Evolution of safety standards for A3 refrigerants in RACHP systems

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Introduction

Why has it been so difficult to implement “favourable” requirements in safety standards for A3 refrigerants?

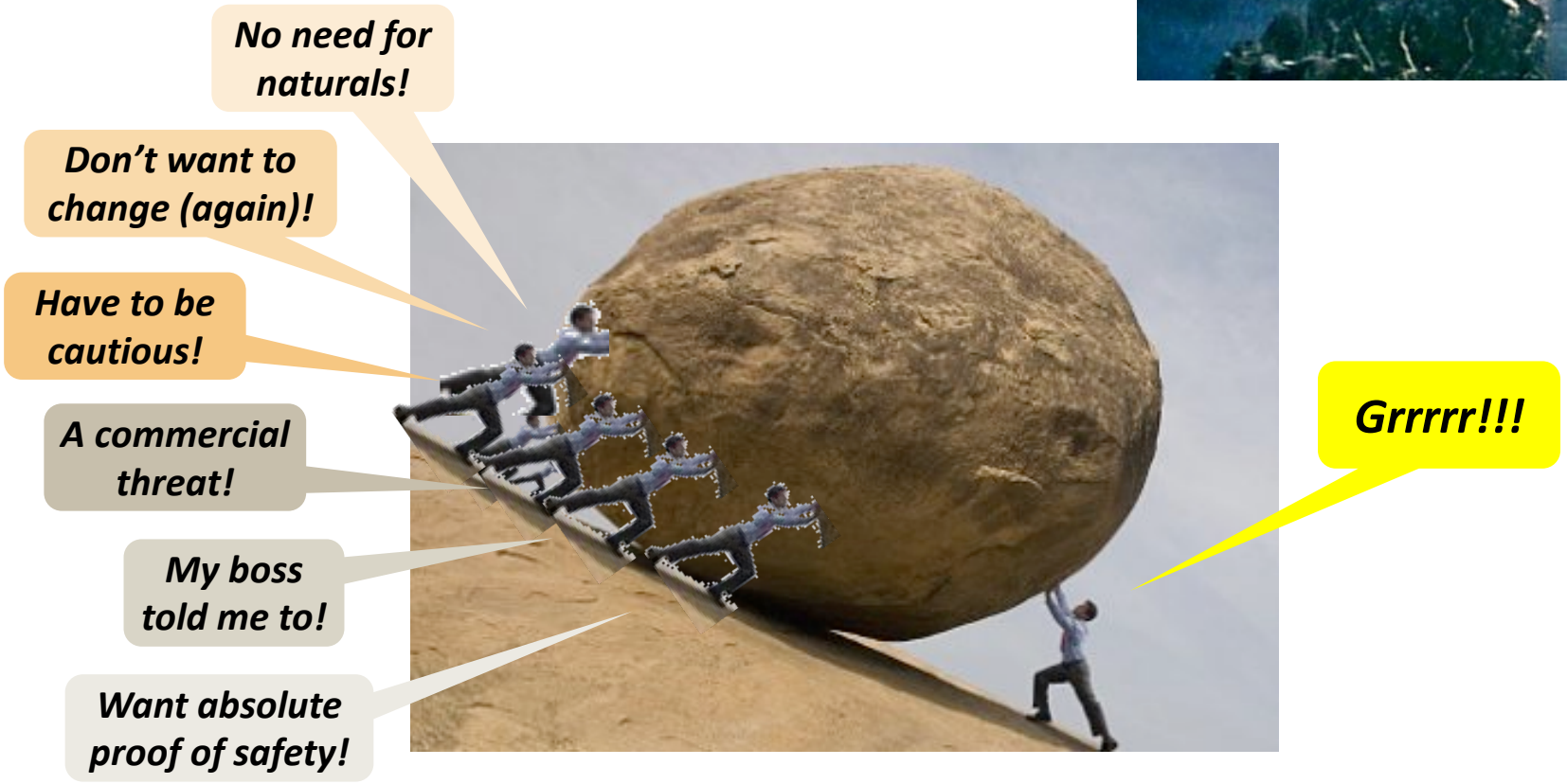
- Primarily, commercial opposition
- Committees and WGs stuffed with very professional, articulate, intelligent technical “lobbyists”

