IEA HPT Project 64:
Safety with flammable refrigerants
Jan 2024 – Dec 2026

Björn Palm, project leader

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Objectives of Annex 64

- Contribute to a broader safe use of flammable refrigerants

- Increase the understanding of the risks
- Investigate system designs to keep risks at acceptable levels
- Perform risk assessments

- Give recommendations for updates of the standards

Scope of Annex 64

- Focus on systems for heating/cooling or hot water production in single family or multifamily houses (< 50 kW).
- Focus on systems placed indoors
- Hydrocarbons and synthetics
- Safety during servicing and end of life will also be considered.

Participating countries and national contacts:

- Sweden: Björn Palm, KTH Royal Institute of Technology
- Germany: Thore Oltersdorf, Fraunhofer ISE
- Korea: Minsung Kim, Chung Ang Univ
- France: Odile Cauret, EDF
- Austria: Bernd Windholz, AIT
- USA: Kashif Nawaz, ORNL

Task 1: Technical solutions for limiting risks

Examples:

- Methods of limiting the amount of refrigerant released
- Rapid ventilation of gas to the ambient
- Ventilated enclosures
- Absorption of refrigerant
- Dilution of released refrigerant
- Avoiding sources of ignition
- …

Task 2: Investigation of leak scenarios

Methods:

- CFD simulations
- Practical tests

Task 3: Leak detection

- Available types of sensors and systems for leak detection accuracy, reliability and cost.
- Effect of the location of sensors

Indirect methods

- Leak detection by monitoring performance

Task 4: Charge reduction

- Compact heat exchangers
- Alternative types of compressors
- Low oil charge
- Compact system designs

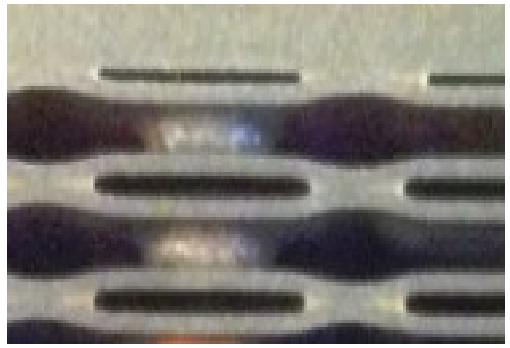
Sub-cooler



< 1 dl oil



210
mm



Task 5: Risk assessment

- Risk assessments for technical solutions suggested in Tasks no 1 and 4.

- Recommendations on how to do risk assessment in practice

Task 6: Communication and dissemination

- Publications in scientific journals
- Publications in technical magazines.
- Seminars
- Webinars
- Web page
- Project report updated annually
- State-of-the Art reports

See also Project website

- https://heatpumpingtechnologies.org/project64/



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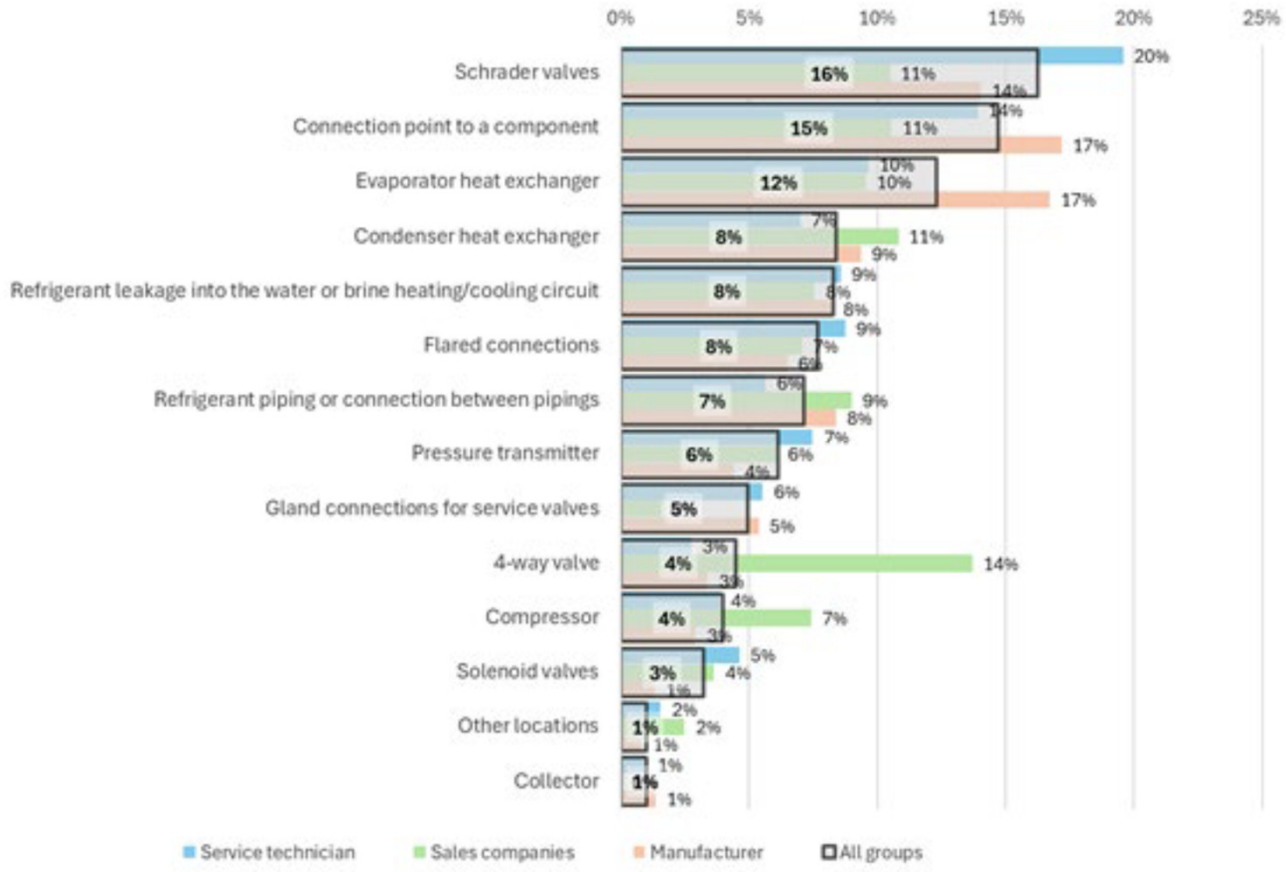


