Inertion of Flammable Refrigerants by HFC-227ea

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HFC-227ea

1,1,1,2,3,3,3-Heptafluoropropane

$$CF_3CHFCF_3$$

Fire suppression: FM-200™

> 10,000 FM-200™ systems installed worldwide

Propellant

Metered dose inhaler

Refrigeration

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HFC-227ea Refrigerant Mixtures:

Component Selection

- Zero ODP
- Nontoxic
- Chemically Stable
- Commercially Available
- Boiling Point within 70 °F of HFC-227ea

- Suitable Components:
  - HFC-32, HFC-125, HFC-134, HFC-134a, HFC-143
  - HFC-143a, HFC-152a, RC-270, R290, R600a, DME

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HFC-227ea Refrigeration Mixtures: Flammability

- Mixture Flammability
  - Explosion sphere
  - Flammability diagram
  - Reveals minimum molar ratio of agent to fuel required to render mixture nonflammable

- Leakage
  - Fractionation possible with zeotropic mixtures
  - Composition of vapor phase changes during leakage
  - Knowledge of vapor-liquid equilibrium required to determine minimum molar ratio of agent to fuel to render mixture nonflammable

Inertion of Flammable Refrigerants by HFC-227ea

Fuel	Flammability Limits Lower	Flammability Limits Upper	Inerting Conc., % v/v	Min. Molar Ratio HFC-227ea:Fuel
Methane	5	15	8.0	-
Propane	2.1	9.7	11.6	3.7
i-Butane	1.8	8.4	11.3	-
Pentane	1.5	7.4	11.6	5.0
Heptane	1.1	7	7.7	-
152a	5.1	17.2	8.7	1.3
32	14	31	3.6	0.21
142b	6.0	15.0	2.6	0.23
EO	3.0	80.0	13.6	2.8

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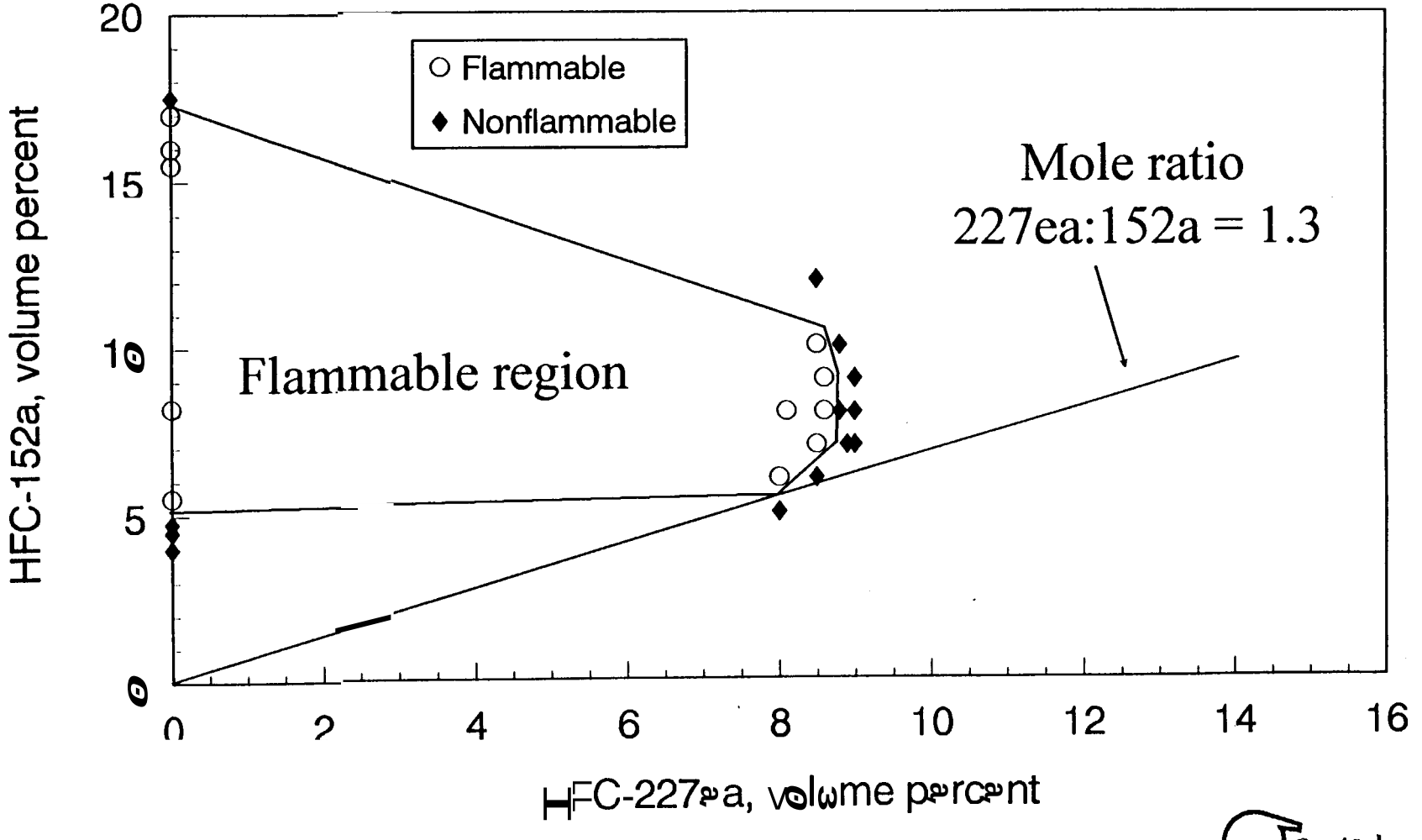
Flammability of HFC-227ea/HFC-152a Mixtures in Air



