

UltimateCooling™ System Application for R134a and R744 Refrigerant

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N.S. AP

R&D Advanced Development
Valeo Engine Cooling



CONTENTS

- Introduction:
 - What 's “UltimateCooling™”
 - How does “UltimateCooling™” work ?
- R134a applications
 - Turbo diesel engine
 - Turbo gasoline engine
- CO₂ application on Turbo diesel engine
- Advantages & Benefits
- Conclusion

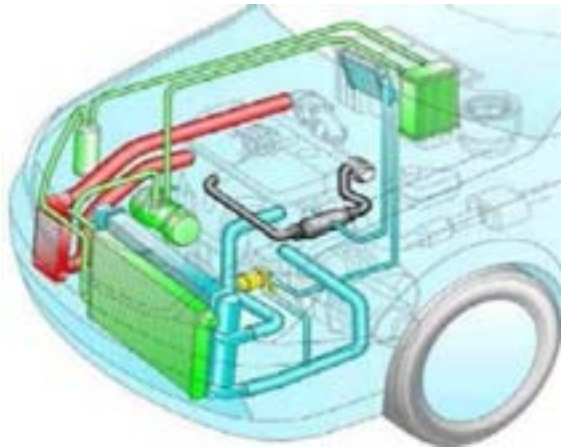
WHY UltimateCooling™ ?

- For Turbo diesel and Turbo gasoline engine, there are more and more Heat Exchangers in the Front End
- Insurance request (Danner) and Pedestrian crash regulation phase 2 (SAFE)
→ Need more free space
- Overlapping of heat exchangers leads to interferences
 - Radiator performance polluted by A/C condenser
 - Available room reduced for pipes routing
 - Clearances between heat exchangers = wasted room
- Moreover, each heat exchanger is today sized for its own worst case condition (i.e. : A/C condenser at idle, radiator at full load). Conditions being not similar for all Heat Exchangers, lead to global over-sizing.

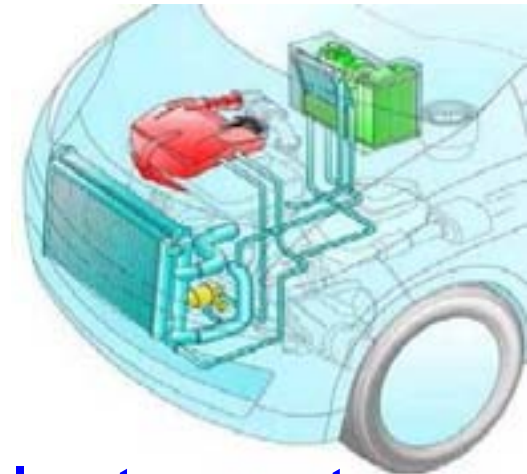


UltimateCooling™: How does it work ?

Today design



UltimateCooling™

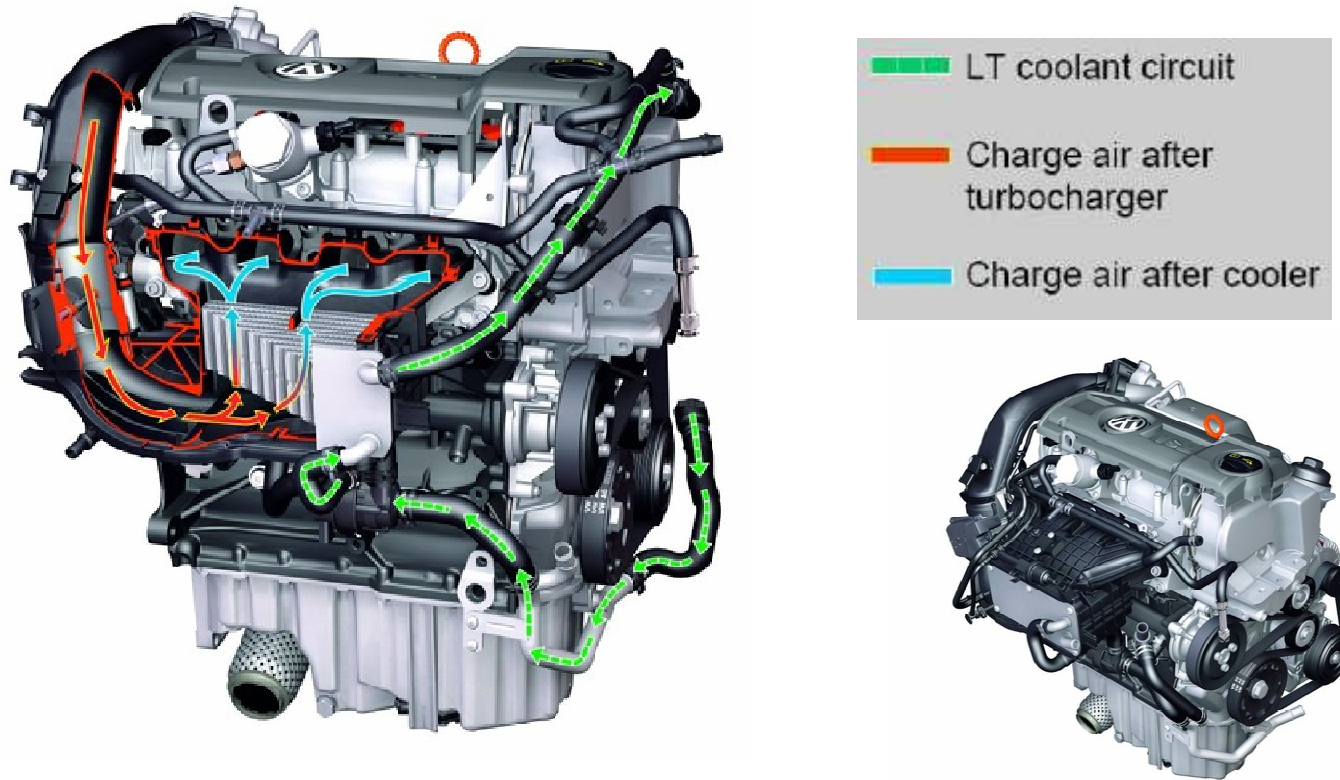


A/C condenser : Refr. to air	➔	Refr. to low temp water
Charge Air Cooler : air to air	➔	air to low temp water
Oil cooler : oil to air	➔	oil to high/low temp water
Fuel cooler : fuel to air	➔	fuel to low temp water
EGR cooler : gaz to water	➔	gaz to hi/low temp water

All engine fluids will be cooled by water
➔ need Multi-temperature (HT/LT) radiator

