

Fiat, Renault and PSA outlook on the selection of a Global Alternative Refrigerant

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SAE 2007
World Congress



Automobiles and
Light Commercial Vehicles



PSA PEUGEOT CITROËN



Agenda

- 1- Job sharing
- 2- What did we do?
- 3- Focus on specific tests
- 4- Fluid comparison
- 5- Next steps
- 6- Conclusion

1- Job sharing

- Risk and Toxicology assessment, Environmental impact, stability :
 - ⇒ These are the main issues for Chemical Industry
- Materials compatibility testing, durability of components
 - ⇒ These are the main issues for Tier 1 and Tier 2 suppliers
- **Can we reach a performance that is compliant with customer needs?**
 - *What Packaging impact and cost to reach R-134a equivalent performance (thermal comfort and NVH)?*
 - *What impact on the Fuel consumption?*
 - ⇒ These are the main issues for OEM's

2- What did we do?

Japanese style:



Done



Not Done



In progress, or So-so, or Guili Guili

2- What did we do?

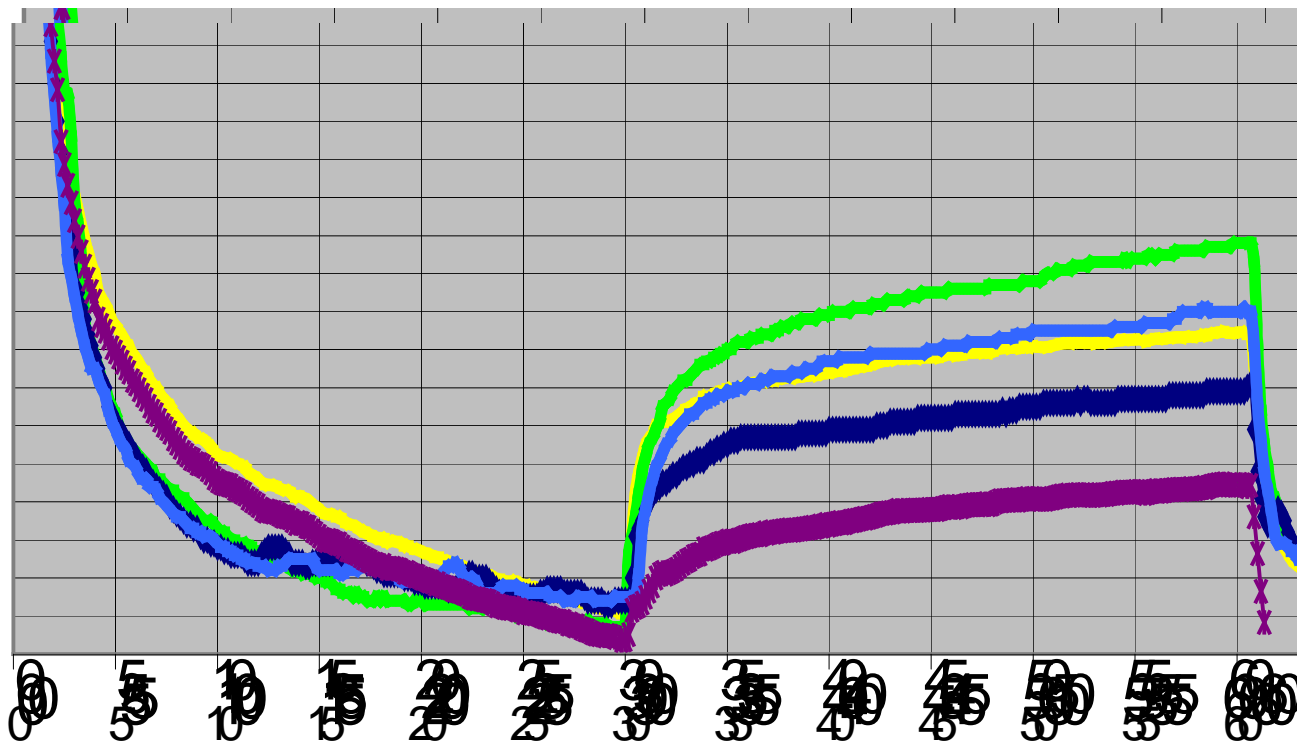
	R-744				Fluid H			
	RSA		PSA	Fiat	RSA	PSA		FIAT
Vehicle	Clio	Laguna 2	407 SW	Idea	Modus	C3	407 SW	-
Bench tests	○	○	✗	○	○	✗	✗	✗
Wind tunnel tests	○	○	○	○	○	○	○	✗
Fuel consumption	○	○	○	○	○ <i>on test bench</i>	✗	○	✗
Noise	○	○	○	○	○	✗	✗	✗
	DP – 1				Auto AC 1			
Vehicle	Modus		407 SW		Modus	407 SW		Panda
Bench tests	○		✗	✗	△	✗		○
Wind tunnel tests	✗		○	✗	✗	○		△
Fuel consumption	✗		✗	✗	✗	✗		✗
Noise	○		✗	✗	✗	✗		✗

3- Focus on specific tests

Cool down performance (45° C/40%HR/1000W/m²)

1°c by
division

R-744 : Renault Clio

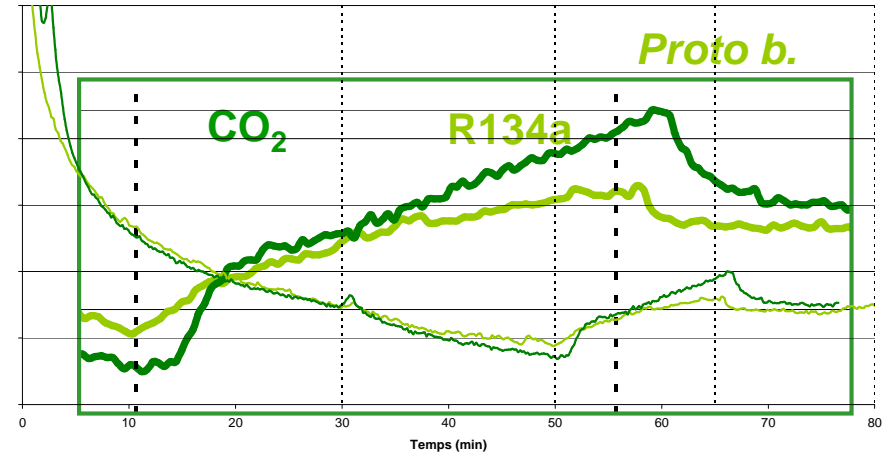
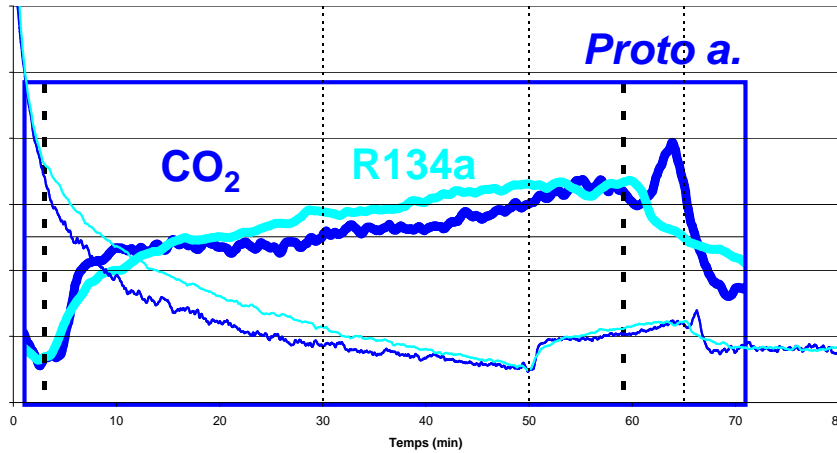


- Good performance during the driving part
- Insufficient performance at idle part
(even by improving engine air inlet tightness)

