

"Providing maximum benefits to the customer through leadership in product technology and excellent service at competitive prices"

We are innovative

We are reliable

Status of R744 Development

We are cost-focussed

We are people-oriented

Harald Riegel

February 15th, 2007

Heat up. Cool down.

BEHR

Status R744

- R744 is under development for 13 years
- Investigation and development of alternative refrigerants
- Assessment of R744 tool box and results to compact cars

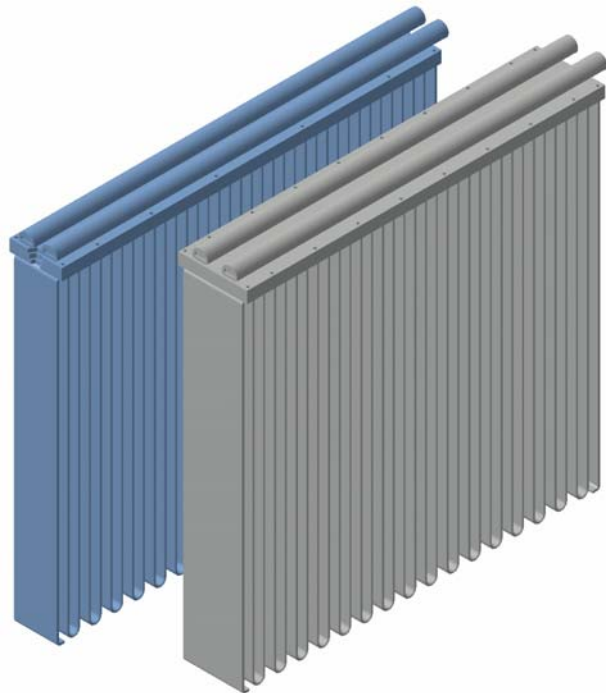
R744 Heat Exchanger Concepts

Variable depth for every application

Evaporator Depth

40 mm luxury and full size

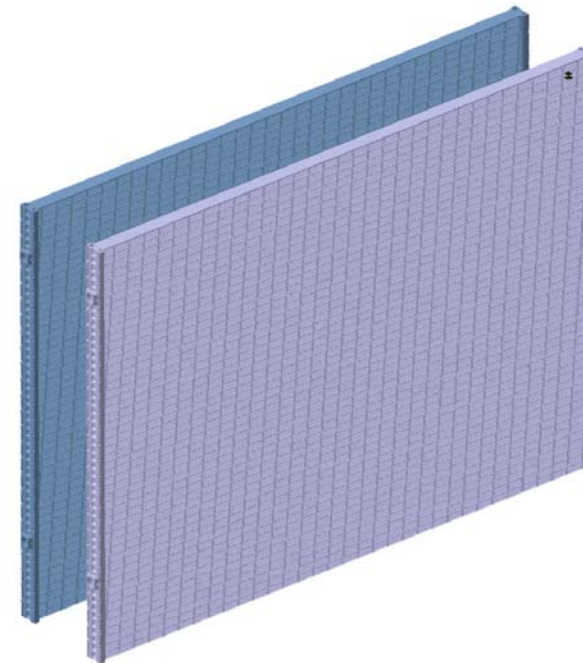
29 mm compact class



Gascooler

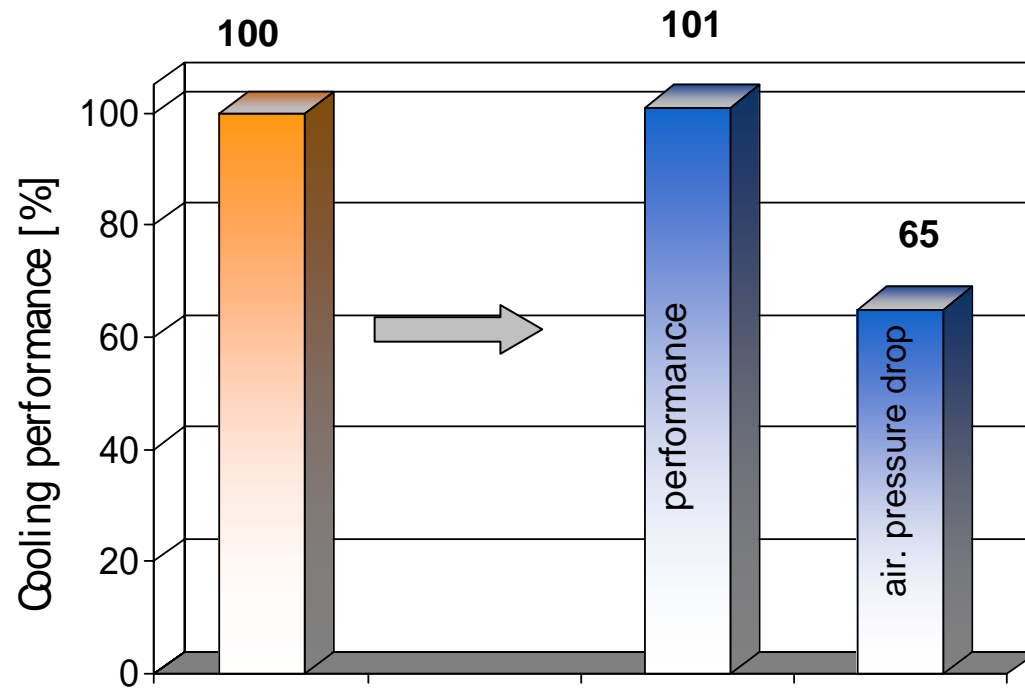
16 mm luxury and full size

