Agenda

• Refrigerant Overview and Classification of Flammable Refrigerants
• Standards in the Context with Regulations
• EN378
• EN60335-2-89 Charge Extension & Safety Concept
• EN60335-2-40
• Summary
Refrigerant Overview

- F-Gas Regulation has an impact to the refrigerant selection
- System Architecture = f(Refrigerant Properties)
## Classification of Refrigerants (1)

<table>
<thead>
<tr>
<th></th>
<th>Lower toxicity</th>
<th>Higher toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher flammability</td>
<td>A3</td>
<td>B3</td>
</tr>
<tr>
<td>Flammable</td>
<td>A2</td>
<td>B2</td>
</tr>
<tr>
<td>Burning velocity ≥ 10cm/s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower flammable</td>
<td>A2L</td>
<td>B2L</td>
</tr>
<tr>
<td>Burning velocity &lt; 10cm/s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No flame propagation</td>
<td>A1</td>
<td>B1</td>
</tr>
</tbody>
</table>

### Behavior of Flames

<table>
<thead>
<tr>
<th>Substance</th>
<th>Class A3 Propane</th>
<th>Class A2 HFC152a</th>
<th>Class A2L HFC32</th>
<th>Class B2L Ammonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burning velocity</td>
<td>43 cm/sec</td>
<td>23 cm/sec</td>
<td>6.7 cm/sec</td>
<td>7.7 cm/sec</td>
</tr>
<tr>
<td>Heat of combustion</td>
<td>46 MJ/kg</td>
<td>16 MJ/kg</td>
<td>9 MJ/kg</td>
<td>19 MJ/kg</td>
</tr>
</tbody>
</table>

Quelle: Daikin

2L refrigerants do not propagate due to their slow BV. Additionally, heat of the combustion of HFC32 is low and the range of any impact by its flame is limited.
Refrigerant Classification (2)

Quelle: Daikin
Classification Rules defined in the Global Harmonized System (GHS). Industry started an initiative to change the classification in GHS in order to differentiate between A2L and A3.
European Regulations & Standards

European Treaty

Art. 95

OEM

Single market
TBT Technical Barriers of Trade
Product Harmonisation
PED/MD/LVD/EMC
......

ATEX (94/9/EC) (product) - IEC/EN 60079

Art. 137

Customer

Safety of workers
Remark: Only minimum requirements

National regulations:
Dangerous Substances and Explosive Atmospheres Regulations (DSEAR): UK
Betriebs-Sicherheits-Verordnung (BetrSichV): DE

ATEX (99/92/EC) (workplace) - TRBS-2152
International and European Committees and Standards

TC 86 SC1
ISO (DIS) 5149
plus others

TC 61 SC 61C
IEC 60335-2-24,
IEC 60335-2-89

TC 61 SC 61D
IEC 60335-2-40

TC 182
EN 378
plus others

CLC 61
EN 60335-2-40
EN 60335-2-24
EN 60335-2-89
Horizontal & Vertical Safety Standards

Horizontal Standard **For All Ref. Systems:** EN378
(Horizontal Standard Covers Fundamental Principles, Concepts, Terminology Or Technical Characteristics)

- **Household Appliances Or Similar Use**
  - EN 60335 series
    - -2-24
    - -2-89
    - -2-40

- **Commercial Systems**
- **Industrial Systems**

**Standards Update for A2L /A3**
- EN 378 is harmonized with ISO 5149
- EN 60335-2-40
  - Voting 2017 for A2L
  - WG started, A2/A3 Charge Ext. 2017
- EN60335-2-89
  - WG A2/A3 started Charge Ext. 2018
  - Target: Refrigerant Charge up to 0,5 kg
EN378 in the Context with Other Regulations & Standards

EN 378

Building standards

EN 60335

ADR

GHS (safety data sheet)

MD

TRBS

PED

ATEX
Scope EN378: Normative References

**EN378**

**Part 1: Basic requirements, definitions, classification and selection criteria**
- EN 12263
- EN 14276-2
- ISO 817

**Part 2: Design, construction, testing, marking and documentation**
- EN 13445…
- EN 13480…
- EN 14276…
- EN 60335…
- EN 837…
- EN 60079 (Explosive Atmospheres, ATEX harmonized)…

**Part 3: Installation site and personal protection**
- EN 1363
- EN 1364
- EN 1365

**Part 4: Operation, maintenance, repair and recovery**
- ISO 11650
- ISO 13043
- EN 60335-2-104

*I guess all documents are more than 1000 pages, not so easy!*

Schaffhausen, 22nd / 23rd June, 2017  Page 11
What is new in EN378

Part 1: Basic Requirements, Definitions & Classifications

• Vocabulary
  o Separate Machinery Room
  o Access Category
  o Open Air
• Flammability Class 2L
• Additional Calculation for human comfort
• Alternative risk management for occupied space
• Refrigerant tables updates
## Determine the charge based on flammability