	Gap from specification	
R134a current design (1999)	4K	engine cooling study is required : is it feasible ?
R744 with same cooling design	6K	
R744 with total nozzle	6K	
R744 with side sealing (compressor rpm:1000)	4.5K	
R744 with side sealing with increasing idling RPM (1200 RPM)	2.5K	
R134a 2011 design	0K	

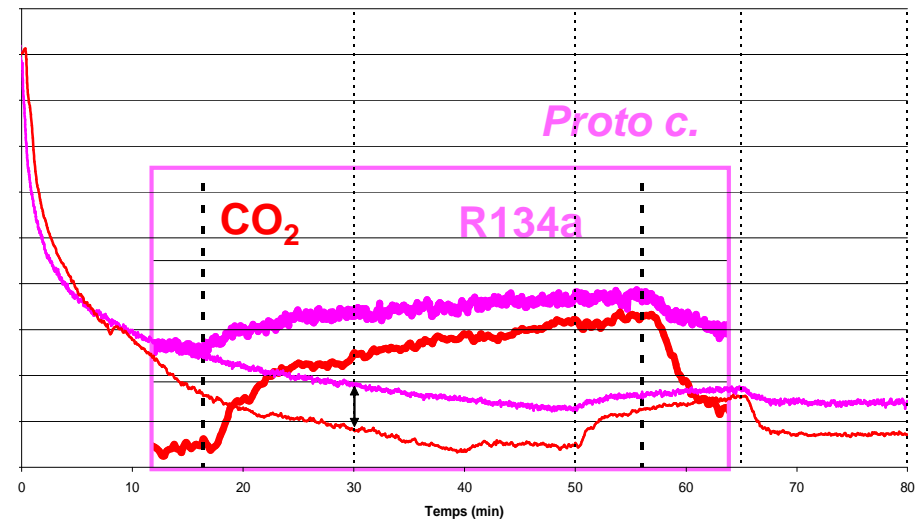
3- Focus on specific tests

R-744 : PSA 407 SW (3 prototypes)



Improved cooldown performance
on driving phases (1 to 2 K heads)

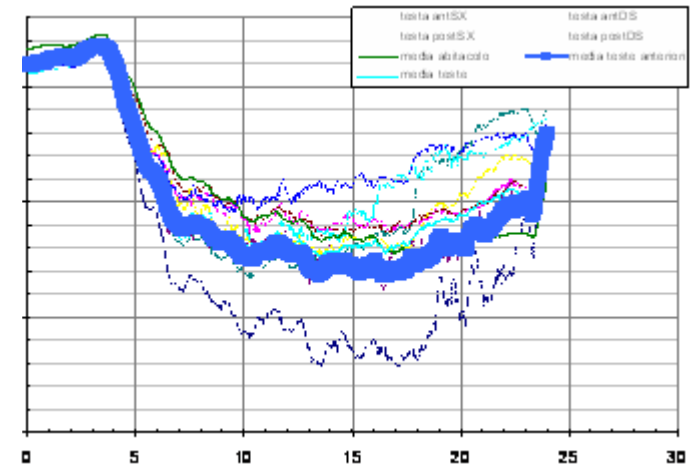
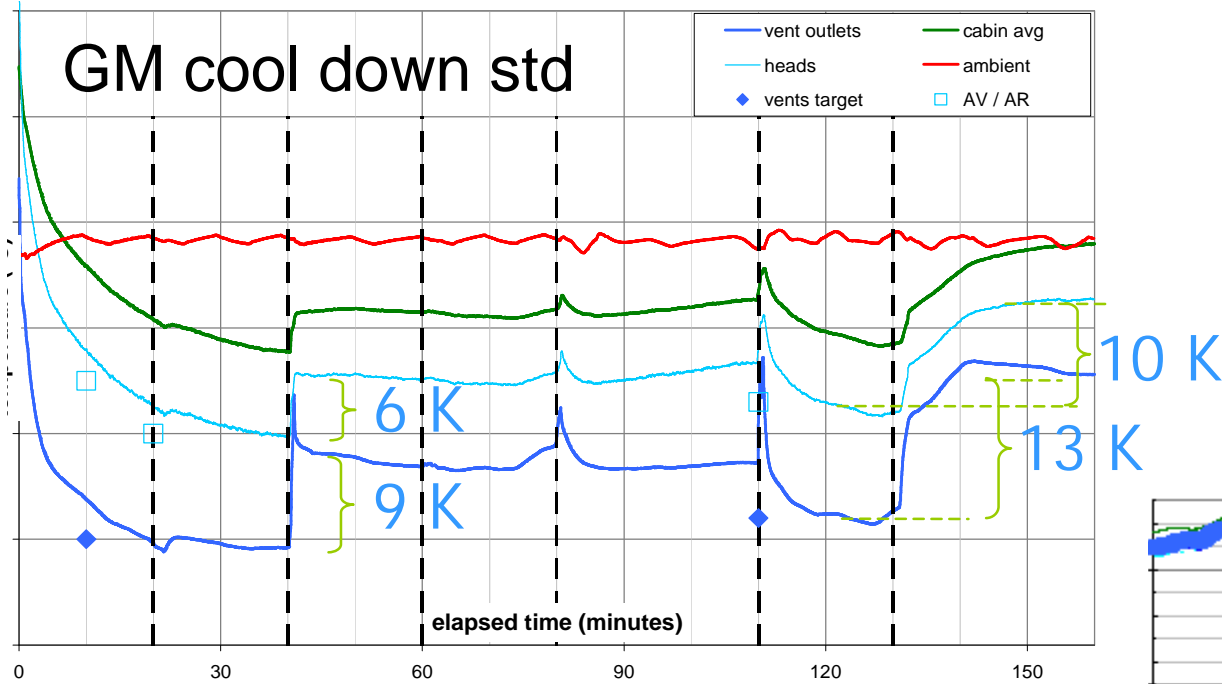
Gap is lost in IDLE phases



3- Focus on specific tests

R-744: FIAT Idea sde

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presented at the 2007 SAE World Congress
(SAE paper #2007-01-1191)

- comfort with R-744 not achieved:
sensible worsening in idle and fresh air mode
- higher SPL at idle and 2000 rpm
- huge impact on engine cooling