Examples of results

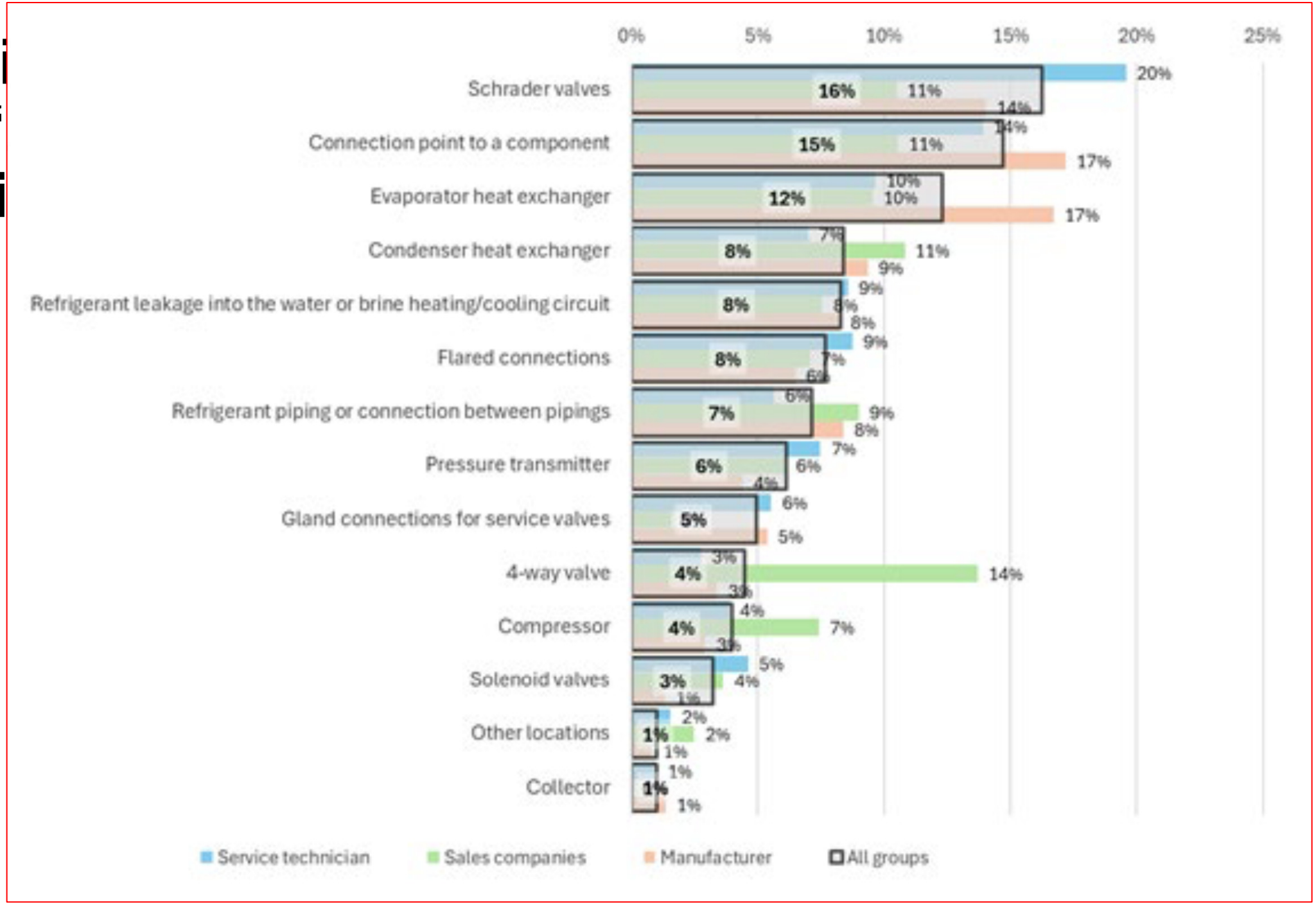
- Leak statistics
- Numerical modelling of leakages
- Charge reduction
- Methods of leak detection
- Reports on safety with flammable refrigerants

Allocation of leaks, From “**Austrian National Country Report 2: Investigation of leakage scenarios**”