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HFC-22 ea Refrigerant ixtures:

Composition of Leaking Vapor

- Account for changes in vapor phase composition during leakage

- Assume:
  - Raoult's Law applies
  - Vapor and liquid in equilibrium
  - Specific amount of vapor removed and replaced with new vapor from liquid
  - Equilibrium re-established
  - Ideal gases

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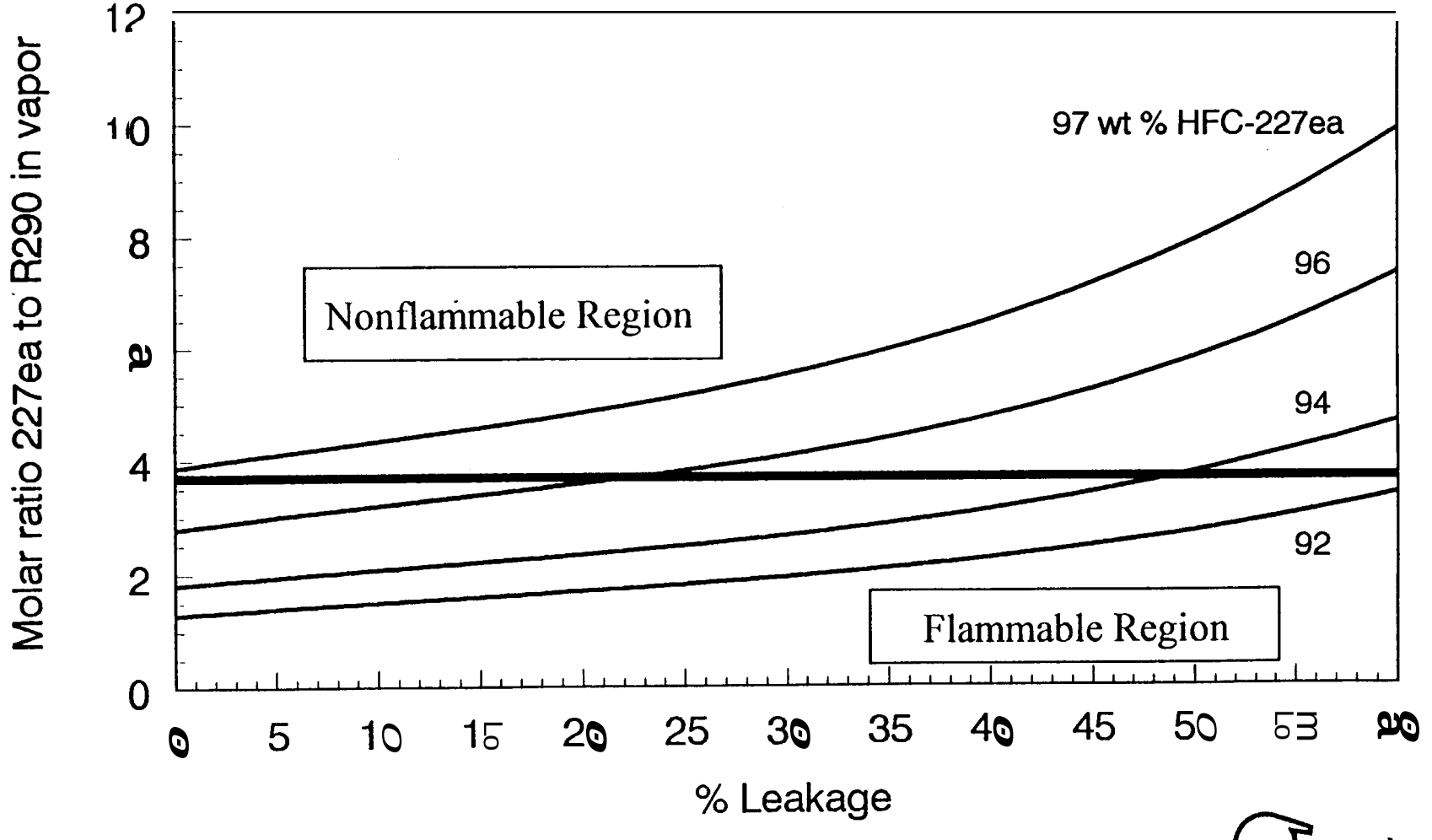
Ratio of HFC-227ea to R290 in Vapor Phase

