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giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of
Federal Ministry for Economic Cooperation and Development
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

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Contribution to development of improved hydrocarbon refrigerant charge size limits for commercial refrigeration and air-conditioning appliances

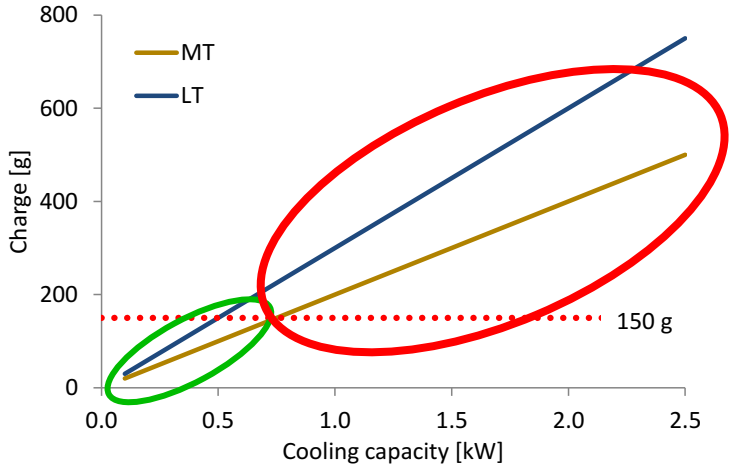
26. September 2017, Berlin

Presented by Philipp Denzinger, GIZ Proklima

Prepared by D Colbourne, c/o HEAT GmbH

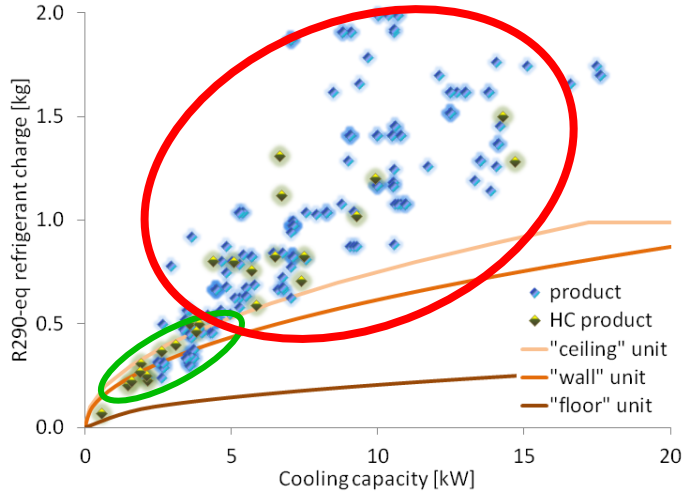
IEC 60335-2-89

Current limit for comm ref appliances (60335-2-89): *Max charge 150 g of flammable refrigerant*



IEC 60335-2-40

Current limits for air conditioners (60335-2-40): *Max charge 990 g R290 per circuit + limited by room area and install height*

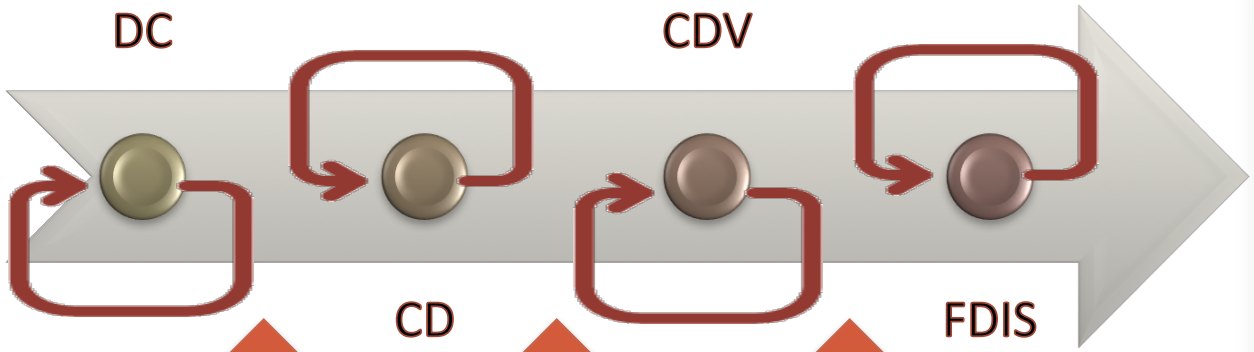


Practically, charge limits are prohibitive and obstructive for HCs

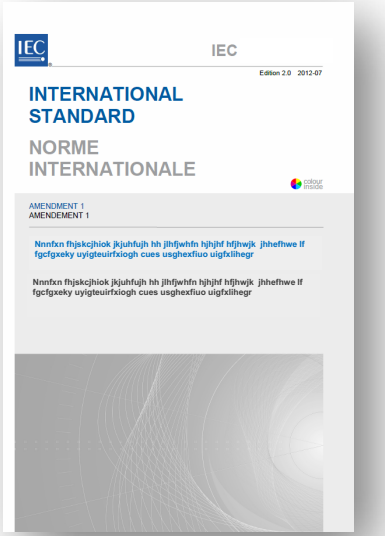
→ Drastically inhibits product and market development

Standards development process

National committee



Working group



Overview of proposed new requirements

IEC 60335-2-40

(Current)

Basic measures ($m_{max} = 2.5 \times LFL \times h \times A^{.5}$)

(Proposed)