- Result of survey



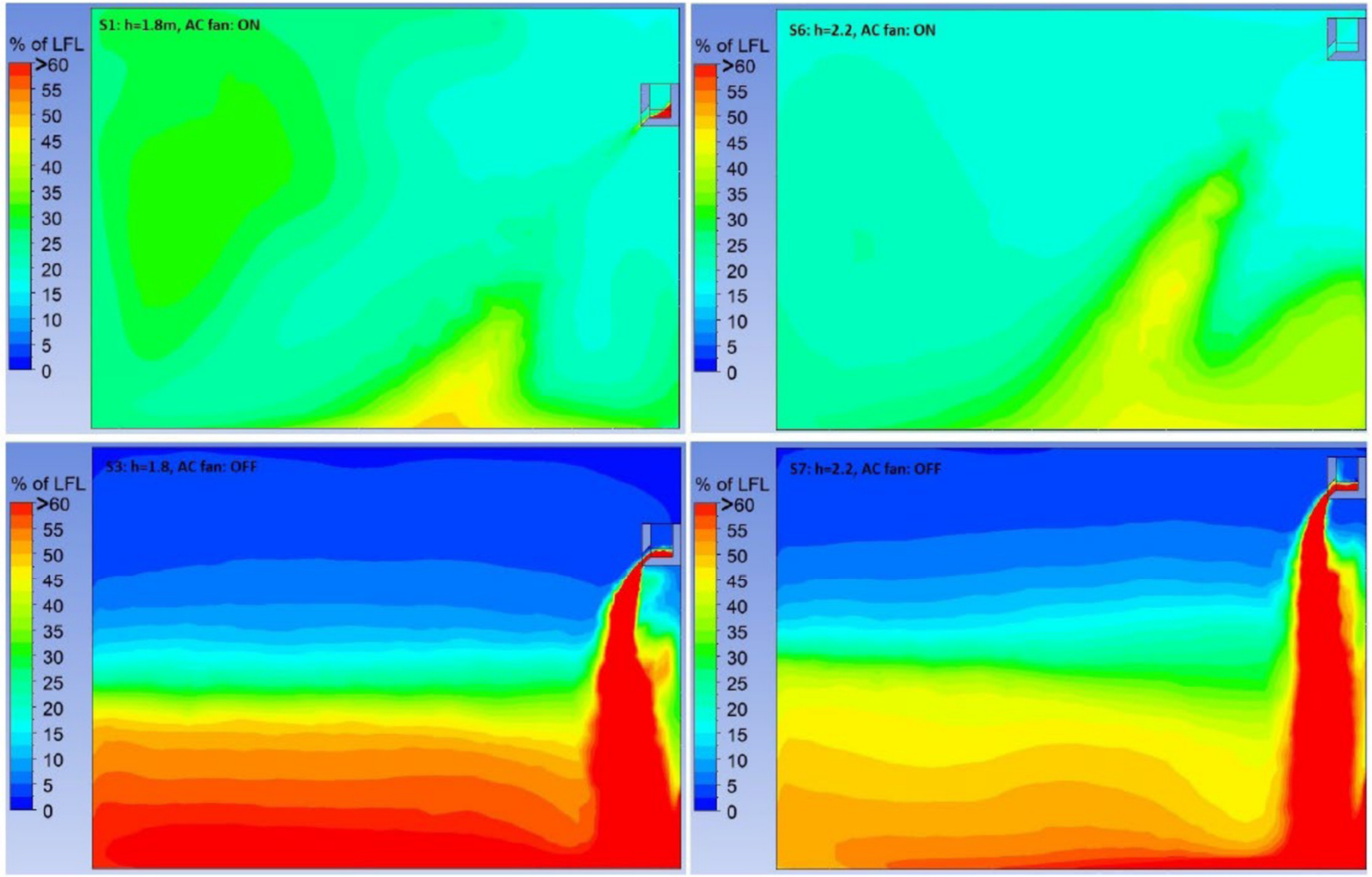
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Investigation of leak scenarios

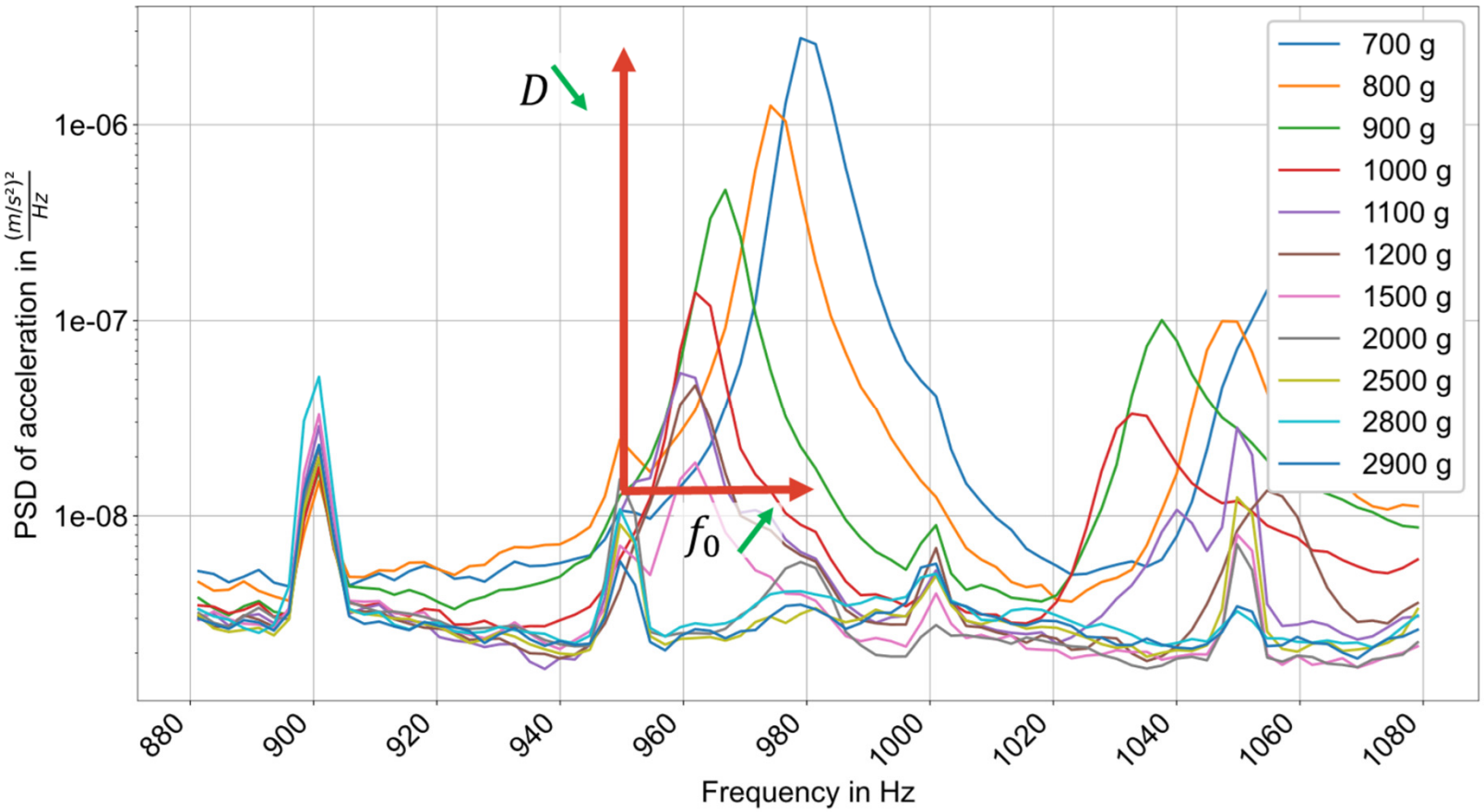
Effect of installation height and fan on/off.
Colors indicate % of LFL, from 0% to 60%

- Fan on
- Fan off



Acoustic identification of charge

Analysis of vibration response on receiver with different charges



Acoustic properties

Actual components

Comparison of four leak samples recorded with pressurized air.



