Development of climate friendlier truck refrigeration systems with R-290

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TRANSFRIG

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

EUROPE ATMOsphere solutions for europe

natural refrigerants

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the dti
Department:
Trade and Industry
REPUBLIC OF SOUTH AFRICA

On behalf of

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

of the Federal Republic of Germany

HEAT

Environmental impact of transport refrigeration

- Refrigerant HFC-404A with GWP of 3,922 is standard
- High leakage rates of 20%, 30-50% in developing countries
- Promoted alternative refrigerants with GWPs of > 1000
- High energy consumption
- Relevance for food security

TRANSFRIG

- the cooperation partner

- Only South African transport refrigeration company
- Founded in 1980
- Local production in Johannesburg
- High market share for trucks and vans in South Africa
- Sales in Sub-Saharan countries and internationally
- leader for environmental friendly transport refrigeration technology in Africa

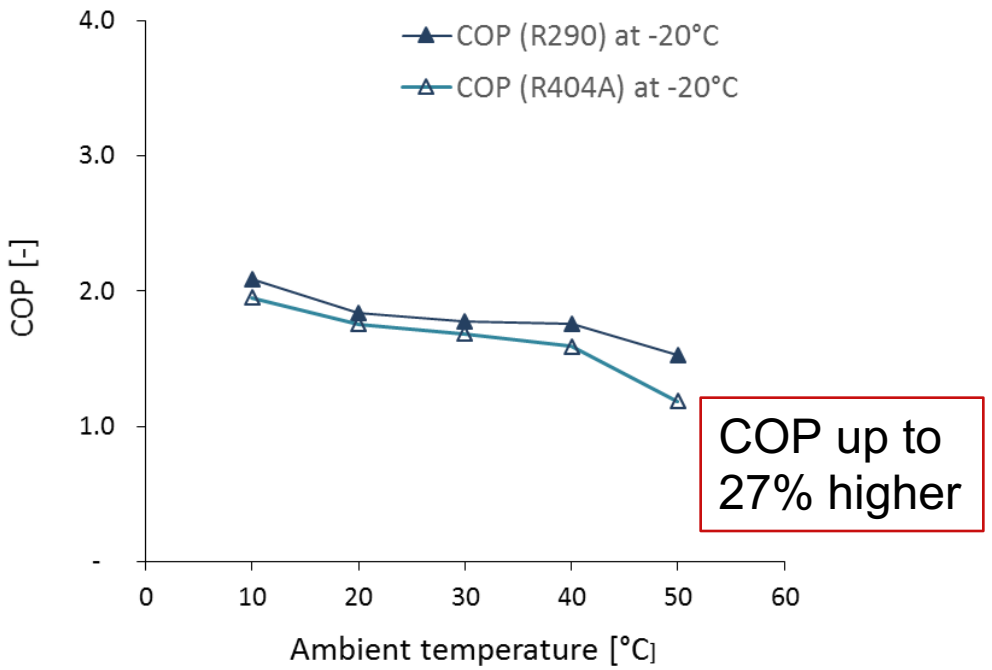
Timeline

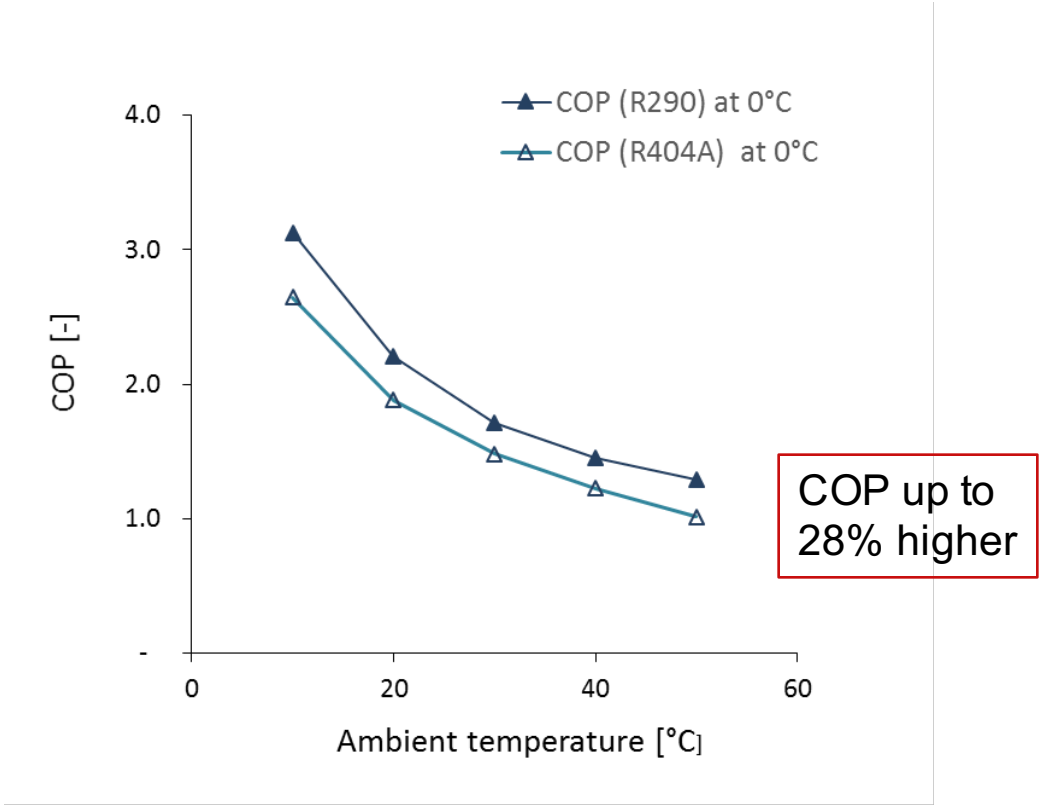
- Start of development: November 2014
- Field trial: Spring 2016
- Advanced field trial South Africa: Autumn 2016
- International: 2017

Technical specification of R-290 unit MT480

Unit name	MT450	MT480
Refrigerant	R-404A	HC-290
Initial refrigerant charge	3.5 kg	0.65 kg
Cooling capacity	7.95 kW for 0°C 4.55 kW for -20°C	7.95 kW for 0°C 4.55 kW for -20°C
Powered by	Open-type, driven by diesel engine	Semi-hermetic compressor, electrically driven, diesel-driven alternator
Expansion device	Thermostatic expansion valve	Electronic expansion valve
Compressor	Fixed speed	Variable speed (60 – 100%)
Condenser tubing	9.5 mm	5 mm
Evaporator tubing	9.5 mm	7 mm