Totally unreasonable conduct at a time when climate change is becoming so critical

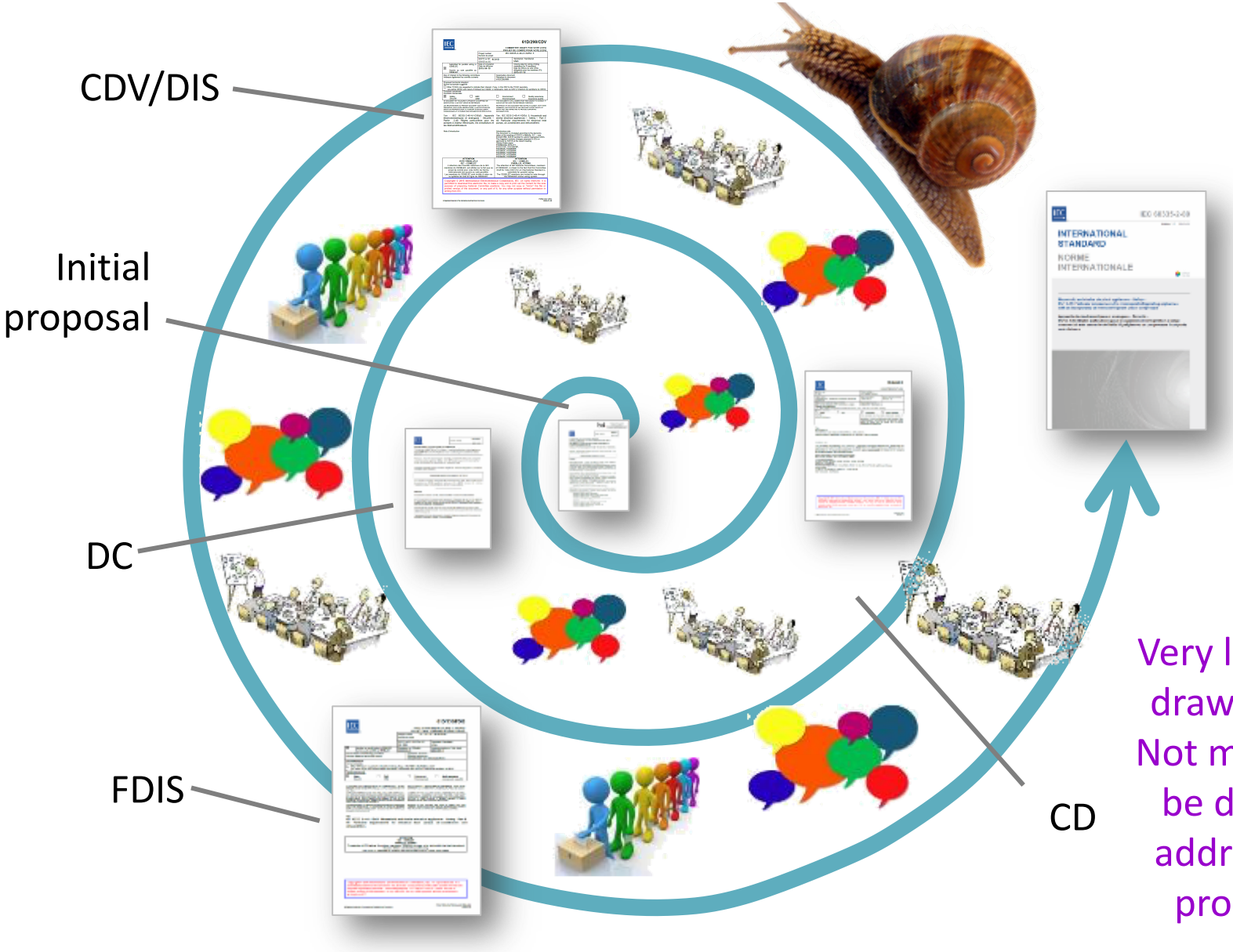
Introduction

How to overcome these barriers?

