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Developing Low Charge R290 Room Air Conditioners Using Smaller Diameter Copper Tubes

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Global Market Overview

- There is a heightened awareness of atmospheric damage from HCFC refrigerants such as R22 and an increasing demand for replacements with low Global Warming Potential (GWP) and low Ozone Depletion Potential (ODP)
- EPA's Significant New Alternatives Policy (SNAP) in 2011 approved HC refrigerants R290, R600a & R441a as acceptable substitutes
- China has aggressively and successfully combined MicroGroove small diameter copper tube technology with R290 refrigerant in window and room air conditioners

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Global Market Overview (continued)

- An estimated 17 million residential air conditioning (RAC) systems are manufactured each year in China
- Major Chinese RAC OEM's include Haier, Midea, Gree, Chigo, Kelon Hisense
- Chinese OEM's already use MicroGroove technology in RAC systems exported to North America
- R290 refrigerant is widely used in domestic Chinese markets as an environmentally friendly refrigerant

Can R290 MicroGroove RAC in North America be far behind?

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Business Factors Supporting the Use of R290 in North America

- 2012 U.S. shipments of central air conditioners and air-source heat pumps totaled 5,613,665 units (source: Air-Conditioning, Heating and Refrigeration Institute).

- Mini-split and split-type AC systems common in China and Europe have similar components and refrigerant requirements as North American central AC systems.

- With R290 approved by SNAP and R290 costs a fraction of R22 and R134a, significant reductions in refrigerant charge from MicroGroove technology can make R290 systems economically viable in North America.

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R290 as a Replacement for R22 Refrigerant

- R290 GWP = 3.5 ODP = ~0
  R22 GWP = 1700 ODP = 0.05

- R290 beneficial properties
  - -Low density allows total refrigerant to be reduced 40% to 60% compared to R22
  - -Thermal conductivity and heat transfer coefficient are higher compared to R22
  - - Low cost; 10% of R22 cost and 5% of R134a
  - - No need for new lubricants
  - - Compressors are now available designed for R290

- R290 concerns ⇨ FLAMMABILITY

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Designing Room Air Conditioners with R290

Structural parameters	Original air conditioner		Designed air conditioner	
	Indoor unit	Outdoor unit	Indoor unit	Outdoor unit
Inner diameter of tube, mm	6.50	8.96	4.60	6.50
Length/Width/Height, mm	228/22/320	708/43.3/480	228/27.2/320	706/36/462
Row Number/Column Number Per Row	2/12	2/20	2/12	2/22
Row space/Column space, mm	11.0 /19.0	21.6/25.4	13.6/19.0	18/21
Bottom Boundary Space of Each Row, mm	4.75, 14.25	6.5, 18.9	4.75, 14.25	5.25, 15.75
Path number	2	2	3	4
Fin Thickness, mm/Fin Pitch, mm	0.105/1.6	0.105/1.8	0.105/1.4	0.105/1.4
Fin type	Louver fin	Wavy fin	Louver fin	Wavy fin
Tube Thickness, mm/Tube Diameter, mm	0.25/7.0	0.28/9.52	0.20/5.0	0.25/7.0

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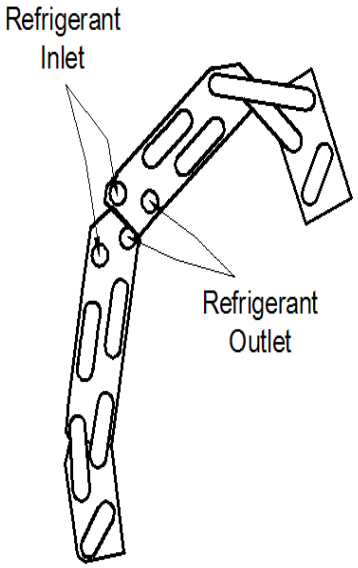
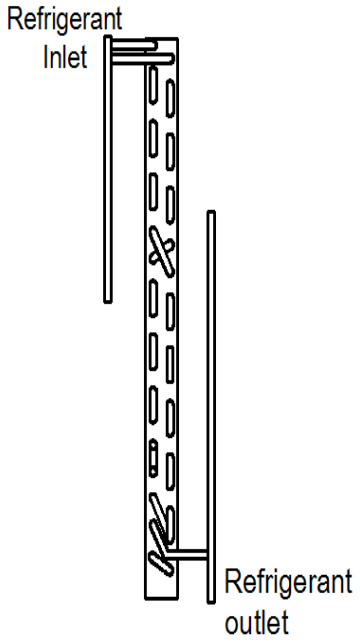
Designing Room Air Conditioners with R290