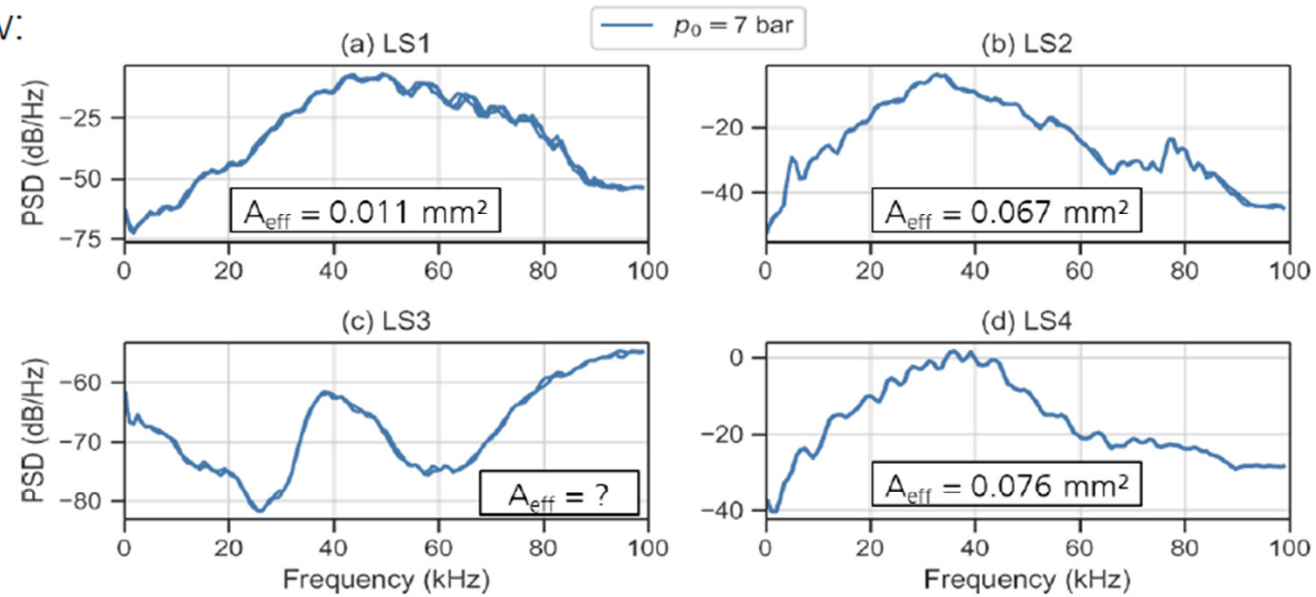
d = 0.5 mm:
A = 0.20 mm²
A_{eff} = 0.16 mm²

- Each spectrum shows a peak at ~ 40 kHz.
- Tendency: The greater the area (resp. the mass flow) the louder the leak (at the same pressure).
- Relationship between pressure, area and mass flow:

$$\dot{m}_{choked} = C_d A \sqrt{\gamma \rho_0 p_0 \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma+1}{\gamma-1}}}$$

Simplification:
p_0 = const. (= 7 bar)
γ = const.
ρ_0 = const.

$$\dot{m}_{choked} \sim C_d A \; (= A_{eff})$$

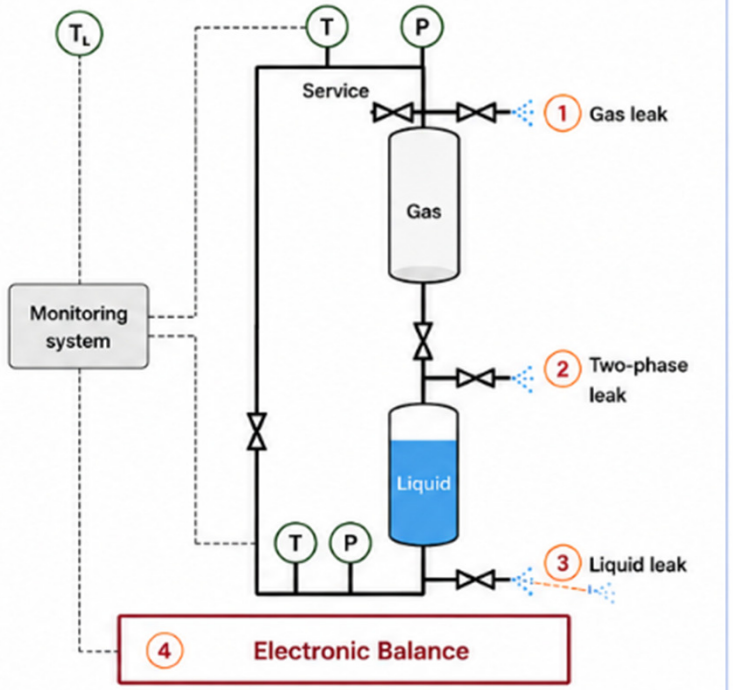


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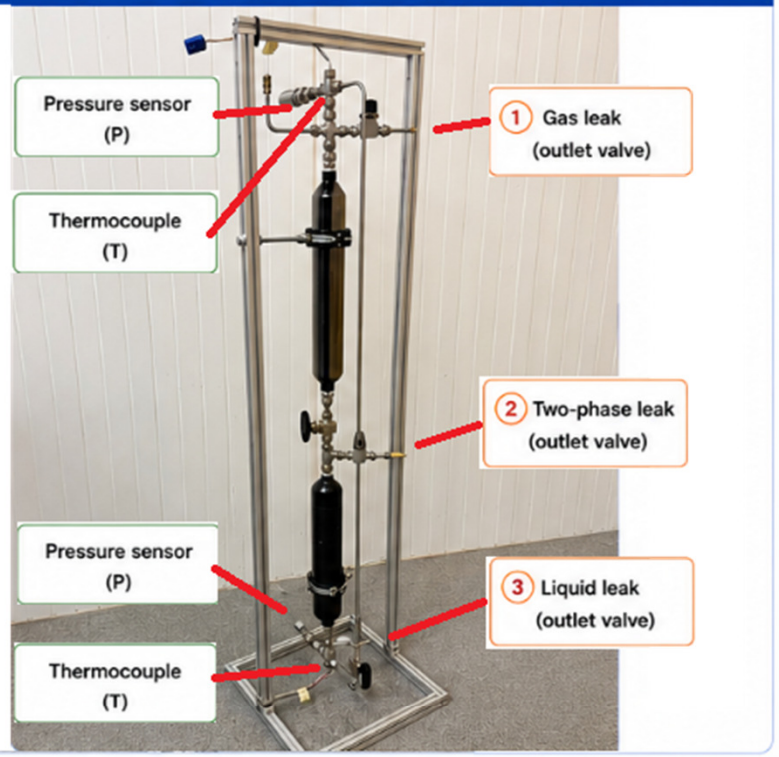
Fraunhofer ISE

