Overview of SAE Cooperative Research Program CRP150 for Alternative Refrigerants

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Formation History

Initially proposed at 2006 SAE Congress of Interior Climate Control Standards Committee meeting in Detroit

- Invitations to join were delivered in May, 2006

Discussed again at the 2006 SAE Alternate Refrigerant System Symposium in Phoenix

- OEM's agreed that this was a good approach and agreed to support
- Formal invitations were again delivered in July, 2006

CRP150 was adopted due to 150 GWP limit set by EU regulation

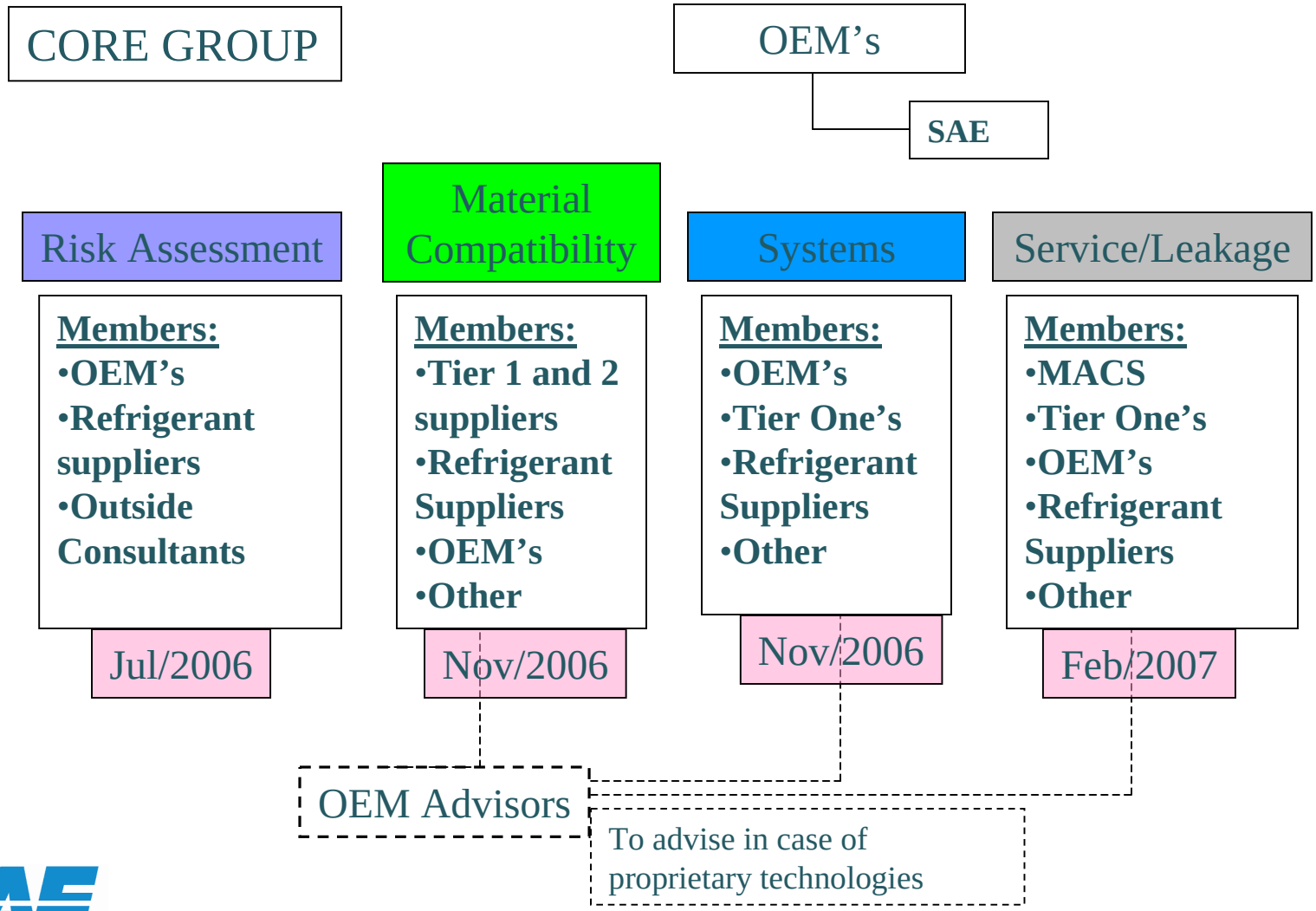
Team one meetings on Toxicology began in August, 2006

