



# HFC152a as the alternative refrigerant

Presented by:  
William R. Hill  
General Motors Corporation



# Content



- ❖ Background
- ❖ Performance
- ❖ Direct emissions issue
- ❖ Mass
- ❖ Cost
- ❖ Risk Assessment
- ❖ Efficiency/LCCP
- ❖ Service/Timing
- ❖ Technical Issues Remaining
- ❖ Conclusions

Note: Organizer questions are shown in **RED**

## Acknowledgement:

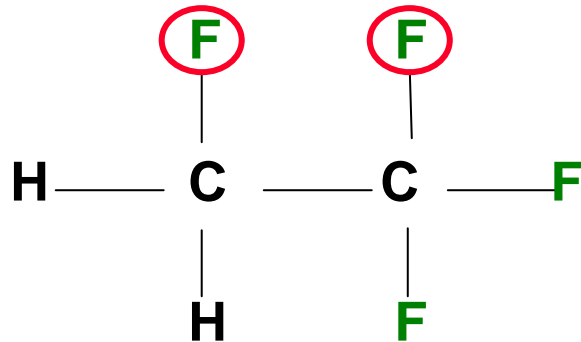
- |                    |                               |
|--------------------|-------------------------------|
| ❖ Larry Kettwich   | Underwriter's Lab             |
| ❖ James A. Baker   | Delphi Automotive AC Supplier |
| ❖ Stella Papasaava | General Motors Corporation    |