- Match the strength of personnel
- Generate irrepressible technical arguments and data



Standards development process



Very long and drawn-out… Not much can be done to address the process…

Vast tables in horizontal standards…

E.g., from EN 378: 2016 (Just for class A refrigerants …)

Flammability class	Access category		Location classification			
			I	II	III	IV
2L	a	Human comfort	According to C.2 and not more than m_2 [a] × 1,5 or According to C.3 and not more than m_3 [b] × 1,5			
		Other applications	20 % x LFL × Room volume and not more than m_2 [a] × 1,5 or According to C.3 and not more than m_3 [b] × 1,5			
	b	Human comfort				
		Other applications				
	c	Human comfort				
		Other applications				
		<1 person per 10 m^2				

a $m_2 = 26\ m^3 \times LFL$.
b $m_3 = 130\ m^3 \times LFL$.
c For open air, EN 378-3:2016, 4.2 applies and,

Flammability class	Access category			Location classification			
				I	II	III	IV
2	a	Human comfort		According to C.2 and not more than m_2 [a]			
		Other applications		20 % × LFL × Room volume and not more than m_2 [a]			
	b	Human comfort					
		Other applications					
	c	Human comfort					
		Other applications	Below ground				
			Above ground				

a $m_2 = 26\ m^3 \times LFL$.
b $m_3 = 130\ m^3 \times LFL$.
c For open air, EN 378-3:2016, 4.2 applies and, for m

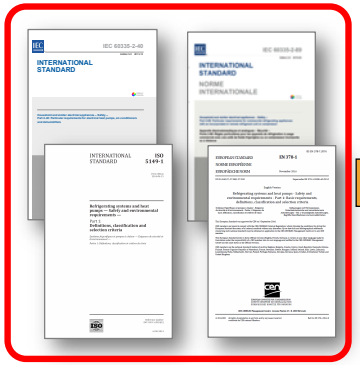
Flammability class	Access category			Location classification			
				I	II	III	IV
3	a	Human comfort		According to C.2 and not more than the greater of m_2 or 1,5 kg			
		Other applications	Below ground	Only sealed systems: 20 % × LFL × Room volume and not more than 1 kg		Not more than 5 kg [c]	
			Above ground	Only sealed systems: 20 % × LFL × Room volume and not more than 1,5 kg			
	b	Human comfort		According to C.2. and not more than the greater of m_2 or 1,5 kg			
		Other applications	Below ground	20 % × LFL × Room volume and not more than 1 kg [a]		Not more than 10 kg [c]	Refrigerant charge not more than m_3 [b]
			Above ground	20 % × LFL × Room volume and not more than 2,5 kg			
	c	Human comfort		According to C.2. and not more than the greater of m_2 or 1,5 kg.			
		Other applications	Below ground	20 % × LFL × Room volume and not more than 1 kg [c]		No charge restriction [c]	
			Above ground	20 % × LFL × Room volume and not more than 10 kg [c]	20 % × LFL × Room volume and not more than 25 kg [c]		

a $m_2 = 26\ m^3 \times LFL$.
b $m_3 = 130\ m^3 \times LFL$.
c For open air, EN 378-3:2016, 4.2 applies and, for machinery rooms, EN 378-3:2016, 4.3 applies.

Allows formation of questionable/arbitrary segmentation & barriers

- Boxes off the “disliked” technologies

Possible approaches include three general options



Max charge +

other requirements

Basic options

Prescrip-tive

Risk assess-ment

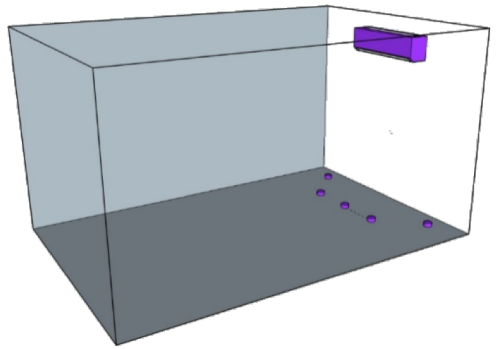
Black box/ testing

$$f_i^* = f_{leak,j} P_i^{F*}$$

$$P_i^{F*} = \sum_{N=1}^{N_{soi}} \left\{ 1 - \left[(1 - P_{V,i}^F) + P_{V,i}^F (1 - P_{soi,i}^F) \right]^{N_E} \right\}_{N_{soi}}$$

