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Safety Aspects for the Use of Hydrocarbon Refrigerants

Dr. Ralf Catanescu, Thorsten Lerch

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Content

- Regulation (EU) No 517/2014 on fluorinated greenhouse gases
- Properties of Refrigerant Fluids
- Explosions
  - Explosion-Triangle
  - Avoiding of Explosions
- Regulations
  - Product Safety Act
  - Directive 2006/42/EC on Machinery
  - DIN EN 378

Regulation (EU) No 517/2014

- Article I: Subject-matter
  - The objective of this Regulation is to protect the environment by reducing emissions of fluorinated greenhouse gases.
  - Accordingly, this Regulation:
    a) establishes rules on containment, use, recovery and destruction of fluorinated greenhouse gases, and on related ancillary measures;
    b) imposes conditions on the placing on the market of specific products and equipment that contain, or whose functioning relies upon, fluorinated greenhouse gases;
    c) imposes conditions on specific uses of fluorinated greenhouse gases; and
    d) establishes quantitative limits for the placing on the market of hydrofluorocarbons.

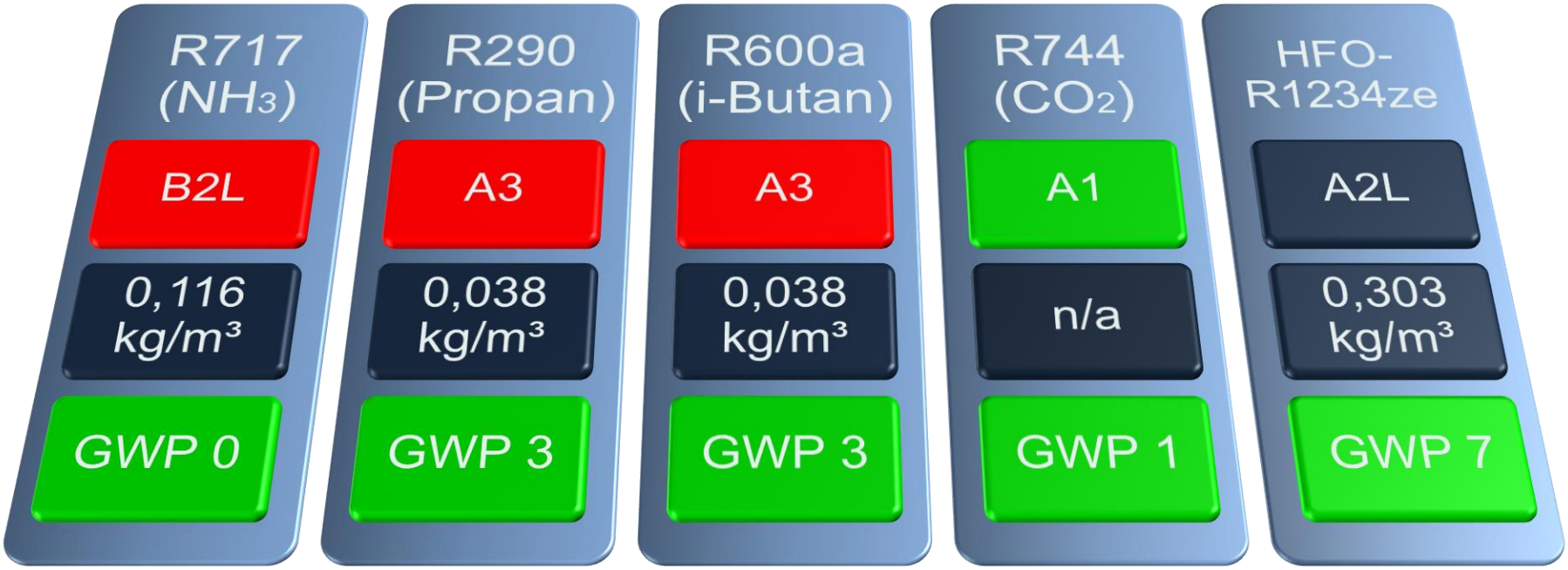
Regulation (EU) No 517/2014

- Article I: Subject-matter
  - The objective of this Regulation is to protect the environment by reducing emissions of fluorinated greenhouse gases.
  - Consequence:

    Alternative refrigerants have to be used

Properties of Refrigerants

Natural Refrigerants / HFO (Hydrofluoroolefine)



Advantages/Disadvantages of Natural Refrigerants

R717 (NH_3) / R290 / R600a / R744 (CO_2)

Advantages

- Price (inexpensive)
- Availability
- Pressure / cooling performance similar to R22
- No corrosion (exception: NH_3)
- Proved refrigerants
- Low GWP