Experimental measurement of leak flow in liquid and gas phase

Schematic representation



Real experimental rig



Key measurement features

Pressure sensors (P)
Monitor system pressure and depressurization during leakage.

Thermocouples (T)
Measure temperature and cooling due to leakage and evaporation.

Leak valves
Enable controlled gas, liquid and two-phase leakage.

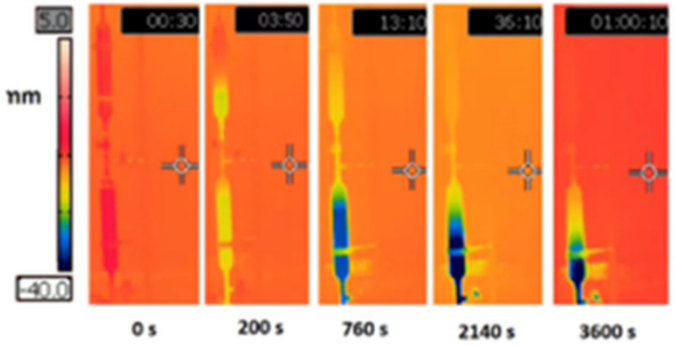
Electronic balance
High-accuracy mass measurement for leak rate determination.

The dual-cylinder setup enables controlled and repeatable measurements of leakage rates under different conditions.

IR thermography

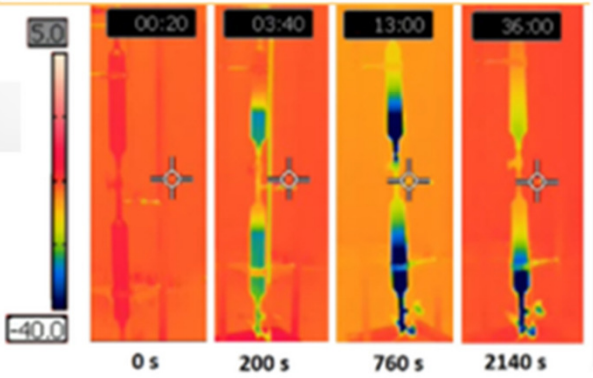
GAS LEAKS (top port)

a) Gas – 0.5 mm hole



Gradual cooling follows slower pressure decay. Evaporation occurs inside the cylinder throughout the depressurization period.

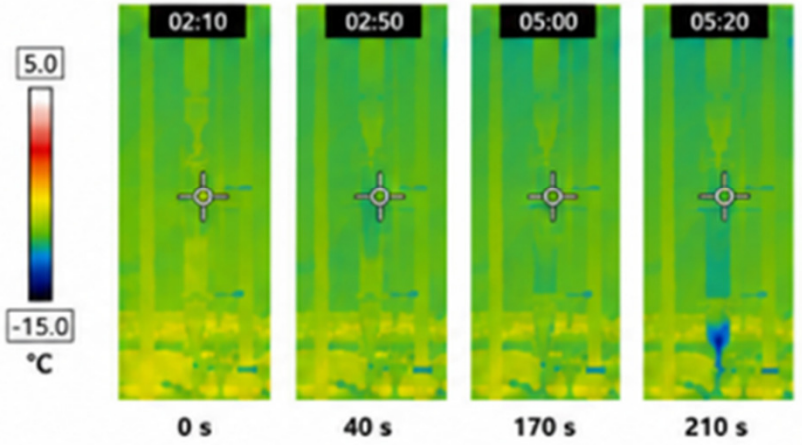
b) Gas – 1 mm hole



Stronger and faster cooling due to rapid pressure drop. Larger thermal gradients develop inside the cylinder. Discharge ends earlier.

LIQUID LEAK (bottom port)