With risk-reducing measures

- Improved tightness
- Unit airflow
- Limited released mass

Continuous or with detection

Passive or active

IEC 60335-2-89

(Current)

≤150 g

(Proposed)

>150 g: With risk-reducing measures

- Improved tightness
- Proof by test

May require airflow

Proposals must not pose (individual) risk greater than current

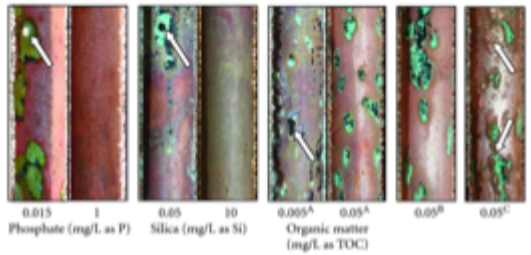
60335-2-40 & -89: Improved tightness

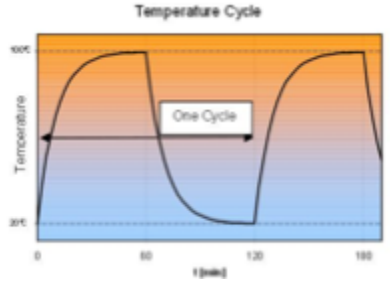
Introduce measures to improve system tightness

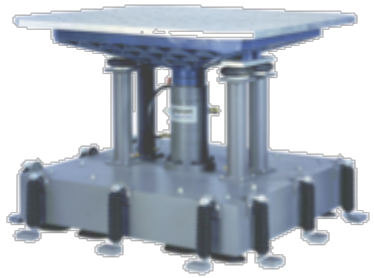
- Strength pressure test
- Leak tightness test

Current standards

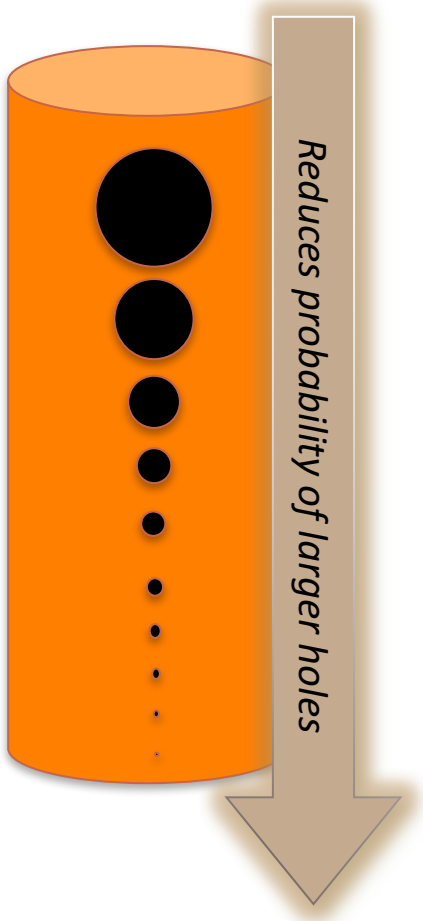
- Additional tests and measures







Improved leak tightness



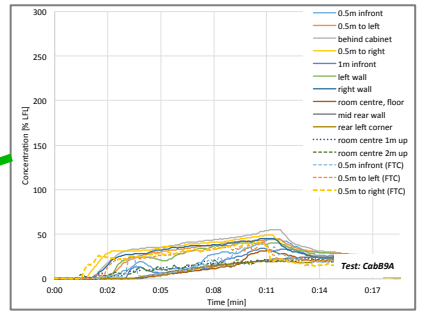
Improved tightness corresponds to lower probability of a given leak hole size

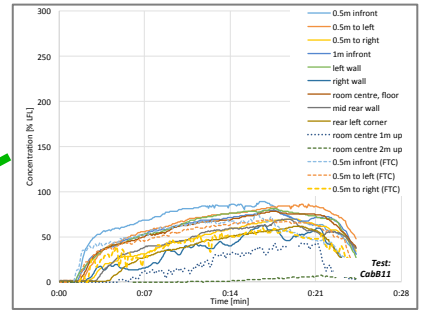
60335-2-89: Analysis of behaviour of leaked R290

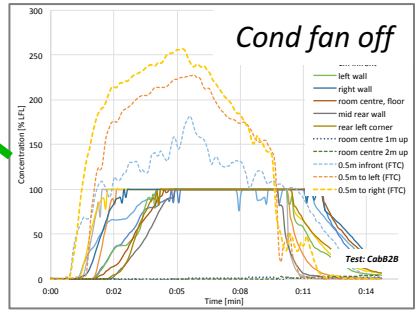
Hundreds of full-scale leak simulation tests carried out to understand and characterise effects of

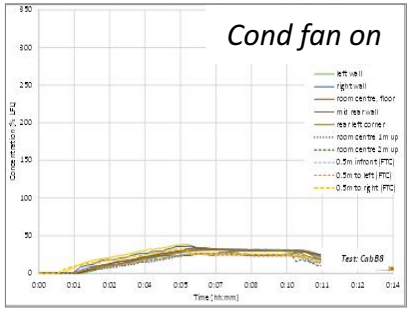
- Leak location and direction, release mass, leak rate, room size, cond/evap airflow, unit positioning, area congestion, doors (opening), unit size, kick-plates, roof covers, etc., etc.