12 mm compact class



R744 Evaporator for Compact Cars

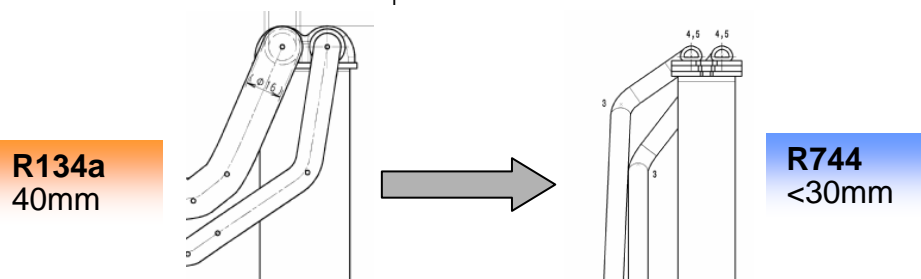
Performance



- Evaporator design with performance adequate for mid/small size vehicles
- Cost -and package reduction (mass segment)

Technology

- Single-tank
- New header design with cost reduction
- Reduced core depth < 30 mm

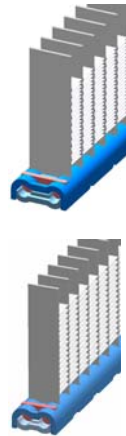


R744 Gascooler

Gascooler with a depth of 16 mm and 12 mm

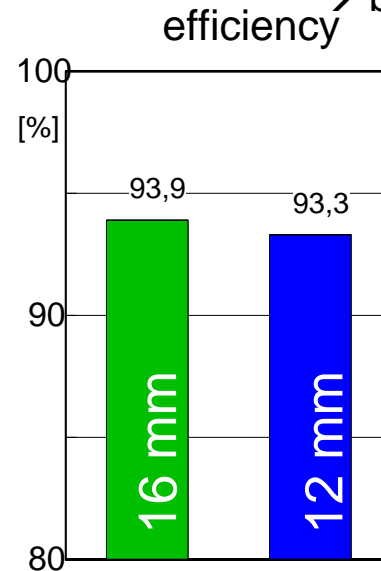
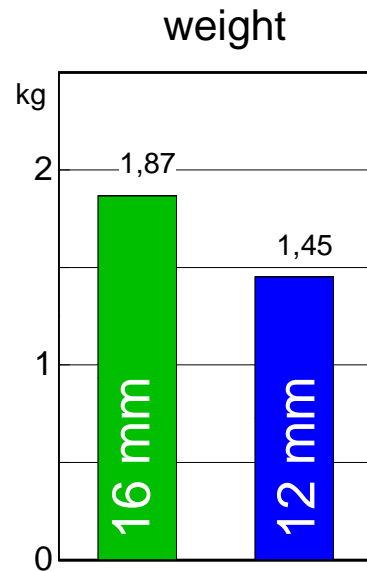
■ 16 mm depth, 75 fins/dm

■ 12 mm depth, 85 fins/dm



- reduced space (- 4 mm)
 - lower weight (- 0,42 kg)
 - comparable performance
 - reduced air side pressure drop (- 7 %)
 - lower refrigerant volume (- 14 %)
 - Higher refrigerant side pressure drop (+ 27 %)
- at same mass flow