UltimateCooling™: Application example

Water charge air cooler (WCAC) is intergrated in the engine air manifold on new VW 90kW TSI engine



Extract from 28th International Wiener Motorensymposium 2007

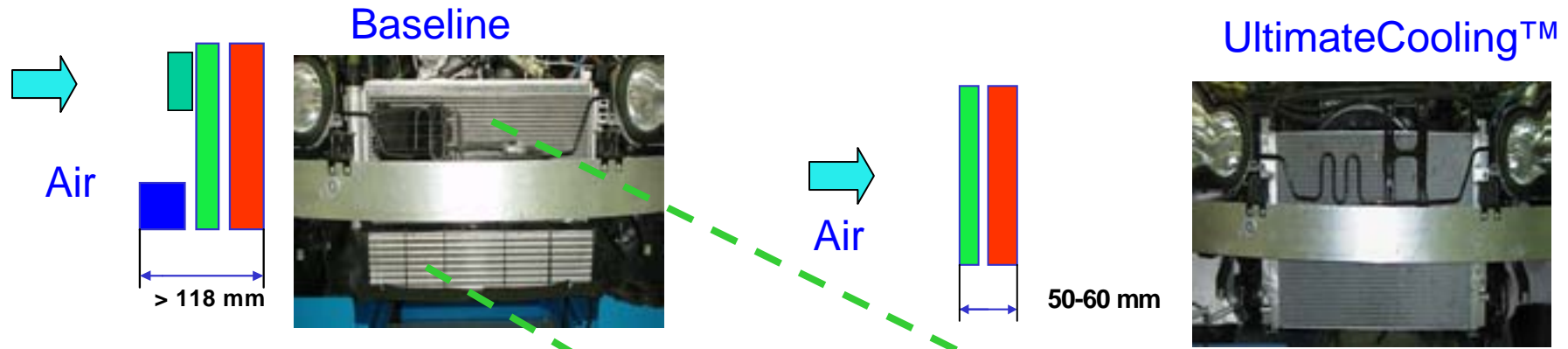
UltimateCooling™ system applications on :

- Mercedes CDI : Turbo diesel engine 2.2 140hp
- Nissan Xtrail : Turbo gasoline engine 2.5

