Overview of SAE Cooperative Research Program CRP1234-2 for Alternative Refrigerants

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The goal - an introduction

- Test of selected material properties with the focus on maximum workload conditions
- Determination of aging effects and permeation under defined conditions
- Low temperature behavior not investigated

HFO1234yf / ND8-1 modified

Test about DOW “UCON RL-XPR17” in progress

Interim results from CRP1234-2 are presented.

Content

- SAE CRP1234-2 Objectives
- Investigated materials
- Aging & permeation conditions
- Investigated properties & testing equipment
- Target values
- Selected R134a baseline results as samples
- General overview about the interim results
  - Hoses for high and normal temperature application
  - O-rings / slabs
- Summary & conclusions

SAE CRP1234-2 Objectives

Evaluate materials and determine if current materials of construction can be used with HFO1234yf

Give detailed information regarding results to CRP1234-2 sponsors

CRP1234-2 Sponsors

DuPont	Renault	DOW
Honeywell	Trelleborg	Egelhof
Chrysler	Valeo	Freudenberg
Fiat Auto Group	Visteon	Goodyear
Ford / Volvo	Contitech	Hutchinson / LJF
GM / Opel	Dayco	Sanden
Hyundai	Delphi	Maflow
Landrover	Denso	Parker

Investigated materials

Refrigerant:	HFO1234yf
Oils:	ND8-1 mod., UCON RL-XPR17
O-rings:	CR, EPDM, HNBR
Hoses / barriers:	Butyl, CR, IIR, PA
Thermoplastics:	PPS, PEI – mid July 2008

The suppliers were invited to deliver materials from production and optimized materials.

Baseline on selected materials with R134a/ND8 as reference

Aging & permeation conditions

Aging – Compatibility (HFO1234yf / PAG oils):

Component	Short term (168 h)	Long term (500 h)
O-rings / slabs	140 °C	125 °C
Ht-hoses		
Nt-hoses	125 °C	100 °C

Permeation (HFO1234yf saturated conditions, no oil):

Component	90 °C	40 °C
O-rings / slabs	■ 100 h ■ 240 h ■ 500 h	240 h
Ht-hoses		
Nt-hoses		

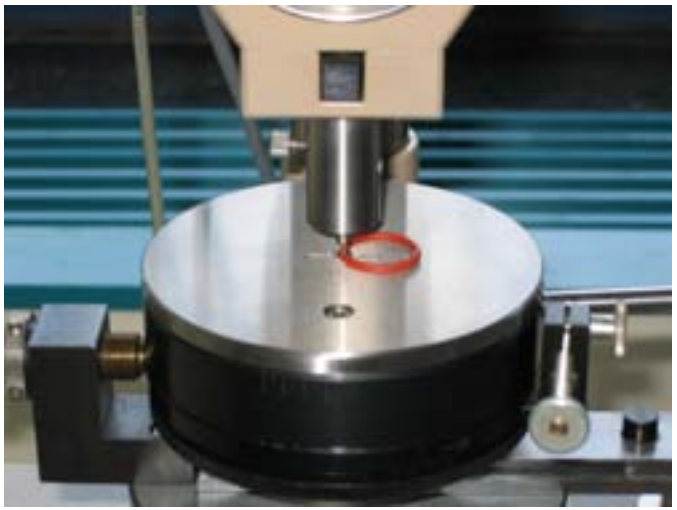
Investigated properties & equipment

Compatibility:

Material changes on aging:

- Tensile properties (ISO 37: E_b, TS_b, S@50%E, S@100%E)
- Hardness (ISO 48: IRHD micro)
- Swelling, shrinking, volume change

- Oil changes as indicator for material changes only:
  - Water Content, Total Acid Number
  - Qualitative interpretation only (oil values not comparable to the sealed tube test)
  - Viscosity – changes in viscosity



Investigated properties & equipment

Permeation & refrigerant extract:

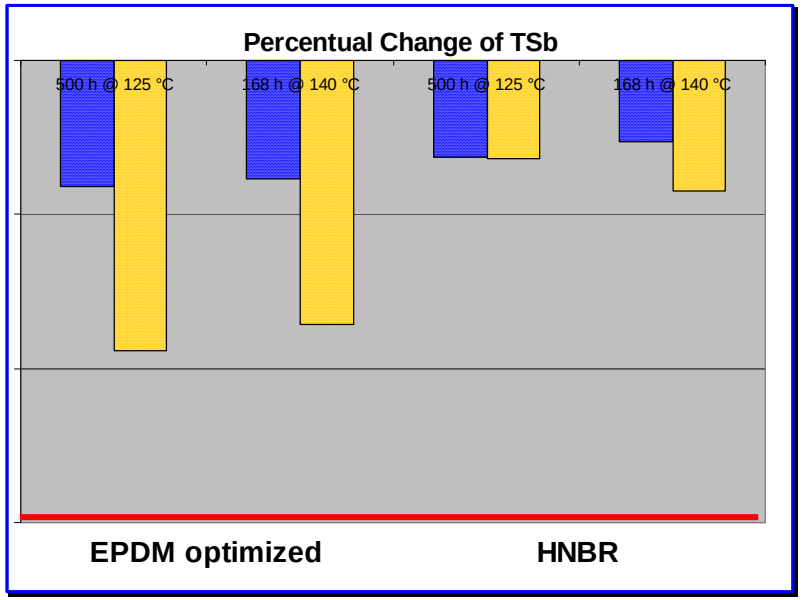
- Permeation investigations:
  - Adapted permeation housings for slabs & hoses
  - Determination of the permeation rate with GC
- Refrigerant extract after the permeation tests:
  - Gravimetric tests, GC, MS
  - Identification of the character of the extract
  - Mass of the extract

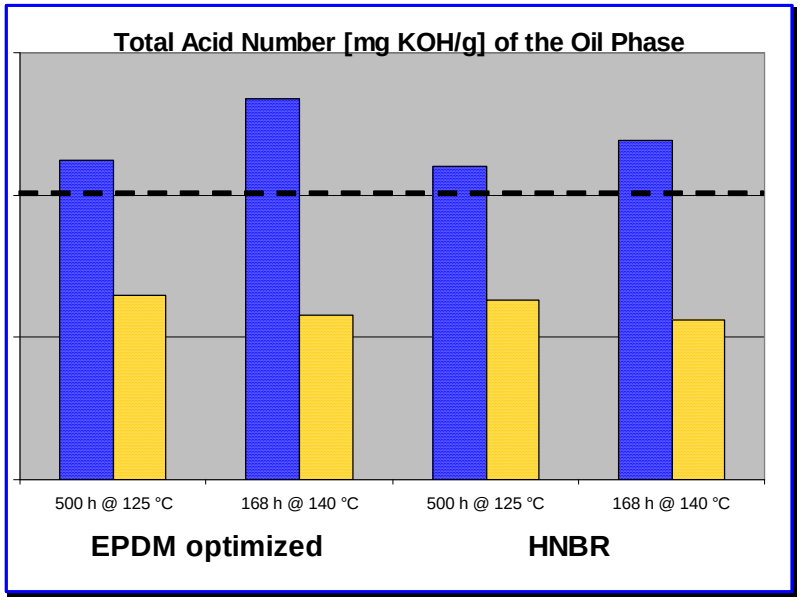
  (estimated end June 2008)