→ but lower refrigerant mass flow for compact cars necessary



High Load, driving condition

R744 Heat Exchangers

Validation Status

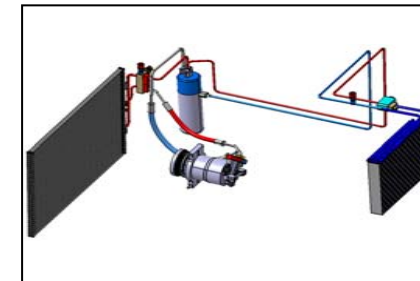
	Description	Status
Variant 1	▪ Evaporator 40 mm	▪ Ready for Tooling
Variant 2	▪ Evaporator 29 mm	▪ Samples
Variant 3	▪ Gascooler 16 mm	▪ Ready for Tooling
Variant 4	▪ Gascooler 12 mm	▪ Samples

Concepts for R744 Refrigerant Circuits

Possible Integration Concepts for IHX

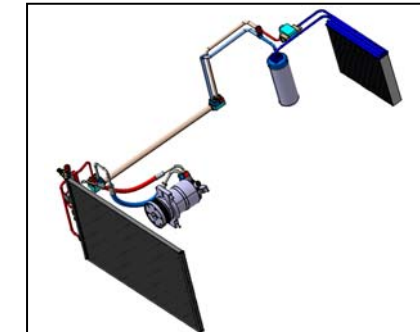
■ Accu-IHX-Combination (Variant 1):

- IHX integrated in the accumulator
- 5 refrigerant lines



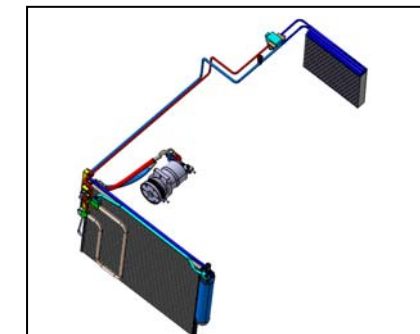
■ IHX as line (Variant 2)

- Accumulator in engine compartment
- 6 refrigerant lines



■ Gascooler-Module (Variant 3):

- IHX with accumulator at gascooler
- 6 refrigerant lines



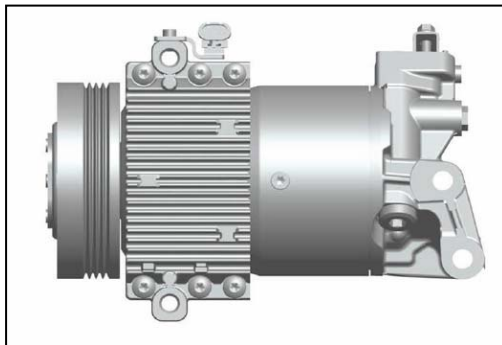
Packaging of IHX and Accumulator

Status of Validation

	Description	Status
Variant 1	<ul style="list-style-type: none">IHX integrated in accumulator	<ul style="list-style-type: none">samples available
Variant 2	<ul style="list-style-type: none">IHX coaxialAccumulator stand alone	<ul style="list-style-type: none">samples available
Variant 3	<ul style="list-style-type: none">Gascooler-Module Gen. 1Gen. 2	<ul style="list-style-type: none">Ready for toolingSamples available

Concepts for R744 Refrigerant Circuits

Compressor – Expansion Valve - Combination



Swash-Ring for all Classes

Variable displacement (0...20 ccm, 0..31 ccm)

Externally controlled

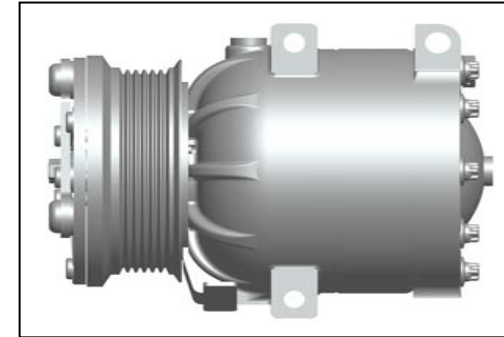


Delta p - Valve

or



FXV-BY (Fix Orifice with Bypass)



Fixed Displacement for Compact Cars

Fix displacement (15 ccm, 23 ccm)

