Service Issues Related to Using Blend Refrigerant in Mobile Air Conditioning Systems

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Service Issues Related to Using Blend Refrigerant in MAC Systems

Summary of Presentation

- Using Blend Refrigerant in MAC Systems
- Identifying Composition of Blend refrigerant
  - In MAC System
  - Recovered Refrigerant
- Recovery of Refrigerant From MAC System
  - On-site Handling Process
    - Recovery
    - Re-use
- Issues relative to charging due to vehicle manufacturing
Blend Refrigerants in MAC Systems

- For Many Years Mobile A/C systems have used single chemical refrigerants

- Blend refrigerants contain multiple chemicals

- Use of Blend Refrigerants in MAC systems require slightly different handling techniques with on site Service Equipment

- Refrigerant recovery is the same for all refrigerants

- Processing for direct re-use requires identification of the recovered refrigerant composition and reconstitution prior to recharging the system
MAC Service Issues using Blend Refrigerants

- Testing Overview of Lower GWP Blend Refrigerants
  - Blend “AC6” Composition
    - 6% CO$_2$, 10% R134a, 84% R1234ze

- Potential for composition shift of ternary blend composition whenever a vapor-liquid interface is created

- Composition will vary as liquid level and temperature change
MAC Service Issues using Blend Refrigerants

Summary of AC6 service test evaluation

Evaluation of blend composition stability with service use

- Single 10kg cylinder of blend with correct composition
- Vehicle was repeatedly charged, engine run, then recovered
- Accurate composition samples taken under a variety of conditions;
  - Pre-charge – *direct from charging cylinder*
  - Engine running – *direct from High and Low service port fittings*
  - Engine off – *direct from High and Low service port fittings*
  - Recovered state – *direct from recovered one litre cylinders*
  - “Mulligan Stew” – *is defined as the combined composite refrigerant and their % ratios when recovered from each run into a single 10kg cylinder*

Key objectives
- Review stability of blend from charging cylinder
- Review blend stability during use
- Review feasibility for re-use of recovered blend
Analysis of AC6 composition is not consistent in all conditions.

Only use “Key Data” (pre-charge, engine running or recovered data).

AC6 - All CO2 Composition samples

AC6 composition specification
CO2 = 6%; R134a = 10%; R1234ze = 84%

Only use "key" data for more reliable results (e.g. pre-charge, engine on, or recovered data)

Samples taken during the engine off or soak periods show high variance, so do not use in future analysis.
Analysis of composition is not consistent in all conditions

- Results are explicable with vapour / liquid equilibrium (VLE) properties
  - **Engine off-state is variable and inconsistent, even with correct composition**
    - Equilibrium condition of the vapour / liquid compositions - **See image below**
  - **Engine running or recovered state is more consistent and closer to correct composition**
    - Engine running gives a steady state condition of the compositions & is more stable
    - Liquid measurement of the recovered condition is closer to correct composition
  - Variability also effected by running state, temperature and actual fill level

**The position of the Hi & Lo charge ports on the vehicle system, dictates if the static composition sample taken is gas or liquid – the same as if it were in a cylinder**
AC6 Blend Composition Evaluation

- Analysis of CO₂ composition is not consistent in all conditions

The CO₂ % composition varies outside specification with usage

Engine running composition data is within 1% tolerance of spec, but is above that of Pre-charge & Recovered composition data

Reducing CO₂ % value as cylinder volume reduces

Most recovered samples were low of spec

CO₂ leakage when recovering to trolley

Spec. Range
AC6 Blend Composition Evaluation

- Analysis of R-134a composition is quite stable
AC6 Blend Composition Evaluation

- Analysis R-1234ze composition is quite stable

**Spec. Range**

The R1234ze% composition is quite stable within specification

Most samples are within 1-2% tolerance of spec

Caused by CO2 leakage when recovering to trolley
AC6 Blend Composition Evaluation