$$P_{soi,i}^F = P_{avail} \frac{(t_{soi} + t_i^F)}{t'} \quad P_{V,i}^F = \frac{\overline{V}_h^F}{V_h'} P_{sys} P_{perc}$$

$$\chi_{\Delta p} = \sum_{i=1} \sum_{j=1} f_{i,j}^* \Delta p_{i,j}^\circ \qquad \chi_I = \sum_{i=1} \sum_{j=1} f_{i,j}^* I_{occ,i,j}$$



Or a combination of two or more…

Incremental black box testing

…As in draft IEC 60335-2-40

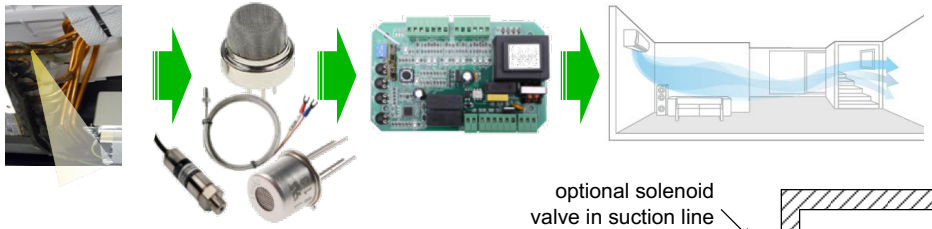
Assumed leak rate, constant mass flow

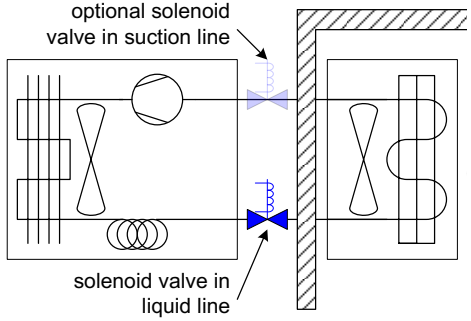
Response of detection system

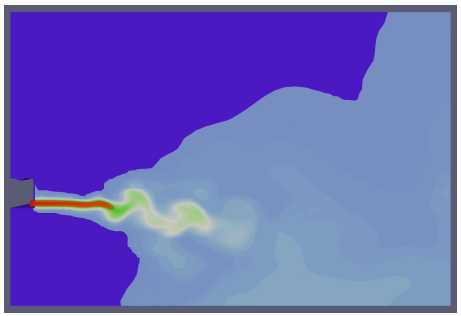
Releasable charge amount

Calculated min airflow rate

etc.

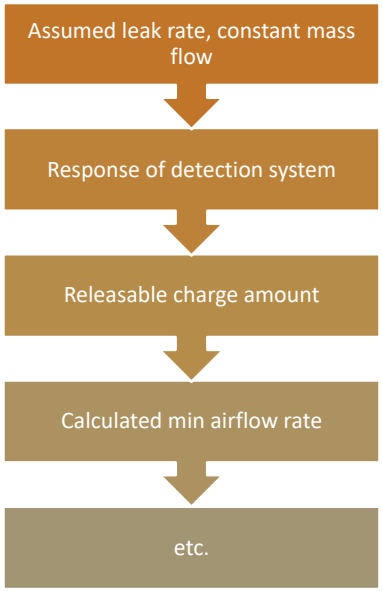






Lots of broadly disconnected, formulae, tests, etc.!

Joined-up black box testing



Why do lots of different tests, when one or two could suffice?
Vision: make a hole in the system and see what happens!

