Efficient Climate System for Mobile Air Conditioning

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Climate · Electronics · Interiors · Lighting

Agenda

- Motivation
- Component and System Approach
- Results for Cooling Performance
- Investigation on Efficiency and Fuel Consumption
- Summary and Outlook

Motivation for System Development

Growing legislator attention to reduce CO_2 emissions:

- For vehicle operation (homologation drive cycles)
- For systems operation (e.g. air conditioning)
- CO_2 equivalent emissions (GWP of refrigerant type, refrigerant leakage)

Examples:

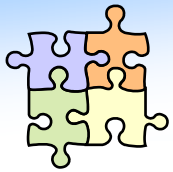
- EPA Green House Gas Rules - 40 CFR Parts 85, 86, and 60 including credits for A/C system efficiency improvements and low leakage A/C systems
- EU Regulation (EC) 443/2009 to reduce CO_2 vehicle emissions
- EU Directive 2006/40/EC banning the use of refrigerants with a GWP >150 and limiting systems leakage

New development on system level demands:

- Reduce component and system weight
- Increase efficiency
- Implementation of low-GWP refrigerant as alternative to R134a
- Reduce systems leakage

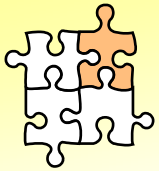
Efficient Climate System

System level demands on mass - efficiency - leakage - Low-GWP refrig.






Reengineering on component level:



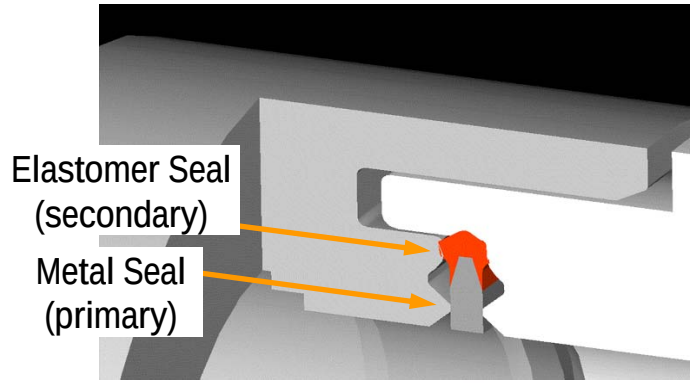
- New designs for connectors of refrigerant lines for decreased (eliminated) direct emissions of refrigerant 
- Smaller, more compact components (downsizing of compressor displacement, heat exchanger core thickness) 
- Coaxial tube IHX with increased heat exchanger capacity  

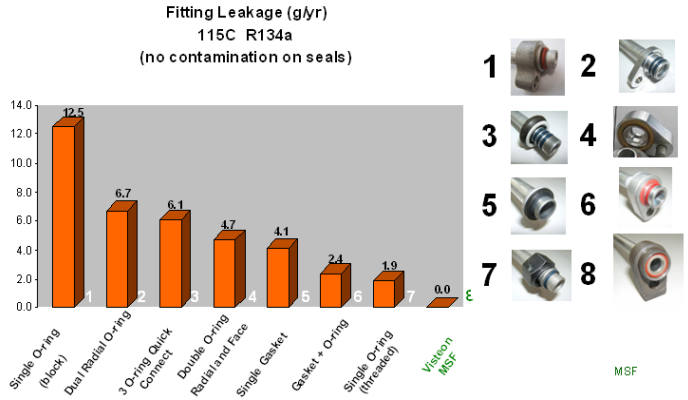
Trade-offs for specific vehicle application:


- Performance requirements, package conditions & environmental aspects drive system layout, component selection, integration & tuning

Component Development

- Issues with conventional polymeric seals:
  - Refrigerant migration through the material (direct emissions)
  - Damage, incorrect assembly and contamination of seal (additional unintended refrigerant leakage)
- Metal seal fitting to minimize refrigerant leakage:
  - Utilizes metal to metal sealing surfaces for primary tight sealing
  - Full flow (no restriction to cause pressure drop)
  - Robust to contamination (hair, metal chips, plastic, etc)
  - Robust to rough handling (nested seal and sealing surfaces)
  - Robust to assembly misalignment (proper piloting)





Component and System Development

- Internal heat exchanger (IHX) for increased cooling capacity and/or enhanced system efficiency
- Refrigerant properties impact IHX design parameters
  - R1234yf has lower capacity and efficiency than R134a in A/C systems
- Component impacts system behavior (tuning required)
  - Due to thermodynamic properties R1234yf compressor discharge temperature is ~10K lower than with R134a
- Base IHX modified for R1234yf:
  - Enhanced heat transfer at comparable pressure drop
  - Utilizes the lower compressor discharge temperatures to improve R1234yf efficiency and capacity compared to R134a