FE assessment @ 35 °C

3- Focus on specific tests

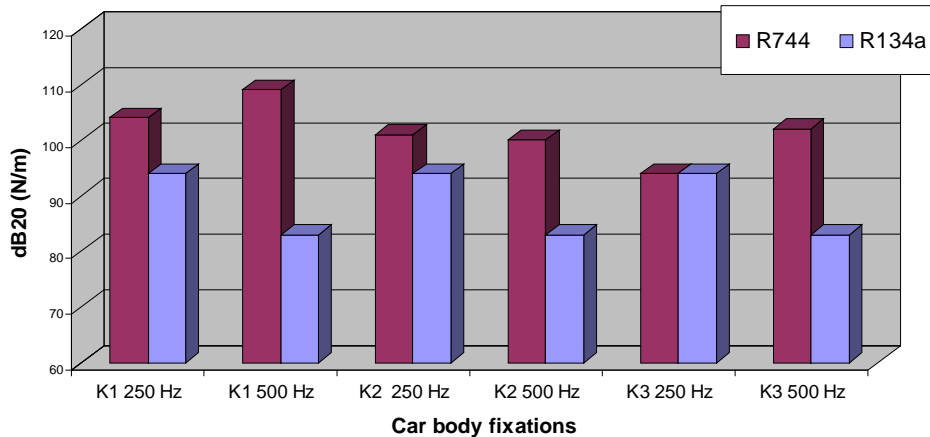
R-744 : NVH @ Bench: Renault Clio



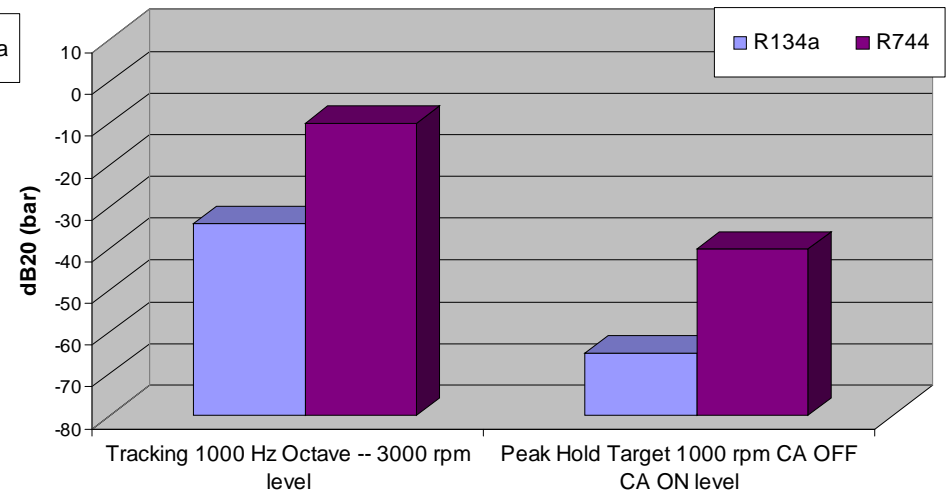
Tests:

- ↪ Dynamic pressures of LP & HP in 1000 to 5000 rpm acceleration AC ON 120 bars of HP.
- ↪ Dynamic pressures of LP & HP at Idle AC OFF → AC ON
- ↪ LP pipe's stiffness matrix measure on bench.

Stiffness Matrix Middle Octave Levels



Dynamic discharge pressure



➤ NVH performance target is not achieved so far.

3- Focus on specific tests

R-744 : Fuel efficiency – Clio 3



Delta R744 / R134A	
Ambiance	<i>l/100</i>
20°C AC Off	<i>0</i>
20°C AC On	<i>0,13</i>
30°C AC On	<i>0,41</i>
35°C AC On	<i>0,46</i>



Annual additional fuel consumption in France if applying this R744 definition.	<i>l/100</i>
PARIS	<i>0,06</i>
STRASBOURG	<i>0,06</i>
MARSEILLE	<i>0,12</i>
AVERAGE	<i>0,08</i>

Optimistic hypothesis : AC is OFF under 20° C

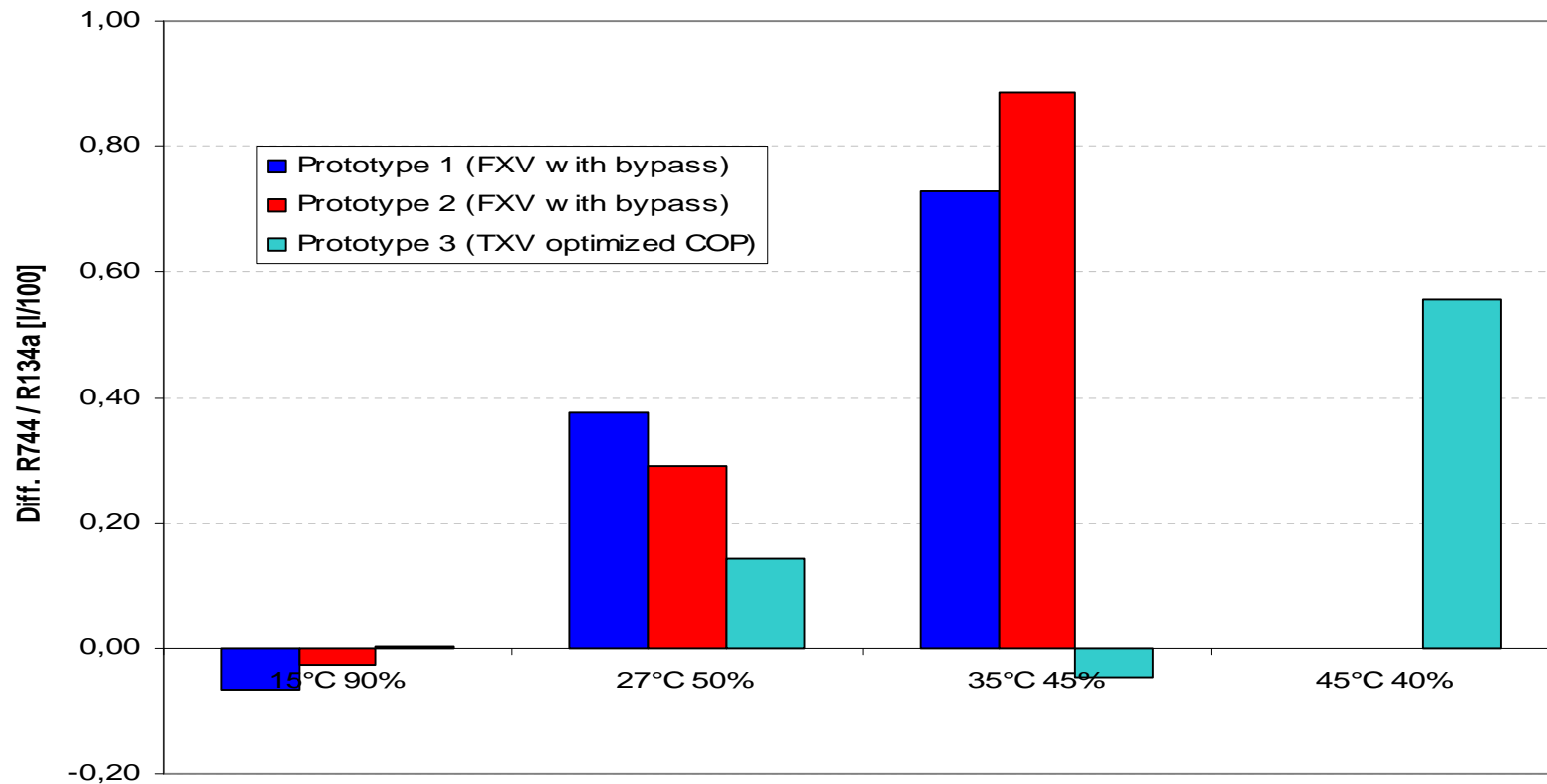
- Additional annual fuel cons of **+0,08 l/100** is not negligible.
- The chosen baseline (Clio 3 R-134a), thus not been engineered to achieve AC fuel efficiency, seems to be a good reference.
- Some improvements could be studied on R-744 system (expansion valve, compressor improvement,...) but also on current system.
- The choice of the baseline system for fuel consumption is extremely important.

We cannot be satisfied with fuel consumption increase, so improvement is mandatory.