- Provides certainty of possible concentrations arising from vast range of possible leak scenarios





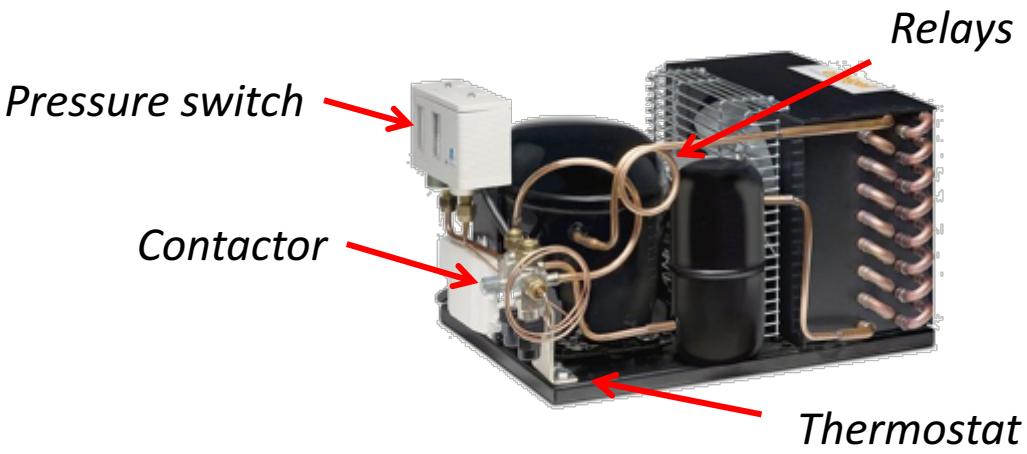




60335-2-89: Addressing adjacent appliances

Important consideration specific to commercial ref appliances

- Possible close proximity of ignition sources on non-flammable refrigerant models
- Greatest number and most regular sources of ignition (SOI) likely in adjacent (non-HC) cond unit



- Developed dedicated “surrounding concentration” test

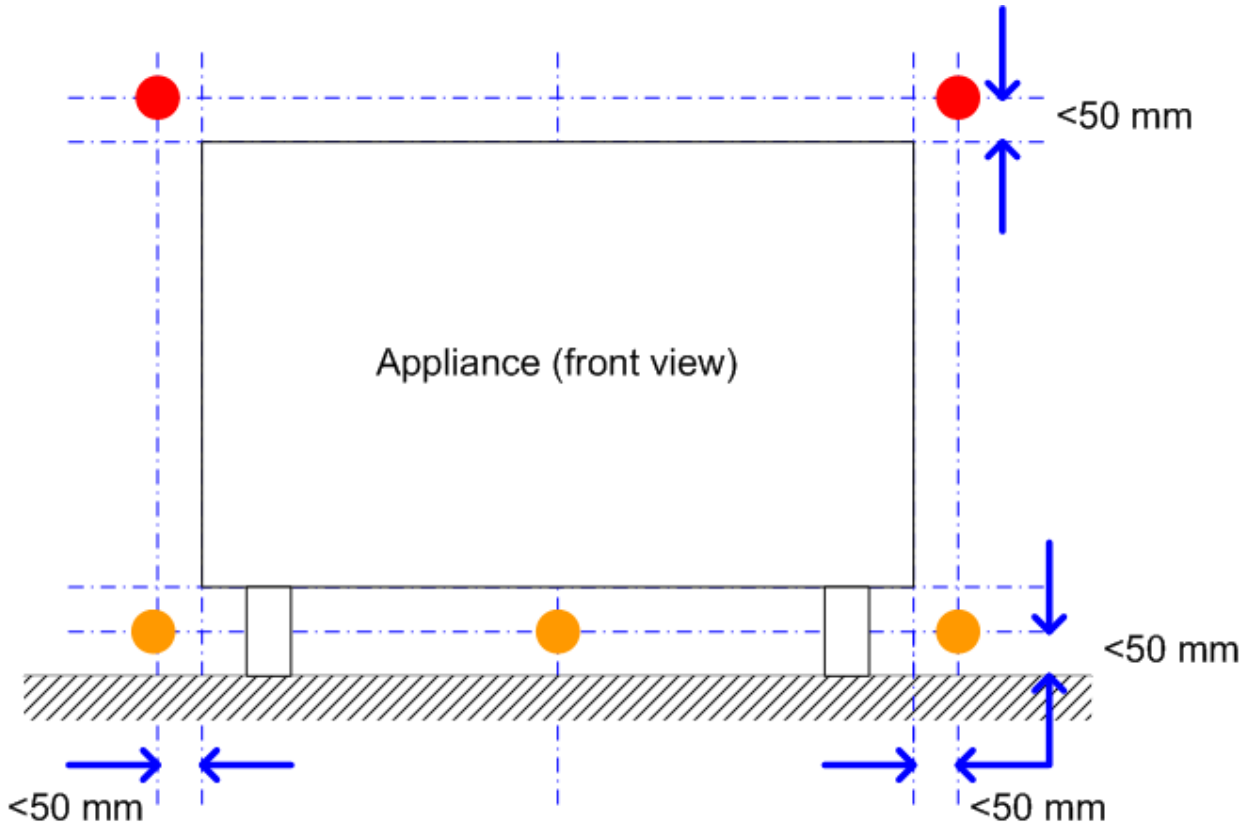
60335-2-89: Summary of current proposal

Main elements

- Scope limited to approx. 500 g of HC per circuit (1.2 kg for others, eg A2Ls)
- Minimum room area → $A_{min} = (1.8 \times m)/LFL$
- Measures for improved tightness
- Pass “surrounding concentration” test

