134a/R-1234ze(E)	(42/58)	A1	604
	XP-10	R-134a/R-1234yf	(44/56)	A1	631
	AC5	R-32/R-152a/R-1234ze(E)	(12/5/83)	A2L	92
	ARM-42a	R-134a/R-152a/R-1234yf	(7/11/82)	A2L	117
	R1234yf	R1234yf	100	A2L	4
	R1234ze	R1234ze	100	A2L	6
	R600a	R600a	100	A3	11
	R290/R600a	R290/R600a	(40/60)	A3	11

List of Low GWP Candidates in Phase I

Baseline	Refrigerant	Composition	(Mass%)	Classification (Note 1)	GWP ₁₀₀ (Note 2)
R404A	ARM-32a	R-32/R-125/R-134a/R-1234yf	(25/30/25/20)	A1	1577
	DR-33	R-32/R-125/R-134a/R-1234yf	(24/25/26/25)	A1	1410
	N40a	R-32/R-125/R-134a/R-1234yf/R-1234ze(E)	(25/25/21/9/20)	A1	1346
	N40b	R-32/R-125/R-134a/R-1234yf	(25/25/20/30)	A1	1331
	ARM-30a	R-32/R-1234yf	(29/71)	A2L	199
	ARM-31a	R-32/R-134a/R-1234yf	(28/21/51)	A2L	491
	D2Y65	R-32/R-1234yf	(35/65)	A2L	239
	DR-7	R-32/R-1234yf	(36/64)	A2L	246
	L40	R-32/R-152a/R-1234yf/R-1234ze(E)	(40/10/20/30)	A2L	285
	R-32	R-32	100	A2L	675
	R-32/R-134a	R-32/R-134a	(50/50)	A2L	1053
R290	R-290	100	A3	11	
R410A	ARM-70a	R-32/R-134a/R-1234yf	(50/10/40)	A2L	482
	D2Y60	R-32/R-1234yf	(40/60)	A2L	272
	DR-5	R-32/R-1234yf	(72.5/27.5)	A2L	490
	HPR1D	R-32/R-744/R-1234ze(E)	(60/6/34)	A2L	407
	L41a	R-32/R-1234yf/R-1234ze(E)	(73/15/12)	A2L	494
	L41b	R-32/R-1234ze(E)	(73/27)	A2L	494
	R32	R32	100	A2L	675
	R-32/R-134a	R-32/R-134a	(95/5)	A2L	713
	R-32/R-152a	R-32/R-152a	(95/5)	A2L	647

Notes:

- Refrigerants' classifications or intended classifications according to the ASHRAE Standard 34 (ASHRAE, 2010).
- Estimated GWP values from chemical producers

List of Low GWP Candidates in Phase II

Baseline	Refrigerant	Composition	(Mass%)	Classification (Note 1)	GWP ₁₀₀ (Note 2)
R22/R-407C	DR-93	R-32/R-125/R-1234yf/R-134a	20/20/31/29	A1	1251
	N-20b	R-32/R-125/R-134a/R-1234yf	13/13/31/43	A1	988
	R-449B	R-32/R-125/R-1234yf/R-134a	25.2/24.3/23.2/27.3	A1	1412
	ARM-20b	R-32/R-1234yf/R-152a	35/55/10	A2L	251
	DR-3	R-32/R-1234yf	21.5/78.5	A2L	148
	L-20a (R-444B)	R-32/R-1234ze/R-152a	41.5/48.5/10	A2L	295
R404A	ARM-35	R-32/R-125/R-1234yf	12.5/61/26.5	A1	2220
	DR-34 (R-452A)	R-32/R-125/R-1234yf	11/59/30	A1	2140
	N-40c (R-448A)	R-32/R-125/R-134a/R-1234yf/R-1234ze	26/26/21/20/7	A1	1387
	ARM-20a	R-32/R-1234yf/R-152a	18/70/12	A2L	139
	HDR110	R-32/R-1234yf/CO2	21.5/75.5/3	A2L	148
	ARM-71a	R-32/R-1234yf/R-1234ze(E)	68/26/6	A2L	460
R410A	DR-5A (R-454B)	R-32/R-1234yf	68.9/31.1	A2L	466
	DR-55	R-32/R-125/R-1234yf	67/7/26	A2L	698
	HPR2A	R-32/134a/1234ze(E)	76/6/18	A2L	600
	L-41-1 (R-446A)	R-32/R-1234ze/Butane	68/29/3	A2L	461
	L-41-2 (R-447A)	R-32/R-1234ze/R-125	68/28.5/3.5	A2L	583