3- Focus on specific tests

R-744 : Fuel efficiency – 407 SW



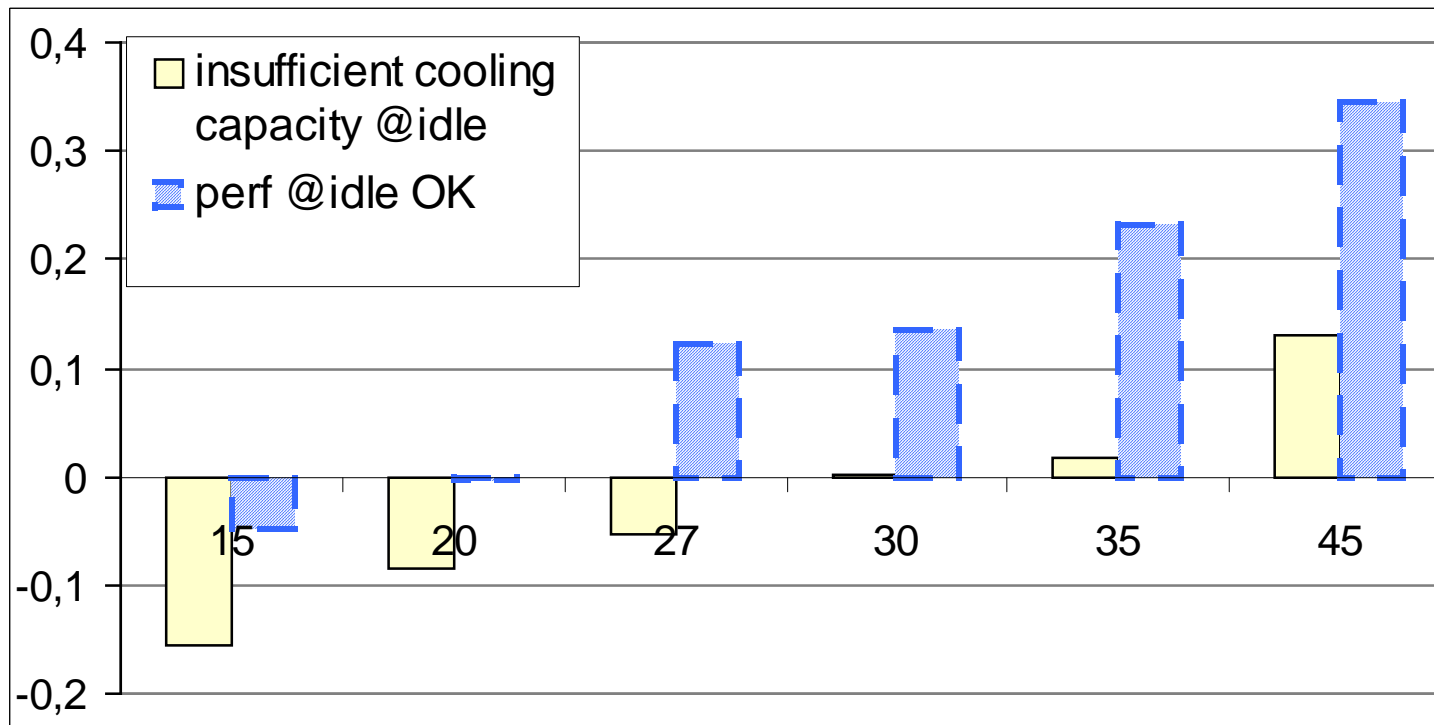
- ⇒ Big increase of fuel consumption with R-744
- ⇒ The use of a COP-optimized expansion device can limit these effects

3- Focus on specific tests

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R-744: Fuel efficiency – Fiat Idea



N.B. estimated fuel consumption with system achieving cooling perf: +2% in idle mode

3- Focus on specific tests

R-744 - CONCLUSION

Fiat, PSA and Renault are not confident with R-744:

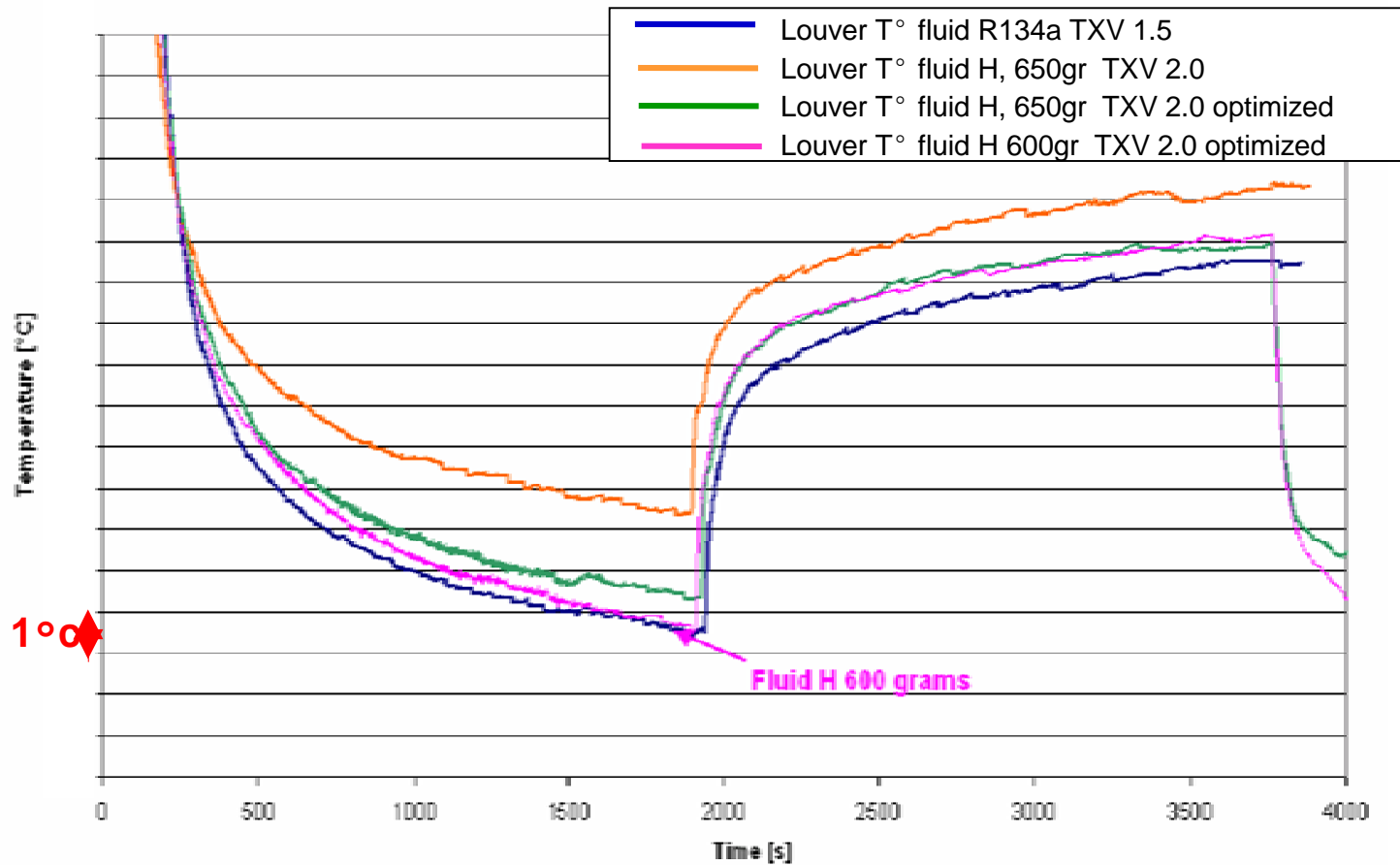
- a. Latest Fuel consumption tests with Major Suppliers do not show any good result
- b. Cooling performance at idle is not achieved
Feasibility of improvement (with strong improvement of the Tightness of engine air inlet) is not assured today on small cars because of engine cooling
- c. Huge impact on packaging, the feasibility is not assured for small cars