Performance improvements due to use of R-290 at high ambient temperatures

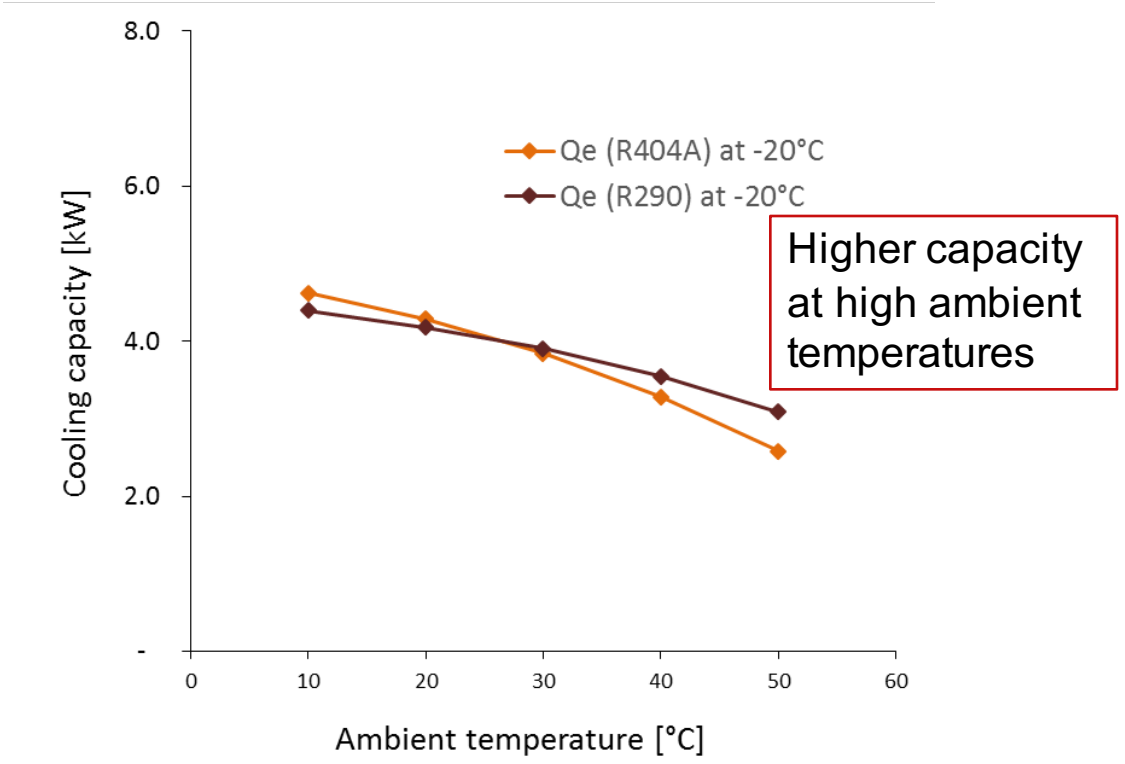




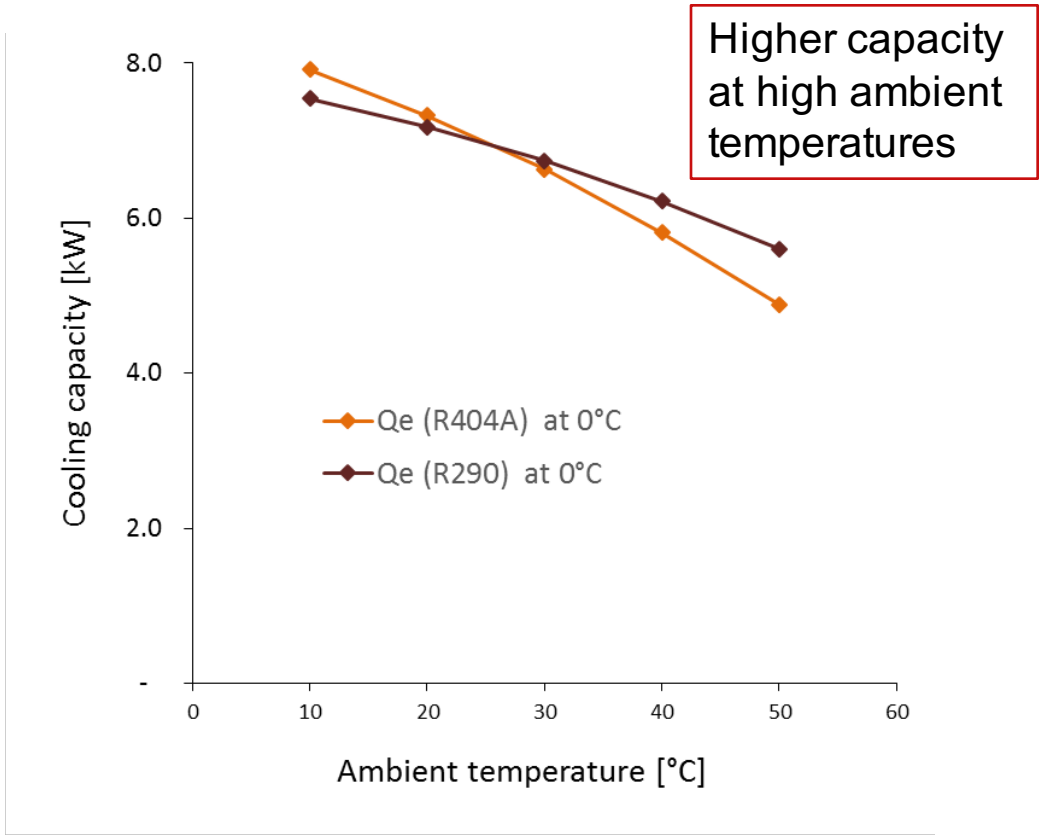
Performance at extreme conditions for LT (T = -20°C)

Performance at extreme conditions for MT (T = 0°C)

Higher cooling capacity at high ambient temperatures



Cooling capacity at extreme conditions for LT (T = -20°C)



Cooling capacity at extreme conditions for MT (T = 0°C)

Improvement of performance

Measure	Efficiency benefits
Thermodynamic properties of HC-290 refrigerant	✓
Optimised HC-290 compressor (including oil)	✓
Redesign of condenser (e.g. circuitry and reduced tube size)	✓
Redesign of evaporator (e.g. circuitry and reduced tube size)	✓
Liquid suction heat exchanger (in-receiver accumulator)	✓
Pipe sizes, line components	n/a