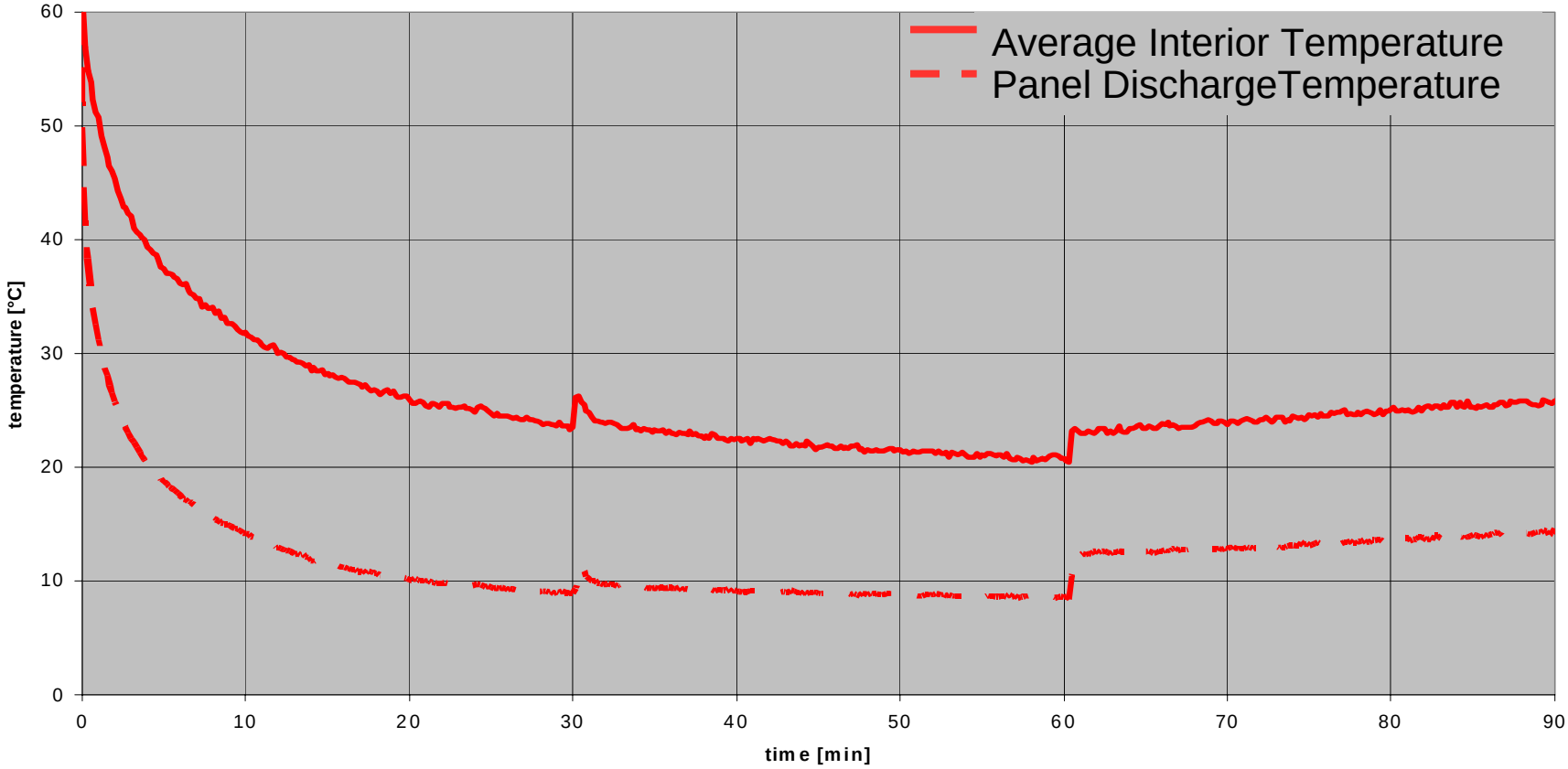
System Integration

- A/C system for midsize production vehicle (SOP 2010) was upgraded:
  - C-segment MPV
  - Single evaporator system
  - Air side temperature control with blend door
  - Refrigerant R134a