Leakage Calculation



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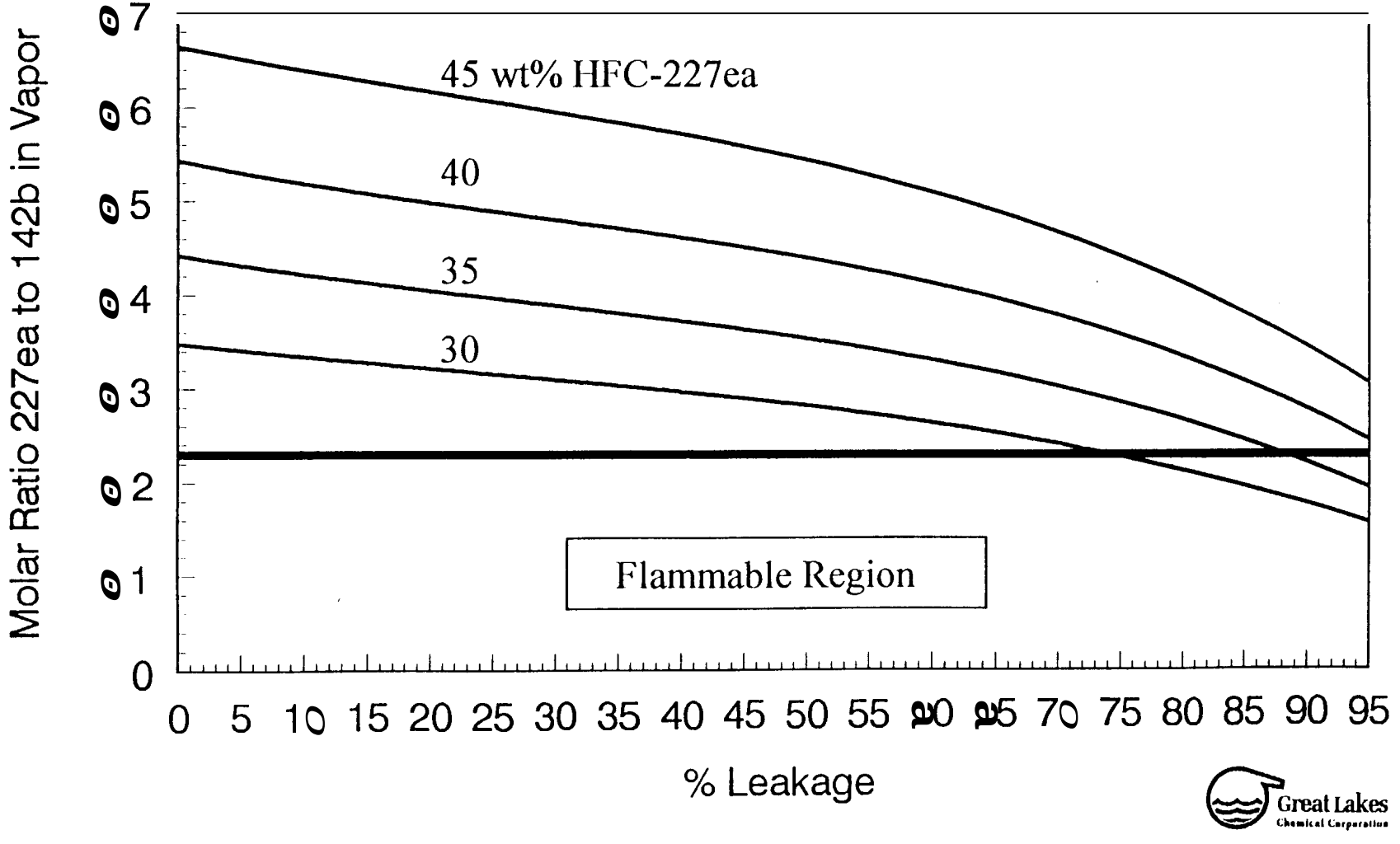
Ratio of HFC-227ea to HCFC-142b in Vapor Leakage Calculation