3- Focus on specific tests

Fluid H : Renault - Modus

↪ Modus AC loop

↪ Internal controlled compressor



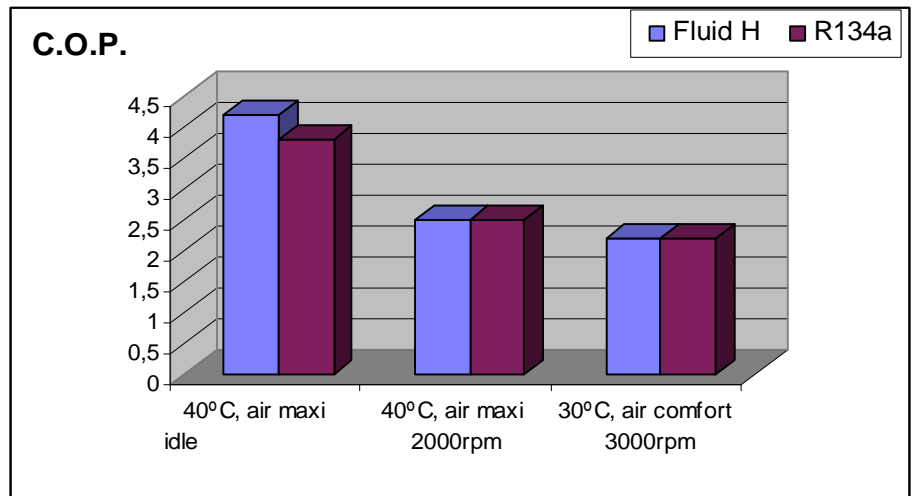
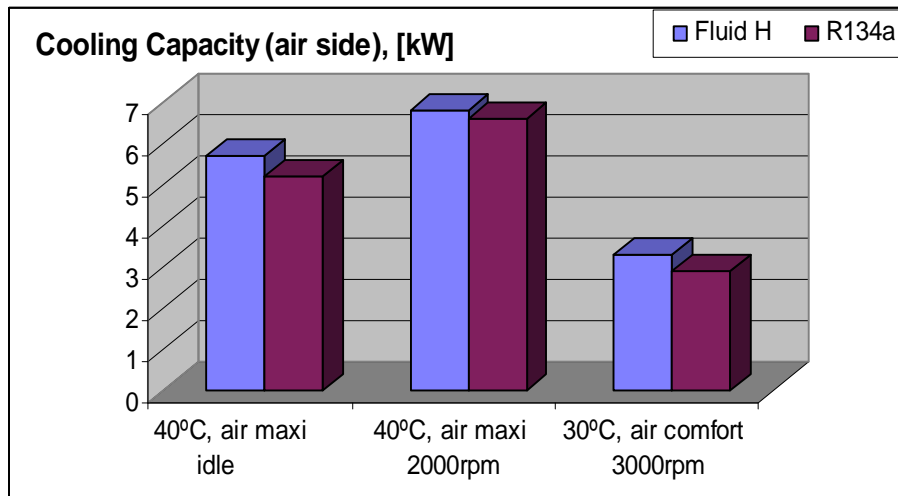
- Very close performance to current R-134a system obtained with **overcharged system**

3- Focus on specific tests



Fluid H : Renault Bench Testing - Modus

- MAC system :
 - ↳ Optimized Modus AC loop – **increased sub-cooling and reduced charge** (without additional exchangers)
 - ↳ Internal controlled compressor
- Tests conditions :
 - ↳ Medium and high load testing

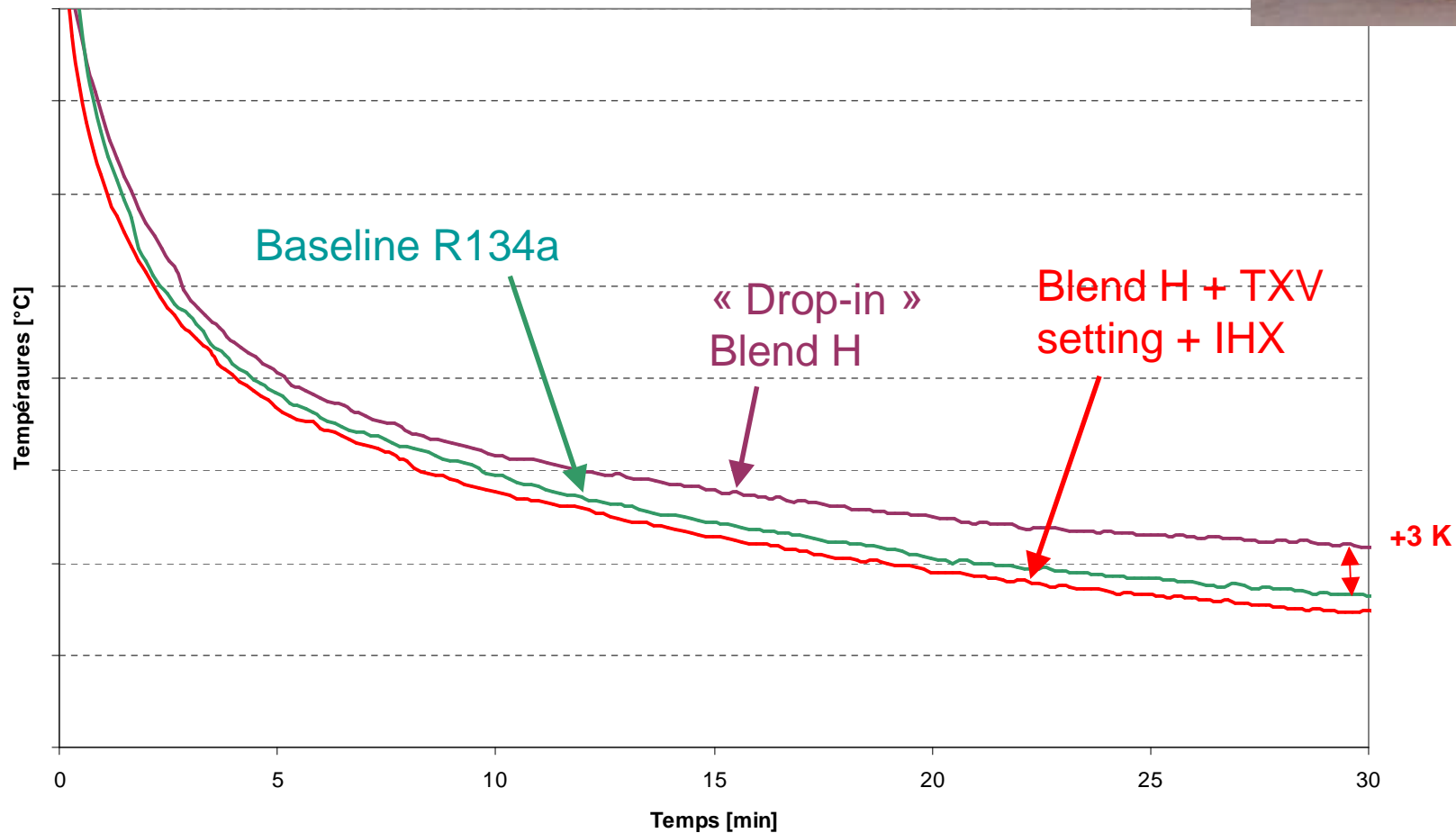


- Performance of the baseline achieved or improved with the optimized fluid H AC loop.
- COP (efficiency) is similar or improved compare to R-134a