Team two meetings on material compatibility began in early November, 2006

Team three meetings on performance evaluations began in late November, 2006

Team four first meeting February, 2007

SAE CRP150 Project Organization



CRP150 Chemical Companies

Refrigerant Companies	
Honeywell [USA]	**Active in CRP150-1,2,3,4**
Ineos Fluor [Great Britain]	**Active in CRP150-1,2,3,4**
Solvay [Belgium]	**Active in CRP150-1,2,3,4**
DuPont [USA]	**Active in CRP150-2**
Sinochem [China]	No response
Arkema [USA]	No response

CRP150 Contributing Companies

Team 1*	Team 2*	Team 3*	Team 4*
Audi	Audi	Audi	MACS
BMW	BMW	BMW	Audi
DaimlerChrysler	DaimlerChrysler	DaimlerChrysler	BMW
Ford	Ford	Ford	DaimlerChrysler
General Motors	General Motors	General Motors	Ford
Porsche	Porsche	Volkswagen	General Motors
PSA	Volkswagen	Air International	Robinair
Renault	Dayco	Bergstrom	Snapon
Volkswagen	Denso	Denso	Skye
Fiat	Dow Automotive	Dow Automotive	Inficon
	Parker Hannifin	Eaton	Spectroline
	Trelleborg	Fujikoki	Hickok
	Valeo	Sanden	U-View
	Visteon	Sanyo	RTI
	Hutchinson	Valeo	CPS Products
	Maflow	Visteon	SPX
	Goodyear		Norco
			Shrader Bridgeport
			Neutronics
			Norco Industries

*Refrigerant companies are supporting as indicated on the previous slide

CRP150-1 Risk assessment

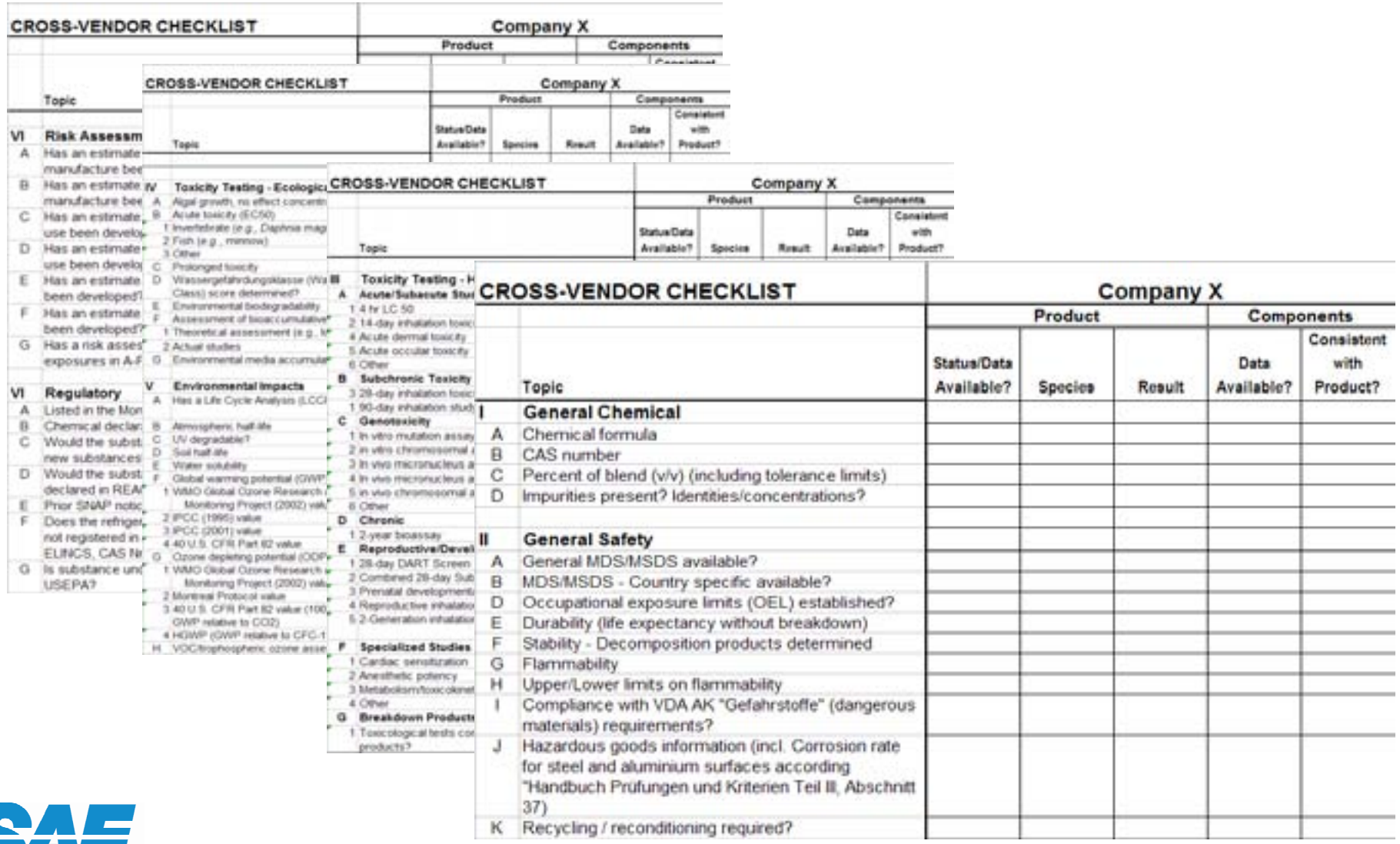
Summary of toxicology information developed