c) Liquid – 0.5 mm hole

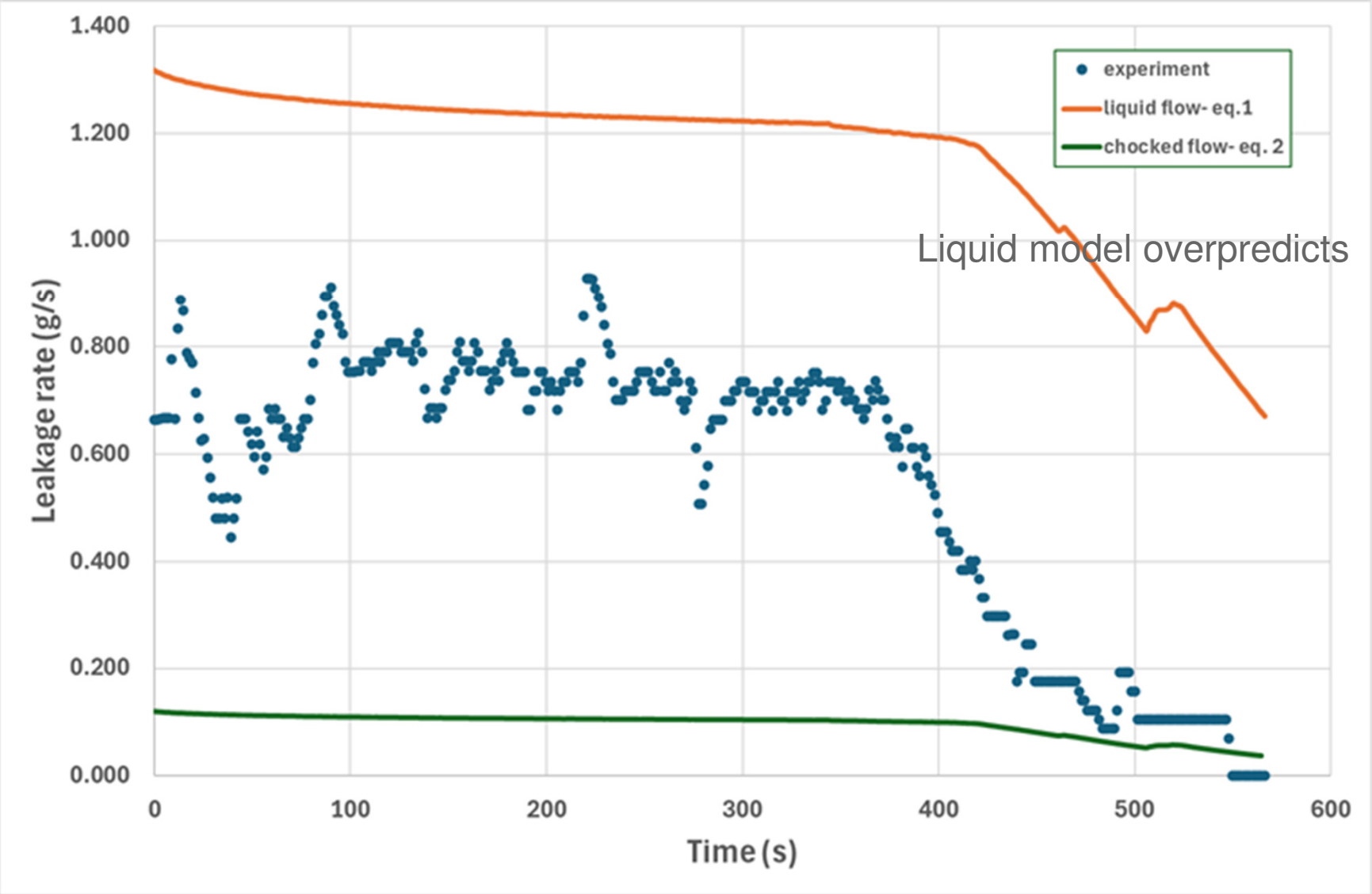


Limited internal cooling observed.
Most of the flashing and evaporation occur outside the cylinder immediately after discharge.
Rapid mass discharge but less internal cooling.

IR results show that gas leaks produce stronger internal cooling because evaporation occurs inside the cylinder during depressurization, while liquid leaks mainly flash outside the cylinder.

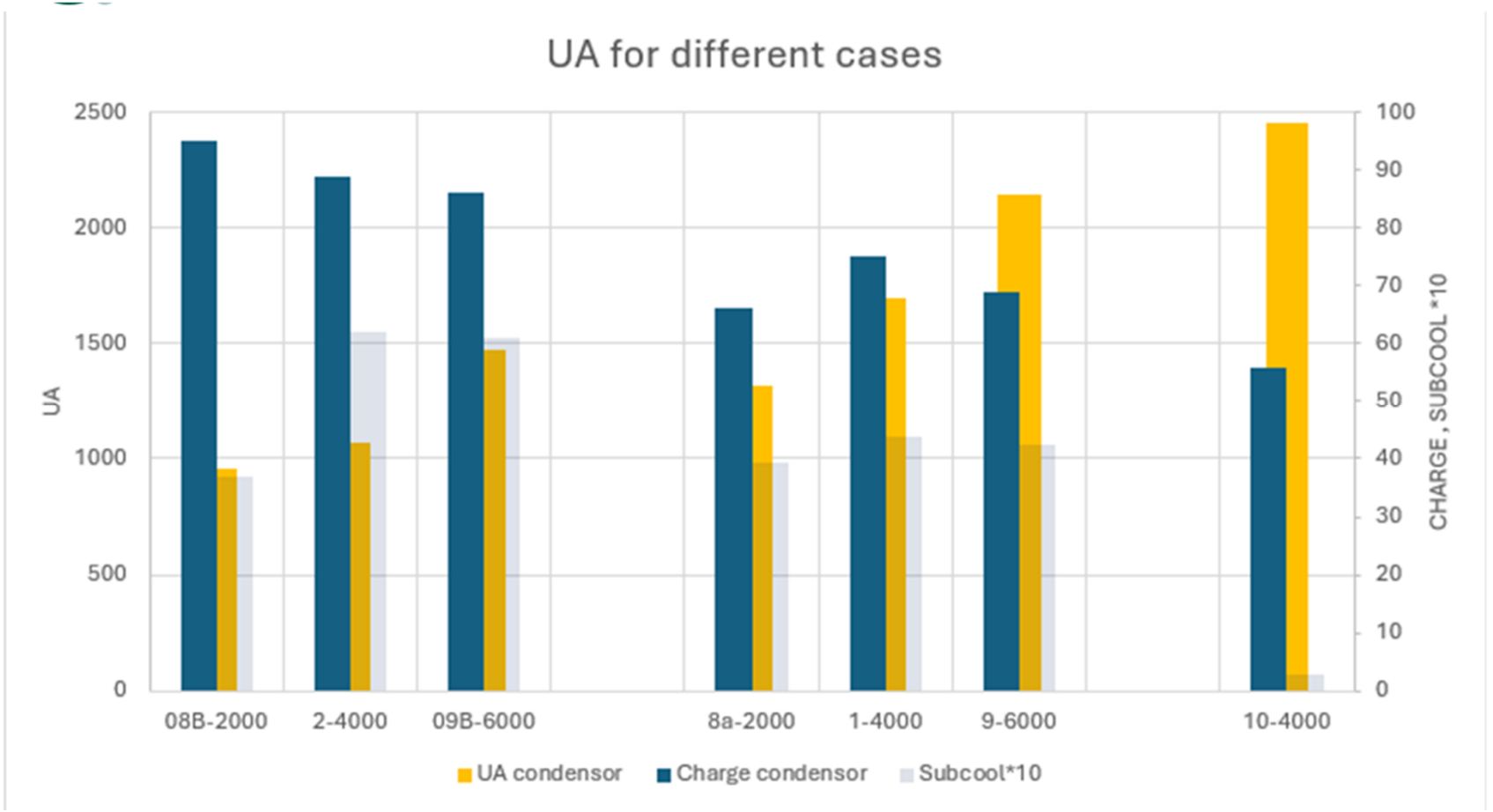
2020

Liquid-Phase Leakage Rate Comparison (0.3 mm)