— Simulate leak from “critical” locations
— Leak rate function of refrigerant properties
— Sensors at 5 cm beyond appliance
— Concentration cannot exceed 50% LFL

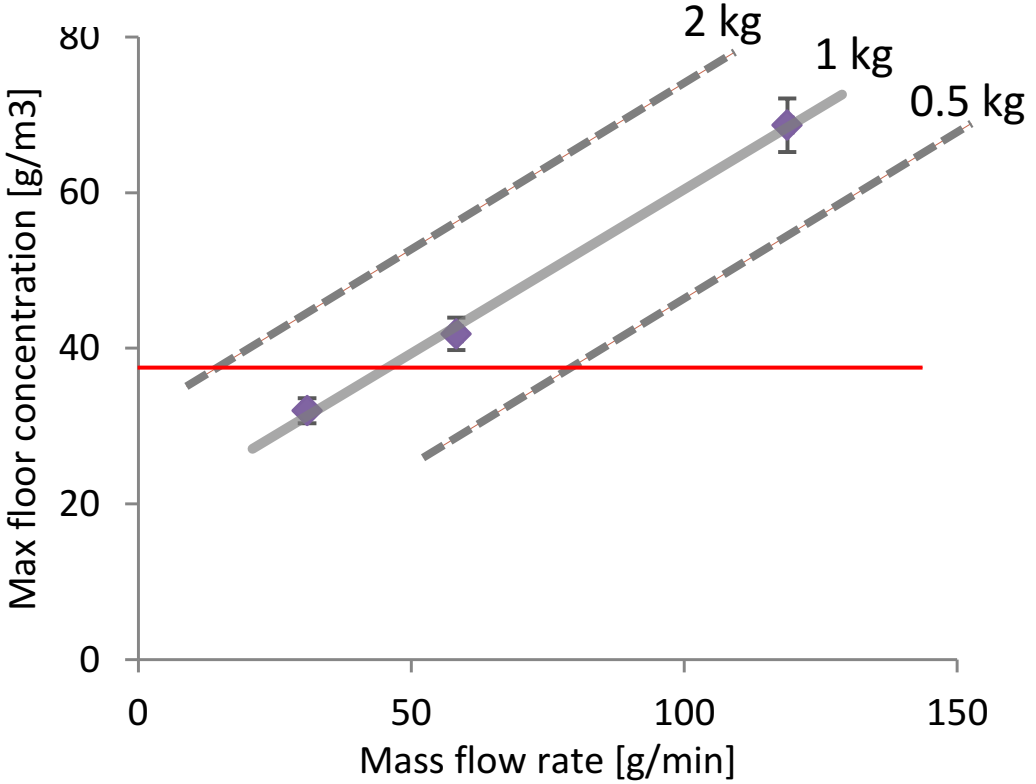
Hopefully, proposal will be issued as a “CDV” (committee draft for vote) at the end of October for a three months of commenting and a vote of national committees

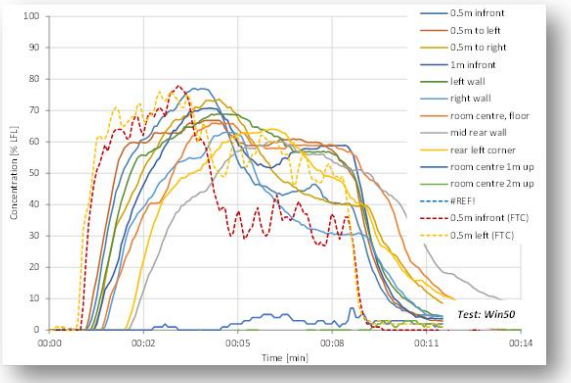


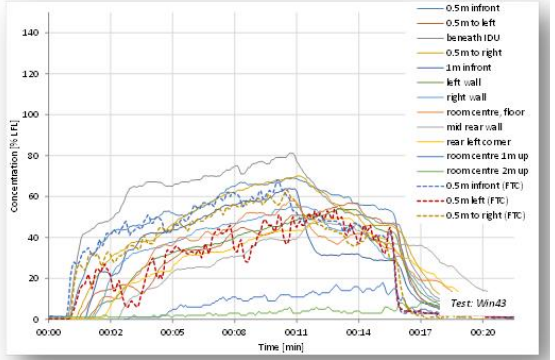
60339-2-40: Improved tightness

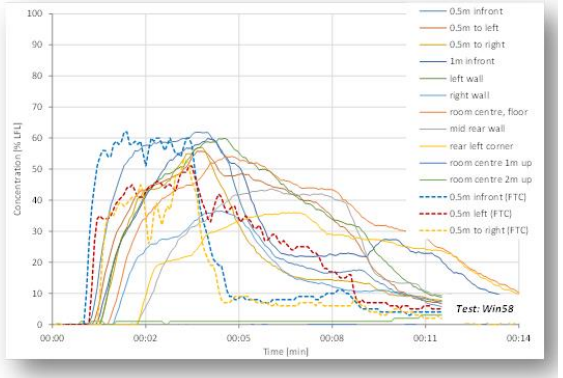
Generally, lower the leak rate, lower the developed concentrations