Components	Production System w/ R134a	Visteon Efficient System /w R1234yf	ΔWeight
HVAC	2-zone	unchanged	⇄
Evaporator	58 mm P/F	45 mm T/F	↓
Expansion device	TXV	EXV	↑
Compressor	VS16	VSe14 (w/ clutch & oil sep.)	↓
Condenser w/ integrated receiver/drier	16 mm	12 mm	↓
IHX	Production design	Modified	↓
Refrigerant lines	standard	modified for shorter IHX	⇄

Test Results: Cooling Performance

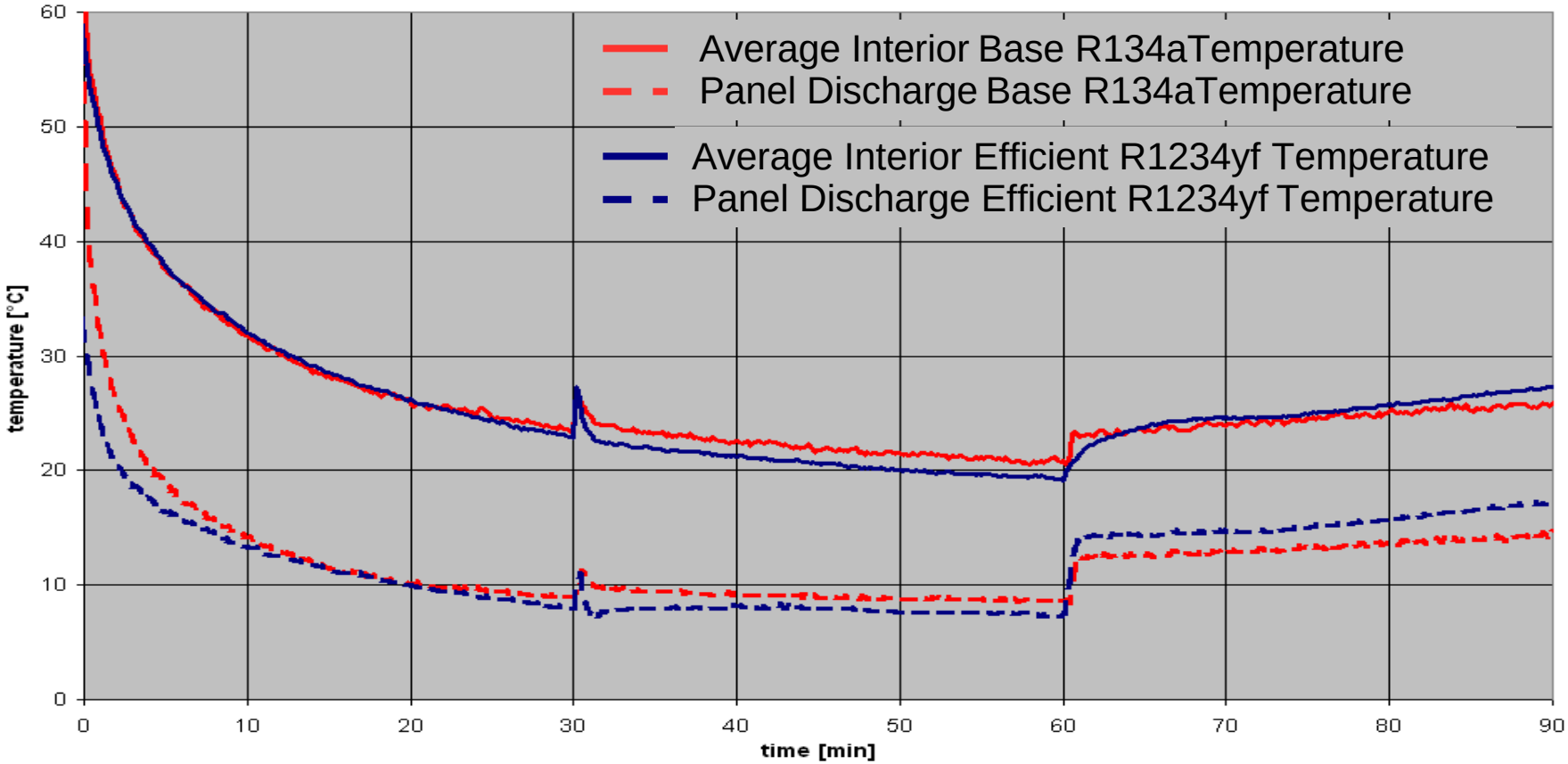
- Pull down test at 43° C/40 % rH, sunload 1000 W/m^2 acc. to customer specification