Protective features, eg, airflows, leak detection, etc

Unit construction characteristics

Room dimensions

Max reft charge / min room size

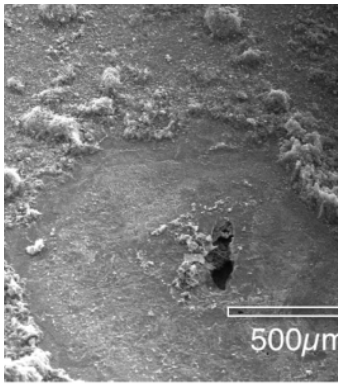
Conditions, eg, leak mass flow

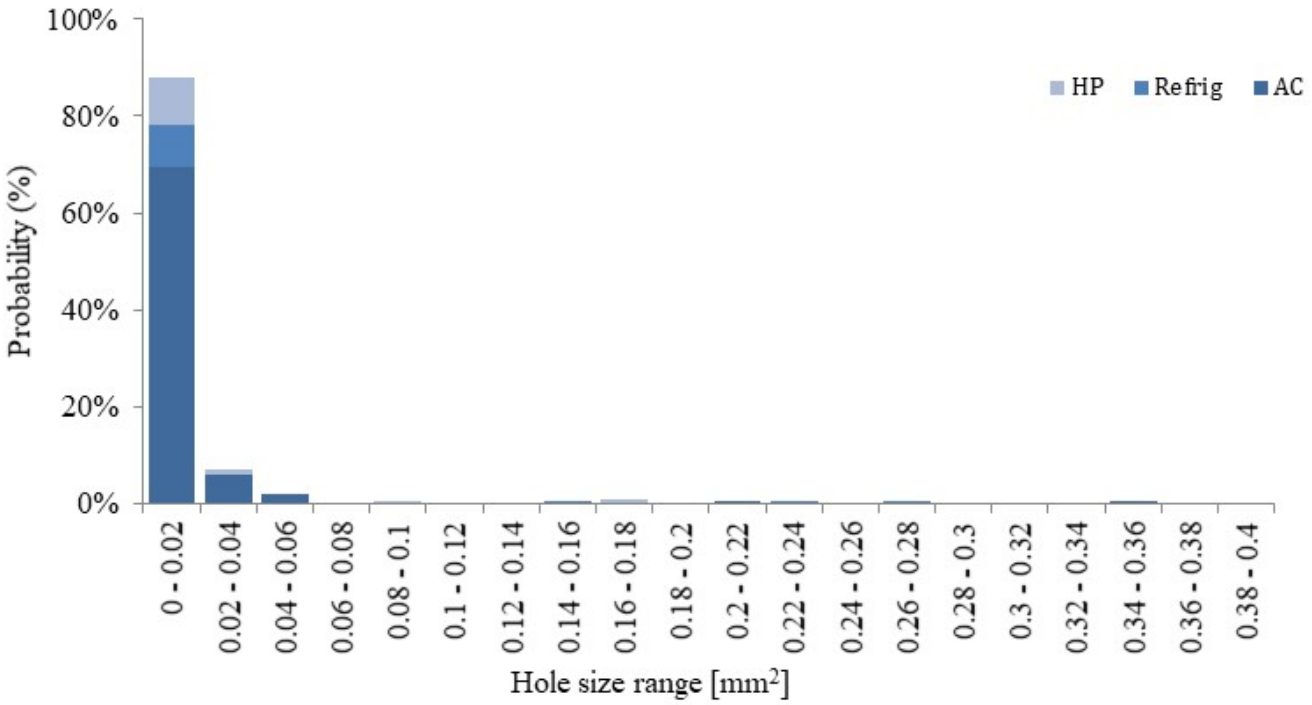
Constraints (e.g., max conc, etc)