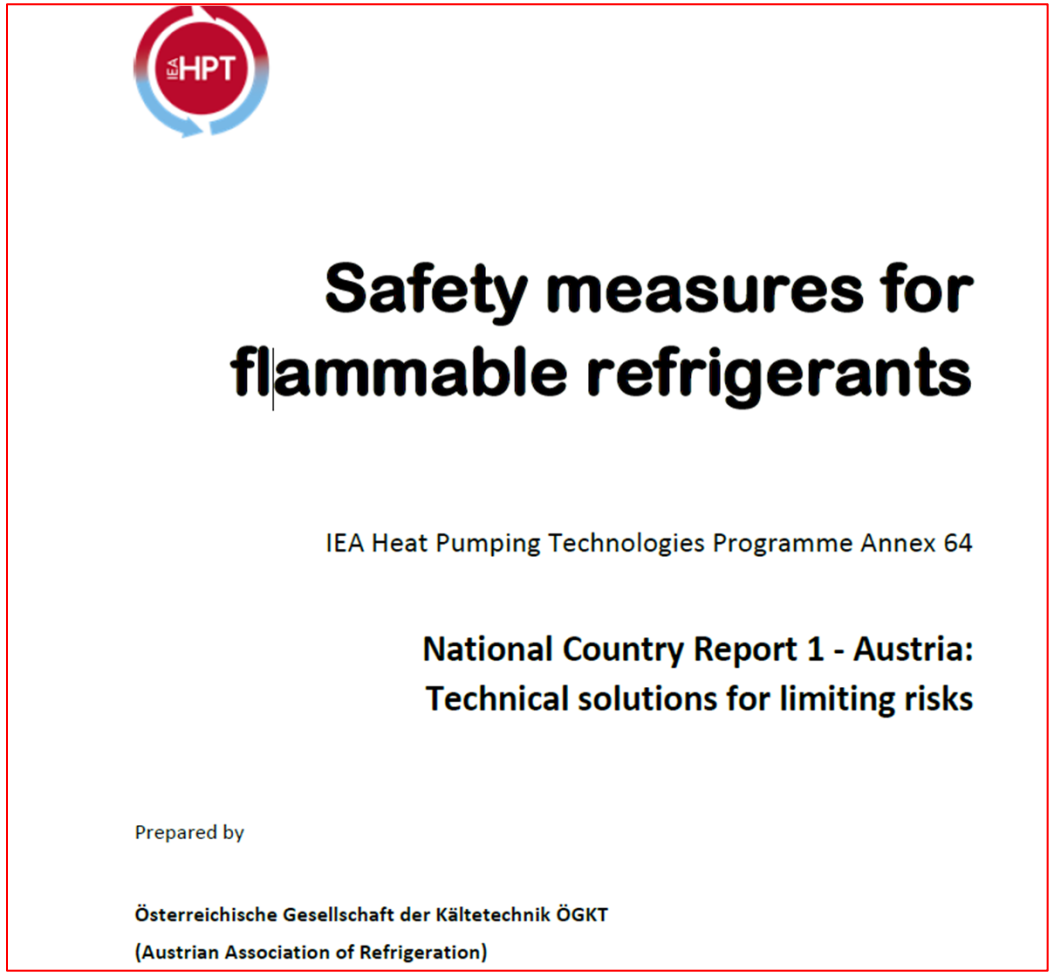
Where is the charge?
System with quick-closing valves allows investigating this

UA value of condenser and subcooling vs compressor speed and total charge of system



Dissemination activities

National report from Austria



Safety measures for flammable refrigerants

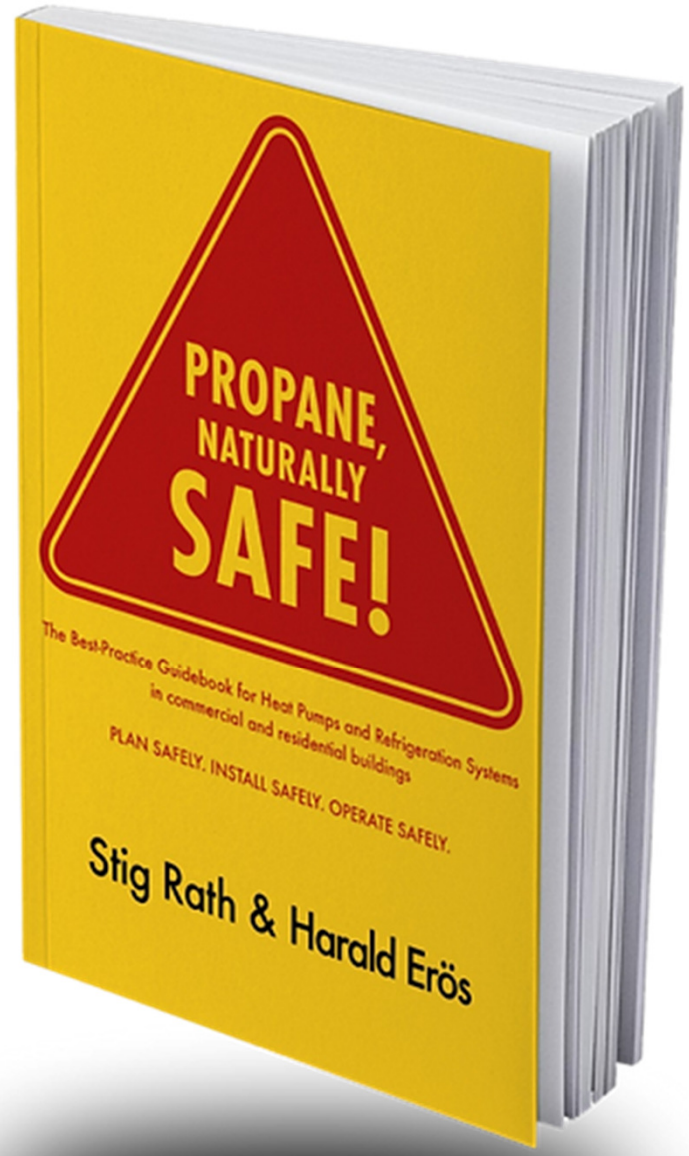
IEA Heat Pumping Technologies Programme Annex 64

National Country Report 1 - Austria:
Technical solutions for limiting risks

Prepared by

Österreichische Gesellschaft der Kältetechnik ÖGKT
(Austrian Association of Refrigeration)

New book!