<table>
<thead>
<tr>
<th>Flammability class</th>
<th>Access category</th>
<th>I = Occupied space</th>
<th>II Comp. In mach.-room / open air</th>
<th>III All ref component in mach.-room / open air</th>
<th>Ventilated enclosure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Human comfort</td>
<td>According to C.2 and not more than $m_2^a \times 1.5$ or According to C.3 and not more than $m_3^b \times 1.5$</td>
<td></td>
<td></td>
<td>No charge restriction $^c$</td>
</tr>
<tr>
<td></td>
<td>Other applications</td>
<td>$20 % \times LFL \times Room volume$ and not more than $m_2^a \times 1.5$ or According to C.3 and not more than $m_3^b \times 1.5$</td>
<td></td>
<td></td>
<td>No charge restriction $^c$</td>
</tr>
<tr>
<td></td>
<td>Human comfort</td>
<td>According to C.2 and not more than $m_2^a \times 1.5$ or According to C.3 and not more than $m_3^b \times 1.5$</td>
<td></td>
<td></td>
<td>Refrigerant charge not more than $m_3^b \times 1.5$</td>
</tr>
<tr>
<td></td>
<td>Other applications</td>
<td>$20 % \times LFL \times Room volume$ and not more than $m_2^a \times 1.5$ or According to C.3 and not more than $m_3^b \times 1.5$</td>
<td></td>
<td></td>
<td>Refrigerant charge not more than $m_3^b \times 1.5$</td>
</tr>
<tr>
<td></td>
<td>Human comfort</td>
<td>According to C.2 and not more than $m_2^a \times 1.5$ or According to C.3 and not more than $m_3^b \times 1.5$</td>
<td></td>
<td></td>
<td>Refrigerant charge not more than $m_3^b \times 1.5$</td>
</tr>
<tr>
<td></td>
<td>Other applications</td>
<td>$20 % \times LFL \times Room volume$ and not more than $50 \text{ kg}$ or According to C.3 and not more than $50 \text{ kg}$</td>
<td></td>
<td></td>
<td>Refrigerant charge not more than $m_3^b \times 1.5$</td>
</tr>
<tr>
<td></td>
<td>&lt; 1 person per 10 m²</td>
<td>$20 % \times LFL \times Room volume$ and not more than $50 \text{ kg}$ or According to C.3 and not more than $50 \text{ kg}$</td>
<td></td>
<td></td>
<td>Refrigerant charge not more than $m_3^b \times 1.5$</td>
</tr>
</tbody>
</table>
EN378 has 3 Levels of Refrigerant Charge

1. \( m_1 = 4 \text{ [m}^3\text{]} \times \text{LFL [kg/m}^3\text{]} \) (-> small kitchen)
2. \( m_2 = 26 \text{ [m}^3\text{]} \times \text{LFL [kg/m}^3\text{]} \)
3. \( m_3 = 130 \text{ [m}^3\text{]} \times \text{LFL [kg/m}^3\text{]} \)
   
   • Additional risk assessment and additional ventilation

Examples:
Propane, A3, LFL = 0,038 kg/m\(^3\)

\[
\begin{align*}
\text{m}_1 & = 4 \text{ m}^3 \times 0,038 \text{ kg/m}^3 = 0,150 \text{ kg} \\
\text{m}_2 & = 26 \text{ m}^3 \times 0,038 \text{ kg/m}^3 = 0,988 \text{ kg} \\
\text{m}_3 & = 130 \text{ m}^3 \times 0,038 \text{ kg/m}^3 = 4,94 \text{ kg}
\end{align*}
\]

R32, A2L, LFL = 0,307 kg/m\(^3\)

\[
\begin{align*}
\text{m}_1 & = 4 \text{ m}^3 \times 0,307 \text{ kg/m}^3 \times 1,5 = 1,8 \text{ kg} \\
\text{m}_2 & = 26 \text{ m}^3 \times 0,307 \text{ kg/m}^3 \times 1,5 = 11,97 \text{ kg} \\
\text{m}_3 & = 130 \text{ m}^3 \times 0,307 \text{ kg/m}^3 \times 1,5 = 59,87 \text{ kg}
\end{align*}
\]