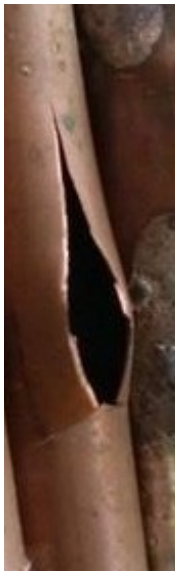
Main question is hole size

Ordinarily, hole size (leak mass flow) is most challenging issue

- Choice of hole size affects everything else…







Largest hole size found in project so far

- 0.4 mm^2 in “uninterfered” cases
- 0.8 mm^2 with human interference

Another issue: refrigerant distribution in a space

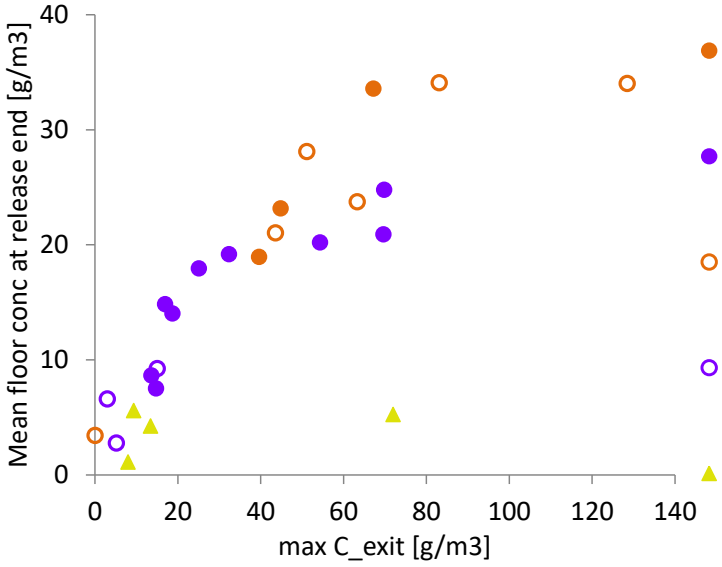
Until recently standards assumed, either

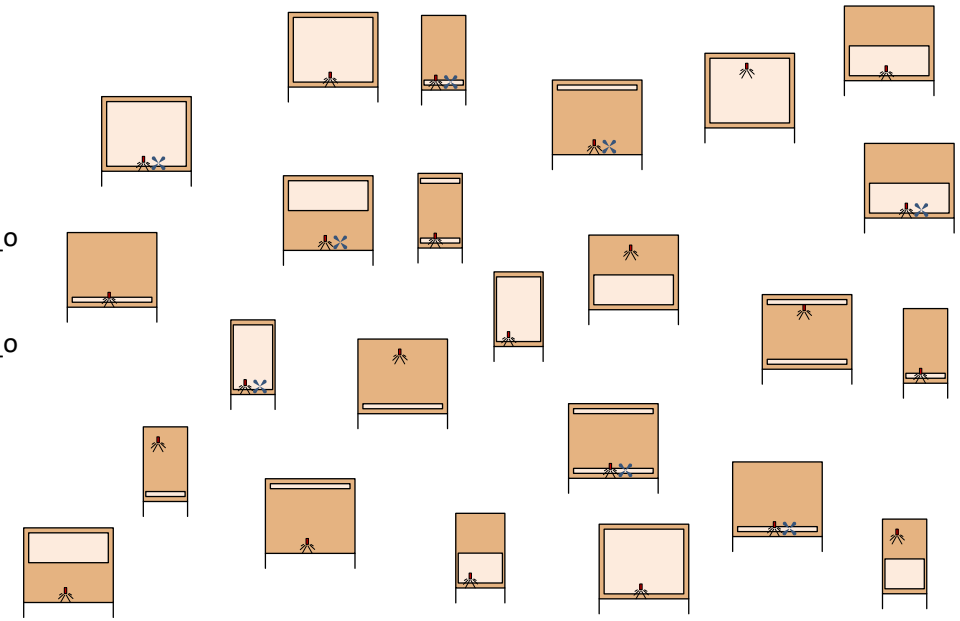
- Quadri-homogenous mixture in room,
- Or severely stratified layer in room based on severely pessimistic assumptions

GIZ Proklima C4 and EULF project looked into distribution in room and associated assumptions

- In addition to leak hole size, effect of enclosure geometry, airflow, etc.