Refrigerant : R134a



Cooling module, WCAC and WCDS



Turbo diesel engine
2.2 L 140 HP

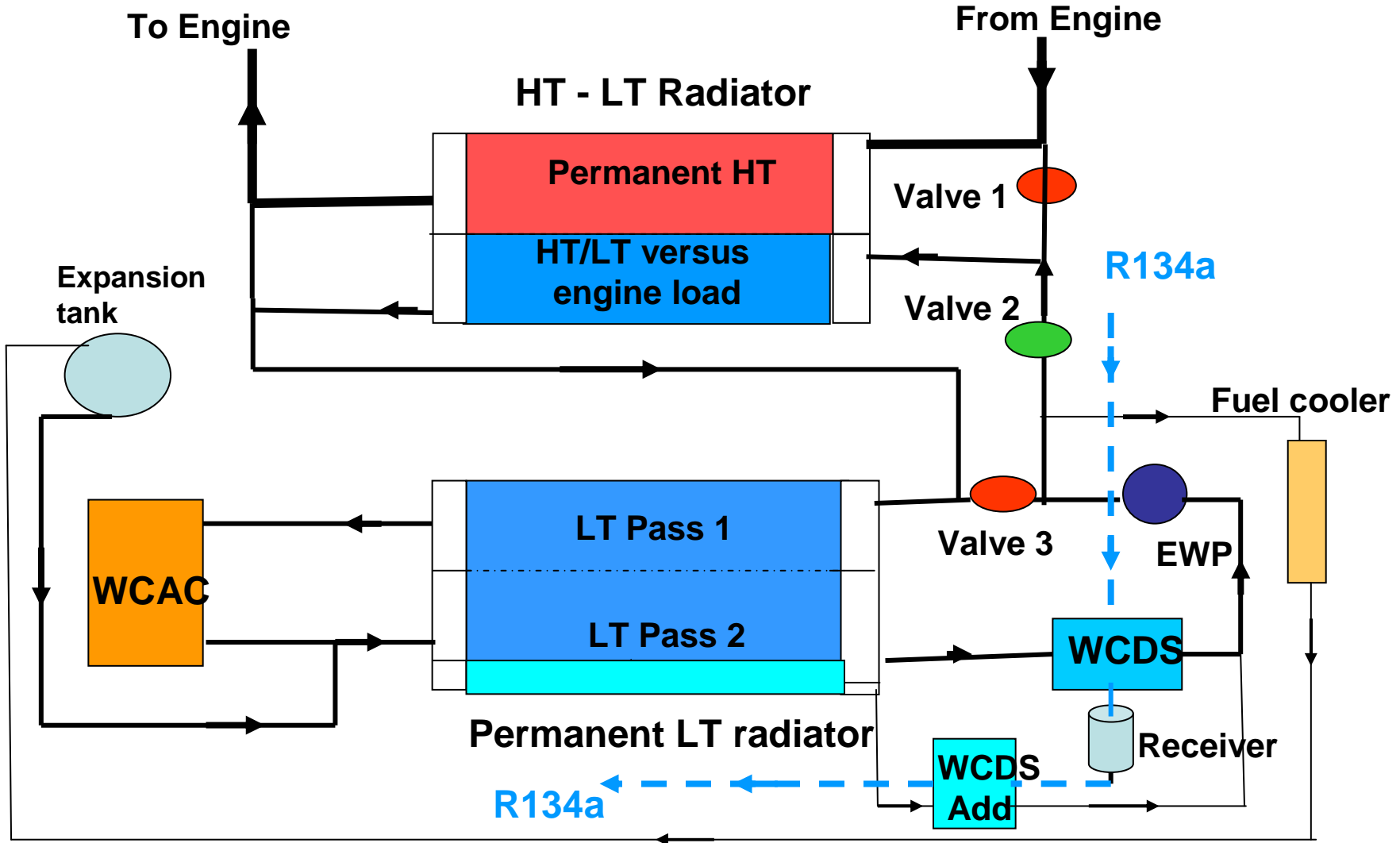


Underhood volume
Front-End volume
Overhang

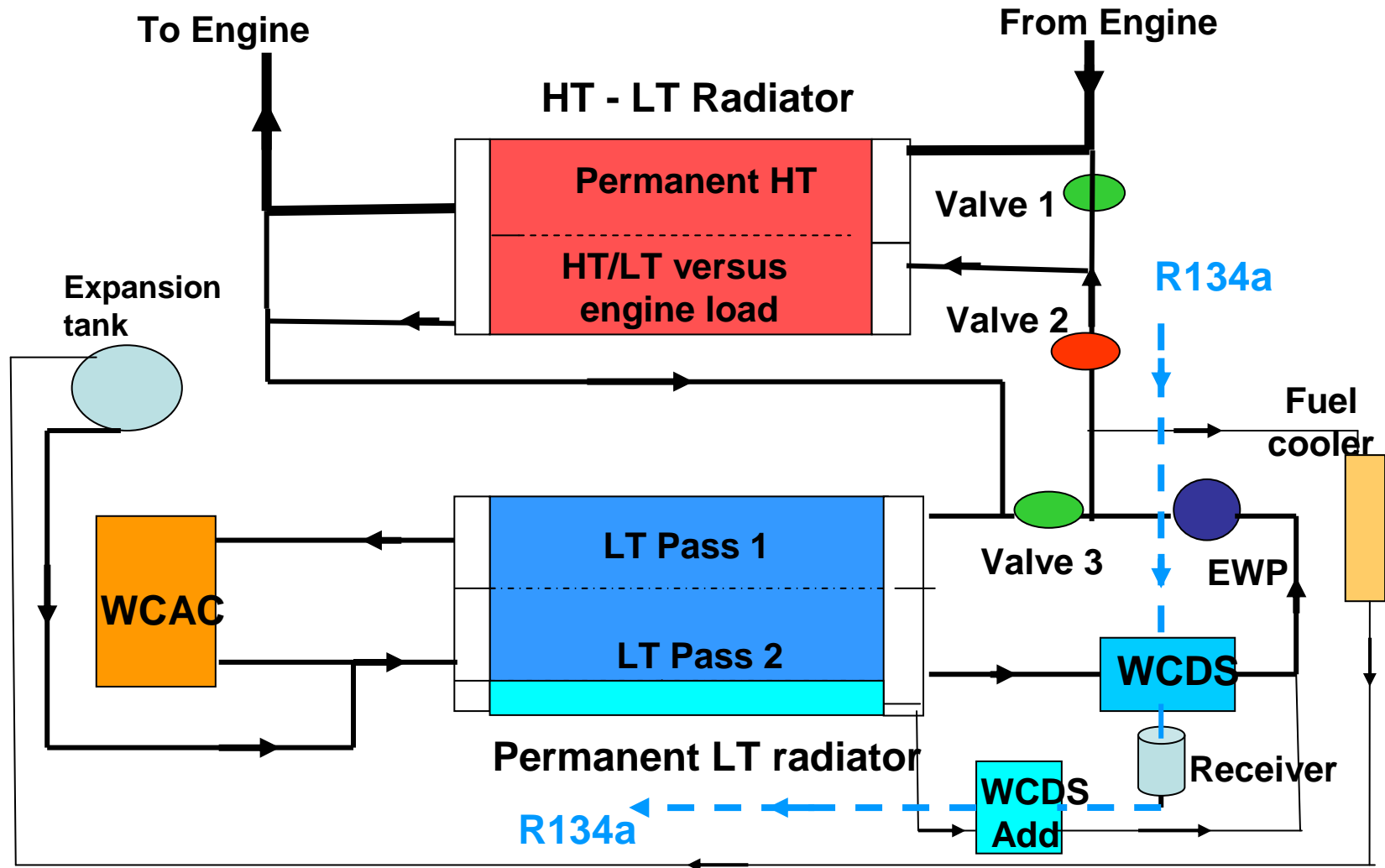
3	→	7 :	+ 4 dm ³
24	→	14 :	- 10 dm ³ (- 40%)
118	→	60 :	- 58 mm (- 49%)



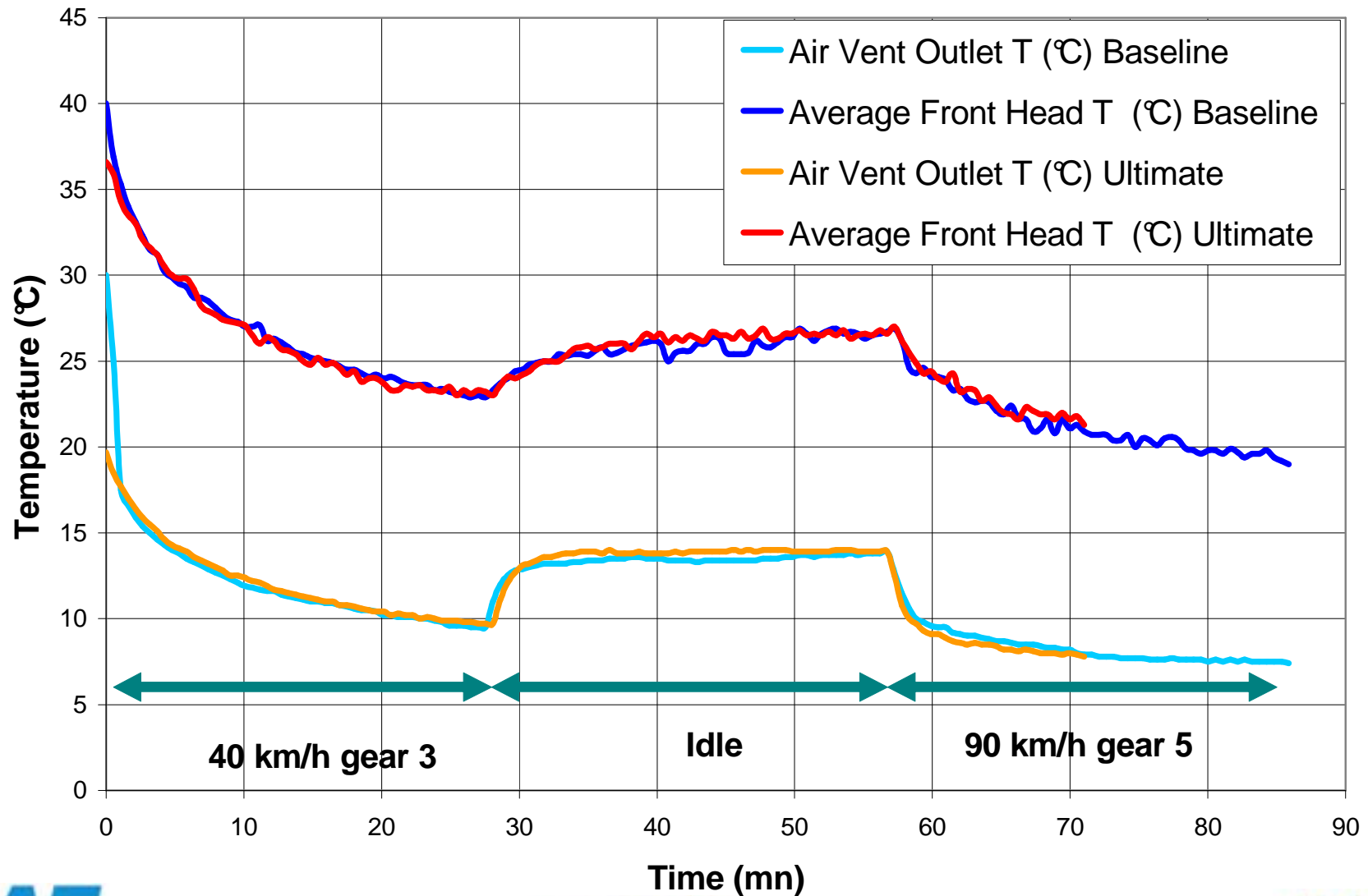
Coolant architecture of cooling module (low and medium speeds)