- Inputs are being collected and assessed from each refrigerant supplier

Risk assessment methodology developed

- Modeling of leakage for each refrigerant has begun
- Fault trees are developed
- Failure rates developed

CRP150-1 Toxicology Checklist



CROSS-VENDOR CHECKLIST				Company X				
				Product			Components	
	Topic	Status/Data Available?	Species	Result	Data Available?	Consistent with Product?
I	**General Chemical**					
A	Chemical formula					
B	CAS number					
C	Percent of blend (v/v) (including tolerance limits)					
D	Impurities present? Identities/concentrations?					
II	**General Safety**					
A	General MDS/MSDS available?					
B	MDS/MSDS - Country specific available?					
D	Occupational exposure limits (OEL) established?					
E	Durability (life expectancy without breakdown)					
F	Stability - Decomposition products determined					
G	Flammability					
H	Upper/Lower limits on flammability					
I	Compliance with VDA AK "Gefahrstoffe" (dangerous materials) requirements?					
J	Hazardous goods information (incl. Corrosion rate for steel and aluminium surfaces according "Handbuch Prüfungen und Kriterien Teil III, Abschnitt 37)					
K	Recycling / reconditioning required?					

Risk Assessment Approach

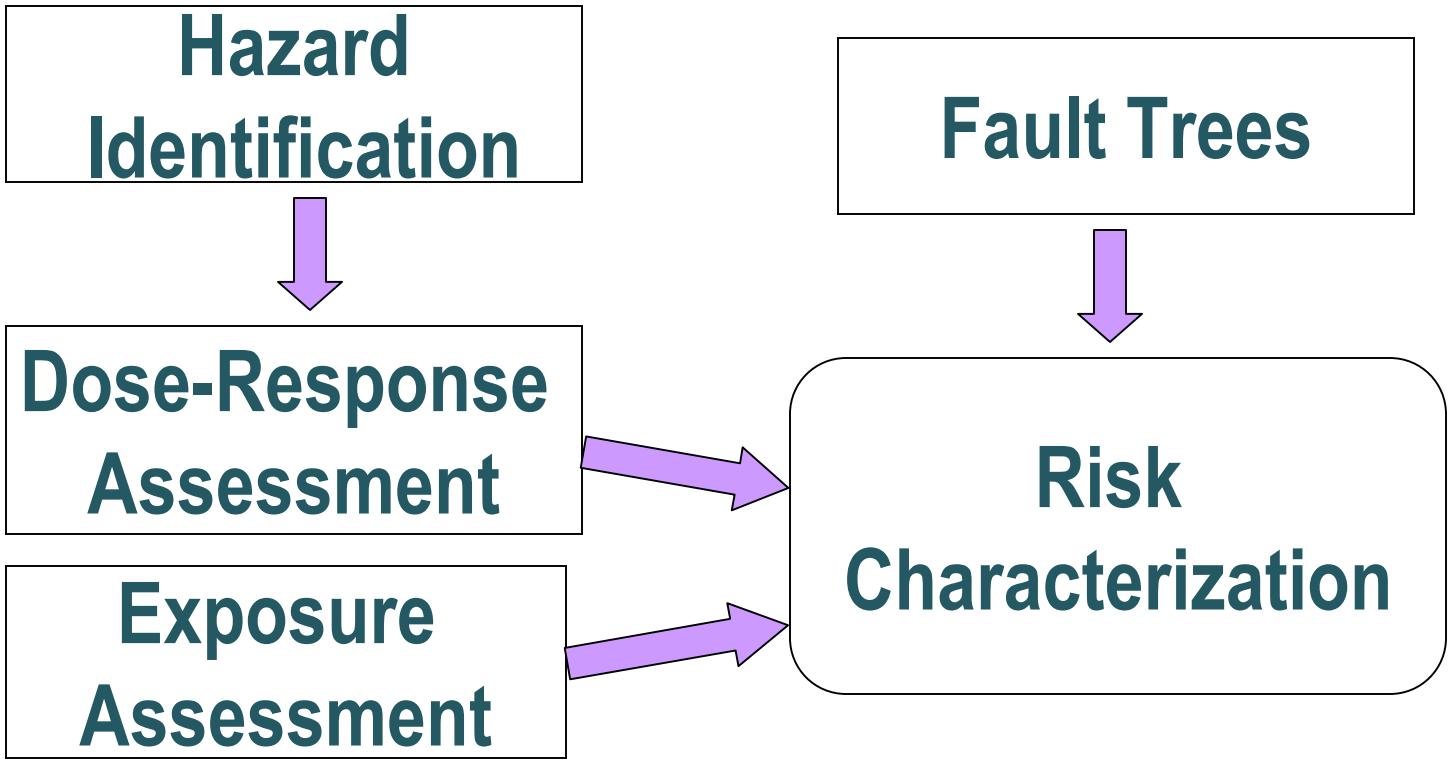
Employ standard risk assessment approach tailored to U.S. EPA Significant New Alternatives Policy (SNAP) issues

Peer reviewed by automotive industry engineers/scientists

An iterative process with new evaluations conducted to address concerns as they arise

Risk Assessment

Employ standard risk assessment approach tailored to address SNAP issues



CRP150-2 Material Compatibility Assessment

All testing completed by independent labs

- Thermal stability
  - Two Temperatures
  - Four refrigerants, with common and different oils
  - Two moisture levels
- Refrigerant/lubricant compatibility
  - Solubility
- Elastomer compatibility
  - Four refrigerants, one lubricant for each, two temperatures
  - Different temperatures for high and low temperature materials
- Elastomer permeation
  - Four refrigerants
  - Different temperatures for low and high side hoses