Disadvantages

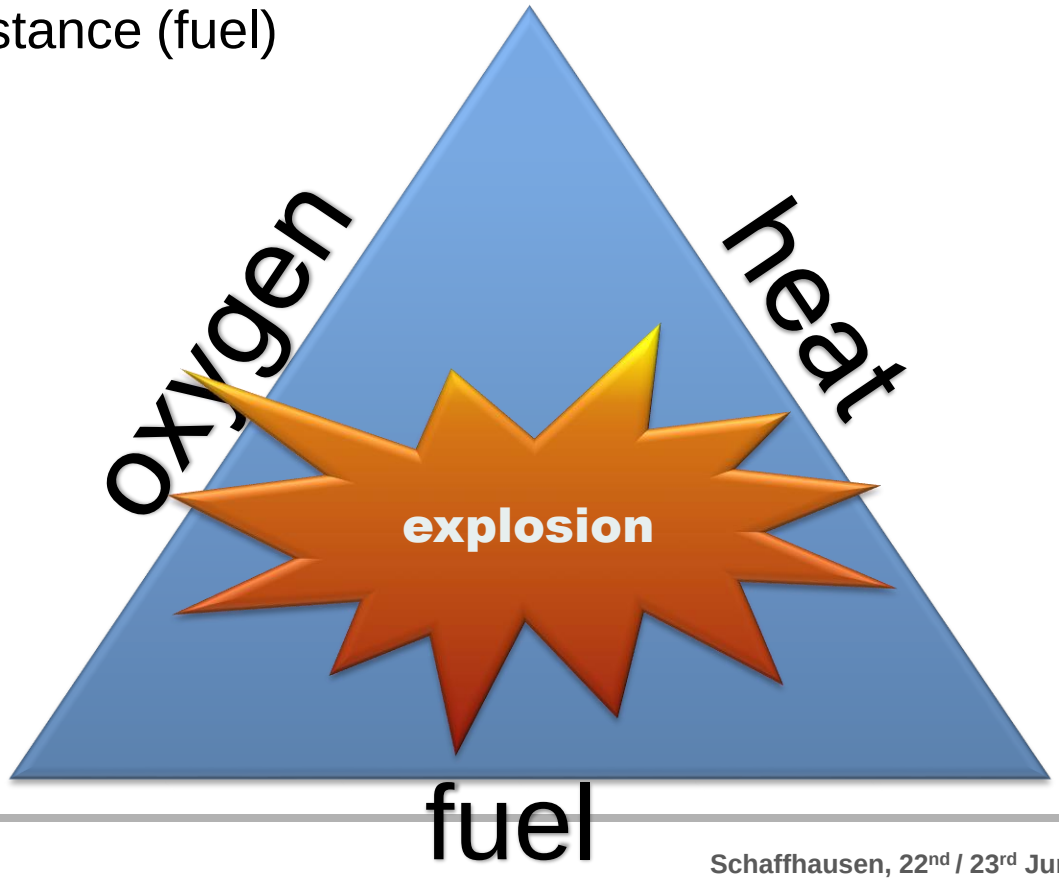
- Easily flammable
- Explosive
- Compatibility with existing designs
- High pressure levels (CO_2)
- Volume limits
- Disposal (R290)

Properties of Refrigerants

- Hydrocarbon (e.g. R290, R600a)
  - High energy efficiency and high performance compared to Hydrofluorocarbons (HFC).
  - Limited to small systems and water coolers (e.g. chillers for systems in food retail or air condition applications) due to flammability.
  - At use with heat pumps, low evaporation temperatures can be achieved without overheating of the compressor (HFCs require electrical heating for very cold days).

What is an Explosion?

- The **combustion triangle** is a simple model for understanding the ingredients necessary for an explosion:
  - Flammable substance (fuel)
  - Oxygen
  - Heat



Avoiding Explosions

- Explosions protection is done “in steps”:
  - Measures to prohibit or limit the development of an explosive atmosphere
    → primary explosion protection
  - Measures to avoid the ignition (firing) of an explosive atmosphere
    → secondary explosion protection
  - Limitation of the impact of an explosion to an uncritical level
    → tertiary explosion protection
  - If everything fails: Rescue service

Avoiding Explosions

- Measures to prohibit or limit the development of an explosive atmosphere (primary explosion protection)
  - Use of inert gas (e.g. Argon, Nitrogen, CO_2)
  - Closed systems
  - Venting measures
  - Monitoring of concentrations (gas warning)

Avoiding Explosions

- Measures to avoid the ignition (firing) of an explosive atmosphere (secondary explosion protection)
  - Ex zone classification
    Depending on the type of the Ex zone, the mechanical and electrical operation resources have to fulfill certain requirements in order to not act as an ignition source.
  - Avoid ignition sources

Avoiding Explosions

- Constructional measures:
  - Closed construction
  - Explosion proof construction

- Regulations:
  - e.g. TRBS (Technische Regeln für Betriebssicherheit / technical regulations for operation security)

Avoiding Explosions

- Organizational measures:
  - Maintenance
  - Information and guidelines for operators and concerned employees
  - Trainings
  - Instructions and work releases (in written form!)
  - Marked Ex zones

Regulations

- In order to avoid explosions, in most countries regulations (laws, legal orders, standards) ensure a high security level.
- Examples:
  - Product Safety Act (German law)
  - Directive 1999/92/EC (ATEX)
  - Directive 2006/42/EC (machinery)
  - Directive 2014/68/EC (pressure equipment directive)
  - Technical regulations (German, e.g. TRBS 2152, TRGS 555)
  - DGUV regulations (German)
  - DIN EN 378
  - …

Act on making products available on the market

§1 Scope of Application

(1) This Act shall apply whenever products are made available on the market, exhibited on the market or used for the first time in the context of a commercial activity.