Coolant architecture of cooling module (high speeds & hill climbing)

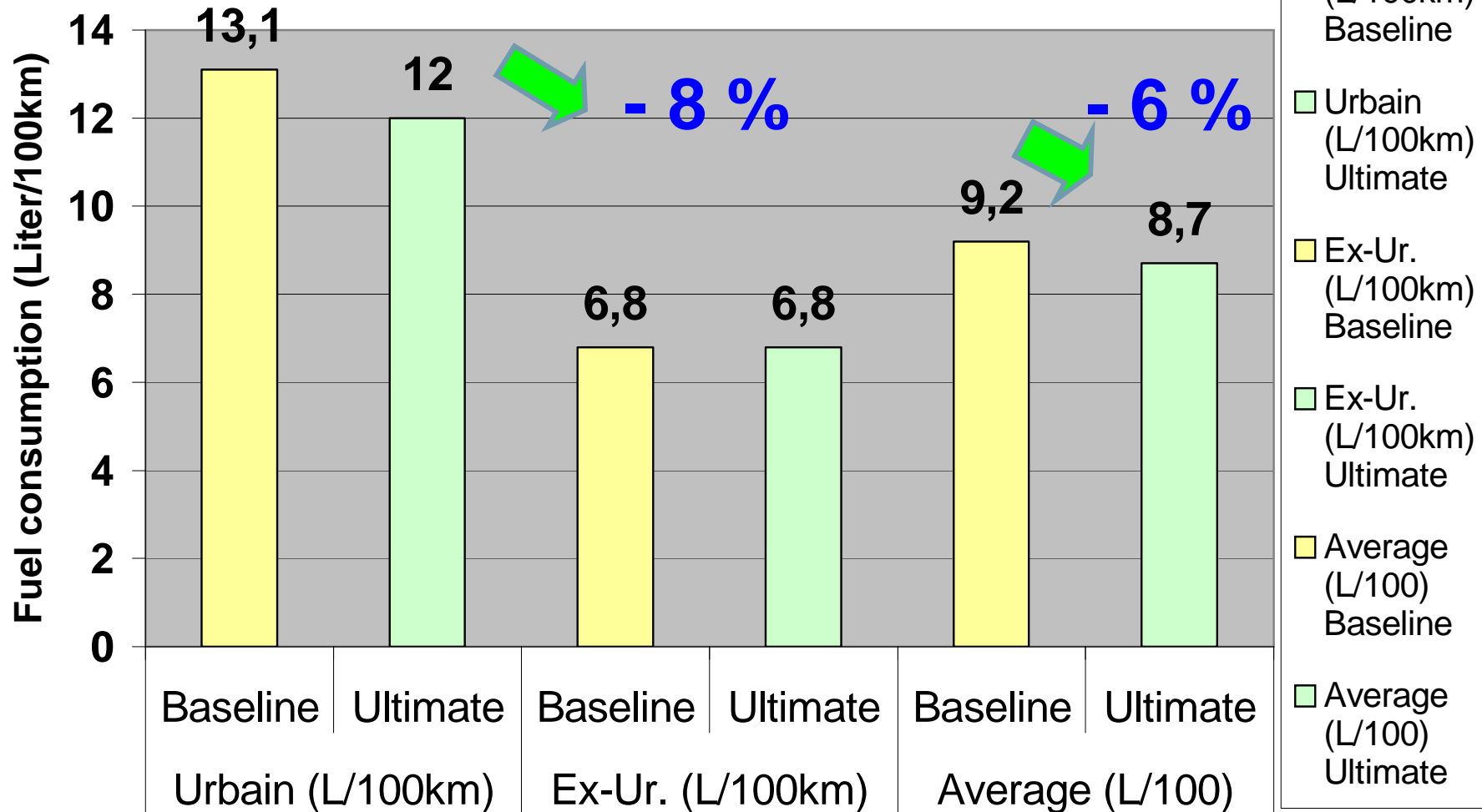


Cool down test results at $T_a = 45\text{ }^\circ\text{C}$ on MercedesC 220 CDI



Fuel consumption test results

Fuel consumption measurement (MVEG cycle)
Cold start, A/C "on", blower max., Ta = 28 °C

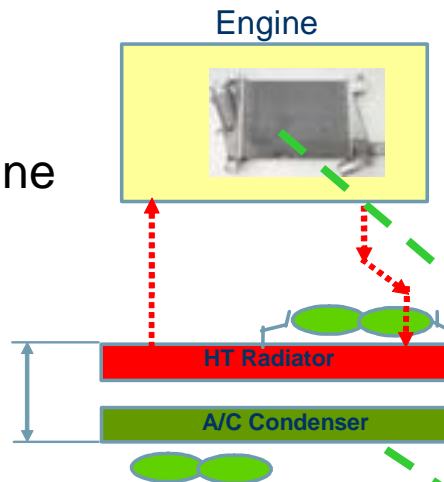


Cooling module, WCAC and WCDS

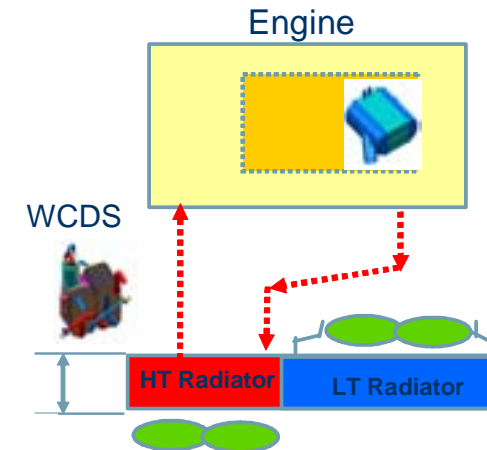


Turbo gasoline engine

Baseline



UltimateCooling™



- Overhang reduction (mm) : - 42 %
- Cooling module volume (dm³) : - 38 %
- Cooling module weight (kg) : - 10 %
- Global volume (dm³) : - 42 %

Extract from Fisita
Paper n°F2006P078



Test results : Engine Cooling, AC and Fuel consumption comparison UltimateCooling™/ Baseline

- **Engine cooling performance :**

- ▶ Generally similar or warmer but acceptable
- ▶ Air intake T is up to 4 to 20 °C colder → very good for acceleration and down sizing of engine
- ▶ Acceleration tests from 70 to 150 km/h : Air intake T remains constant, stable due to the inertia of coolant in the WCAC.