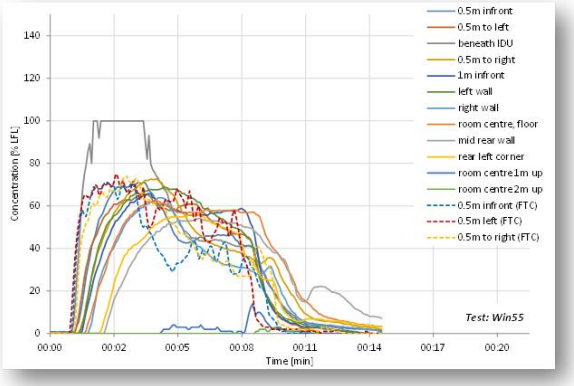
- With improved tightness, smaller holes sizes → lower leak rates → tolerate higher charge
- Extensive leak simulation testing with different types ACs, release mass, room sizes, etc., etc. to determine “safe” charge level







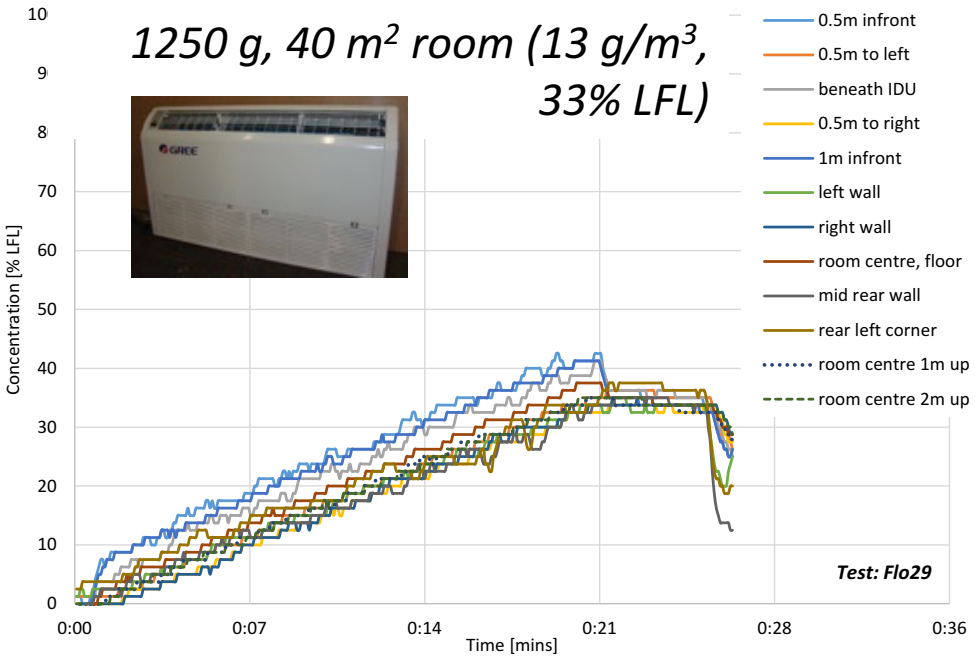


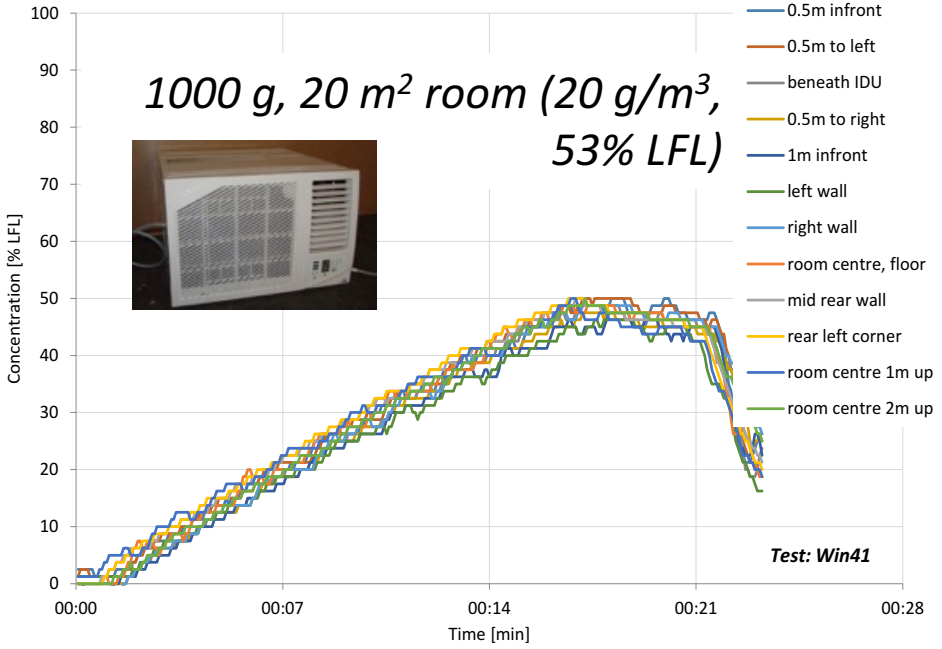


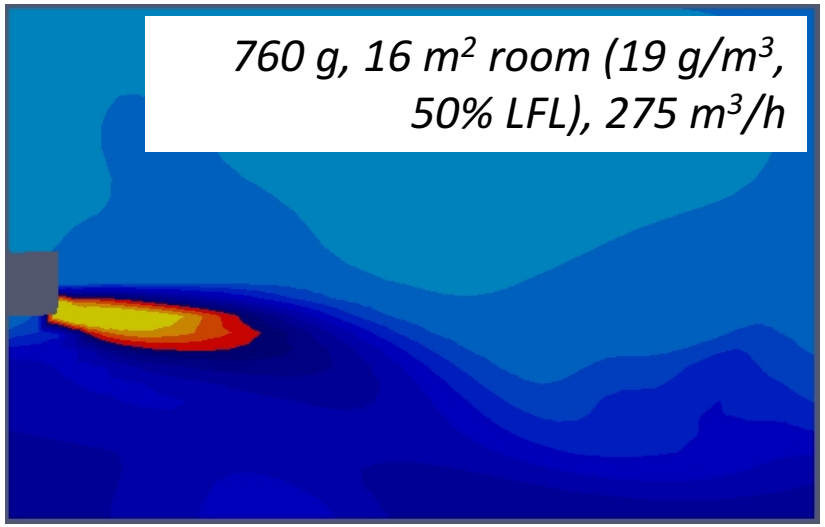
60339-2-40: Unit airflow – continuous

Extensive leak simulation testing and CFD modelling to characterise effectiveness of unit airflow (and settings)

