United Nations Environment Programme

Workshop on HFC management technical issues
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Transport Refrigeration

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Agenda

- Challenges to replace HFC-404A, -134a
- Solutions for high-GWP Applications
- Availability of alternative technologies
- Example for reefer container using R290

Transport Refrigeration: Truck and Trailer

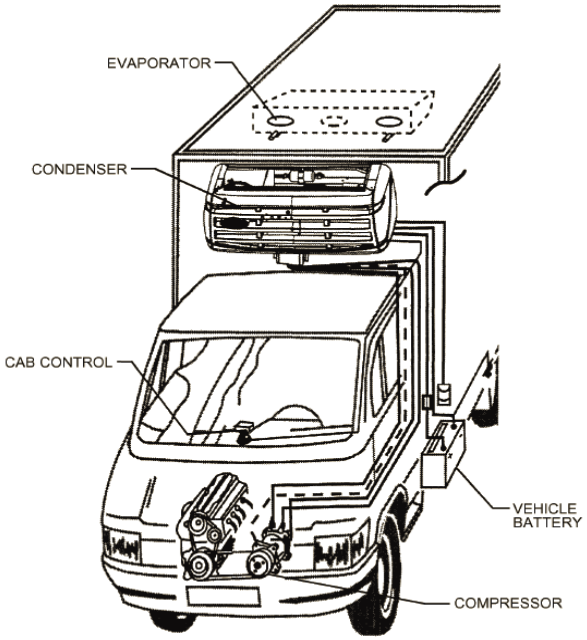
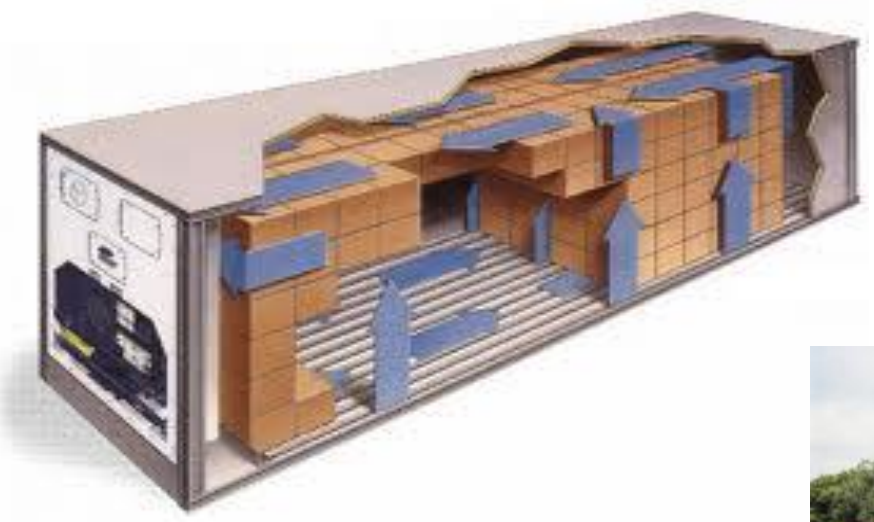


Fig. 7 Small Truck Refrigeration System

Transport Refrigeration: Reefer Container



Transport Refrigeration : general

- **Truck & Trailer: major manufacturer are technology driver**
- **Reefer: limited manufacturer, very competitive market**
- Ship: various refrigeration systems, often custom made → covered in industrial refrigeration

- Operation at ambient conditions from -30 to +50°C
- **Operation mainly in open air or ventilated enclosure** (cargo holds on board of ships)
- **Global technology platform**
- **Introduction of new refrigerants require high investments**
  - Global availability of spare part kits for reefer container

Transport Refrigeration : Status Quo

- Replacements for R134a, R404A

Refrigerant	GWP	Flammability[4]	Comments
R-744 (CO_2)	1	1	Transcritical R-744 is being developed for large road vehicles and for intermodal containers. Use of R-744 requires major changes to the design of transport refrigeration systems and the development of many new components. Some systems were trialled in 2014 and it can be expected that R-744 may be widely available for transport applications by 2020.
R-407A	2107	1	There has been some limited use of these blends in road vehicles as R-404A alternatives. High compressor discharge temperature must be addressed in high ambient e.g. using liquid injection.
R-407F	1825	1	
R-448A	1387	1	Newly developed blends with properties similar to R-407A and R-407F, but lower GWP. Currently there is very little commercial experience or availability in transport sector, but they may be suitable as R-404A alternatives in new systems. High compressor discharge temperature must be addressed in high ambient e.g. using liquid injection.
R-449A	1397	1	
R-452A	2141	1	A new blend targeted at the transport sector; an R-404A alternative with low discharge temperature at high ambient.
R-450A R-513A	601 631	1 1	Newly developed blends with properties similar to HFC-134a. May be suitable for new road vehicles and containers that are currently designed to use HFC-134a.
HFC-32	675	2L	Recent developments are showing high efficiencies and acceptable risks for operation with certain flammable refrigerants including HCs and HFC-32. Use of flammable refrigerants require special safety measures and new designs.
HC-290 HC-1270	3 2	3 3	

Transport Refrigeration : available technology

- CO_2 (R744) systems: on the market, penetration limited
- R452A: as replacement of R404A, 50% lower GWP, introduction starting 2015
- R32: proposed for reefer refrigeration
- R290/R1270: announced for reefer refrigeration, production start planned for 2018-19

Transport Refrigeration Refrigerants: Challenges

- No optimal refrigerant with low GWP available
  - CO2: lower efficiencies @ high ambient, high costs
  - GWP Range < 700: all refrigerants flammable

- Flammability is main concern
  - Safety Standards currently proposed to cover safety issues
  - Safe designs for flammables refrigerants is possible
  - operational safety is a challenging step, currently investigated
    - ➔ Intermodal operation
    - ➔ Guidelines, best practice, education, training, etc.

Transport Refrigeration Refrigerants: Conclusion, summary

- Technology to replace high GWP refrigerants are available, including HC's in some years
- Risk studies show acceptable risks for flammables, ongoing work
- CO2 systems are available
- Clear regulation are requested from policymakers

Future Refrigerants Project: Reefer container using flammable refrigerants, safety concept

References
and Scientific Papers

11th IIR Gustav Lorentzen Conference on Natural Refrigerants
Natural Refrigerants and Environmental Protection
August 31-September 2, 2014
Hangzhou, China

SHANGHAI WORLD EXPO
EXHIBITION AND
CONVENTION CENTER
上海世博展览馆
2015年3月24-26日

Future Refrigerants Project

Reefer container using flammable refrigerants

Project owner and sponsor

MAERSK CONTAINER INDUSTRY

Project Management

ref-tech
engineering office refrigeration technologies

Participating companies and organisations for safety investigations

DNV·GL

BAM Federal Institute for Materials Research and Testing

Summary

Flammable refrigerants (Propane, Propene and R32)

- Safety concept for reefer container developed
- Acceptable hazard and risks frequencies found in risk assessments
- Outstanding efficiencies
- The ***intrinsically safe design*** is ***simple***
- For ***safe operation***: 360° safety management required