Safety aspects: General Risk Assessment approach according to EN1127-1:2011

STEP 1: Avoidance of flammable atmospheres

- Identification of dangerous substances → R290 – flammable!
- Characterise possibility of flammable regions → Leak simulation tests
- Limit the extent of flammable regions → Ventilation, restricting leak amount

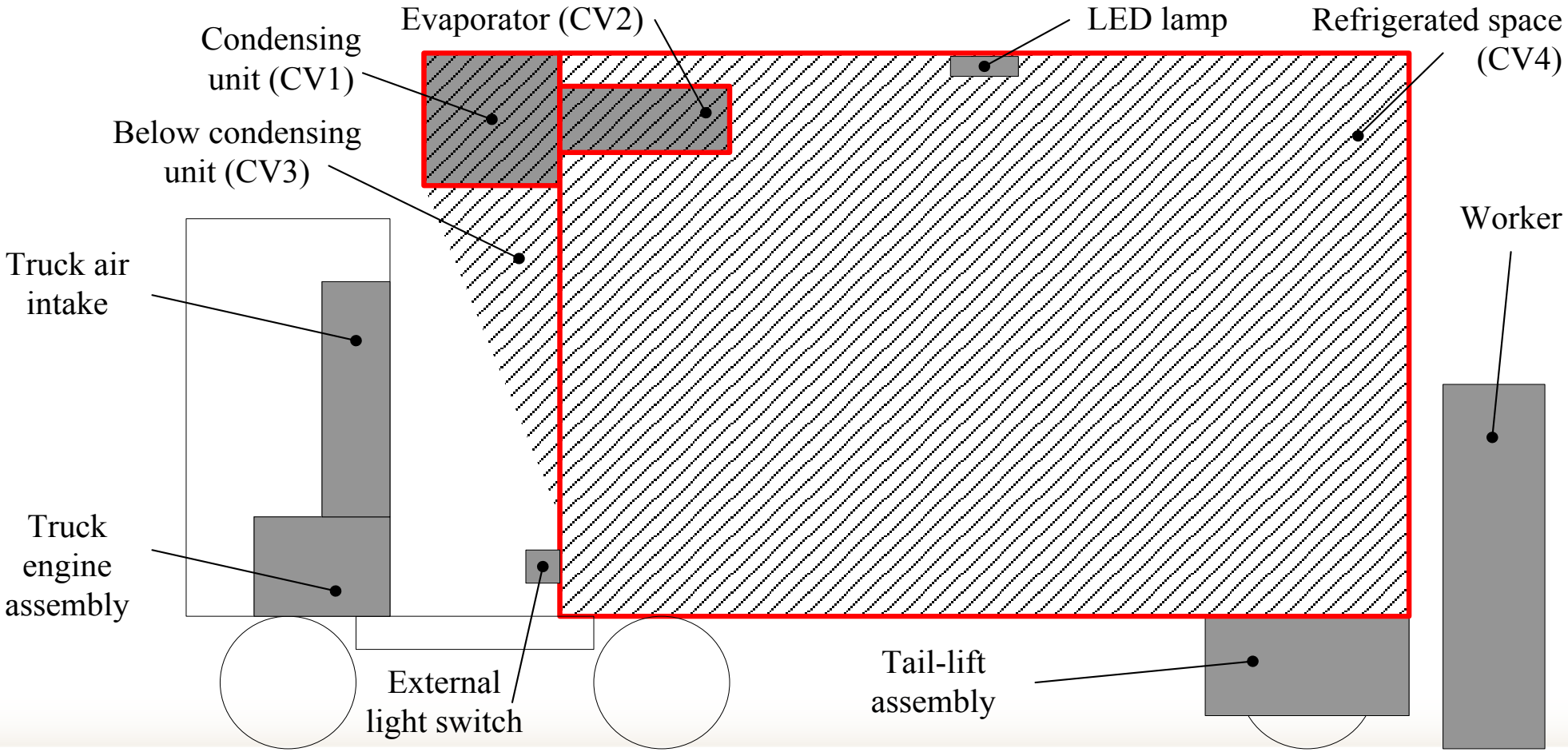
STEP 2: Elimination of ignition sources

- Identification of potential sources of ignition → Those within flammable zone
- Eliminate or protection of potential sources of ignition → Ventilation, enclosure, Ex-rating, etc

STEP 3: Limiting the consequences of ignition

- Estimate the severity of consequences → Overpressures, thermal radiation
- Adopt features to minimise the severity of ignition → Relief measures, alarms/warnings