# HFC152a-background



**Chemically Similar – Environmentally Very Different**

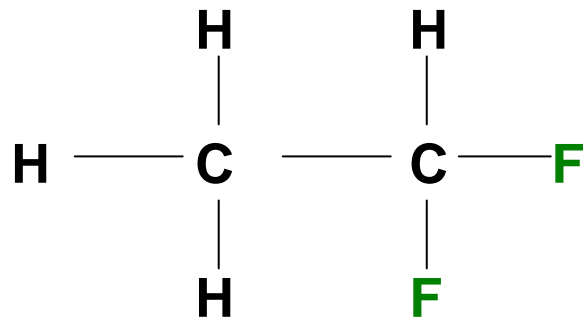


**HFC-134a**

**ASHRAE A1 [Non-flammable]**

**GWP = 1300**

Used in most production vehicles today



**HFC-152a**

**ASHRAE A2 [flammable]**

**Similar Materials Compatibility**

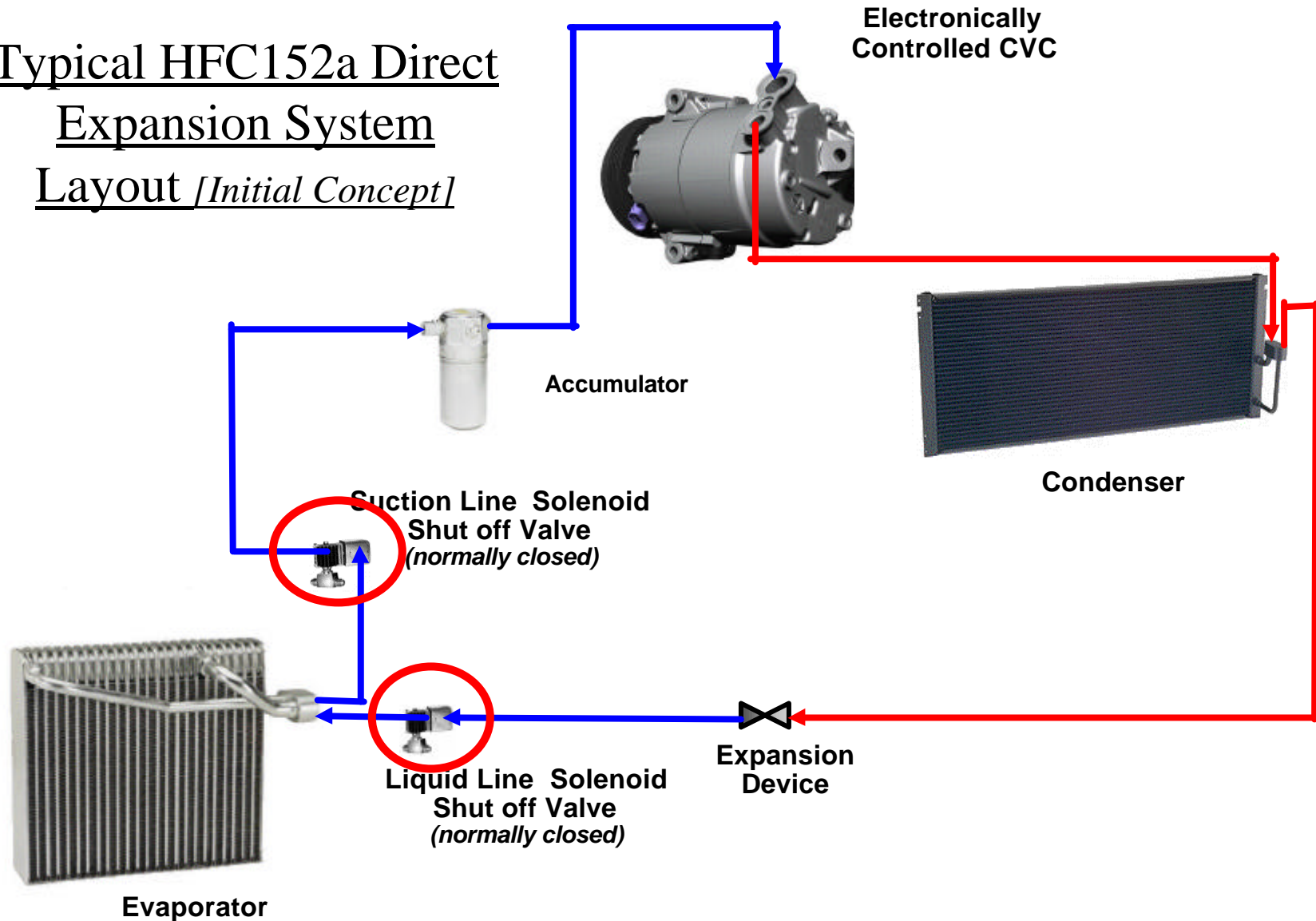
**GWP = 120**

Used in many refrigerant blends today



# HFC152a-background

## Typical HFC152a Direct Expansion System Layout [Initial Concept]



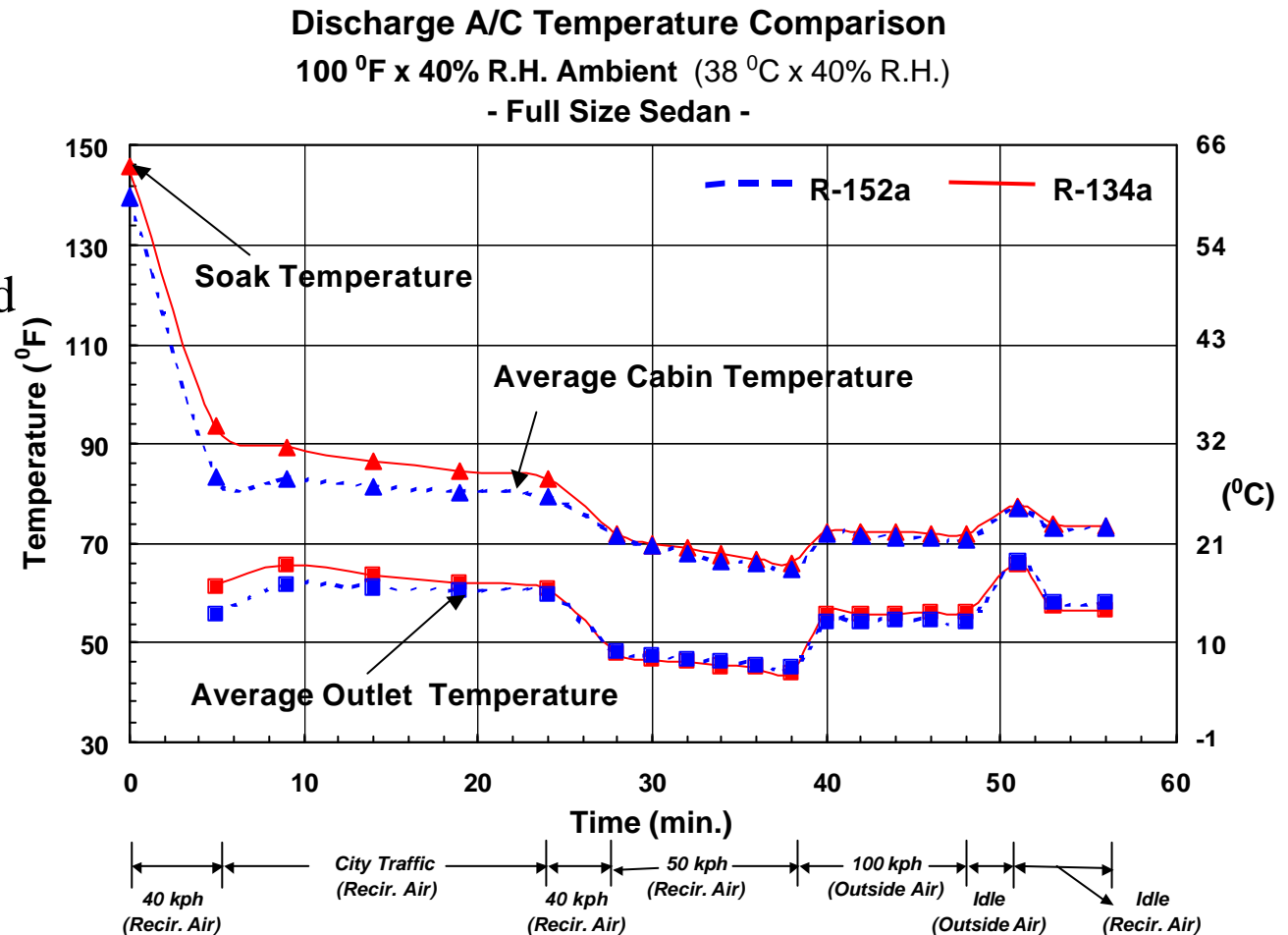


# HFC152a-Performance



## Vehicle Wind Tunnel Cool-down

- Without system optimization [Drop-in]
- HFC152a shows improved cool-down performance as compared to HFC 134a



Direct Evaporation System reported by Delphi/GM/EPA at SAE Phoenix Alternate Refrigerant Symposium 2002



# HFC152a- Direct Emissions



- ❖ 95+% Reduction in Direct Refrigerant GHG Emissions as compared to HFC134a
  - GWP of HFC152a is 120 vs 1300 for HFC134a\*
  - Smaller Refrigerant charge
    - 35% less than HFC134a as demonstrated in Phoenix in Summer, 2003
  - Leakage is less than HFC134a due to molecular weight and lower system pressures with equivalent system hardware