3- Focus on specific tests

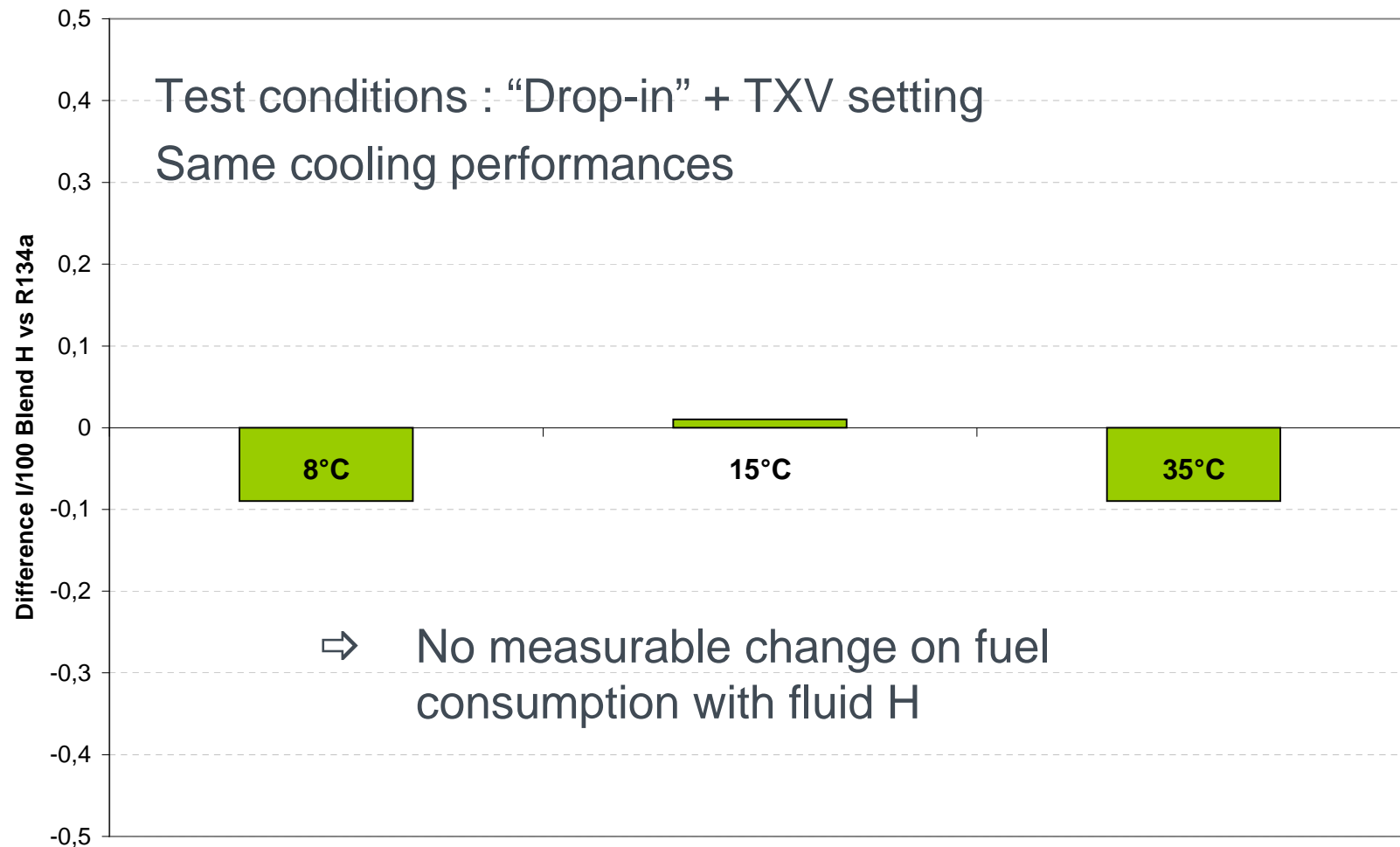
Fluid H : Cooldown tests – C3



- ⇒ High improvement of cooling capacity with IHX
- ⇒ Improvement of COP expected (in progress)

3- Focus on specific tests

Fluid H : Fuel efficiency tests - 407



3- Focus on specific tests

Fluid H - CONCLUSION

1. Fiat, PSA and Renault are confident about Fluid H performance
 2. Optimization at low additional cost has to be done (optimized condenser, ↗ sub-cooling, □ pressure drop)
 3. No concern with packaging
 4. High potential of cooling capacity improvement by adding IHX
- ⇒ Fluid H is good candidate to take over R-134a regarding performance, COP and packaging.