Target values

Test Category	Metrics	Targets
Oil compatibility	1. Coloration 2. TAN	1. Total Acid Number ~ 1.0 (Guiding value)
Elastomer compatibility	1. Hardness Change (IRHD micro) 2. Tensile Strength Change 3. Elongation Change 4. Stress @ 100% Change 5. Volume Change	Hoses after 500hr: 1. Change of elongation at break -45 % max (Elastomer and PA) 2. Change of tensile strength -30 % max (Elastomer only) 3. Change of micro-hardness ±15° Seals after 500hr: 1. Change in Volume: zero to +15% 2. Change of elongation at break -50 % max 3. Change of tensile strength ±30 % max 4. Change of micro-hardness ±15°
Elastomer permeation	Total leakage quantified	1. Total leakage Equivalent to R134a 2. Leakage: - HT-hoses: 0.34 g/(cm² a) - NT-hoses: 0.60 g/(cm² a) - O-rings 40 g/(cm² a) derived from CRP150-2

Selected results – compatibility O-rings

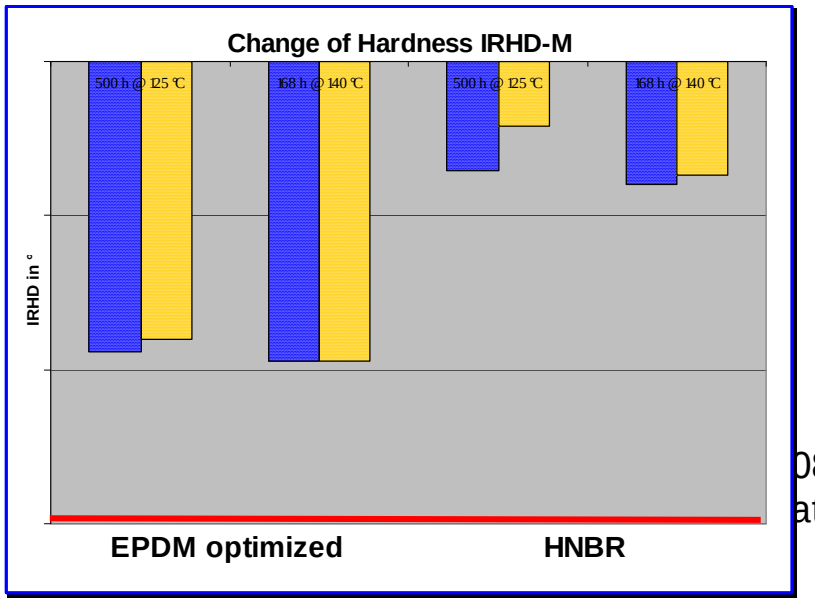




R134a/ND8

HFO1234yf/ND8-1 mod.