(2) This Act shall also apply to the erection and the operation of installations subject to mandatory inspection, which are used for commercial or economic purposes or which may put employees at risk, with the exception of installations subject to mandatory inspection

§2 Definitions

"equipment subject to mandatory inspection" shall mean

- pressure vessel systems with the exception of steam boilers,
- installations for the filling of compressed, liquefied gases or gases dissolved under pressure,
- ducts under internal overpressure for combustible, corrosive or toxic gases, vapours or liquids,
- …

§3 General requirements for making products available on the market

Where a product is subject to one or more ordinances in accordance with […], it may only be made available on the market if it

- complies with the requirements stipulated therein and
- does not put at risk the safety and health of persons or other legal goods, as stipulated in the ordinances in accordance with [..] when used as intended or foreseeable.

Product Safety Act

- European directives, which are implemented in German law by regulations of the Product Safety Act:
  - Directive 2014/35/EU (low voltage directive)
  - Directive 2006/42/EC on machinery
  - Directive 1999/92/EC (ATEX)
  - Directive 2014/68/EC (pressure equipment directive)
  - …

  The directives are implemented in German law by Product Safety Edicts (ProdSV).

§4 Harmonized standards

(1) Compliance of a product with the requirements under […] may be assessed on the basis of harmonized standards.

(2) A product complying with harmonized standards or parts thereof and whose references have been published in the Official Journal of the European Union, shall be presumed to comply with the requirements under […], insofar as they are covered by the corresponding standards or parts thereof.

1.5.6 Fire

- Machinery must be designed and constructed in such a way as to avoid any risk of fire or overheating posed by the machinery itself or by gases, liquids, dust, vapours or other substances produced or used by the machinery.

Is applicable to all cooling devices, especially if flammable refrigerants are used.

1.5.7 Explosion

- Machinery must be designed and constructed in such a way as to avoid any risk of explosion posed by the machinery itself or by gases, liquids, dust, vapours or other substances produced or used by the machinery.

Is applicable to cooling devices with flammable refrigerants in a closed loop without external explosive atmosphere.

1.5.7 Explosion

- Machinery must comply, as far as the risk of explosion due to its use in a potentially explosive atmosphere is concerned, with the provisions of the specific Community Directives.

Is applicable to cooling devices with flammable refrigerants in an explosive atmosphere.
→ ATEX directive

6.2.10 Protections against hot surfaces

- The temperature of surfaces which can get in contact with refrigerants of the groups A2, A3, B2, or B3 in the case of a leakage must not exceed 100K below the auto-ignition temperature of the refrigerant.

6.2.13 Protections against danger of explosions

- Refrigerating systems must be constructed in a way, that in areas with electrical components that can act as source of ignition and can be operated under normal operating conditions or at occurrence of a leakage, no refrigerant can flow or accumulate in a way, that there is a risk of fire or explosion.

  Note:

  - This standard does not cover requirements for the use of devices in areas with the risk of explosion.
  - General requirements: See ATEX directive

8.8 Detectors for refrigerants A2/A3

- A detector for a refrigerant of the groups A2/A3 has to be sensitive for a critical value of concentration of max. 25% of the lower explosion limit of the refrigerant in air.
- If the detector responds, he has to
  - Automatically initiate an alarm (acoustically and optically)
  - Start the mechanical venting
  - Shutdown the refrigerating system

Summary

- The regulation (EU) No 517/2014 on fluorinated greenhouse gases limits the use of established refrigerants.
- Natural refrigerants offer good alternatives due to their low GWP.
- A major problem of natural refrigerants is their flammability. Among other security aspects, explosion protection has to be considered.
- Requirements for explosion protection and other safety measures are covered in several regulations and standards.
- The Product Safety Act, the directive 2006/42/EC on machinery, and DIN EN 378 cover the key requirements.
- A detailed knowledge of the legal aspects becomes more and more important.

Thank you very much
for your attention!

Contact:

Dr. Ralf Catanescu / Dipl.-Ing. Thorsten Lerch

Bundesfachschule Kälte-Klima-Technik
Bruno-Dressler-Straße 14
63477 Maintal
Germany

Phone: +49-6109-6954-0
Email: Catanescu@bfs-kaelte-klima.de