- **AC performance :**

- ▶ Similar to Baseline
- ▶ HP generally 2 Bars lower

- **Fuel consumption with AC ON at Ta = 28°C (MVEG cycle)**

- ▶ Up to – 6%



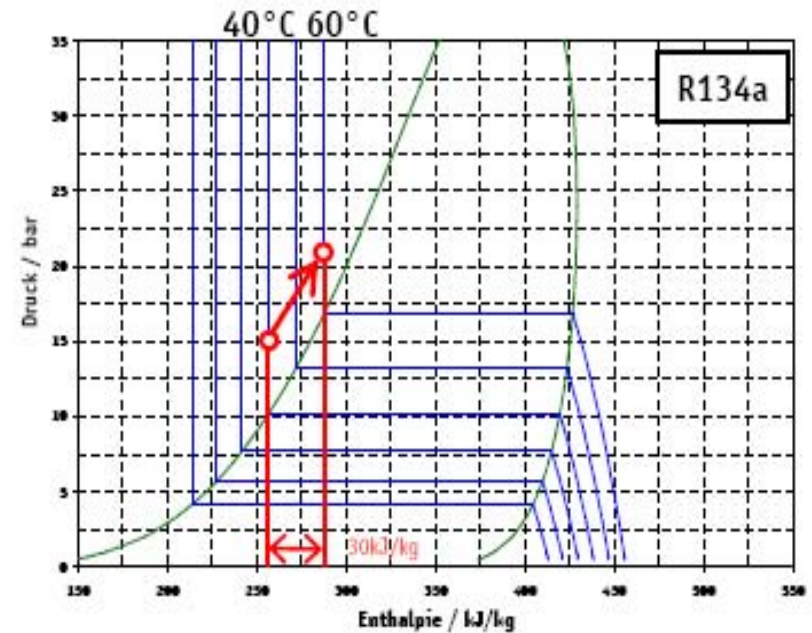
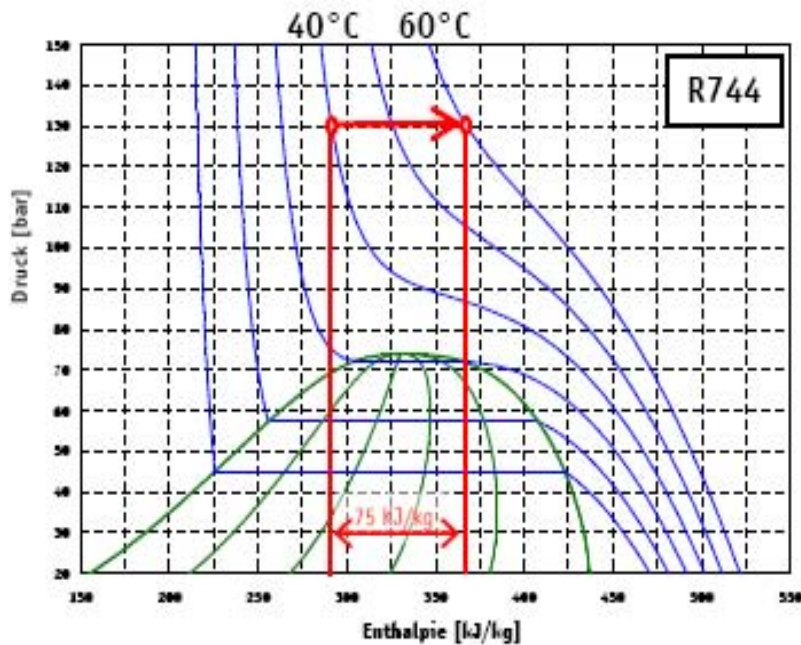
UltimateCooling™ system applications on

Audi A3 : Turbo diesel engine 2.0 140hp

Refrigerant : R744



R744 A/C system: Front end air return issue



R744 A/C systems are very sensitive to hot air circulation at idle due to faster enthalpy decreasing in respect with front air inlet temperature increase