Base system meets customer targets

Test Results: Cooling Performance

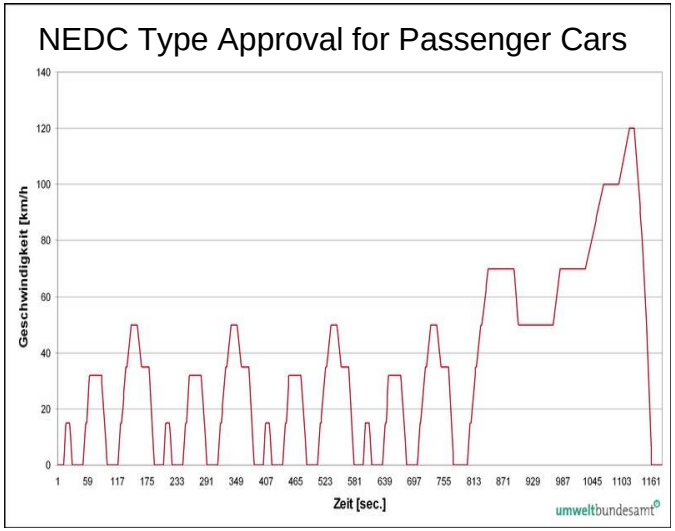
- Efficient system tested at same conditions, but R1234yf as refrigerant



Same performance at 50 km/h, advantage at 100 km/h, nearly same idle performance

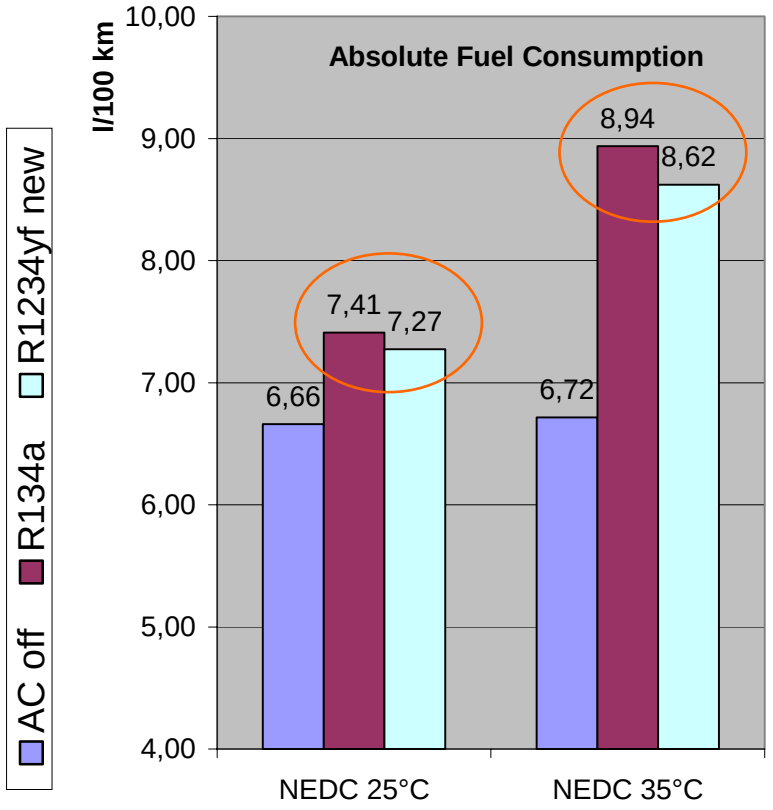
Test Results: Fuel Consumption

- Evaluation based on NEDC procedure
- Vehicle test runs with A/C off / base R134a / modified R1234yf system at different ambient conditions
  - Preconditioning to heat up the engine
  - Temperature soak
  - 2 NEDC cycles for each test session
  - Both systems controlled to same interior conditions