Target value



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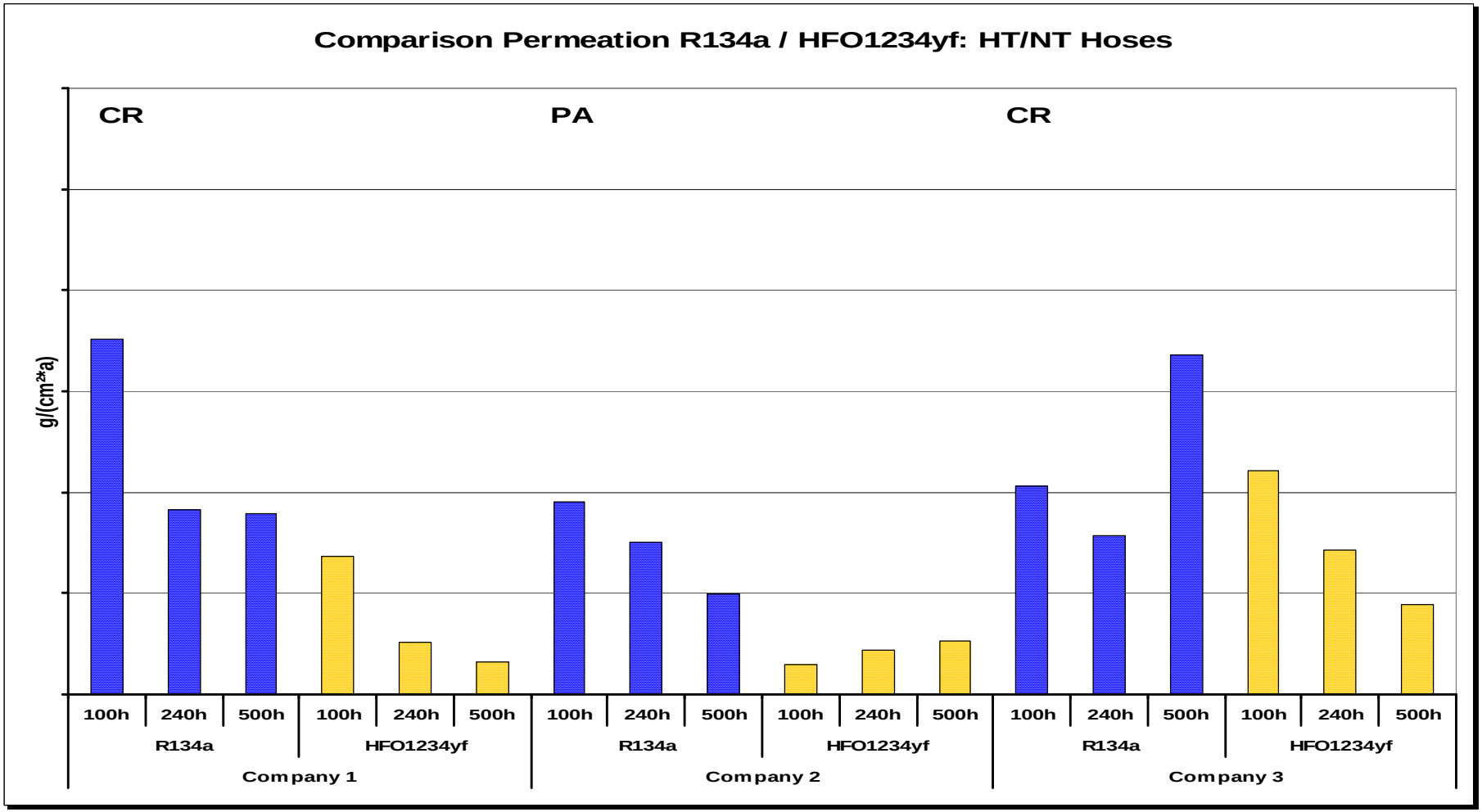
Selected results – permeation hoses



Interim results – O-rings / slabs

Compatibility:

- **All material fit to target values after aging for tensile testing**
- **One EPDM material falls below minimum hardness target; same material had swelling above target value**

Permeation:

- **All materials met the CRP1234-2 target**
- **Standard EPDM materials exceeds the permeation rates of HNBR**
- **Optimized EPDM can meet the same levels as HNBR**
- **CR permeation rate is nearly the same as HNBR**
- **The permeation rate is less than R134a regarding the available references.**

Interim results – NT-hoses

Compatibility:

- **All hoses except one met the tensile testing targets**
- **One Butyl hose failed to meet the target for elongation change**
- **One Butyl hose increased slightly in tensile strength**
- **Rubber based hoses had slight increase in hardness**

Permeation:

- **All hoses met the target value for the permeation**
- **One PA-type hose shows a much lower permeation rate than other hoses**
- **One CR-type hose has a much higher permeation than other hoses**

Interim results – HT-hoses

Compatibility:

- **All materials except one hose met the tensile testing targets**
- **One Butyl hose failed to meet the target for elongation change**
- **One Butyl hose increased slightly in tensile strength**
- **Rubber based hoses had slight increase in hardness**

Permeation:

- **CR type hoses have higher permeation rates than other hoses**
- **One PA-type hose shows a much lower permeation rate than other materials**

Summary & conclusions CRP1234-2

- No fundamental problems with permeation & compatibility experienced with the investigated materials
- Already some working materials available at the market
- Optimization of some materials possible & recommended

Thanks for your attention!

Final results estimated end August 2008