Helped identify and generate new formulae, tuned more to equipment characteristics





In conclusion

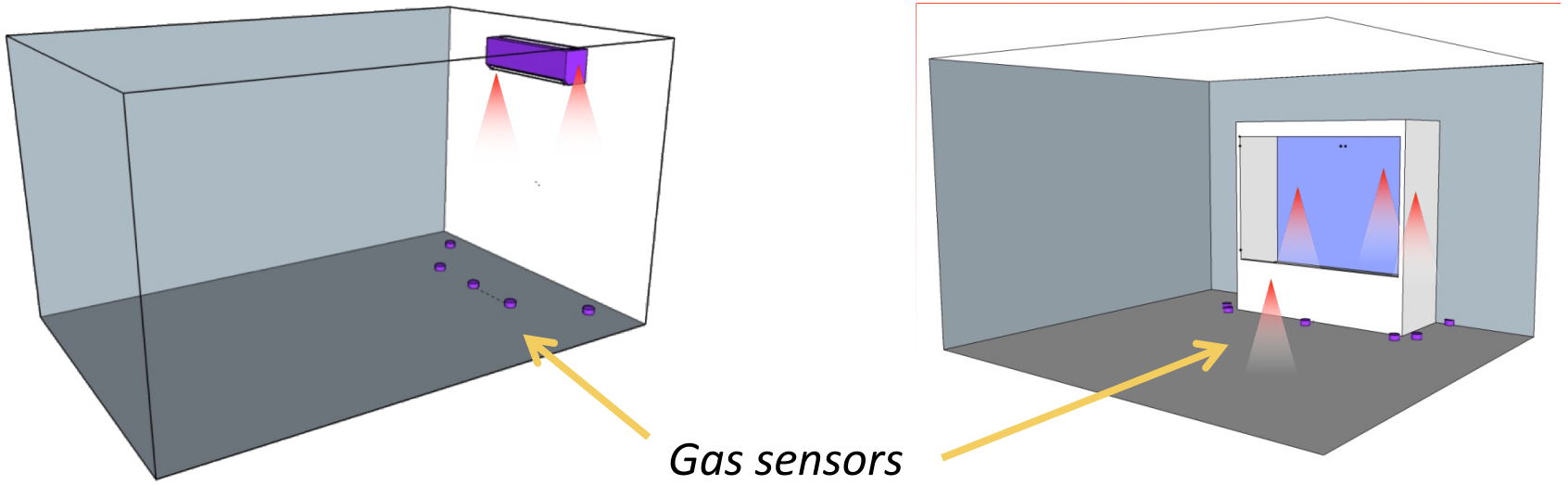
But, very difficult to correlate max floor conc with encl geometry, etc

So, simply…

- Make holes in the refrigerant circuit
- Monitor floor conc surrounding the unit
- Acceptance: $\underline{C_{max}}$ should not exceed X % of LFL

Any charge limiting mechanism, leak detection system, airflow, etc. will function as it does… reliability can be assessed as today

(Similar approach now in IEC 60335-2-89 for commercial cabinets)

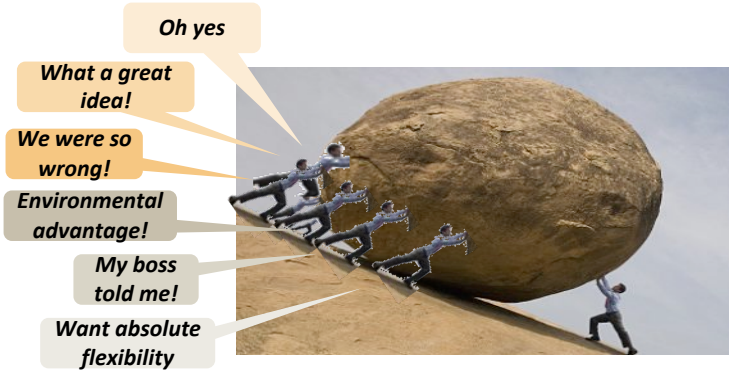


Offers freedom to manufacturers to enhance safe design of unit

Final remarks

Resolving the problem of obstructive RACHP safety standards has been a huge headache!

- Gradually, improvements have been developing; step-by-tiny-step



With the increasing interest in A3 and other natural refrigerants and industry recognition of them as serious alternatives, support for revising RACHP standards has grown

- Stakeholders opposing such progress are becoming more and more ashamed
- Imposing opposition to revised standards illustrates these stakeholders' unsavoury anti-climate motivation!

A variety of approaches have evolved during this journey

Hopefully things will change….

Thank you for your attention!