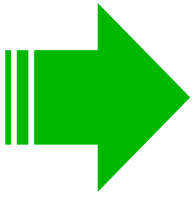
- In all cases, min airflow setting gives near-homogenous mixing

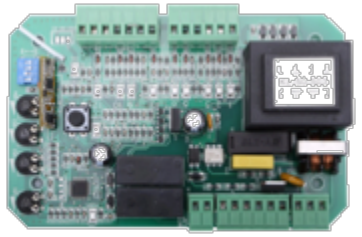






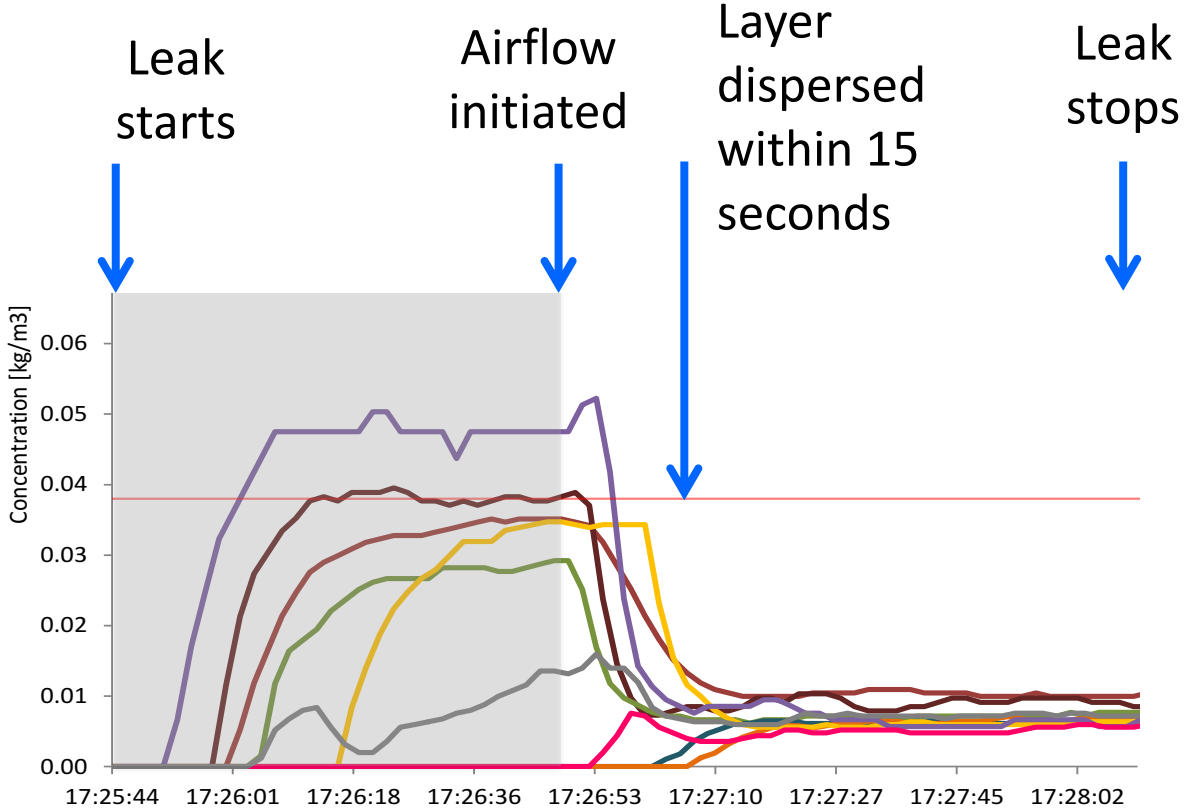
60339-2-40: Unit airflow – active response





Minimum airflow must be

- Sufficiently high to mix stratified layer
- Initiate quickly enough to preclude floor conc above LFL



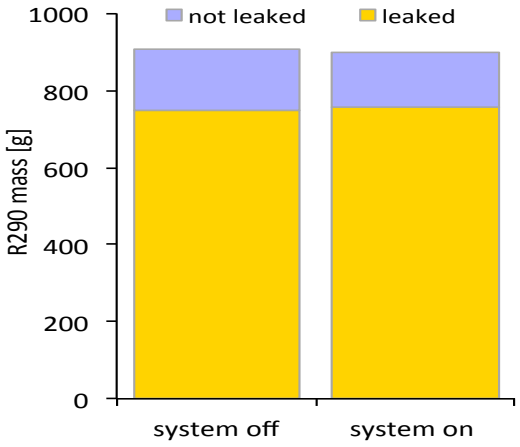
8 kW wall unit at 1 m, 500g R290, 90 g/min, 1260 m^3/h