Typical locations of SOIs and potential flammable zones



Leak identification system

Gas detector

- Immediate detection of leak
- Unreliable in the long-term
- Regular calibration and checking needed
- Easily damaged
- Adds substantial costs

System operating parameters

- e.g. suction pressure & temperature, superheat, degree of EEV opening
- Longer response time than gas detector
- More reliable in the long-term, no calibration needed
- No contamination
- Extensive testing necessary

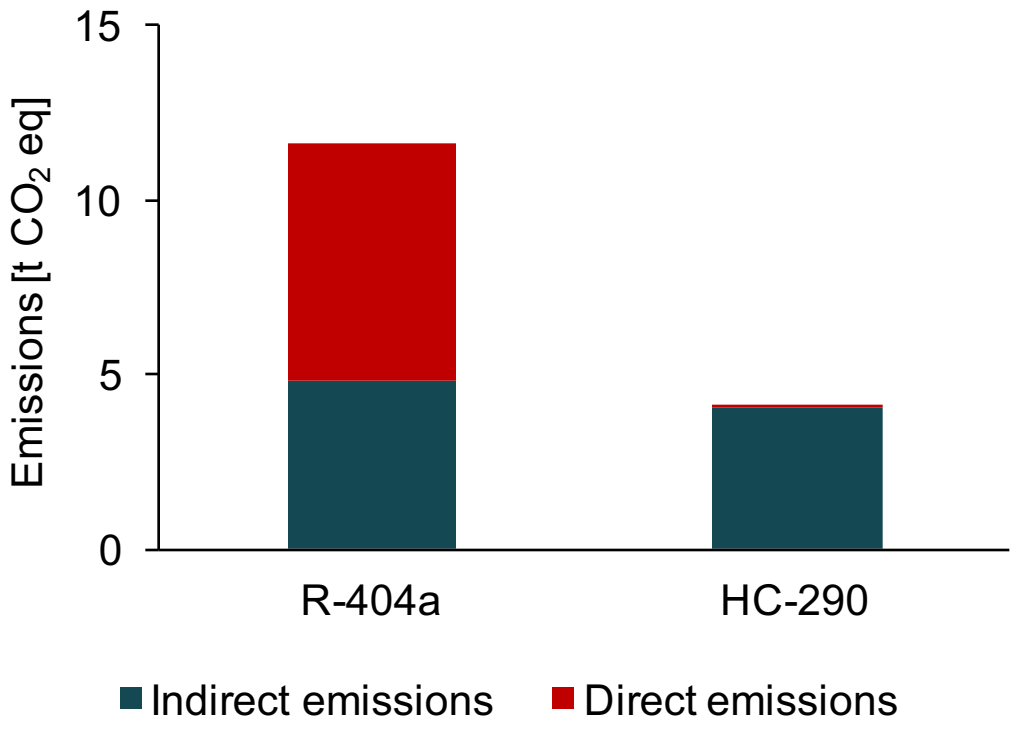
→ **Chosen because of low cost, better reliability, not dependent upon special maintenance over lifetime**

Improvement of energy efficiency

Measure	Efficiency benefits
Thermodynamic properties of HC-290 refrigerant	✓
Optimised HC-290 compressor (including oil)	✓
Redesign of condenser (e.g. circuitry and reduced tube size)	✓
Redesign of evaporator (e.g. circuitry and reduced tube size)	✓
Liquid suction heat exchanger (in-receiver accumulator)	✓
Electronic expansion valve	✓
Variable speed compressor	✓

Life cycle emissions – comparison R-404a and HC-290

	R-404A unit	HC-290 unit
GWP	3,922	3
Charge size	3.5 kg	0.65 kg
Annual leakage rate	50 %	**30 %**
Direct emissions	**6.9 t CO_2 eq**	**0.001 t CO_2 eq**
Fuel consumption*	1.2 L/h	1.0 L/h
Runtime hours	1,500 h/year	1,500 h/year
Indirect emissions	**4.8 t CO_2 eq**	**4.0 t CO_2 eq**
Total emissions	**11.8 t CO_2 eq**	**4.0 t CO_2 eq**



* estimate

Summary

- ✓ Environmentally friendly refrigerant
- ✓ High energy efficiency (also for high ambient temperatures)
- ✓ Reduced refrigerant leakage
- ✓ Comprehensive safety concept for flammable refrigerants
- ✓ Compliance with safety standards