PROPANE,
NATURALLY
SAFE!
The Best-Practice Guidebook for Heat Pumps and Refrigeration Systems
in commercial and residential buildings
PLAN SAFELY. INSTALL SAFELY. OPERATE SAFELY.
Stig Rath & Harald Erös

Dissemination activities of Project 64:

- State of the Art reports and webinars related to each task:
  - Leak detection — Nov 16
  - Leak scenarios — Nov 23
  - Technical solutions for limiting risks — Nov 30
  - Charge reduction — Dec 9
  - Risk Assessment — Dec 14

- Final report

Webinar on Leak detection Nov 16

Arranged by Odile Cauret, EDF, responsible for the State-of-the Art report on leak detection

- Introduction to IEA HPT Project 64 on Safety with flammable refrigerants,
  - Björn Palm, KTH, Project leader/OA

- Practical experience of causes of refrigerant leakage
  - Bernd Windholz, AIT

- A review of leak detection methods
  - Odile Cauret, EDF

Agenda, webinar June 25

- Experimental Study of R-290 Leak Behavior
  - **(Jafar Esmaeelian, KTH Royal Institute of Technology)**
- Austrian survey on the frequency, location, and detection of leaks in heat pump and cooling systems up to 50 kW nominal capacity
  - **(Bernd Windholz, Austrian Institute of Technology)**
- Limits of modelling approach for refrigerant charge assessment in residential heat pumps
  - **(Maëlle Journay, EDF)**
- Interpolation approaches to improve the exploitation of sparse sensor matrix in indoor release experiments
  - **(Arpit Baranwal, Fraunhofer ISE)**

See also Project website

- https://heatpumpingtechnologies.org/project64/

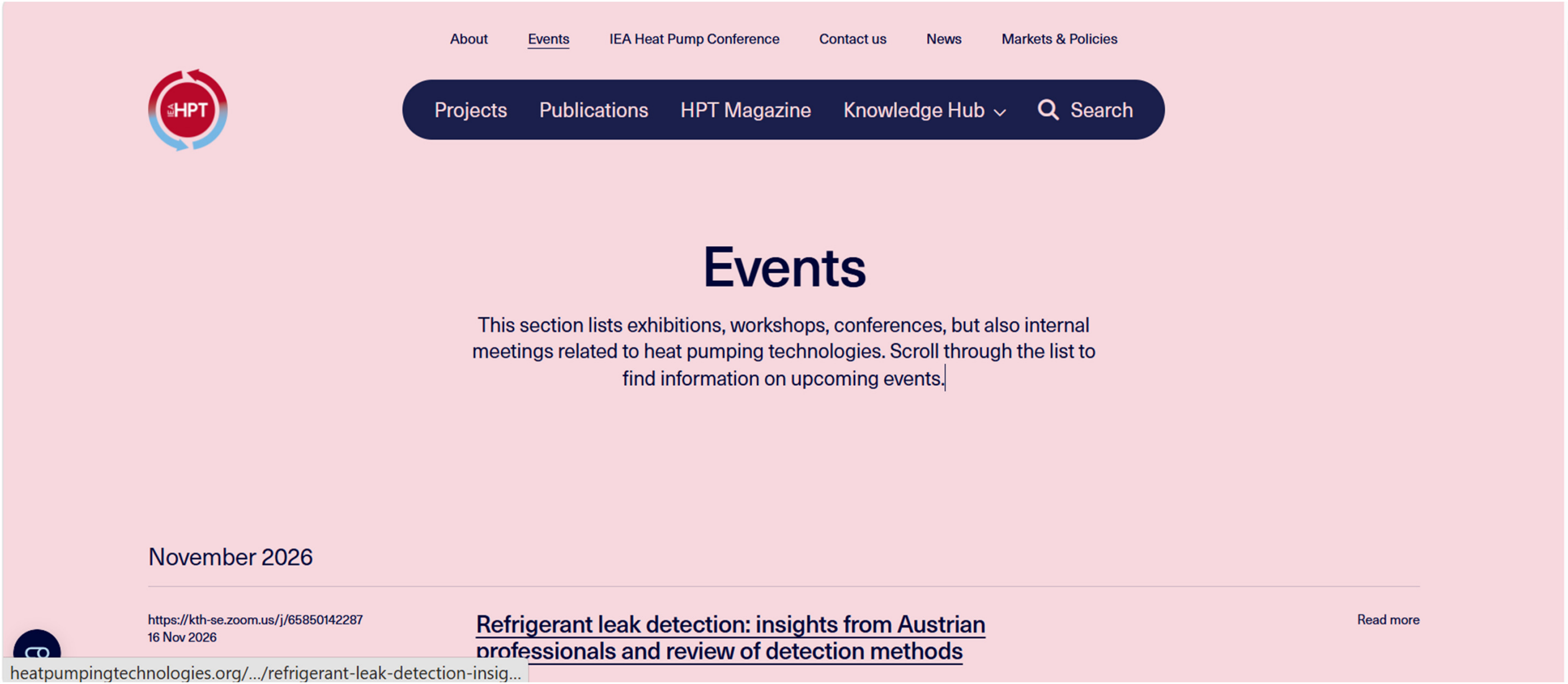


See also Project website

- https://heatpumpingtechnologies.org/project64/



https://heatpumpingtechnologies.org/events/



Other related activities:

- IEA HPT Project 69: Enhanced miniaturized components

- New continuation project planned, led by Thore Oltersdorf, Fraunhofer ISE



Thanks for your attention

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