60339-2-40: Limited release mass

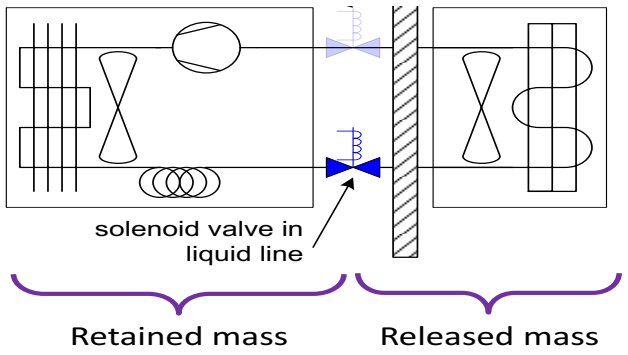
If released mass is less than charged amount, minimum room size can be based on that released mass:

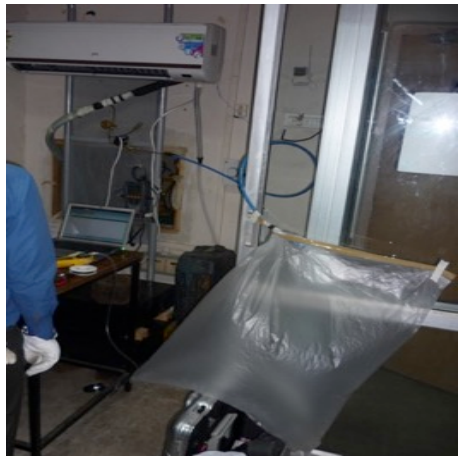
$$M_{max} = M_{charged} - M_{retained}$$

"Passive"

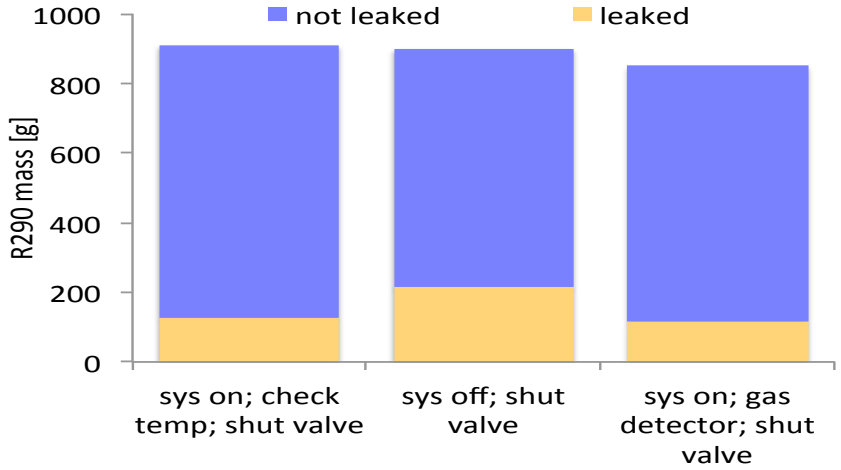


Tests found approx. 15% of R290 charge retained in system





"Active"



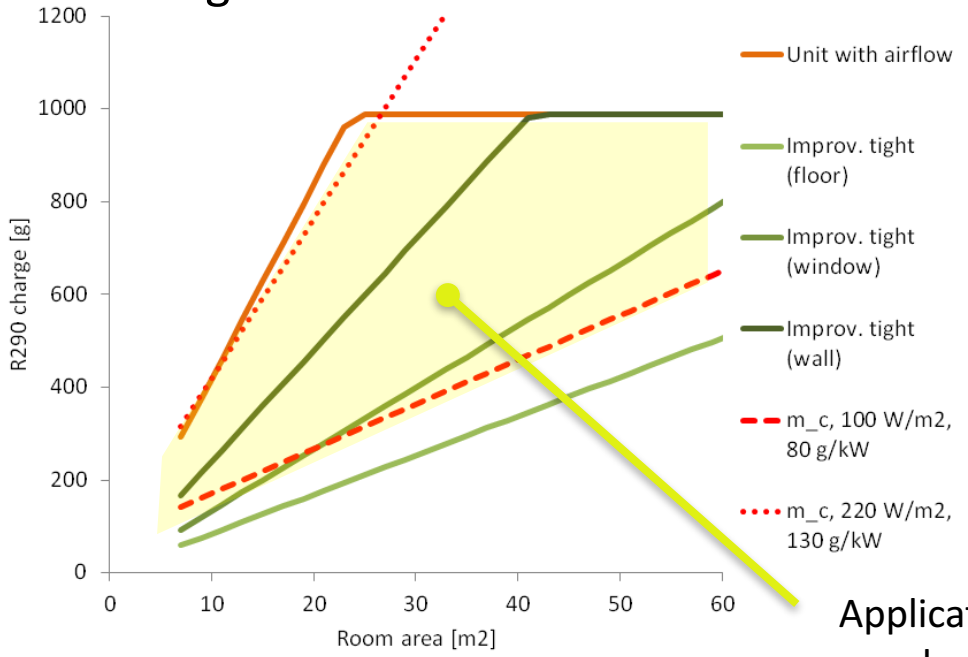
Tests found approx. 80% of R290 charge retained in outdoor part with different control options