CRP150-2 Metrics

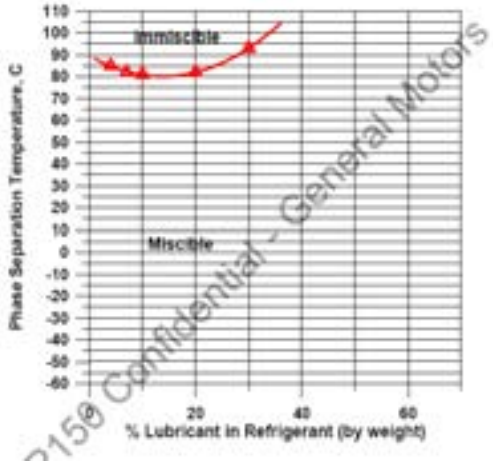
Test Category	Metrics	Targets
Thermal stability	1. Coloration 2. TAN 3. Refrigerant breakdown	1. Total Acid Number < 3.3 2. Total Organic Acids < 600 ppm 3. Halide Concentrations < 240 ppm
Refrigerant/lubricant compatibility	-40 to 100 C solubility	Similar to R134a and ND8 oil
Elastomer compatibility	1. Hardness Change (shore A) 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 Selective leakage quantified	1. Total leakage Equivalent to R134a 2. Selective leakage to cause less than +/- 5% shift in concentration

CRP150-2 Results

- Thermal Stability
  - Four refrigerants tested several with multiple oils
    - Oil/refrigerant mixture was 1:1 for all tests [others test at different mix percentages]
    - Some issues identified which will require further lubricant development

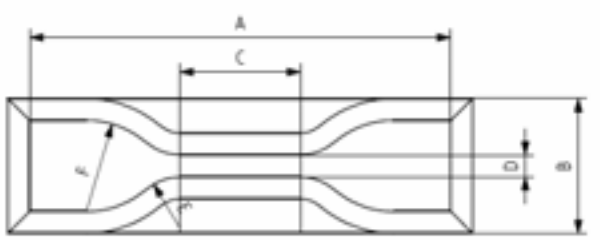
Figure 1: Photograph of Sealed Tubes After Aging at 190°C for 24 hr

- Miscibility
  - Four refrigerants tested
    - Miscibility similar to R134a/ND8

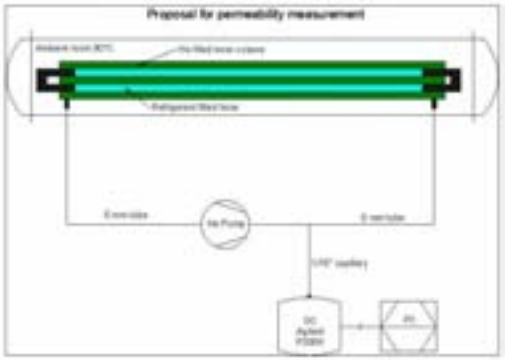


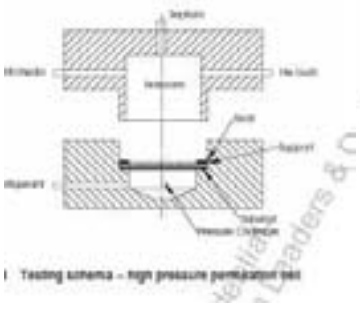
CRP150-2 Results

- Elastomer Compatibility
  - Four refrigerants tested with nine hose materials and six sealing materials
    - Some hoses found to be incompatible
    - Most elastomers acceptable



- Elastomer permeation
  - Four refrigerants tested with nine hose materials and six sealing materials
    - Levels of selective permeation identified
    - Some of new refrigerants leaked less than R134a and some more than R134a





CRP150-3 System Performance Assessment

System performance done at independent lab

- Dual and single evaporator systems with fixed compressor
  - Charge determination
  - Performance
  - Temperature distribution
  - Frost sensitivity
- Evaluation items
  - Effect of various refrigerant mixture percentages
  - Effect of new components [IHX] [single evaporator only]
  - Effect of different heat exchangers
  - Effect of changes to plumbing

Proposed CRP150-3 Metrics

Test Category	Metrics	Target
Charge	Sensitivity relative to R134a baseline	Charge tolerance similar to R134a
Performance	1. Capacity vs R134a 2. COP vs R134a	Tests were run at equal capacity to R134a using speed ratio COP should be equal or better than R134a baseline
Temperature distribution	Sensitivity relative to R134a baseline	Distribution should be no worse than R134a at high and low loads
Frost	Sensitivity relative to R134a baseline	Frost shall not be observed. [thermistor location optimized based on minimal testing]