Suction Throttle, Internal Control-Valve

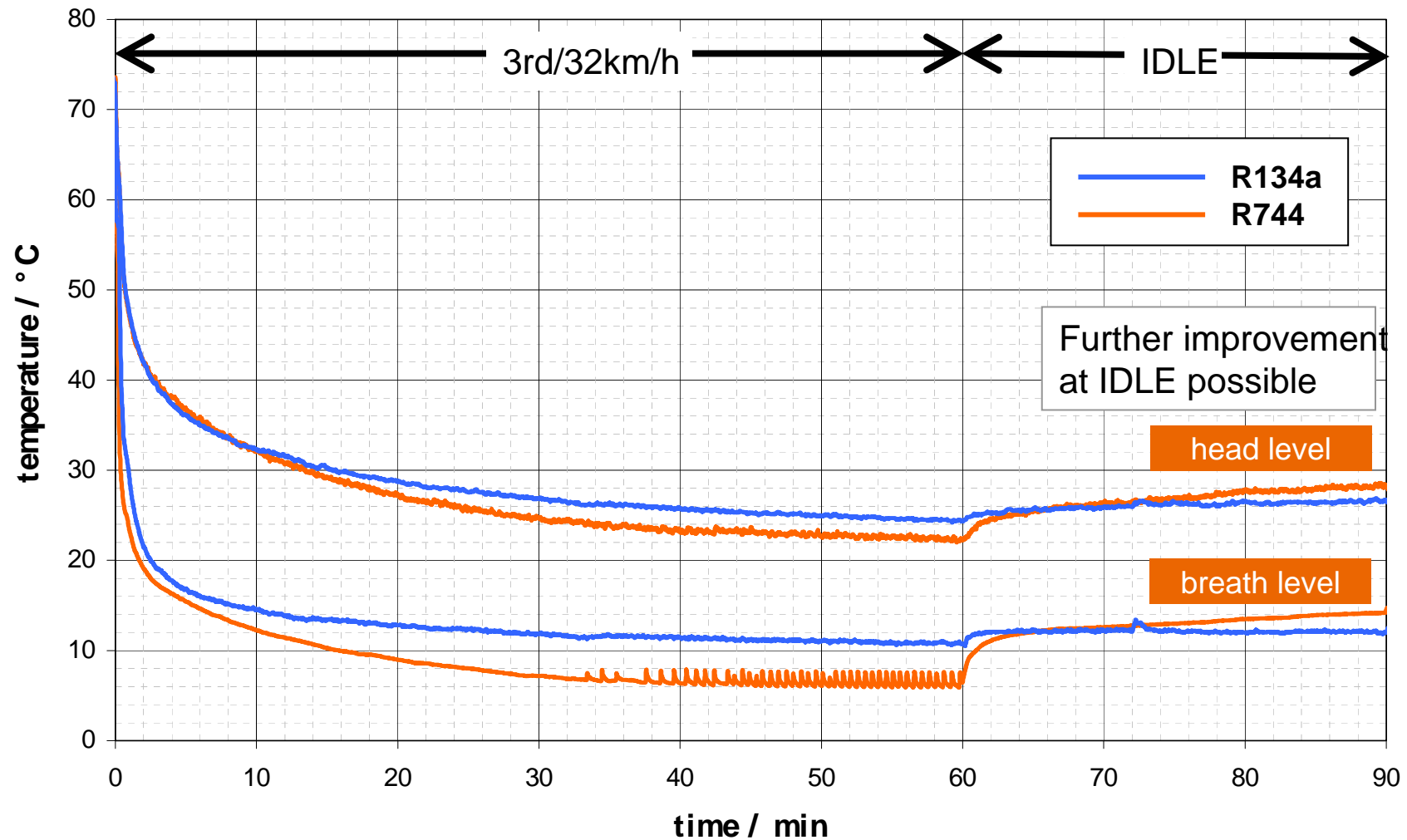
Compressor and Expansion Valve Combinations

Validation Status

	Description	Status
Variant 1	<ul style="list-style-type: none"> ▪ Variable displacement ▪ Fix Orifice Valve 	<ul style="list-style-type: none"> ▪ Single and dual evaporator validated ▪ Results shown in Phoenix 6/2006
Variant 2	<ul style="list-style-type: none"> ▪ Fix displacement ▪ Fix Orifice Valve 	<ul style="list-style-type: none"> ▪ Results attached. Details JSAE 1/2007
Variant 3	<ul style="list-style-type: none"> ▪ Variable displacement ▪ Delta p Valve 	<ul style="list-style-type: none"> ▪ Results available