* 50% more refrigerant charge than A2
C.2 Charge Limit Calculation

\[ m_{\text{max}} = 2.5 \times \text{LFL}^{5/4} \times h_0 \times A^{1/2} \]  
\[ A_{\text{min}} = m^2/(2.5 \times \text{LFL}^{5/4} \times h_0)^2 \]

where

- \( m_{\text{max}} \) is the allowable maximum charge in a room in kg;
- \( m \) is the refrigerant charge amount in the system in kg;
- \( A_{\text{min}} \) is the required minimum room area in \( m^2 \);
- \( A \) is the room area in \( m^2 \);
- LFL is the Lower Flammable Limit in kg/m\(^3\), as defined in Annex E;
- \( h_0 \) is the height factor of the appliance:
  - 0.6 for floor location;
  - 1.8 for wall mounted;
  - 1.0 for window mounted;
  - 2.2 for ceiling mounted,

where the LFL is in kg/m\(^3\) from Annex E and the molecular mass of the refrigerant is greater than 42 g/mol.
Alternative for risk management of ref.- systems in occupied spaces (C.3) - Increase the Charge

- These alternative provisions can only be used for an occupied space which fulfils all of the following conditions:

  - systems where the refrigerant is classified as A1 or A2L according to Annex E;
  - systems where the refrigerant charge does not exceed 150 kg and does not exceed $1.5 \times m_3$ for A2L refrigerants;
  - systems where the rated cooling (heating) capacity of the indoor unit is not more than 25% of the total cooling (heating) capacity of the outdoor unit systems and where pipes serving equipment in the occupied space in question are not oversized relative to the capacity of that equipment;
  - system location is class II in accordance with 5.3;
  - systems where the heat exchanger in the indoor unit and the control of the system are designed to prevent damage due to ice formation;
  - systems where the refrigerant-containing parts of the indoor unit are protected against fan breakage or the fan is designed to prevent breakage;
  - systems where only permanent joints are used in the occupied space in question except for site-made joints directly connecting the indoor unit to the piping;
  - systems where the refrigerant-containing pipes in the occupied space in question are installed in such a way that it is protected against accidental damage in accordance with FprEN 378-2:2016, 6.2.3.3.4 and FprEN 378-3:2016, 6.2;
  - alternative provisions to ensure safety are provided in accordance with C.3.2.2 and C.3.2.3;
  - doors of the occupied space are not tight-fitting;
  - effect of flow down is mitigated in accordance with C.3.2.4.
System Design for Multi-split Units according Risk Assessment C.3

Each piping is not oversized, in case of leakage of one evaporator the other evaporators will still work and limit the leak amount -> preferred design.

If the main pipe is installed in occupied space, the complete gas will leak, this design is not allowed.
What is new in EN378 2(2)

Part 2: Design, construction, testing, marking and documentation
- Aligned with PED and MD
- Flowchart updated
- 4 new Annexes
  - Stress corrosion cracking
  - Leak simulation testing
  - Commissioning procedure
  - Ignition sources

Part 3: Installation site and personal protection
- Separate machinery room
- Requirements for A2L’s
- Equipment not in occupied space nor in machinery room
- Sprinkler in ammonia machinery rooms

Part 4: Operation, maintenance, repair and recovery
- New text for evacuating procedure
- Testing halocarbon for moisture
- Handling Ammonia during service
  - When to dispose as hazardous waste
  - When to vent into water
  - How to dispose water
Applicable types of equipment related to the IEC 60335-2-89

Types of equipment

Out of scope
- Beer cellar coolers
- Ice cream freezer
- Reach-in cabinets
- Preparation counters
- Gondola cabinets

Investigated
- Walk-in display cooler
- Walk-in coldstore
- Serve-over cabinets
- Multi-deck cabinets
- Gondensing units
- Blast freezers
- Water dispensers
- Bottle coolers
- Gelato counters
- Ice makers
- Ice-cream dispensers
- Chilled produce retail areas

Airflow to be considered
May be mounted tabletop or under counter.

Different rooms to be considered
Only considered if it is used in factory sealed systems.
## Relevant standards and resulting amount of low GWP refrigerants