\*Engineered systems, 18(11):74-88, November, 2001



# HFC152a-System mass



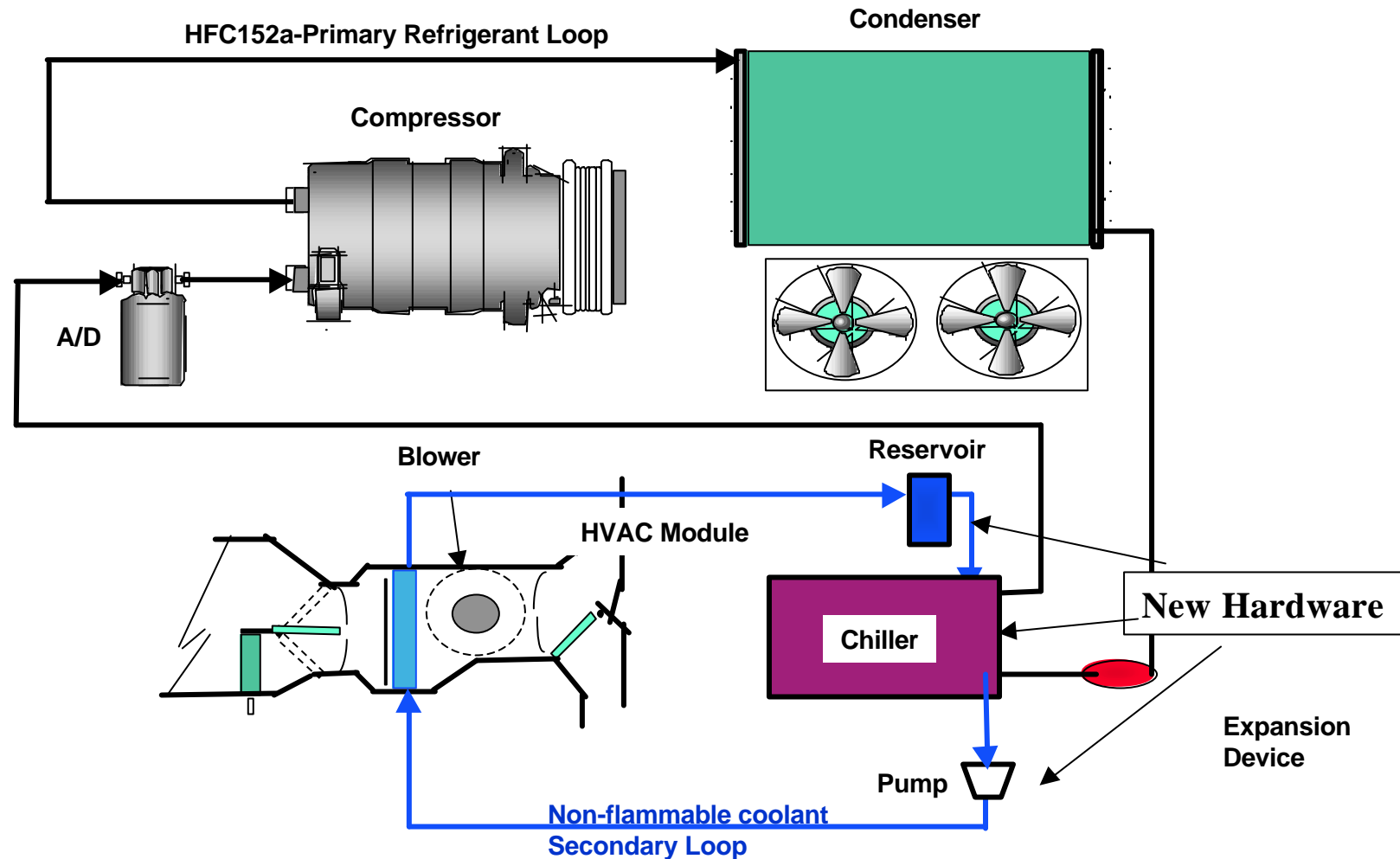
- ❖ System mass is expected to be similar to HFC134a systems with direct expansion system

Evaporator	Same
Compressor	Same
Condenser	Same
Charge	-0.2-0.3 kg.
Plumbing/lines	Same
Safety system	+ 0.2-0.4 kg.



# HFC152a Secondary Loop Option

- ❖ If secondary loop system is used, additional components would add to system mass/cost







# HFC152a-Cost



- ❖ How much more expensive is a current HFC152a based system compared with HFC-134a?

	Direct Expansion	Secondary Loop
Incremental system cost to manufacture	< 15 € [Est.]	< 40 € [Est.]

- ❖ If secondary loop system, safety system is not needed, but there are additional system costs



# HFC152a-Cost



- ❖ Manufacturing/Service (investment) equipment
  - New recovery/recycling equipment and service procedures
  - Additional safety requirements/equipment/training for vehicle assembly plant and service providers
  - Use existing tooling for component suppliers



# Risks Associated with HFC-152a



## ❖ Flammability

- Under the EPA SNAP program, the use of flammable refrigerants in new systems is acceptable if necessary precautions are taken.
- Systems will comply with SAE [Society of Automotive Engineers] J639 [Refrigerant Safety Standards] and J1739 [FMEA-Failure Mode Effects Analysis]

## ❖ Combustion production for HFC-152a/HFC-134a

- MSDS for both HFC134a and HFC152a have identical cautions for decomposition products

## ❖ **Flammability and Atmospheric Decomposition products and their effects will be assessed in the risk assessment**



# HFC152a- Risk Assessment



## ❖ Comparison of flammability:

Fluid	Lower Flammability Limit LFL [%]	Upper Flammability Limit UFL [%]	Heat of Combustion HOC * [kJ/g.]	Realistic Combustion energy [kJ/g]#	Index [RF] ##	Molecular Weight [g.]	ASHRAE Class <sup>1</sup>
HC290 propane	2.1*-2.2 #	9.5 #	50.3	44.0	<b>56.6</b>	44*	A3
HFC152a	3.7*-3.9 #	16.9 #	17.4	6.3	<b>4.6</b>	66*	A2
HFC134a	-	-	4.2*		-	102*	A1

\*RF-No.: a New Index for Combustion Hazard of Refrigerants.

$$RF - No. = [(\sqrt{UFL \cdot LFL} - LFL) / LFL] \cdot (HOC / M)$$

UFL : Upper Flammability Limit, LFL : Lower Flammability Limit

HOC : Heat of Combustion, M : Molecular Weight

Ref. : S. Kondo, K. Tokuhashi, A. Takahashi, A. Sekiya, 31th Symposium on Safety Engineering (Japan), Sg-1 (2001).