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Explosion Drum Test

- 55 gallon drum
- Open end covered with clear polyethylene film
- Electric arc at drum midpoint
- Small fan for mixing

- Flammable
  - Audible sound
  - Drum perceptibly hot
  - Polyethylene cover ruptured
  - Flame observed

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HFC-22 ea/HFC-152a Mixtures

Explosion Drum Test Results

- 37 wt % HFC-152a Nonflammable
- 40 wt% HFC-152a Nonflammable
- 50 wt% HFC-152a Flammable

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HFC-22 and Refrigerant Mixtures:

Performance Criteria

- COP equal to that of current agent
- Discharge pressure less than 380 psia
- Suction pressure greater than 15 psia
- Discharge temperature less than 300 °F

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HFC-227ea Refrigerant Mixtures:

Performance Evaluation

- Theoretical Cycle Simulation Models
  - Cycle 7
  - Cycle 11
  - Cycle Z
  - HPSIM
- Experimental Performance

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HFC-227ea Refrigerant Mixtures

Theoretical Performance: Cycle 7, Cycle Z

- HFC-227ea/HFC-32
  - Low temperature applications
  - NARM
- HFC-227ea/HFC-152a
  - Cold storage, process chilling, automotive
  - Near azeotropic mixture

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HFC-227ea/HFC-152a Mixtures: Refrigerator Test

- Test Conditions
  - AHAM HRF-1-1988, Section 8
  - 16.6 cubic foot Frigidaire refrigerator/freezer
  - POE lubricant
  - Charge optimized
  - Expansion device unaltered
- Test Results
  - Energy consumption (kWh/day) 4% more than with R12
  - No compatibility problems

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HFC-227ea/HFC-152a Mixtures[e]
Automotive Applications

- Test Conditions
  - 2.5 ton Chevy pickup truck
  - R12, lubricant removed
  - POE lubricant
  - 63:37 weight ratio HFC-227ea:HFC-152a
  - Charge optimized

- Test Results
  - No noticeable effect on performance
  - No noticeable effect on gas mileage

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Inertion of Flammable Refrigerants by HFC-227ea:

Summary

- Inertion of hydrocarbon refrigerants requires 90 wt% or more HFC-227ea
- HFC-32/HFC-227ea mixtures containing up to approximately 40 wt% HFC-32 are nonflammable
- HFC-227ea/HFC-152a mixtures containing up to approximately 40 wt% HFC-152a are nonflammable

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