<table>
<thead>
<tr>
<th>Standard</th>
<th>Title</th>
<th>Application</th>
<th>HC charge size limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC and EN 60335-2-24</td>
<td>Particular requirements for refrigerating appliances, ice-cream appliances and ice-makers</td>
<td>Domestic refrigeration</td>
<td>Up to 150 g</td>
</tr>
<tr>
<td>IEC and EN 60335-2-40</td>
<td>Particular requirements for electrical heat pumps air-conditioners, and dehumidifiers</td>
<td>Any air conditioning and heat pump appliances</td>
<td>Up to - 1kg and - 5 kg, depending upon application</td>
</tr>
<tr>
<td>IEC and EN 60335-2-89</td>
<td>Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor</td>
<td>Any refrigeration appliances used for commercial situations</td>
<td>Up to 150 g</td>
</tr>
<tr>
<td>EN 378</td>
<td>Refrigeration systems and heat pumps – safety and environmental requirements</td>
<td>All refrigeration, air conditioning and heat pumps; domestic, commercial, industrial</td>
<td>Variable, depending upon application</td>
</tr>
<tr>
<td>ISO (DIS) 5149</td>
<td>Mechanical refrigerating systems used for cooling and heating – safety requirements</td>
<td>All refrigeration, air conditioning and heat pumps; domestic, commercial, industrial</td>
<td>Variable, depending upon application</td>
</tr>
</tbody>
</table>
Title of committee/working group and task

Title of committee/working group: TC61/SC61C/WG 4

Task of TC61/SC61C/WG4:

IEC 60335-2-89-A2/Ed2: Household and similar electrical appliances - Safety - Part 2-89: Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant unit or compressor

To define the maximum flammable refrigerant amount for appliances according to IEC 60335-2-89 and measures to maintain the equivalent safety level as for the present limit.

Members of the WG4:

26 Members out of 13 countries (AT, BE, BR, CZ, DE, FI, GB, IT, JO, JP, NZ, SK and US)
## EN378 vs EN 60335-2-89

### Standard Supermarket System
- **OEM Building the System**
  - EN378
  - PED
  - MD
  - LVD
  - EMC
  - ATEX Standards
- **Installation on site**
  - **RISK ASSESSMENT**
  - Workplace Safety

### Integrated Display Cabinet
- **OEM Building the Cabinet**
  - EN60335-2-89
  - PED
  - MD
  - LVD
  - EMC
  - ATEX Standards
  - Leak Simulation Test
  - Type Approval Notified Body
- **Installation on site**
What direction is TC61/SC61C/WG4 going

The risk with 500g flammable refrigerant (R290) must be the same as we have with the current limit of 150 g

In detail and out of the proposal from WG4 and comments of NC:

• Refrigerants which are lighter than air (e.g. R50) should be excluded

For appliances with more than 150 g flammable refrigerant…

• Determination of gas concentration might be necessary
• Minimum air flow for appliances between 151 g and 13 x LFL flammable refrigerant could be required or necessary
• The airflow should be guaranteed in any operating conditions
• No refrigerant-containing parts should be exposed to the outside of the appliance
• Low temperature solder alloys will be not accepted for pipe connections
• All electrical components should be non-sparking electrical apparatus
• Application should have a tested tightness control level of less than 3 grams per year
Leak Simulation Test

Top (red) sampling points along axis A-C and B-D is at the most pessimistic position.

Base (orange) sampling points along axis A-B and C-D is at the most pessimistic position.

Base (orange) in the front (E) and rear (E) of cabinet are applicable only for leaks from inside cabinet.

Figure YYY.1: Positioning of concentration sampling points
Possible time scale of TC61/SC61C/WG4

Time scale for including the WG4 proposal into the IEC 60335-2-89:

- October 2016: WG4 meeting and SC61C meeting in week 40 (4th to 8th of October 2016) with work on the compilation of comments on the WG4 proposal – 61C/671/DC
- Q4_2016: Creation of a DC out of the compiled comments
- Q3_2017: Creation of a CDV out of the latest DC
- Q1_2018: Discussion of CDV and creation of a FDIS
- Q2_2018: Publishing of the 3rd edition from the IEC 60335-2-89 standard
Residential & Commercial Comfort EN60335-2-40

- EN 60335-2-40
  - Household and similar electrical appliances. Safety. Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers
    - A2L Refrigerants in current version NOT included
    - A3 Refrigerants can be used up to 1.5 kg only in indirect systems
- EN 60335-2-40 Revision will be launched end of 2017/ early 2018
  - Tailored for A2L refrigerants with a maximum charge of 80 kg A2L
  - Separate Working Group to increase charge limits for A3 refrigerants, driven by China for small Split Systems up to 500g, release not before 2018
Summary

• A2L and A3 Refrigerants are considered in PED, MD and ATEX equally (H220-extremely flammable)
• EN378 propose big differentiations in the charge limits for A2L and A3
• Human comfort for A2L´s can use higher refrigerant charge as refrigeration
• Flammable refrigerants can be used only in appropriate systems, which are designed for flammable refrigerants (EN60079 – ATEX)
• Work place safety (TRBS) to be considered for installation site
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