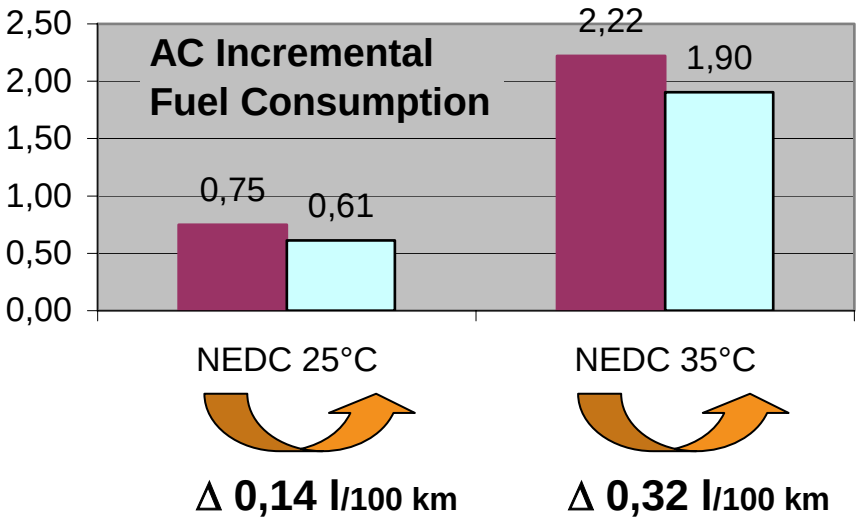


	NEDC @ 25° C	NEDC @ 35° C
Blower	Step 3	Step 4
AC-Settings	Reheat	Reheat
Air-Settings	Panel Fresh	Panel Fresh
Sunload	no	no
Soak (Ave. Breath)	25° C	50° C

Test Results: Fuel Consumption



Effective R1234yf system in comparison to base R134a system

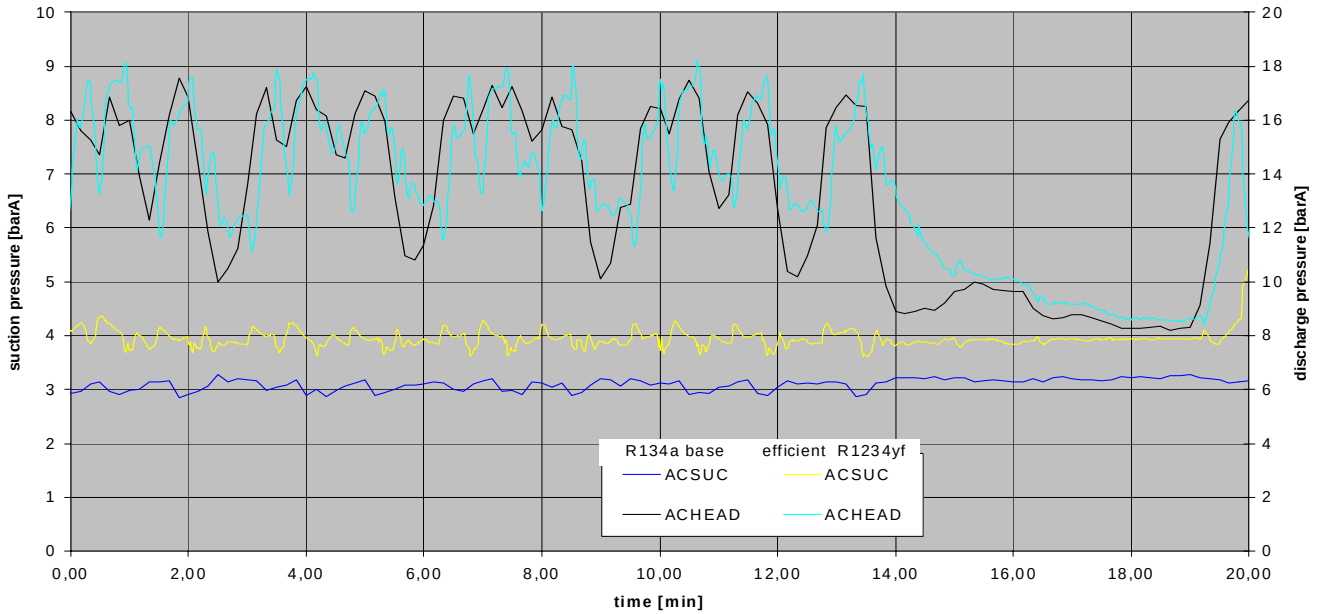


Absolute fuel reduction of 0,14 and 0,32 l/100 km at ambient temperature of 25° C and 35° C

Fuel reduction for add on of 18 % at 25° C and 14 % at 35° C

Test Results: Analysis

- Comparison of refrigerant cycles at ambient temperature 25° C during constant conditions
  - Same COP for both refrigerants allthough R1234yf has a disadvantage regarding thermodynamical properties
  - Adapted (higher) suction pressure for effective R1234yf system during NEDC leads to lower compressor power



Summary

- Optimization of components regarding mass reduction, efficiency increase, leakage elimination and adaptation of new working fluids supports changing legislative situation

- Visteon used reengineered components to build new climate system for testing on the vehicle level

  ➔ R1234yf system with efficiency enhancements reaches same performance as base R134a system

  ➔ Fuel consumption at the same cooling performance could be reduced by 0,3 l/100 km at 35° C. This results a reduction of CO_2 tailpipe emission by 7 g/km in the NEDC cycle

- Results for component and system development can be used for climatization of hybride and electrical vehicle effecting the driving distance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