

Flammable Refrigerants

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Outline

- Flammable Fluids in Vehicles
- Characteristics and Definition
- Use in Stationary and MAC
- U.S. EPA Policy
- Risk Screens

Use in Motor Vehicles

- Flammable fluids are widely used on vehicles
 - Mainly as fuel, lubricants and hydraulic fluid
 - Often with safety mitigation to reduce risk
- Flammable fluids offer many advantages
 - Engine starting, power, economy, toxicity...
- Environmental and safety tradeoffs

Most, Not All Power Sources Are Flammable

- Diesel
- Gasoline
 - Complex mix of hydrocarbons
- Compressed Natural Gas
 - 70-96% methane, 1-14% ethane, others
- Liquefied Petroleum Gas
 - Primarily mix of propane and butane
- Hydrogen
- Electric (ignition source not fuel)

Flammability is Not All the Same

- When is the fluid flammable?
 - Lower Flammability Limit (LFL)
 - Upper Flammability Limit (UFL)
- What is the ignition source?
 - Flame vs. spark
 - Minimum ignition energy
- Is the fluid at the ignition source?
 - Density, air movement
- What are the consequences?
 - Temperature, energy, byproducts, etc.

Flammability is Not All the Same

Fluid	Formula	LFL [%v/v]	UFL [%v/v]	Auto-Ignition Temp [°C]	Heat of Combustion [Btu/lb]	Density at 20C [kg/m ³] (air=1.21)
methane	CH ₄	4.8	16.3	540-705		0.67
ethane	C ₂ H ₆	2.9	13.0	510-630		1.25
propane	C ₃ H ₈	2.0	10.1	450-510	21,625	1.83
n-butane	C ₄ H ₁₀	1.5	10.3	405-510	21,281	2.41
isobutane	C ₄ H ₁₀	1.0	10.0	420-530	21,195	2.47
hydrogen	H ₂	4.0	75.0	520	~55,000	0.083
R-152a	C ₂ H ₄ F ₂	3.7	20.2	455	7,266	2.81

Definition of Flammable

- ASHRAE Standard 34, ISO Standard 817 don't define *flammable*
- But they do classify refrigerants based on flammability under standard tests (e.g., ASTM E681)
 - ASHRAE Standard 34 classifies refrigerants as 1, 2 or 3 based on LFL and HOC
 - ISO 817 draft suggests classification of 1, 2L, 2H or 3 based on LFL, HOC and burning velocity
 - Auto-ignition temperature is NOT a criterion

Use of Flammable Refrigerants

- Pre-CFC days
- HCs in centrifugal chillers in petrochemical plants
- Wide use of ammonia in various refrigeration and air conditioning applications
- HCs in some modern refrigerators
- HCs in a small percentage of chillers, room ACs, etc.
- Illegal, unadvised use of HCs in MACs in U.S., Australia, elsewhere

Flammable Refrigerants Can Be Safe

- Engineering and Training allow for safe use
 - Workers in petrochemical plants deal with flammable fluids regularly
 - Ammonia often located in isolated locations (e.g., by use of secondary loops) to reduce risk of general consumer exposure
 - HC refrigerators use sealed or non-sparking electrical devices, avoid brazing on charged systems, protect refrigerant systems from damage to help avoid leaks, etc.
 - No consumer MAC has been designed to use flammable refrigerant

Guidance for Safe Use

- Guidelines and Standards provide limitations and recommended practices
 - ASHRAE Standard 15 (Safety Code for Mechanical Refrigeration)
 - ISO Standard 5149 (Mechanical Refrigerating Systems Used for Heating and Cooling – Safety Requirements)
 - CEN Standard EN 378 (Safety and Environmental Requirements for Refrigeration Systems and Heat Pumps)
 - ACRIB (Guidelines for the Use of Hydrocarbon Refrigerants in Static Refrigeration and Air Conditioning Systems)
 - SAE J639 (Safety Standards for Motor Vehicle Refrigerant Vapor Compression Systems)

ACRIB 2000 Safe Use Guidance

Maximum HC Charge per ACRIB 2000	Sealed System	Special Machinery Room	Outdoors
Domestic & Public Applications	< 1.5 kg	< 5 kg	< 5 kg
Commercial Private Applications	< 2.5 kg	< 10 kg	< 10 kg

Accidents Have Occurred

- Beer cooler incident in Australia
- Converted Porsche using Enviro-Safe in U.S.
- Demonstration in Australia resulting in hospital trip
- U.S. Department of Justice reports:
 - 10/19/95, Orange County, CA: charging while engine was still hot
 - 8/18/96, Gulfport, MS: low pressure hose from evaporator blew off
 - 9/27/96, Danville, AR: torch used on truck AC unit after venting refrigerant

U.S. EPA Policy on Flammable Refrigerants

- Significant New Alternatives Policy (SNAP) Program regulates ODS substitutes
- Substitutes include retrofit and new systems
- HFC-152a allowed in domestic refrigerator/freezers (3/18/94)
- Certain HCs allowed in Industrial Process Refrigeration (3/18/94)
 - EPA recommended that HCs “be used only at industrial facilities that manufacture or use hydrocarbons in the process stream”

U.S. EPA Policy on Flammable Refrigerants for MACs

- Certain HCs specifically prohibited in MACs (3/18/94)
 - Information provided did not adequately characterize risk
 - Four petitions have been submitted; all denied
 - EPA was sued; EPA decision was backed by court of law

	Submitted	Response
1	Nov 1994	Sept 1995
2	Dec 1995	Aug 1996
3	May 1998	Nov 1998
4	July 2003	Jan 2004

U.S. EPA Policy on Flammable Refrigerants for MACs

- All flammable refrigerants (includes HFC-152a) specifically prohibited (6/13/95)
- HFC-152a (and CO₂) expected to be acceptable for new MAC systems with use conditions to mitigate risk
 - Proponents are not selling or suggesting HFC-152a should be used as a retrofit gas
 - Industry/EPA cooperative risk assessment
 - Risk is comparable to new CO₂ MAC systems (i.e., if concentration is below a threshold of concern, risk is low)

Other Considerations

- Some States prohibit HC use in MACs
- “Since no valid risk assessment addressing the safety of HC refrigerants in either type of system has yet been submitted under the SNAP program, EPA does not believe that HC refrigerants have been proven to be a safe substitute for either CFC-12 or HFC-134a in motor vehicle air conditioning systems.” – www.epa.gov

Risk Screen Elements – Leaks

- Containment reliability
 - During lifecycle of refrigerant and product manufacture, transport, use, service, disposal
- Exposure to
 - Service personnel, vehicle occupants, etc.
- Leak detection
 - Background level and noise (CO₂ and HCs)
 - Time to threshold level of concern vis-à-vis identification and mitigation system activation
- Mitigation of concentrations above threshold level of concern

Risk Screen Elements – Fire

- Amount of refrigerant used/leaked (charge size)
- Refrigerant properties (LFL, HOC, etc.)
- Likelihood of ignition
- Consequences of ignition
- Mitigation of consequences

Risk Screen Elements

- HC contamination of existing systems does NOT prove safety
- Use in other applications does NOT prove safety
- Past and current use does NOT prove safety
- “Large” sales volume does NOT prove safety
- Claiming no reported fires does NOT prove safety

A background image of a bright blue sky filled with soft, white, fluffy clouds. The clouds are scattered across the frame, creating a serene and airy atmosphere. The text 'Thank you' is centered in the middle of the image.

Thank you

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