Compact car issue: Hot air return at idle

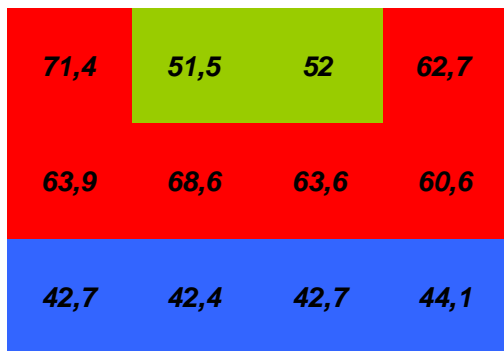


Front end modification to limit hot air return



Gas cooler cartography at end of idle before modifications

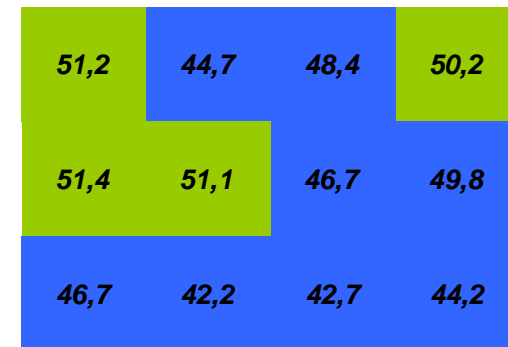
VDA conditions: 40°C, 40%, 1000W



R744 outlet Gas cooler temperature: 62°C

Gas cooler cartography at end of idle after modifications

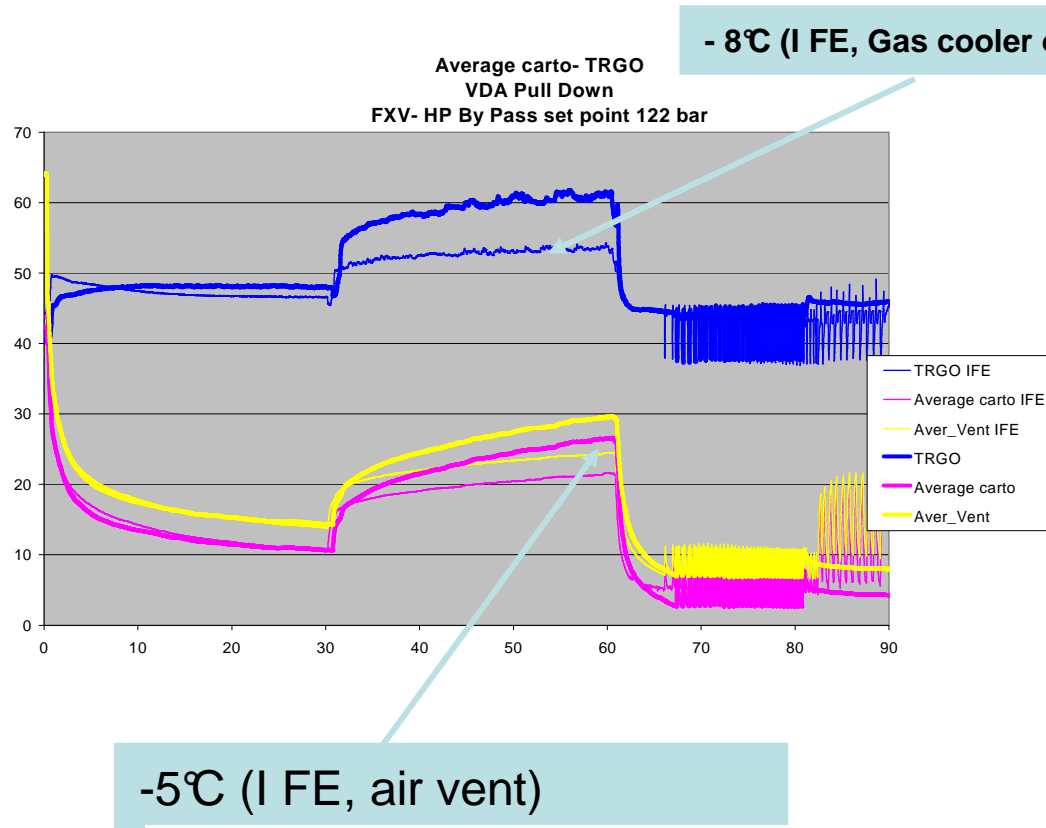
VDA conditions: 40°C, 40%, 1000W