Notes:

- Refrigerants' classifications or intended classifications according to the ASHRAE Standard 34 (ASHRAE, 2013).
- GWP values are calculated based on IPCC AR-4 100 year.

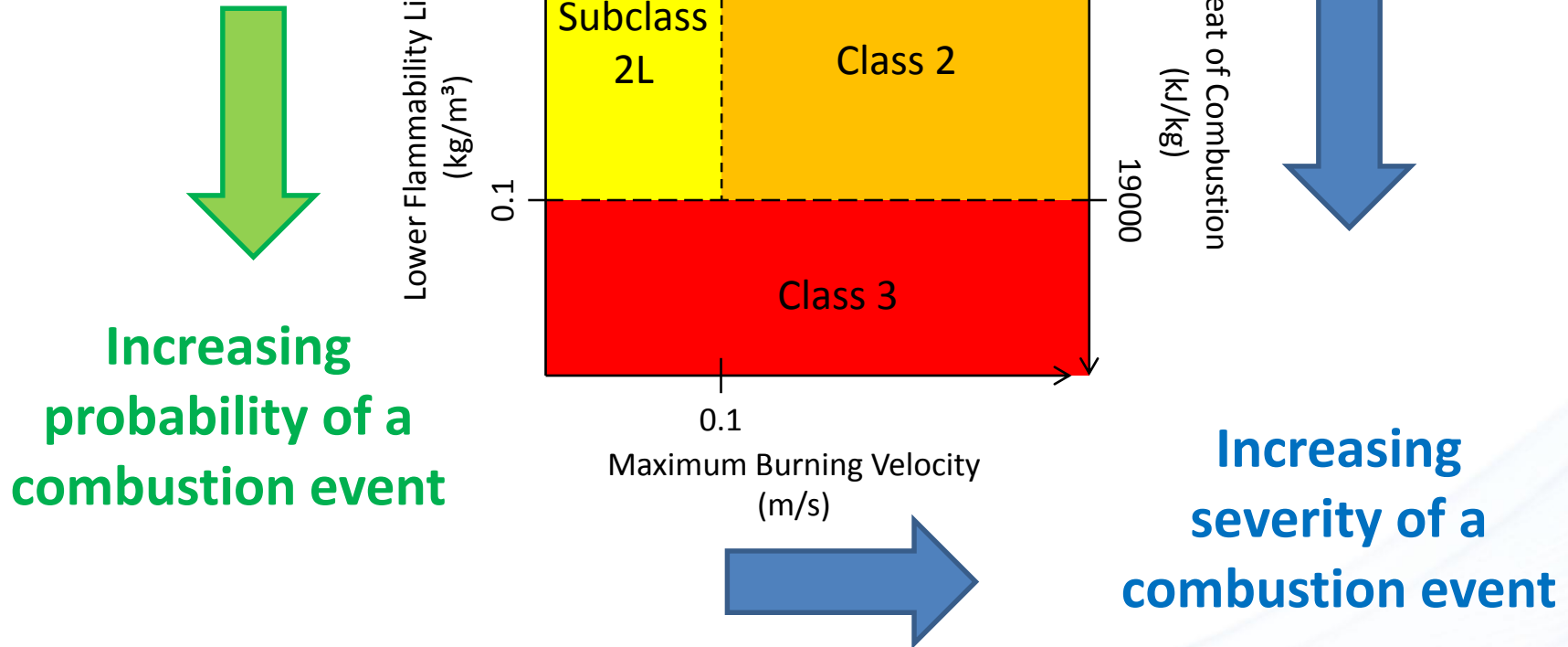
Low-GWP AREP

- **Viable low GWP alternatives exist**
- **Many promising refrigerants are classified 2L under ASHRAE 34 (mildly flammable)**
- **ASHRAE 15 does not currently differentiate between class 2 and 2L refrigerants**
- **IEC 60335-2-40 does not currently have requirements for 2L refrigerants**