Main discussion is choice of test method and test conditions

60335-2-40: Summary of current proposal

Main elements

- Maximum charge remains at “26 × LFL” (approx. 990 g for R290); no change from current requirements
- Min room area for “improved tightness” → $A_{min} = (1.3 \times m)/LFL$
- Min room area for “unit with airflow” → $A_{min} = (0.9 \times m)/LFL$
- For limited released mass, determination of minimum room area may be based on “improved tightness” or “unit with airflow”, but only assuming the charge mass that can leak out

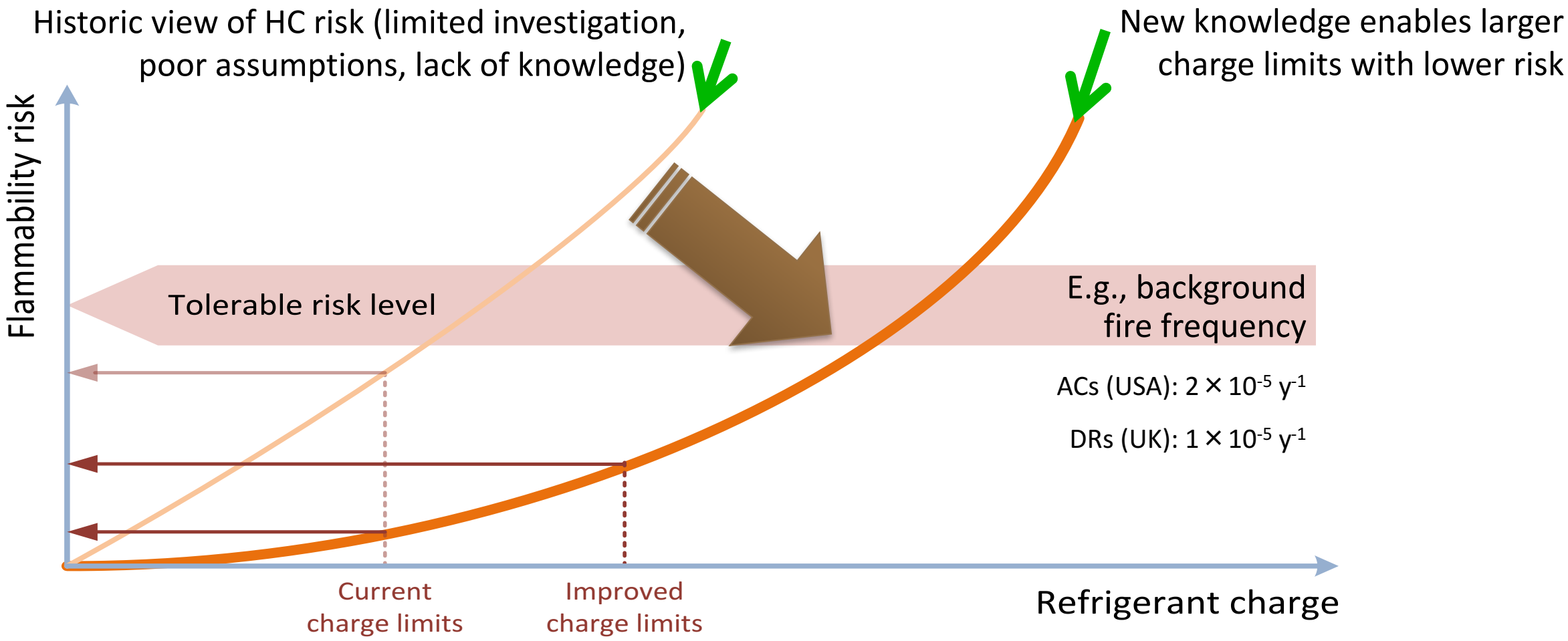


Graph compares required room size and R290 charge amount from proposed requirements and state-of-the-art ACs

- Low-high specific charge and low-high heat load
- Assuming 20% over-sizing and 5 m additional piping, all options (except one) potentially useful

Final remarks

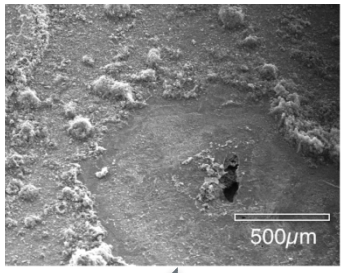
Stakeholders making extensive investigations to help understand relationship between charge amount and flammability and effect of variables and external conditions



Final remarks

Progress is slow (esp. for AC) and challenging – for several reasons…

Most significant issue: "how big a leak hole?"

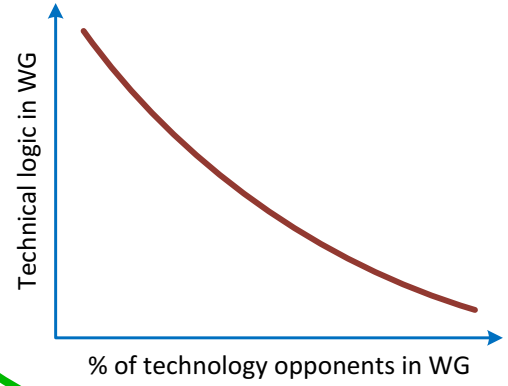


vs.

Less stringent

More stringent

WGs and TCs comprised of technology proponents and opponents; more opponents means harder struggle



Agreement and consensus stakeholders for

is necessary amongst all proposals to progress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Thank you very much!