R744 outlet Gas cooler temperature: 54°C



Compact car issue: Hot air return impact on performance



8°C temperature reduction at gas cooler outlet

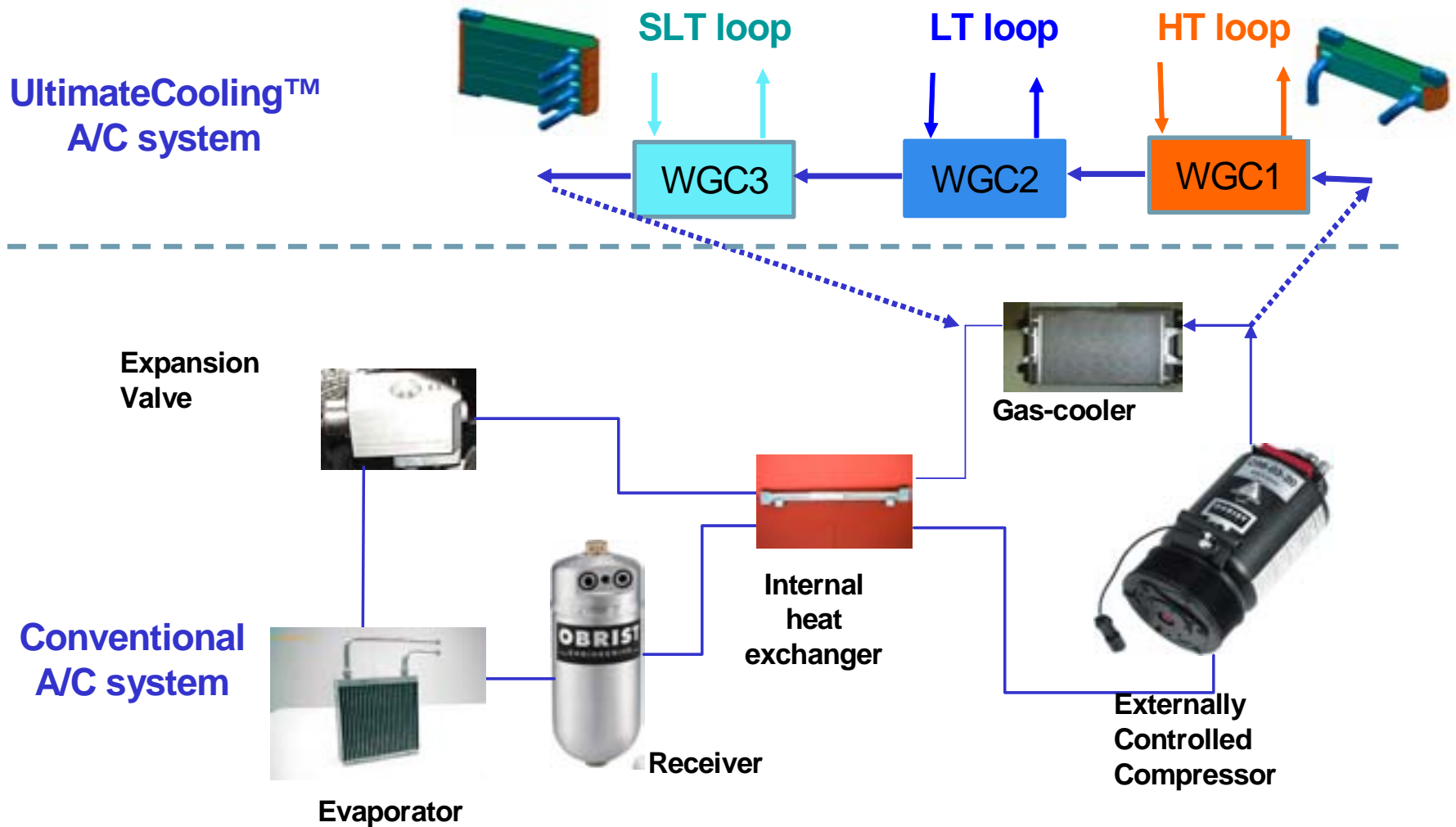
leads to

5°C temperature reduction at vent outlet

Front end management is mandatory to reduce R744 gas cooler temperature outlet

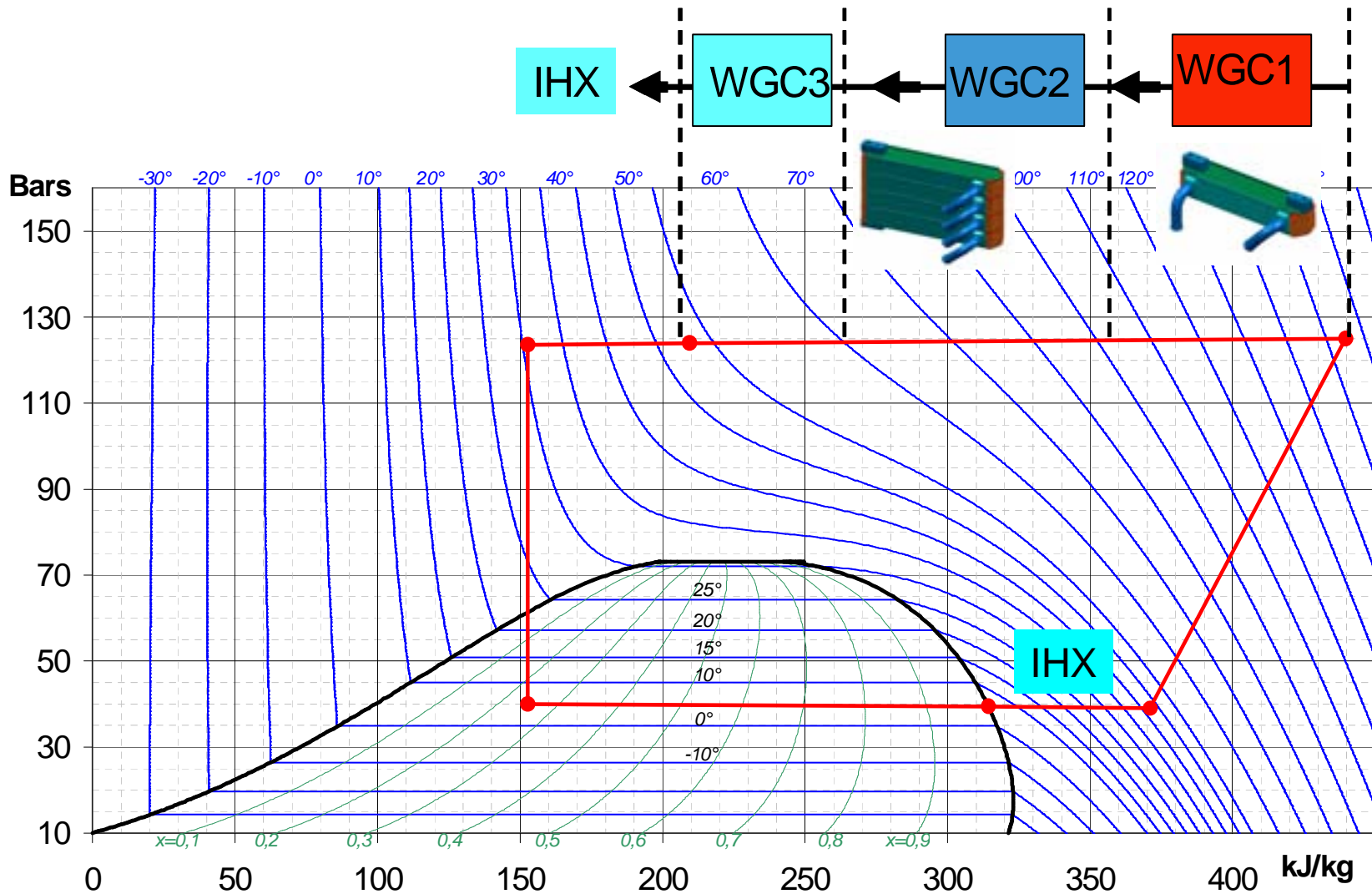
Ultimate Cooling is an option to avoid that issue