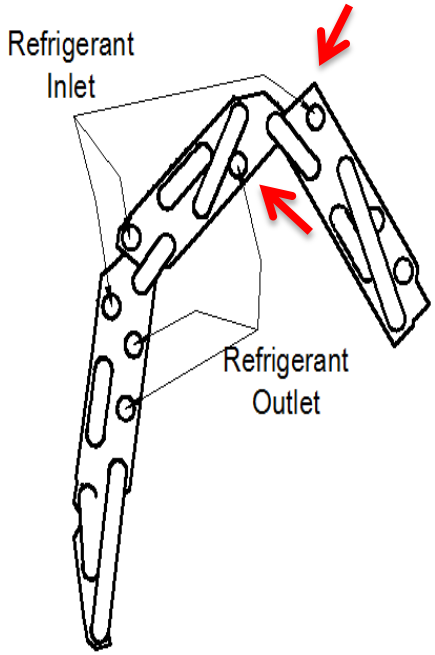


Flow circuits of indoor unit

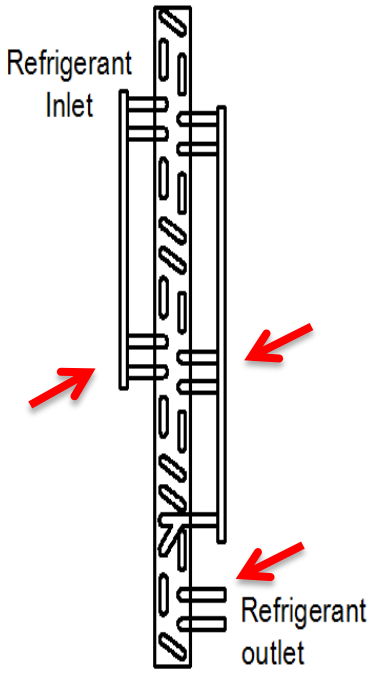


Flow circuits of outdoor unit

Flow Paths – Original Air Conditioner



Flow circuits of indoor unit



Flow circuits of outdoor unit

Flow Paths – Designed Air Conditioner