- Pre-charge composition of CO₂ reduces with depletion of charging cylinder
- Recovered composition of CO₂ is more reliable, but shows further reduction & variability
  - AC6 recovered composition shows further depletion of % CO₂ composition
  - Recovery time must be extended to ensure recovery is complete (double recovery)
  - Recovery cylinder volume also effects results - Small is essential to minimise headspace

![AC6 - CO₂ Pre-charge and Recovered Composition samples](chart)

**AC6 composition specification**
CO₂ = 6%; R134a = 10%; R1234ze = 84%

**Reduction of CO₂ composition with usage**

**CO₂ pre-charge composition level shows a downward trend in line with reduction in cylinder volumes & increase in head space**

**Recovered composition level always shows as less than the pre-charge composition, indicating a further loss of CO₂, so limited opportunity for reuse of recovered composition for next charge without it being below composition specification**

<table>
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<th>T1 - CO₂</th>
<th>T2* - CO₂</th>
<th>T3* - CO₂</th>
<th>T4 - CO₂</th>
<th>T5 - CO₂</th>
<th>T6 - CO₂</th>
<th>T7 - CO₂</th>
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</tbody>
</table>
AC6 Blend Composition Evaluation

- “Mulligan Stew” of AC6 composite recoveries is out of spec.
  - Recovered composition will vary dependent upon % fill of cylinder
- Re-use of recovered blend not possible without blend re-composition

![AC6 "mulligan stew" composition chart]

- Most recovered CO2 values are out of spec in depleted cylinder. Generally CO2 value is seen to increase as head space in cylinder decreases.
- Can not re-use reclaimed AC6 without re-composition, as CO2 is out of spec.
MAC Service Issues using Blend Refrigerants

Summary of service test evaluation of AC6

- Analysis of composition is not consistent in all conditions
  - Pre-charge composition changes with depletion of charging cylinder
  - Vehicle results typical of vapour-liquid equilibrium (VLE) properties
  - Recovered composition is more reliable but still shows some variability
  - “Mulligan Stew” of composite recoveries is out of spec.
  - Composition will vary dependent upon liquid level in cylinder

- In summary, re-use of recovered AC6 blend “as-is”, whilst possible, is not desirable without blend re-composition
The AC6 blend recovery/refill process, including the use of a “Refrigerant Identifier” to establish the correct CO$_2$ composition for a production application, is currently under development.
Blend Refrigerant Handling requirements in MAC Systems

Standards & Procedures

- Technician procedures for Blend Refrigerant are basically similar to existing servicing production MAC systems

- Blend Refrigerant processing will be accomplished by recovery-reprocessing with the charging equipment

- New SAE standards will be required

- Although some changes are contemplated to detail of equipment and process design, from perspective of factory and service personnel the handling of blends will feel similar to handling of R-134a or R-1234yf
Blend Refrigerant Handling requirements in MAC Systems

SAE standards (Some to be revised to include Blend refrigerant(s))

- J639 Safety Standards for Motor Vehicle Refrigerant Vapor Compression Systems
- J1658 Alternate Refrigerant Consistency Criteria for Use in Mobile Air Conditioning
- J2099 Standard of Purity for Recycled R-134a (HFC-134a) and R-1234yf (HFO-1234yf) for use in Mobile Air Conditioning
- J2843 R-1234yf Recovery/Recycling/Recharging Equipment for Flammable Refrigerants for Mobile Air-Conditioning Systems
- J2844 R-1234yf New Refrigerant Purity and Container Requirements Used in Mobile Air-Conditioning Systems
- J2845 Technician Training for Safe Service and Containment of Refrigerants Used in Mobile A/C Systems (R-744, and R-1234yf)
- J2912 R-1234yf Refrigerant Identification Equipment for Use with Mobile Air Conditioning Systems
Blend Refrigerant Handling requirements in MAC Systems

Summary of proposal for AC6 blend handling

- Use virgin or recovered refrigerant
  - Gives more flexibility for reuse of recovered refrigerant

- Use Ternary blend or Binary blend
  - In general the binary blend of two refrigerants have minimal loss and do not have to be replaced but incorporate composition check into reclaim logic before re-use

- Add CO₂ to achieve correct composition
  - This would be added automatically by the charging equipment