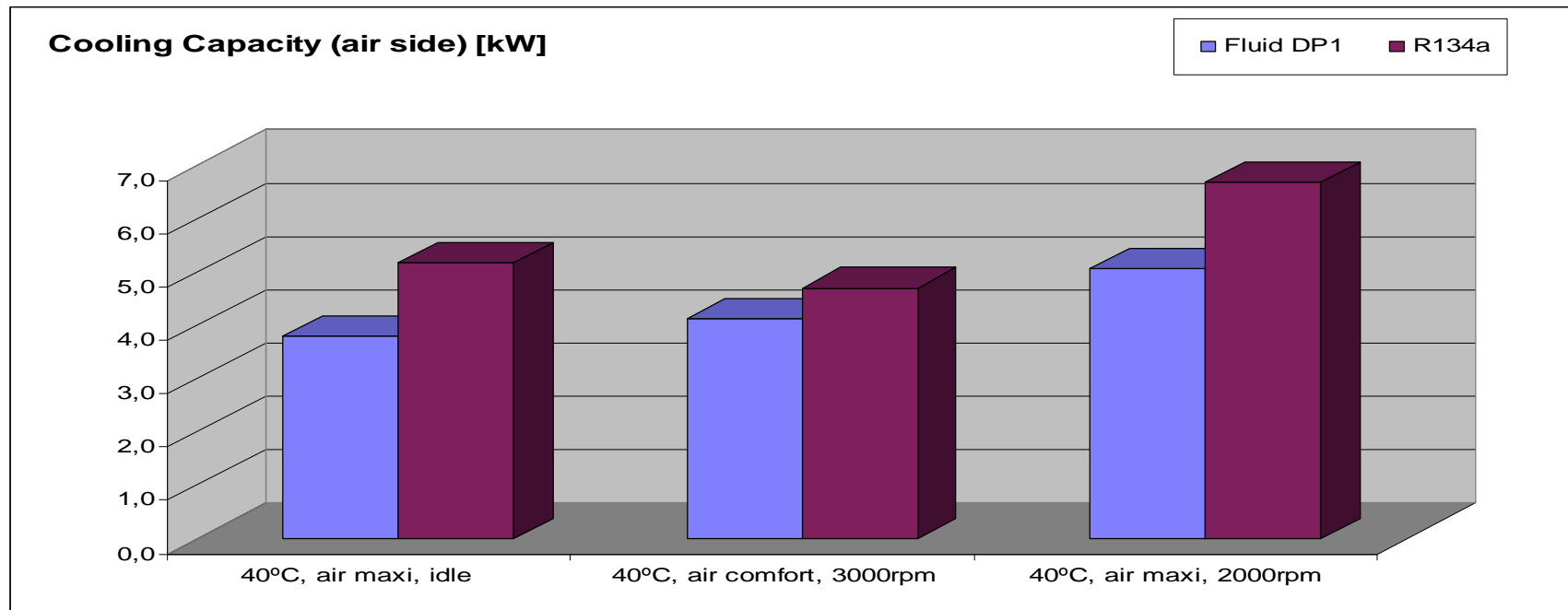
3- Focus on specific tests

DP-1 : Renault Bench tests Modus



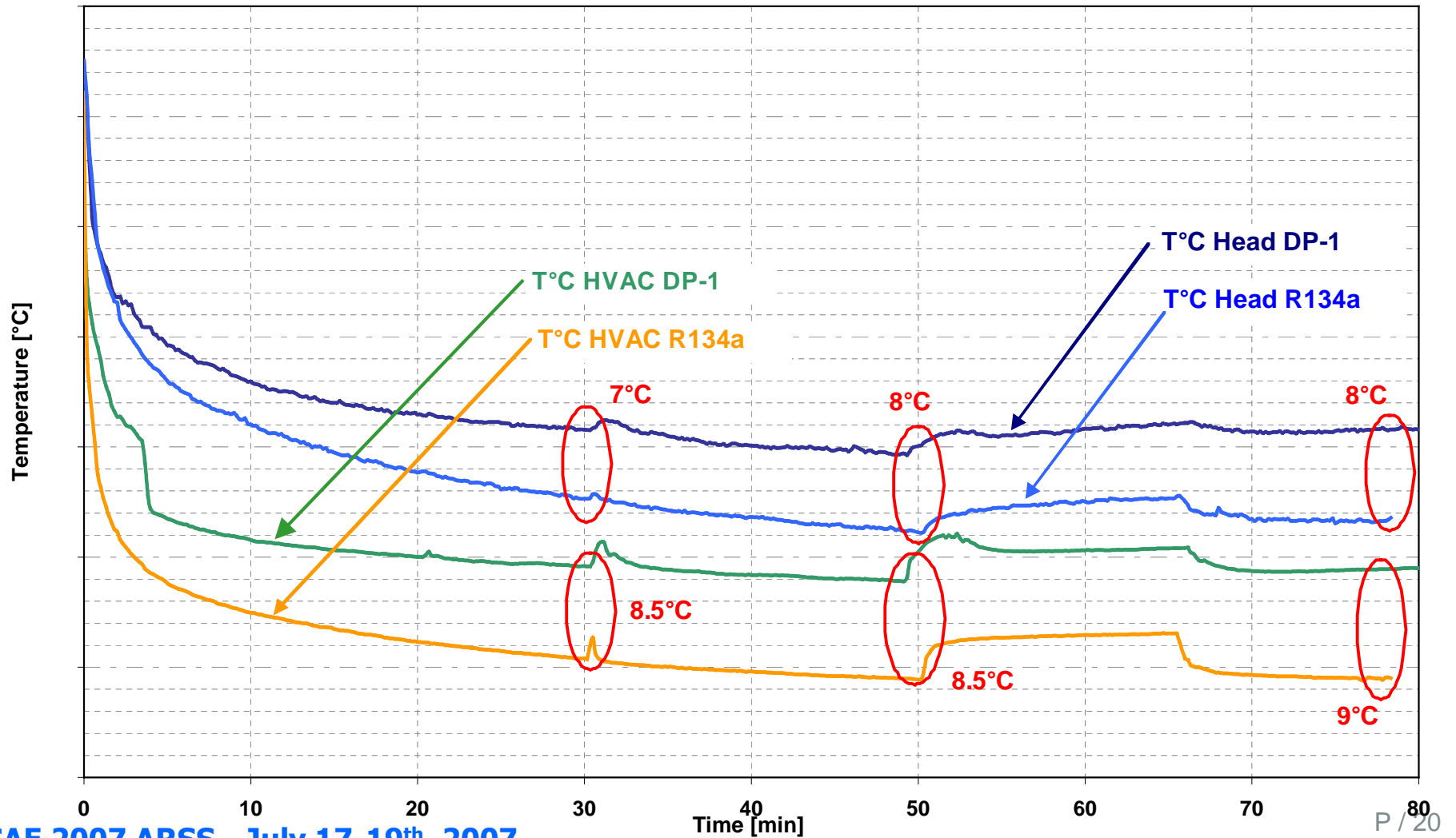
Tests conditions :

↳ Drop-in testing (without additional exchangers).



- Same fuel consumption compared to current system (R-134a) at medium & high load
- Cooling capacity loss with fluid DP-1 at any condition (up to 3 K at high load)
- Optimization is required to reach target performance.

3- Focus on specific tests
DP-1 : PSA tests on 407 SW,
“Drop In” with EXV



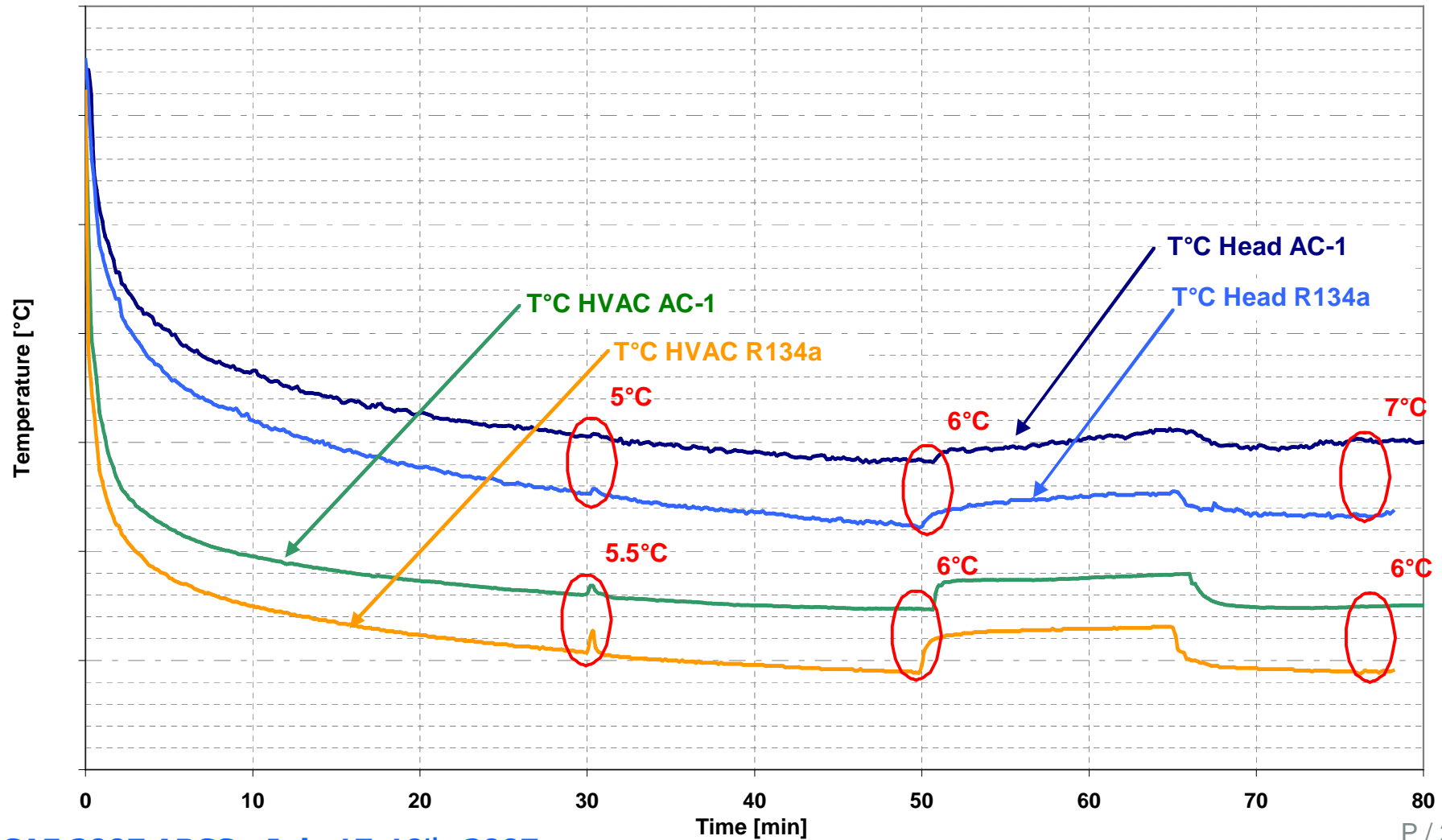
3- Focus on specific tests

DP-1 : CONCLUSION

1. “Drop in” cooling capacity is not enough regarding target performance.
 2. Proposed counter measures to achieve performance :
 - Optimized condenser (↗ sub-cooling)
 - IHX (cost 5 to 10 € ?)
 - Larger compressor capacity on compact car
 - ⇒ Moderate impact on packaging and weight
 3. No issue due to non azeotropic blend (glide) during the tests
- ⇒ DP-1 is a good candidate to take over R-134a but it will require some additional system improvements.