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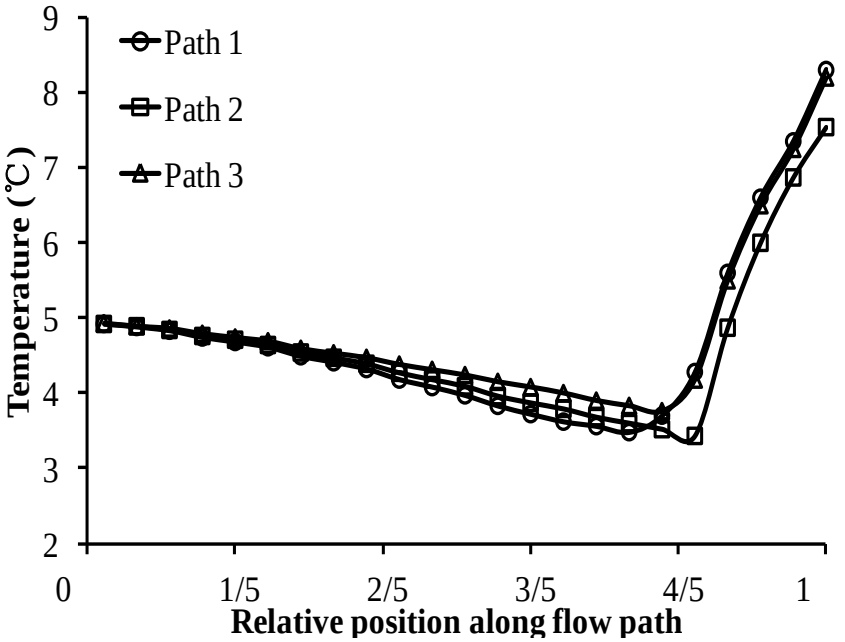
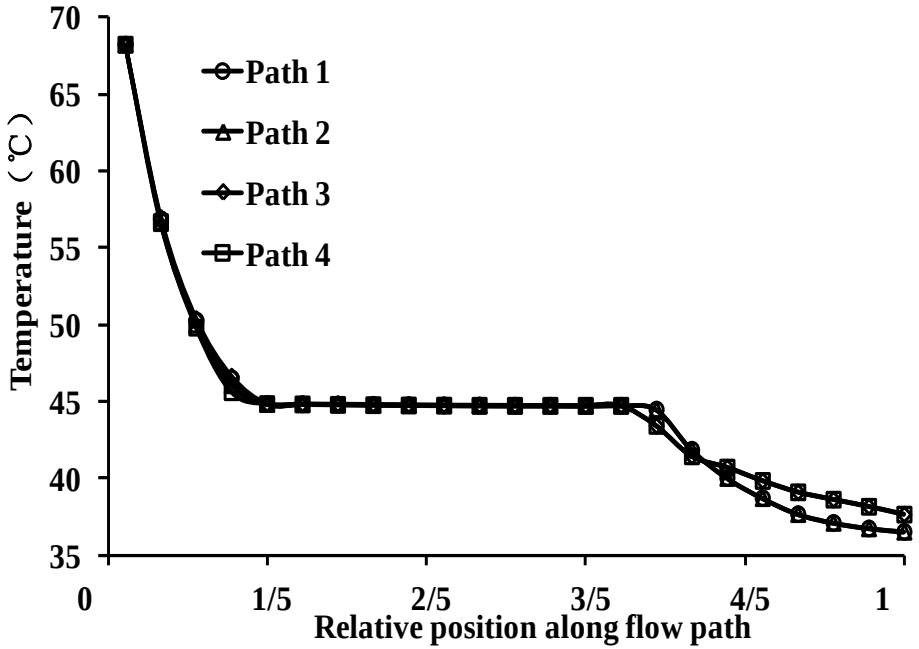


Temperature Distribution – Indoor Unit



Temperature Distribution – Outdoor Unit

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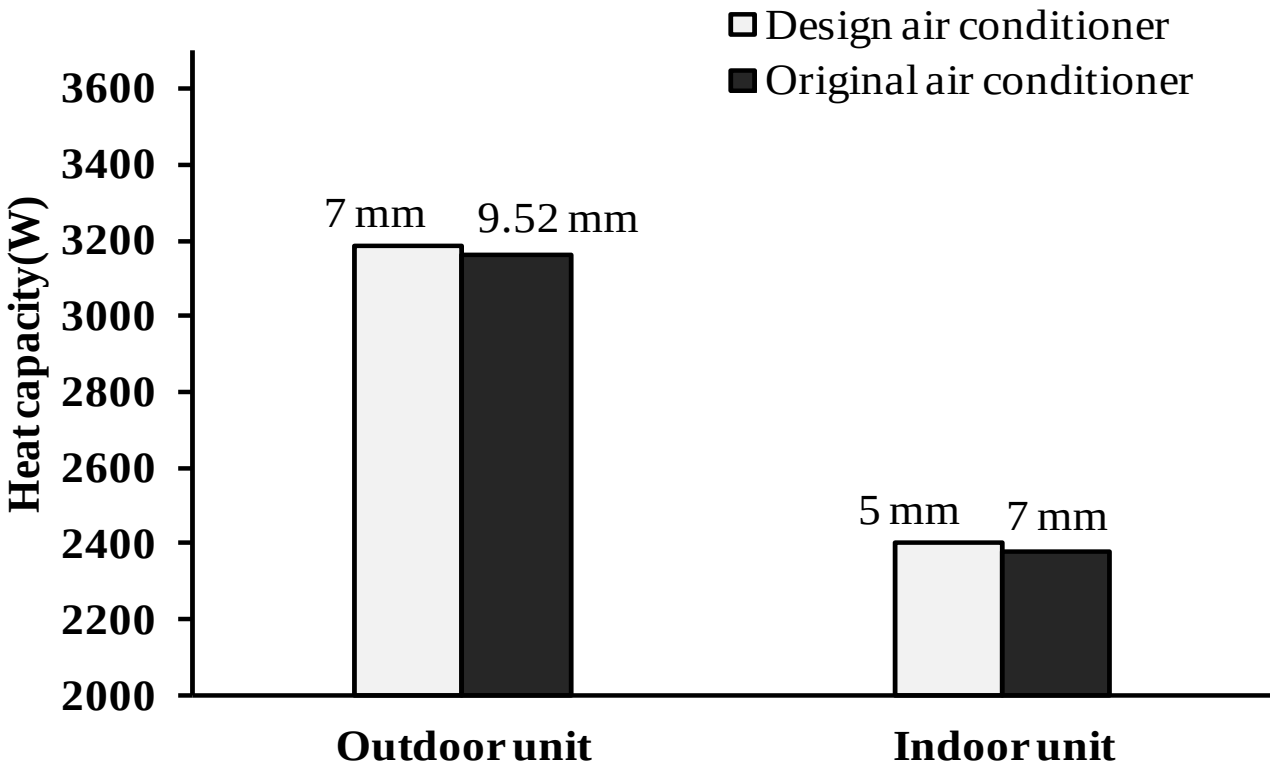