Risks of Flammable Refrigerants

What are 2L Refrigerants:

- Exhibit flame propagation when tested at 60°C
- LFL > 0.10 kg/m³
- HOC < 19000 kJ/kg
- S_U ≤ 0.1 m/s



Slide Source: P. Johnson, ASHRAE 2012 Annual Meeting Seminar 11

Class 2 & 3 Restrictions

- In general, it is very restrictive
- A2 or A2L refrigerants allowed in self-contained systems with less than 3kg (residential) or 10kg (commercial), depending on location in the building
 - The current Standard 15 does not differentiate class 2 and 2L refrigerants because 2L is the sub-class of class 2
- A3 cannot be used except if allowed by AHJ
 - Exceptions:
 - Laboratories with more than 100 ft² (9.3 m²) area per person
 - Industrial occupancies
 - Portable unit systems containing less than 0.331 lb (150 g) of refrigerant charge

ASHRAE Standard 15 Recent Activities

- **2L Working Group (WG) was tasked to propose requirements on equipment using 2L refrigerants. The WG recent activities include:**
 - use of A2L refrigerants for human comfort with certain restrictions
 - requirements for refrigerant leak detectors (definition, reliability, response time, etc.)
 - ventilation requirements for the use of A2L refrigerants in machine room (current focus) and occupied space (later stage).
- **15.2 Subcommittee was created to address residential applications.**

ASHRAE Standard 15.2 Subcommittee

➤ **Proposed equipment coverage:**

- split system AC&HPs and single package AC&HPs
- whole house dehumidifiers, whole house dehumidifiers/ventilators, and
- permanently connected heat pump water heaters

➤ **Proposed scope:**

- one- and two-family dwellings
- multi-family structures with individual dwelling units, where each dwelling unit has its own dedicated heating and air-conditioning system
- detached outbuildings (and garages , guest houses, pool houses, etc.) located on the same private property defined above

ASHRAE SSPC-15 Update

- **ASHRAE 15.2, *Safety Standard for Air conditioning and Heat Pump Systems in Residential Applications***
 - Target an Advisory Publication Review (APR) by the end of 2016
 - Plan Two Publication Public Reviews (PPR) in 2017
 - Standard to be approved by the end of 2017
- **ASHRAE 15:**
 - Issued an APR related to A2L refrigerants. The Committee has addressed received comments and will publish addendum
 - Target the new edition including A2L language approved by the end of 2017

State of Standards and Codes – Global View

- Increasing charge limits for flammables is global trend
- Expect safety standards in 2017; codes follow standards

	Refrigerant Classification	Usage Restriction	Application		
United States	ASHRAE34 Refrigerant Designation & Safety Classification UL2182	ASHRAE15 Safety Standards for Refrigeration Systems 2015-2018	UL1995 Heating and Cooling Equipment 2014-2015	UL471 Commercial Refrigerators and Freezers 2015-2019	UL621 Ice Cream Makers 2015-2019
			UL60335-2-40 Heating and Cooling Equipment -2017	UL60335-2-89 Commercial Refrigeration -2018	
	Refrigerant Classification	Usage Restriction	Application		
International	ISO817 Refrigerant Designation & Safety Classification (2013-2014)	ISO5149 Safety and Environmental Requirements, Phase 1 Phase 2 2014-2015	IEC60335-2-40 Heating and Cooling equipment 2015-2017	IEC60335-2-89 Commercial Refrigeration 2015-2019	IEC60335-2-24 Refrigerating appliances Ice and Ice Cream Makers 2015-2019