3- Focus on specific tests

**AC-1 : PSA tests on 407 SW,
“Drop In” with EXV**

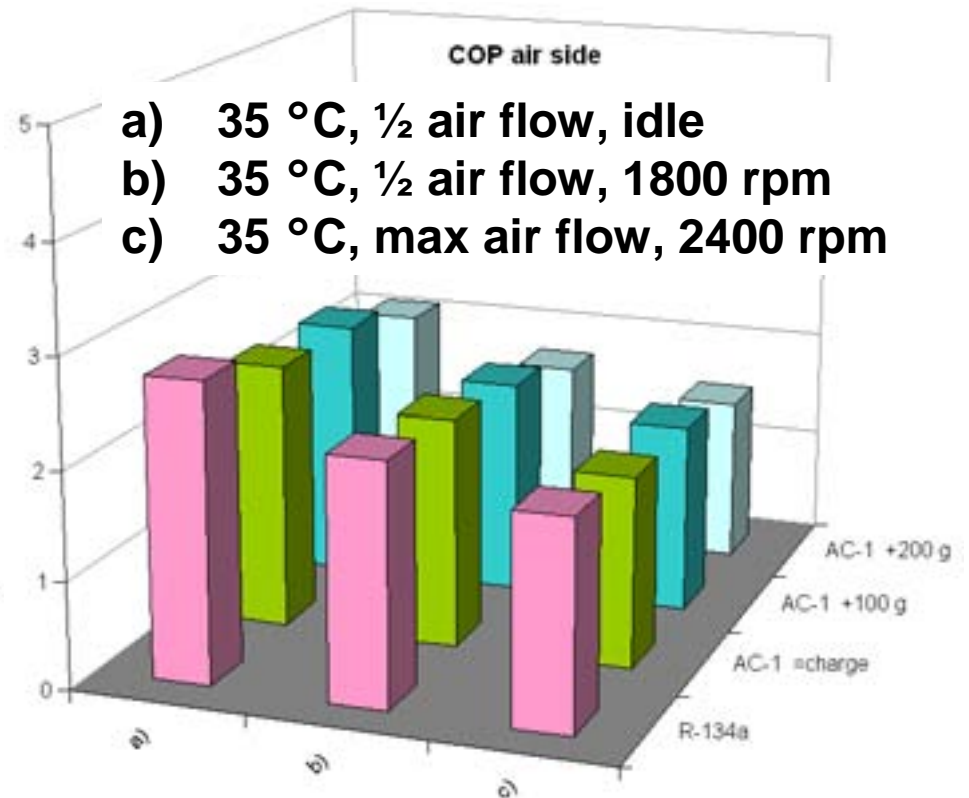
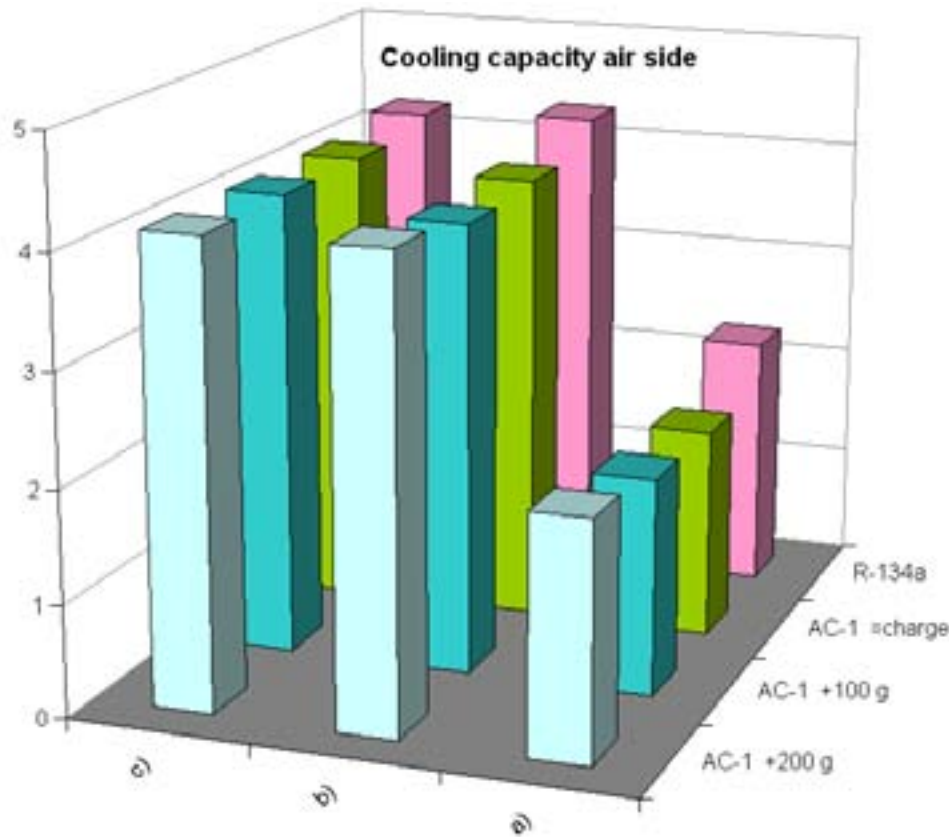


3- Focus on specific tests

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AC-1: FIAT preliminary bench tests on Panda



- additional charge may overcome cooling power loss (80-95 ⇒ 95-105%)
- additional charge causes an increase in COP loss (90-95 ⇒ 75-80%)

3- Focus on specific tests

AC-1 : CONCLUSION

1. “Drop in” cooling capacity is not enough regarding performances requested.
2. Assessment is still on going, no conclusion regarding system optimization can be assessed to date.
3. No issue due to non azeotropic blend (glide) during the tests.

4- Fluid comparison

Western style:

😊 : Good

😐 : So-so




😞 : Bad

☠️ : Not possible










4- Fluid comparison

Items	H	DP-1	AC-1	R-744
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4- Fluid comparison

Items	H	DP-1	AC-1	R-744
<i>Performance “drop in” (no change on Packaging)</i>				















4- Fluid comparison

Items	H	DP-1	AC-1	R-744
<i>Performance “drop in” (no change on Packaging)</i>				
<i>Performance with optimized system</i>		Should be 	Should be 	 (drive)
				 (idle)


















4- Fluid comparison

Items	H	DP-1	AC-1	R-744
<i>Performance “drop in” (no change on Packaging)</i>				
<i>Performance with optimized system</i>		Should be	Should be	 (drive)
				 (idle)
<i>Packaging impact</i>			Pending	

4- Fluid comparison

Items	H	DP-1	AC-1	R-744
<i>Performance “drop in” (no change on Packaging)</i>				
<i>Performance with optimized system</i>		Should be	Should be	 (drive)
				 (idle)
<i>Packaging impact</i>			Pending	
<i>Fuel consumption</i>		Pending	Pending	

4- Fluid comparison

Items	H	DP-1	AC-1	R-744
<i>Performance “drop in” (no change on Packaging)</i>				
<i>Performance with optimized system</i>		Should be	Should be	 (drive)
				 (idle)
<i>Packaging impact</i>			Pending	
<i>Fuel consumption</i>		Pending	Pending	
<i>NVH</i>			Pending	

5- Next steps

1. To continue the assessment on every new fluid that could come on the market until Spring 2008
2. To equip demo cars with optimized systems (performance achievement – incl R-744) to assess Fuel consumption
⇒ end 2007
3. To issue car durability test on the best candidates
⇒ Spring 2008
4. To send Fluid RFQ to all chemical suppliers (1 RFQ per OEM)
⇒ end 2007

6- Conclusion

- Extremely hard to keep many alternatives for OEM's and Tier1 :
 - *Solutions that require big changes on packaging must be decided now.*
 - ***IF** there is a consensus that at least one chemical refrigerant will be acceptable, then Renault/PSA/Fiat suggest to give up R-744 **now** to focus on chemical refrigerants in order to relieve OEM's and Tier's resources*
 - ***BUT** Renault/PSA/Fiat need to have **commitments** from Chemical Industries :*
 - Toxicity, stability and environmental aspect compliance
 - To fulfil with the Deadline of 2011, January 1st.
 - *In case of consensus, agreement in ACEA about acceptable deadline for the choice of the new refrigerant is Spring 2008*

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**Thank you
for your attention**