A/C loop for R744 refrigerant

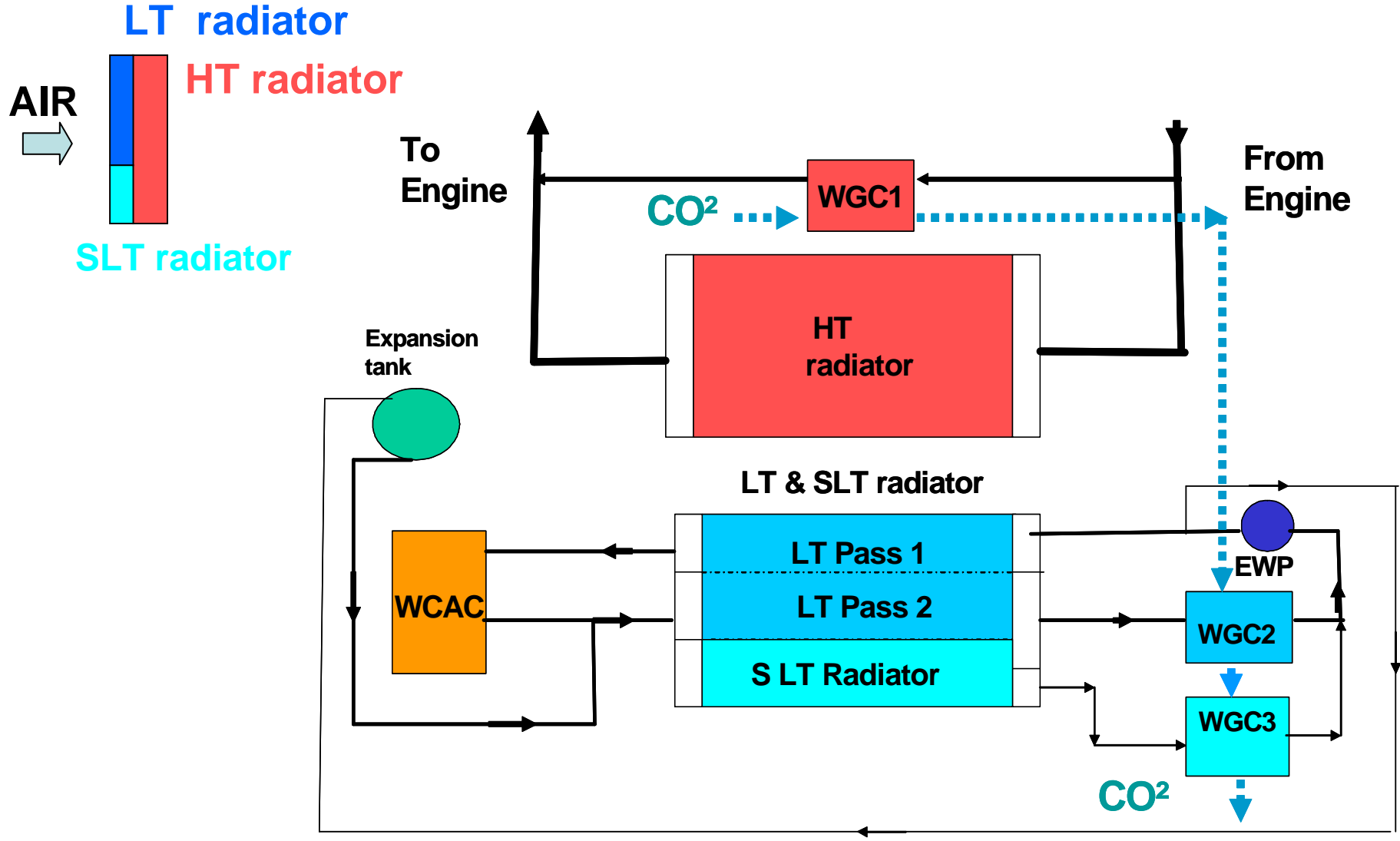


R744 P-H diagram

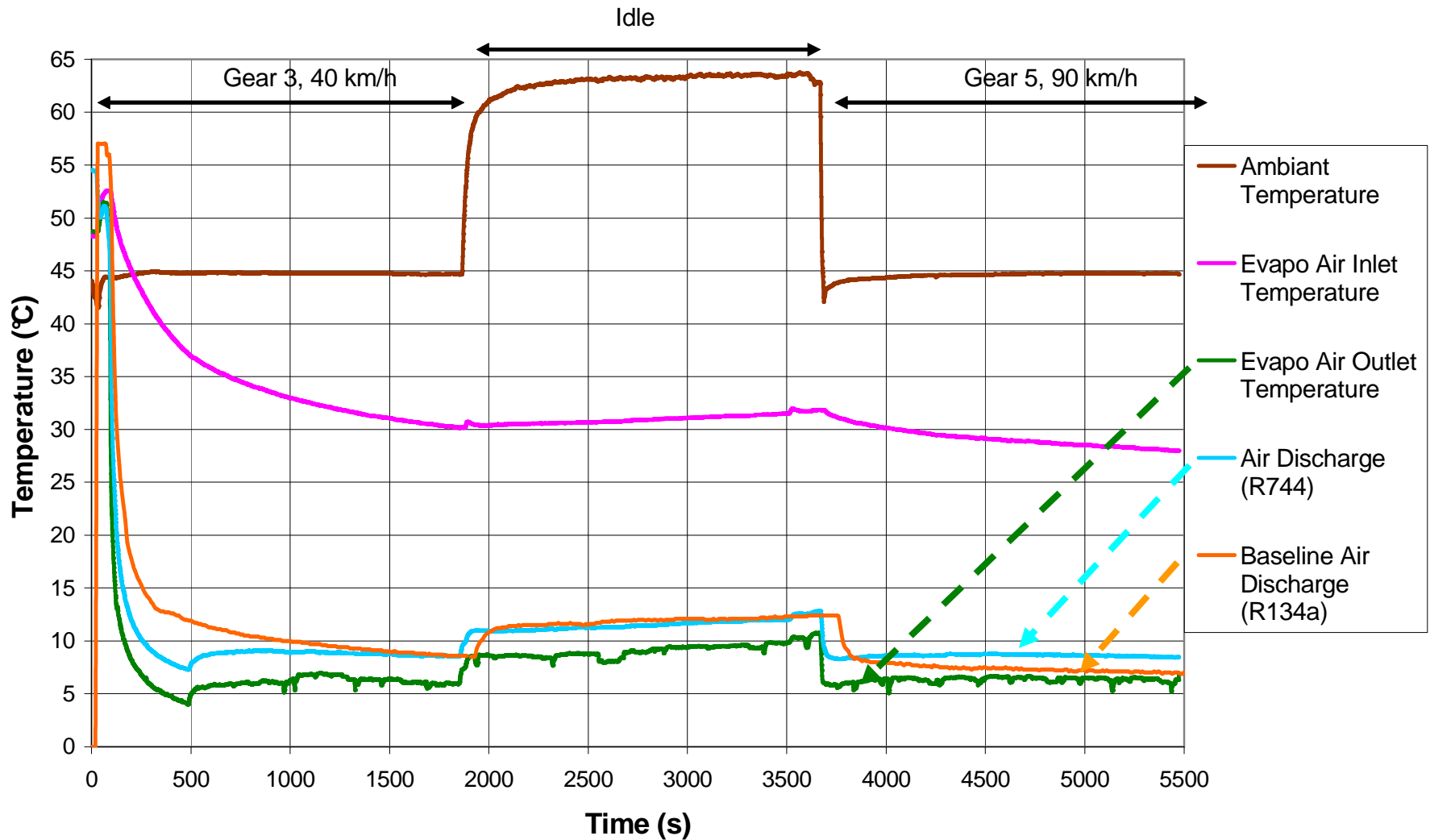
3 stages of Water Gas Cooler



Coolant architecture of cooling module



AC performance at $T_a = 45\text{ }^\circ\text{C}$ Similar to Baseline (R134a)



Advantages & Benefits

- Packaging reduction in Front End up to – 40 %
- Overhang reduction up to – 58 mm (- 50 %)
- Danner crash repair cost reduction
- No refrigerant leak after small crash (~600-1000kg CO²/vehicle R134a)
- Better WCAC performance → Down sizing of ICE
- Better engine performances and dynamic response during acceleration
- Fuel consumption reduction up to – 6% (MVEG, T_a = 28°C, AC ON)
- Supply low temperature coolant to other fluids : fuel, EGR, oil, electronic and electric power-train for **HEV, FCEV**



CONCLUSION

- **UltimateCooling™ system could be used and adapted for every refrigerants (R134a, R744, H, DP1, R152a, Ineos Fluor...) with :**
 - **Better performance of engine → Fuel consumption reduction**
 - **Same AC performance as conventional AC system**
 - **Crash test regulation conformity**



THANK YOU