CRP150-3 Results

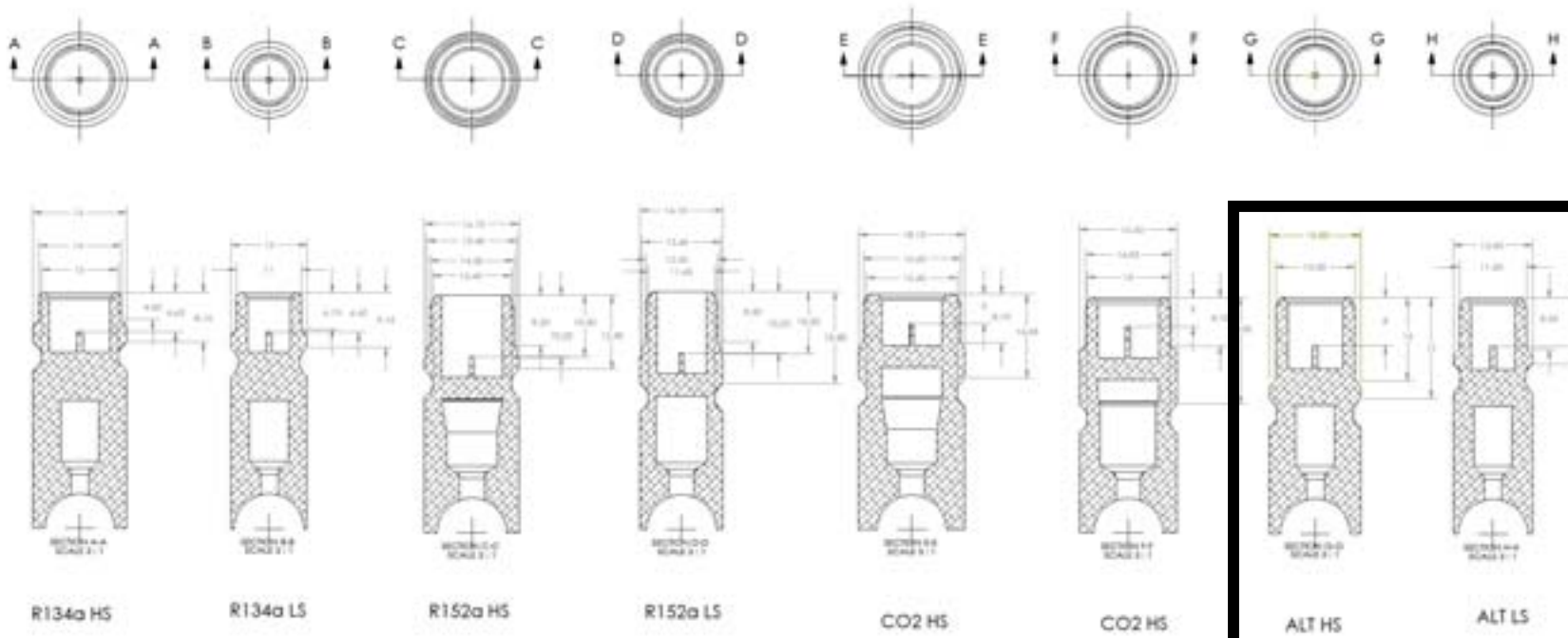
- Dual Evaporator system
  - Two new alternative refrigerants completed
    - COP is better on one and worse on the other as compared to R134a
    - Some frosting observed with one of the alternatives
- Single Evaporator system
  - One new alternative refrigerant completed
    - Results are under evaluation

CRP150-4 Service Impact assessment

Initial formation meeting 02FEb07 at MACS convention

- New service fitting proposal is developed
  - Service hose and quick coupling is also needed
- Questions from Service Organizations reviewed with three of four refrigerant companies
- Refrigerant charge and reclaim equipment standards will be developed
  - New equipment will be required
  - Venting is not permitted
  - May require refrigerant be returned for re-formulation prior to reuse
- Safe handling standard may be required

