Thoughts Concerning Recent DUH Testing

DUH Findings Add No New Information

- Recently released DUH material does NOT show 1234yf to be more dangerous than previously thought:
  - DUH test results provide no new information
  - The potential for HF formation during non-collision-related vehicle fires was included in the SAE CRP1234 2009 analysis
  - The risk from these scenarios was 2×10^{-12} per operating hour
- DUH tests show the amount of HF generated is relatively low
  - DUH tests showed a peak of ~43ppm and a 10 minute TWA of 17 ppm
  - These are NOT HF concentrations that will produce serious irreversible damage for short-term, non-recurring exposures
    - Machle and Evans (1940) reported that exposure of workers to average HF concentrations ranging from 14 to 27 ppm *intermittently for 5 years* produced no adverse effects
  - The MAK value of 1 ppm is meant for 8 hours per day for EVERY day of the working lifetime (30 years) which is inconsistent with the vehicle fire situation
- HF exposure occurs while extinguishing building fires (Fent and Evans, 2011; Jankovic et al., 1991) so firefighters already manage this issue

Thoughts Concerning DUH Test Methods

- HF produced in a vehicle fire will occur as a gradient of concentration, outward from the vehicle
  - HF is a strong irritant: pinching/smarting of eyes, chest tightness, highly irritating to the point of being intolerable
  - The irritancy threshold is < 5 ppm
  - Individuals will leave the area or take action to protect themselves before experiencing significant exposures
- DUH measurements were downwind of the fire
  - Firefighters position themselves upwind of fires to minimize exposures
- DUH did not report on testing with R-134a or without refrigerant
  - HF is already produced in vehicle fires, from R-134a but also from other fluorine containing parts (e.g., seals, wiring harnesses, hoses)
  - The experimental work at INERIS show that R-134a and R-1234yf produce similar amounts of HF in a complete combustion situation
  - After 60+ years of using R-12 and R-134a, there has been no identified risk of adverse effects attributable to HF from fluorinated refrigerants in vehicle fires

Thoughts Concerning DUH Test Methods

- Studies of vehicle fires indicate that other fire byproducts (for example CO, HCN, dioxins, benzene, formaldehyde) will be more significant than exposure to any HF produced
  - Many do not have the warning property of HF's irritancy
  - HF is not identified as a significant health concern in these studies
  - For example Lönnermark and Blomqvist (2006) reported CO concentrations at 200 ppm, HCN at 6 ppm, HCl at 35 ppm along with lesser amounts of the carcinogens benzene, formaldeyde, dioxins, lead and arsenic
- Overall the DUH test results do not provide information that would change the conclusions from all phases of the SAE CRP1234 risk assessment that R-1234yf can be safely used in MAC systems

R-134a and R-1234yf Both Produce HF at Less than Ignition Temperatures

- Temperatures in the engine compartment during a vehicle fire will be well above 1000°C
  - Such temperatures are enough to cause decomposition of both R-1234yf and R-134a
- KBA measured HF production in the engine compartment at approximately 700°C:
- KBA tests with R-134a and R-1234yf under identical conditions
  - Test 17 (R-1234yf) HF = 3.57 ppm
  - Test 21 (R-134a) HF = 3.12 ppm