complete

under revision

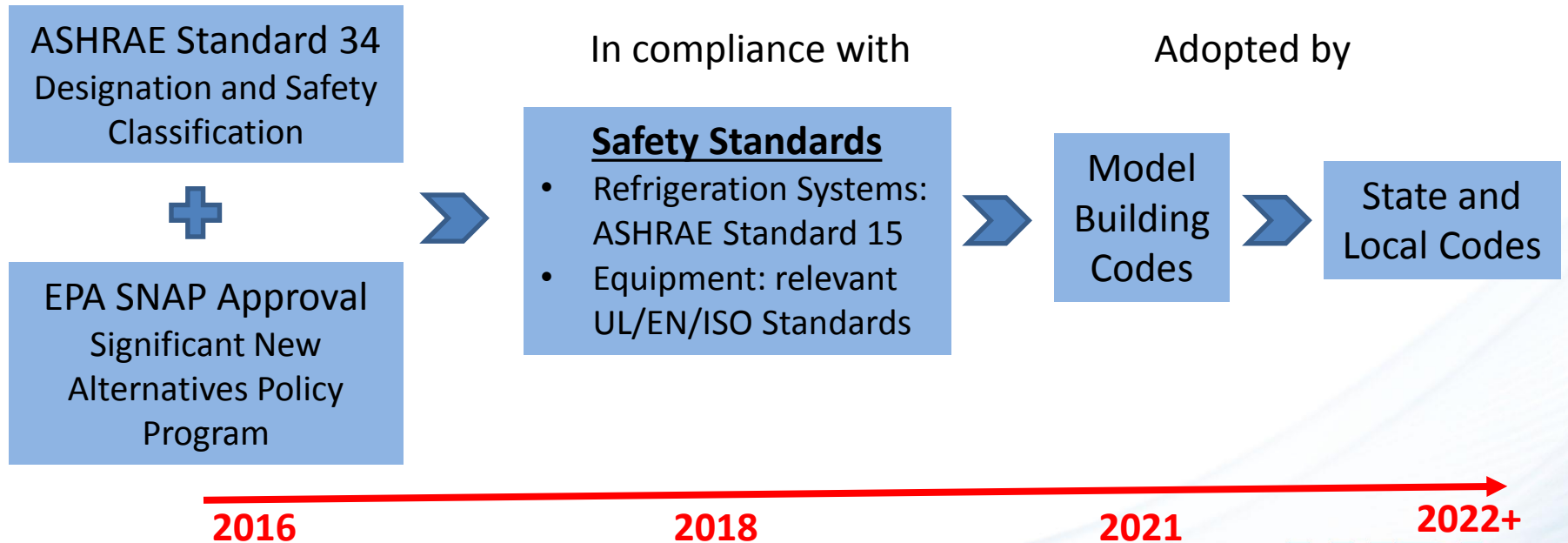
Source: Rajan Rajendran - Emerson

Code Adoption Process of New Refrigerants

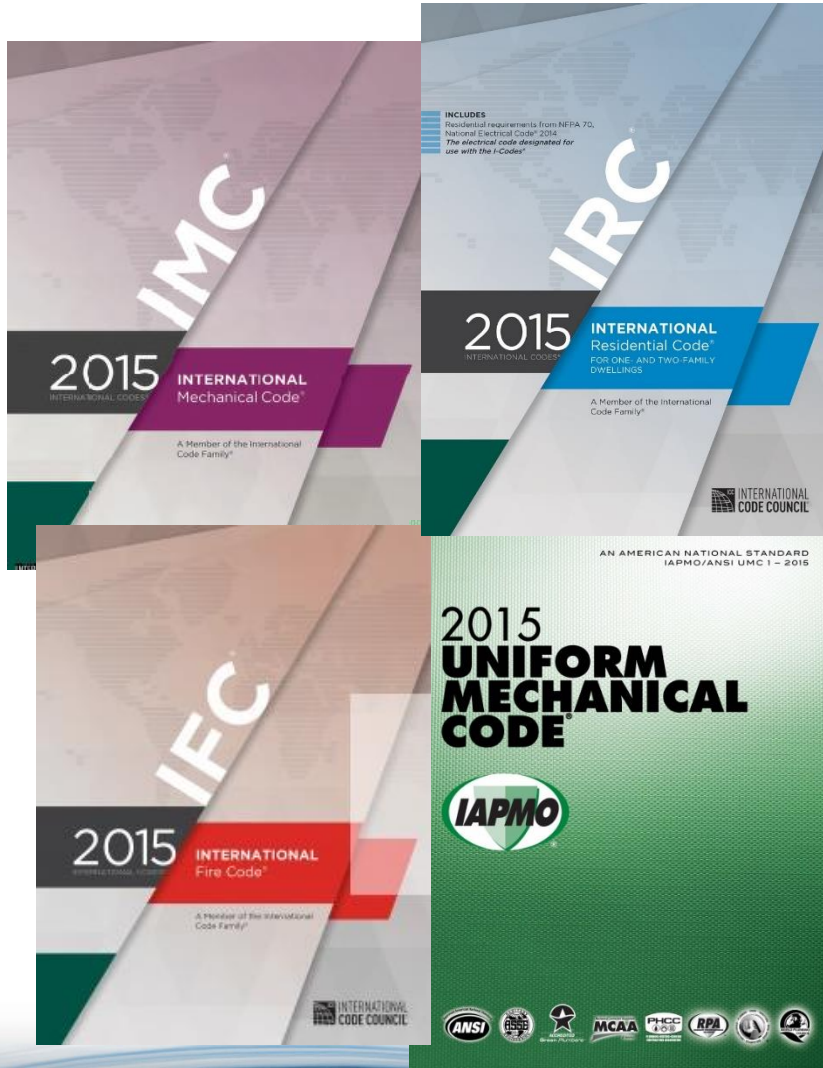
➤ Code adoption process is slow

- Proper safety classification (ASHRAE 34)
- EPA SNAP approval
- Meet relevant safety standards
- Meet relevant building codes

Safety Codes must be modified to ease restrictions on use of 2L and 3 refrigerants



Model Codes addressing Refrigerants



- The ICC International Mechanical Code (IMC) and IAPMO Uniform Mechanical Code (UMC) are the major building codes
 - Used in 48 states
- International Fire Code (IFC)
- International Residential Code (IRC)
- National Fire Protection Association, NFPA 1 – Fire Code

Code Development Cycle

- **Codes are on a 3-year cycle**
- **2018 IMC code cycle over – does not address 2L refrigerants**
- **2018 IFC code cycle underway**
 - Two proposals addressing 2L refrigerants were submitted
 - Final action hearings in October 2016
- **2018 UMC code cycle underway**
 - Several proposals addressing 2L refrigerants submitted
 - UMC will establish a Task Group to develop requirements on 2L refrigerants
 - UMC has an agreement with ASHRAE to reference ASHRAE 15
- **Year 2021 likely to be when 2L refrigerants will be addressed by major codes → Technical issues must be resolved by end of 2017**

AHRI Flammable Refrigerants Research

- **We surveyed relevant codes and standards committees and organizations on:**
 - The main knowledge gaps for the use of 2L flammable refrigerants
 - Any standing issues and gaps that require additional research
 - Current and past research activities on flammable refrigerants
- **Through this survey, we have:**
 - Identified the gaps in existing flammable refrigerant research
 - Developed a roadmap with priorities and a timeline to complete the critical research toward the safe use of flammable refrigerants

AHRI Flammable Refrigerants Research – High Priority

➤ The top priority research needs are:

1. Comparing the risks of A2L and A3 refrigerants to what we use today by benchmarking risks through real life leaks and ignition testing
2. Determining the proper basis for setting charge limits of A2L, A2, and A3 for various types of products.
3. Understanding the risk/consequence after the refrigerant is ignited
4. Determining the ignition temperatures for various 2L refrigerants at various ambient conditions
5. Guide to A2L refrigerant handling
6. Refrigerant leak detector long term reliability

➤ To do this quickly and safely will cost a minimum of \$5 million

Funding Flammable Refrigerants Research

➤ Funding commitments are in from:

➤ U.S. Government: \$3 million

➤ **AHRI**: \$1 million
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➤ **ASHRAE**: \$1.2 million



Thank you for your attention!