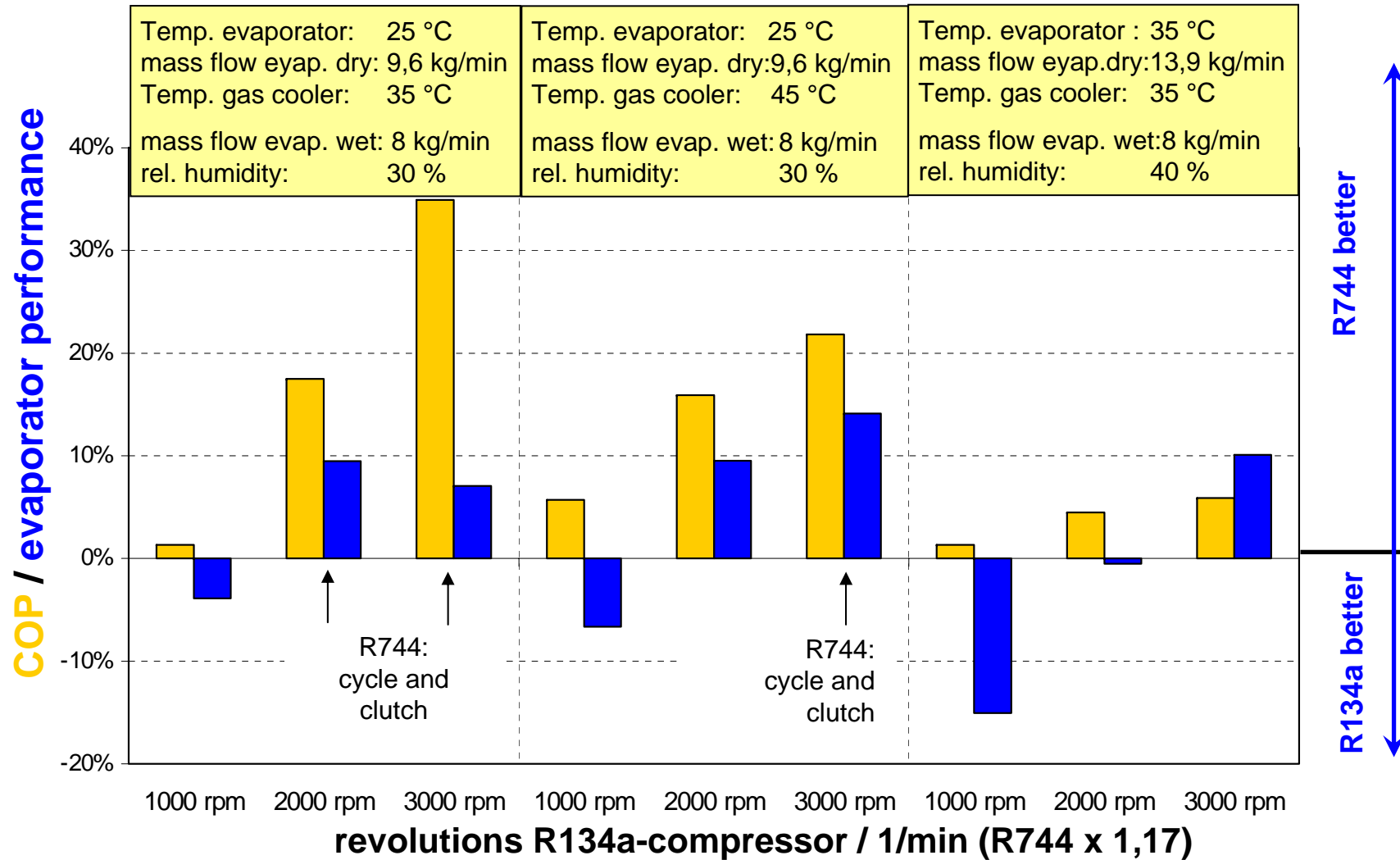
Compact Car with Fixed Displacement Compressor and FXV-Bypass

Cool Down comparison (43°C, 15% rel. humidity) of a VW-Polo (JSAE 1/2007)



Compact Car with fixed displacement compressor and FXV-Bypass

Bench Tests, evaporator depth < 30 mm (JSAE 1/2007)



Summary

- R744 is applicable for all kind of vehicles (compact ... luxury class)
- Integration concepts allow variable packaging
- Heat Exchangers need less or equal packaging
- Performance and COP of R744 is in most conditions better than R134a or Fluid H
(results shown in Phoenix 6/2006 and Tokyo 1/2007)
- We are working on alternative refrigerants