\*Engineered systems, 18(11):74-88, November, 2001

# DuPont Technical Information- presumes less than 100% combustion of refrigerant [3/2002] [NFPA]

##Based on DuPont numbers

[Note:Numbers from Journal of Hazardous Materials, A93-2002 fall in between these values.]

#US EPA 09-MAR-1994, Dean Smith

11-FEB-2003

12

1 ASHRAE=American Society of Heating, Refrigeration and Air Conditioning Engineers



# HFC152a- Risk Assessment



- ❖ Given the liability issues relating to flammability, will the vehicle manufacturers introduce HFC-152a to vehicles?
  - Use of HFC152a [with direct or indirect expansion system] will depend on the risk assessment results.
- ❖ What happens if some refrigerant is mixed with HFC-152a?
  - Not likely this will occur in a vehicle system since all refrigerants have unique service fittings per SAE J639
  - If other refrigerants are mixed with HFC152a during service, results depend on properties of the refrigerant that is added. [L. Kettwich-UL]

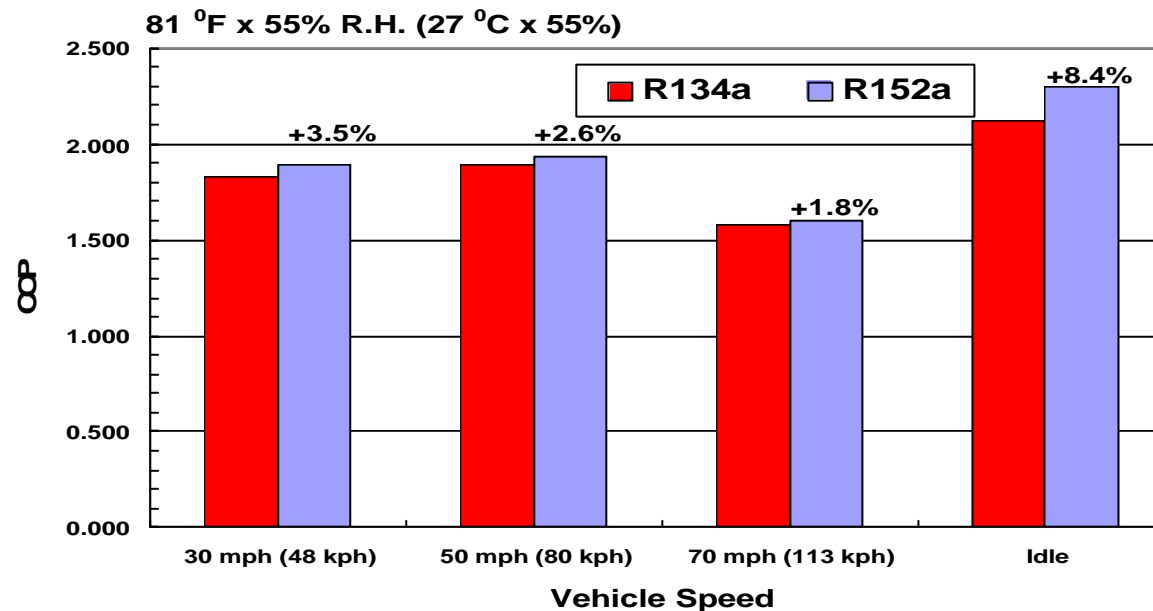


## HFC152a- Efficiency/energy consumption



- ❖ Results of HFC152a tests have shown system to be an average of 10% more efficient than HFC134a at conditions from 27°C to 46°C.
  - Use of secondary loop system will result in efficiency similar to current HFC134a

**Mechanical COP =**  
**System Air Cooling Capacity/ Measured Compressor Shaft Power**



Direct Evaporation System reported by Delphi/GM/EPA  
at SAE Phoenix Alternate Refrigerant Symposium 2002