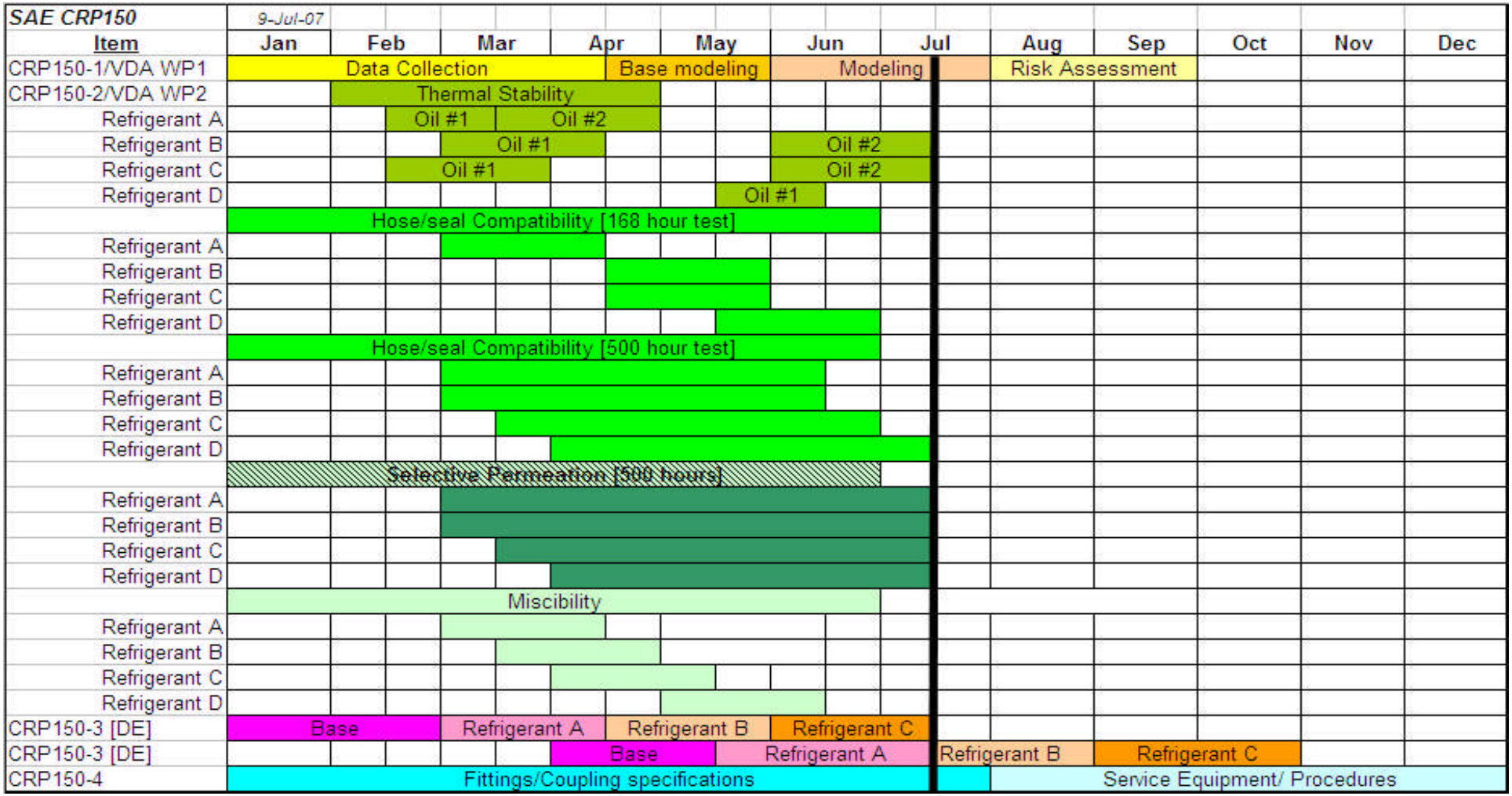
Fitting proposal



Current J639 Service Fittings

Proposed Fitting For new Refrigerant

Timing Overview



CRP150 Summary

Risk assessment is underway

Thermal stability testing complete

- Additional work is on-going with alternate oils

Permeation testing, solubility testing, and elastomer compatibility complete

- Most materials performed acceptably

Performance testing is on-going

- TXV development established
- Charge sensitivity understood
- Frosting issues understood
- Performance and COP issues understood