Executive Summary

From 2006 to 2009 SAE International administered a cooperative research project (CRP1234) which evaluated R-1234yf, a new low global warming potential (GWP) automotive refrigerant. Using fault tree analysis (FTA) the results of the CRP1234 assessment showed that the risk associated with the use of R-1234yf in automotive vehicles is well below those commonly considered acceptable by the general public and regulatory agencies. The risk assessment was submitted to the U.S. Environmental Protection Agency (US EPA) as part of the Significant New Alternatives Policy (SNAP) approval process, and the US EPA subsequently approved R-1234yf for use in US vehicles.

In the EU, manufacturers are required to comply with the Mobile Air Conditioning (MAC) Directive (2006/40/EC) for new vehicle types effective 1 January 2011 with enforcement deferred to vehicles built on or after 1 January 2013. The EU commission has supported the introduction of R-1234yf as this meets the requirements of the MAC Directive. Manufacturers who have certified new vehicle types to this directive are obliged to build vehicles from 1 January 2013 with a low global warming potential (GWP) refrigerant.

On September 25, 2012 the German automotive manufacturer Daimler issued a press release suggesting that new testing conducted by the company had shown R-1234yf to pose a greater risk of vehicle fire than was estimated by the CRP1234 analysis. To address the Daimler claims, a new CRP (CRP1234-4) was organized in October of 2012. All OEMs were invited to attend.

After extensive testing and analysis, the new CRP concluded that the refrigerant release testing completed by Daimler was unrealistic. Their testing created extreme conditions that favored ignition while ignoring many mitigating factors that would be present in an actual real-world collision.

With this in mind, the new CRP, with input from Daimler, initiated two new fault tree scenarios to realistically address these claims. The new CRP also reviewed and analyzed extensive new OEM test data which was used to complete the new FTA. The two new fault tree scenarios consider the possibility of an individual being unable to exit the vehicle due to a collision or a

non-collision event that involves a refrigerant/oil release, the refrigerant/oil being ignited and the fire propagating. The FTA examined average risks across the entire global fleet and used a number of conservative assumptions to ensure that the final risk estimate would be more likely to overestimate rather than underestimate actual risks.

Based on the updated analysis, the estimated overall risk of vehicle fire exposure attributed to use of R-1234yf is conservatively estimated at 3 x 10^{-12} events per vehicle operating hour. This is nearly six orders of magnitude less than the current risk of vehicle fires due to all causes (approximately 1 x 10^{-6} per vehicle operating hour) and also well below other risks accepted by the general public. The table below shows the current overall risk of occupant exposure to adverse events based on R-1234yf usage is on the same order of magnitude as that estimated in the prior work of CRP1234. Therefore, the conclusions of the former CRP risk assessment are still valid: risks are still very small compared to the risks of a vehicle fire from all causes and well below risks that are commonly viewed as acceptable by the general public. All OEMs in the new CRP have indicated agreement with these conclusions. The members* are European, North American and Asian OEMs: Chrysler/Fiat, Ford, General Motors, Honda, Hyundai, Jaguar Land Rover, Mazda, PSA, Renault and Toyota.

Event	Probability per vehicle per operating hour	Citation
Probability of being in a police reported vehicle collision	4 x 10 ⁻⁵	NHTSA, 2013
Probability of automotive vehicle fire (any cause)	1 x 10 ⁻⁶	Ahrens, 2013; FHA, 2009
Probability of vehicle collision due to vehicle brake failure	3 x 10 ⁻⁷	New York State DMV, 2008
Probability of dying in a regularly scheduled plane trip in a developed nation	7 x 10 ⁻⁸	Barnett, 2011
Estimated probability of vehicle occupant/former occupant experiencing HF exposure above health based limits associated with an R-1234yf ignition event	5 x 10 ⁻¹²	CRP1234, 2009
Estimated probability of vehicle occupant being exposed to a vehicle fire due to R-1234yf ignition (due to leak and ignition in engine compartment)	3 x 10 ^{.12}	Current analysis
Estimated probability of vehicle occupant being exposed to an open flame due to R-1234yf ignition (primarily due to leak and ignition in cabin)	9 x 10 ⁻¹⁴	CRP1234, 2009

Probability of Various Adverse Events Compared to Estimated Probability of Events Associated with Vehicle Operation-Related Leaks of R-1234yf

*Daimler, BMW and Audi initially participated in the new CRP but eventually chose to withdraw.