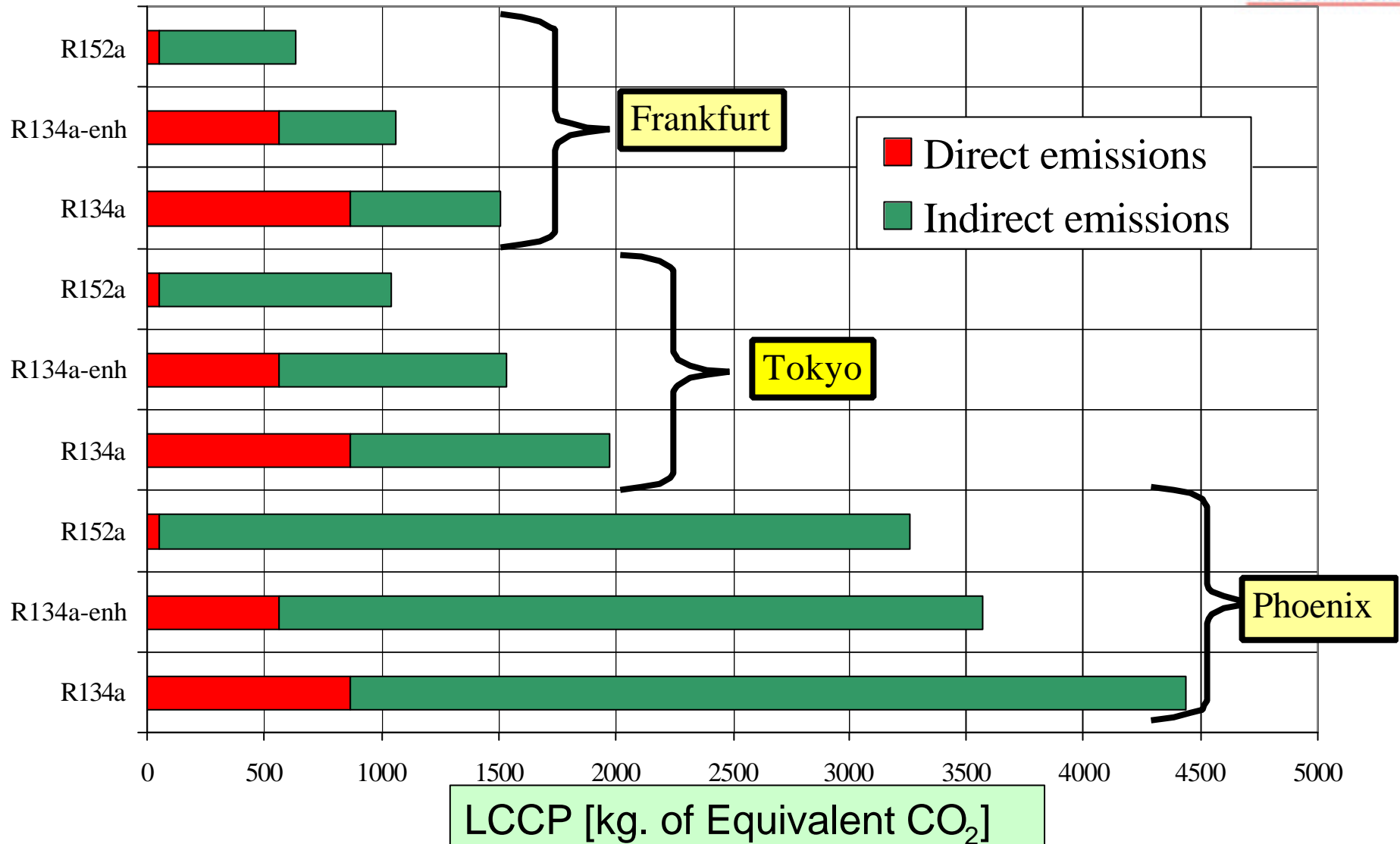
## HFC152a- Efficiency/energy consumption



- ❖ What are the potential efficiency improvements and what is the limit to these improvements?
  - Oil Separator
  - Suction line heat exchanger
  - Improved Effectiveness of heat exchangers
  - Improved efficiency of compressor
  - Capacity Controlled compressor, externally controlled
  - Controlled Air Re-circulation on the evaporator
  - Improved lubricant compatibility
- ❖ A secondary loop needs to be assessed
  - Mass and Cost will increase, efficiency similar to current HFC134a systems
- ❖ Is it possible to produce a cost vs efficiency improvement pareto?
  - Similar to those items under consideration with the enhanced R134a system



