



R441A
An EPA-
Approved
Multi-blend

Pure
Hydrocarbon
Refrigerant

Air-Conditioning and
Refrigeration Applications

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R441A

- A pure multi-blend hydrocarbon refrigerant
- First in the HCR188C line of efficient, climate-friendly refrigerants
- In use in USA for 15 years; US and int'l patents
- Designated R441A by ASHRAE 34 Committee
- First EPA SNAP-Approved HC for sale in the U.S.
- Designated replacement for R134A
- Available for purchase from ComStar International (New York NY)

R441A Formula/Properties

- Pure multi-blend hydrocarbon refrigerant
 - Ethane
 - Propane
 - Isobutene
 - n-Butane
- Zero Ozone Depletion Potential (ODP)
- Very low Global Warming Potential (GWP)
- National Fire Protection Association Ratings: Red 4, Blue 1, Yellow 0



R441A Target Applications

- Commercial/residential refrigerators and freezers
- Residential window air-conditioning systems
- Automotive air-conditioning systems
- Vending machines
- Refrigerated transportation systems
- Refrigerated display cases

Multi-Blend HC Advantages

- Single hydrocarbons can only be used under one set of operating conditions
- Multi-blend HCs can have operational properties “tuned” to the application
 - Significantly reduced charge rates
 - Higher energy savings
 - Lower risk of flammability
 - Smaller size system components/reduced wear
 - Improved cooling capacity
 - Faster cooling operation

R441A

Research & Development

- In development since 1997
- Performance testing conducted by independent laboratories; examples:
 - 2007 – wind-tunnel automotive a/c system vs. R134A
 - 2011 - lab-bench refrigeration system vs. R134A
- Material property testing and risk assessment by Texas Oil Tech Laboratories, Whitmyre Research, Chemir Analytical Services and Safety Consulting Engineers

R441A Case 1: Whirlpool Residential Refrigerator

- **Intertek Testing Services** - Cortland, NY – tested Whirlpool 18 cu-ft residential refrigerator (April 2007); measured performance first with R134A, then with vs. R441A
- Tested with 25% charge rate: held same refrigerator temp; freezer 5 degrees colder; 67% energy draw yet 1/4 volume and lower cost
- Still in use in employee cafeteria (5 years+)

R441A Case 2:

Haier Residential Refrigerators

- **Haier America** – tested 2.7 cu-ft and 18.2 cu-ft Haier refrigerators (July 2008)
 - Measured performance first with R134A, then with 25% charge volume of R441A
 - Cooling same or within 2 degrees, at $\frac{1}{4}$ volume and $\frac{1}{3}$ cost
- **Intertek**, Edison NJ – tested 21 cu-ft Haier top-freezer/refrigerator (July 2010)
 - Measured performance first with R134A, then with 28% charge volume of R441A
 - Cooling 1 degree better; freezing 10 degrees better, at approx $\frac{1}{4}$ volume and $\frac{1}{3}$ cost

R441A Case 3: Toyota T100 Truck Air- Conditioner

- 1996 new truck (personal)
- Air-conditioning refrigerant replaced with early version of HCR188C in 1998
- 105,000 miles currently
- Pulled out a/c system components for inspection in 2008 – hardly any wear, clean oil; replaced refrigerant with newer R441A formulation
- Still operational and effective a/c in 2012 (Passengers note a/c almost too cold)

R441A Case 4: Toyota Camry automotive air- conditioner

- **Valeo Engine Cooling** - Jamestown, NY; performed wind-tunnel operational air-conditioning testing of 2007 Toyota Camry (June 2007), with R134A vs. R441A
 - Exterior air temp: 109 degrees
 - R441A - Tested at 65 mph/25 mph: interior air 54 degrees/59.4 degrees; tested at park/idle – cooled by 30 degrees (maintained 80 degrees)
 - Used charge rate of 26%
 - R134A - Similar performance at speed; at idle, could only maintain upper 90s temp

R441A Energy Efficiency Test vs. R134A - Intertek

- **Intertek** - Columbus OH, capillary tube test-stand evaluations of R134A to R441A
 - Tested charge rates of 5.05 lb (R134A) and 1.55 lb (R441A) performance
 - Same energy usage
 - 4 degrees cooler with R441A yet at 31% charge rate

R443A: A Pure Multi-Blend HC Replacement for R22

- R443A: Second pure HC blend from A.S. Trust, designed as a replacement for R22
- Designated R443A by ASHRAE 34 Committee
- Operational testing #1: drop-in replacement for R22 in two 100-ton Carrier 50DJ104 Weathermaker IV commercial a/c units at CalExpo fairgrounds - Sacramento CA (July 2011)
 - 4 degree cooling improvement; 9% increase in power efficiency; 5% EER increase; expect even better performance if newer compressor used

R443A: A Pure Multi-Blend HC Replacement for R22 (cont.)

- R443A Operational testing #2: drop-in replacement for R22 in Mitsubishi PUH-J1 60GA 72E00361 split air-conditioning unit (5 hp/ 3.75 kw); Kyozon Technology - Japan (April 2012)
 - R22 – full charge 5.7 kg
 - R443A – charged with 1.7 kg (30%)
 - R22 – energy used: 3.06 kwh
 - R443A – energy used: 2.46 kwh -> **significant energy savings: 20%**

R441A/R443A Lessons Learned

- Benefits of R441A/R443A Multi-Blend HCs
 - Significantly reduced charge rates
 - Higher energy savings
 - Lower risk of flammability
 - Smaller size system components
 - Improved cooling capacity
 - Faster cooling operation
 - Reduced component wear

R441A/R443A Lessons Learned (Cont.)

- Both HC multi-blends are easily produced using existing industrial chemical facilities under standard operating procedures
- Some refrigeration systems would benefit from using a temperature-control system whose parameters could be adjusted to recognize the lower pressure operation of R441A/R443A and cycle accordingly
- Manufacturers could design compressors with increased efficiency to take advantage of the lower refrigerant volumes possible with R441A and R443A

Future Plans for Multi-Blend HCs

- Current pricing \$8/pound (20 lb canister), manufactured in Texas by Comstar Intl (NY)
- Applied for EPA SNAP approval for Refrigerated Transport application
- Awaiting EPA SNAP approval for multiple additional applications and retrofit safety valve (originally developed for automotive applications, but applicable to other HC uses)
- Pursuing US and international manufacturing partnerships

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