## HFC152a- LCCP



Direct Evaporation System reported by Delphi/GM/EPA at SAE Phoenix Alternate Refrigerant Symposium 2002



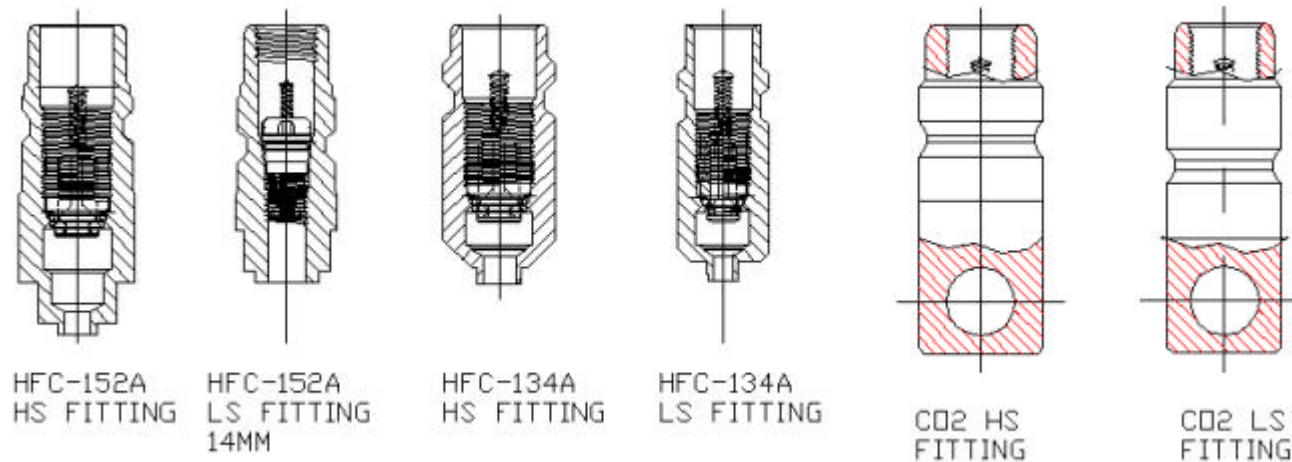


# HFC152a-Service Assessment



## ❖ Can leaks be identified?

- Use of Infrared technology has been demonstrated to work similar to HFC134a leak detectors.
- Service fittings are identified





## HFC152a-Timing/feasibility for production



- ❖ What would be such a reasonable transition period?
  - 2 additional years of development are necessary to optimize system efficiency, durability, safety, and mass and assure refrigerant manufacturing capacity
  - 2-4 additional years is necessary for a global vehicle model introduction
- ❖ How mature is the technology itself?
  - Component technology developed [current HFC134a hardware]
  - System controls are still under development
- ❖ To what extent are the problems relating to the introduction of HFC152a systems related to technology itself, and how much to “simply” cost?
  - Problems related to introduction are mainly technical issues around flammability control in operation, servicing and production.



# HFC152a-Technological issues



## ❖ Dual evaporator loops?

- Secondary loop system would be used for dual evaporator loops

## ❖ Direct expansion vs secondary loop?

- No problem to use HFC152a with secondary loop systems
- Secondary loop will have additional cost and reduced efficiency as compared to direct expansion

## ❖ Heat pump capability?

- Per SAE paper 2003-01-0733
  - System demonstrated with coolant as Heat Source
    - Heat capacity at -18°C is over 8 kW
    - Results were similar with both R134a and R152a



# HFC152a-Conclusions



- ❖ Environmental Consideration
  - 95+% reduction in direct refrigerant emissions vs. HFC-134a
  - Up to 10% reduction in indirect emissions vs. HFC-134a [reduced fuel usage]
- ❖ AC system considerations
  - HFC-152a and HFC-134a have nearly identical pressure / temperature curves-minimal component changes required
  - Cooling performance and overall energy efficiency are better than HFC-134a
  - Current HFC-134a components, lubricants and materials can be used with HFC-152a
    - Flexible component manufacturing possible
- ❖ Relative ease of industry conversion
- ❖ Risk Assessment
  - Low flammability
  - R152a is still an HFC and it could fall under any HFC regulations
  - Risk assessment results will be available when complete

Thank you for your kind attention!