Heat Capacity (W); Original vs. Designed Air Conditioners

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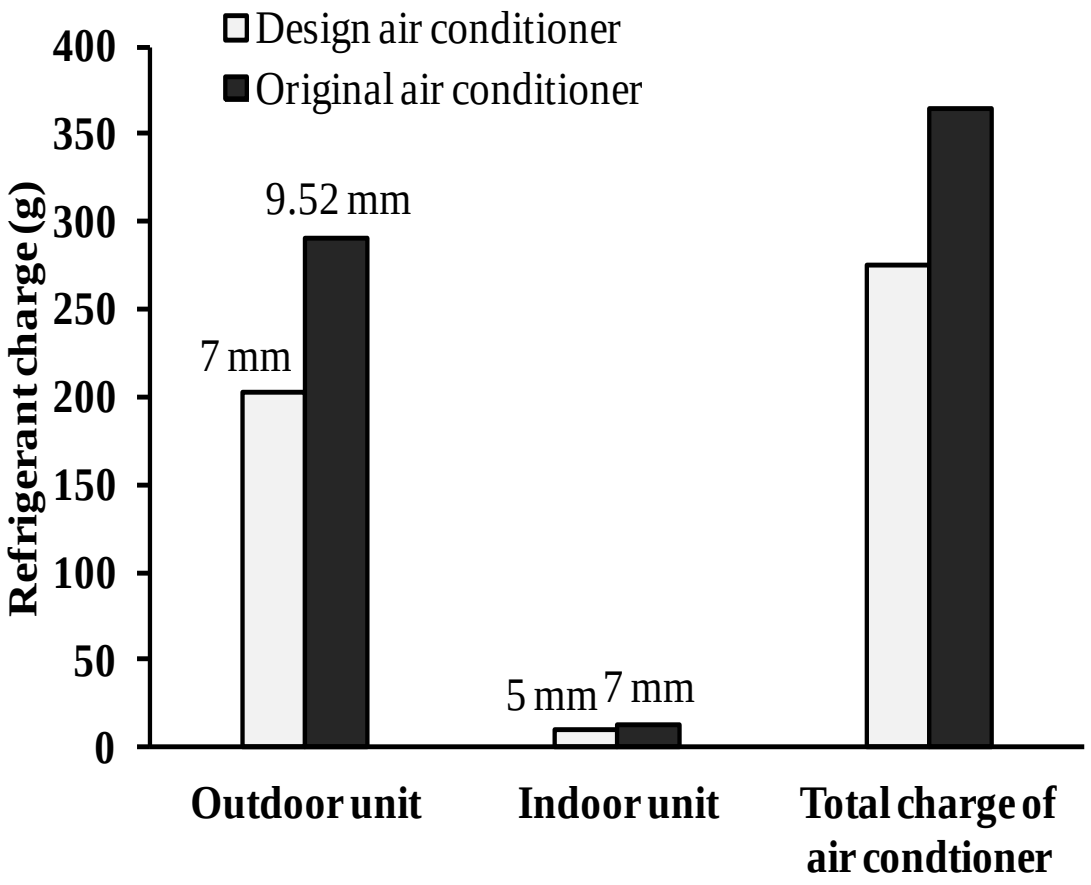

Refrigerant Charge; Original vs. Designed Air Conditioners

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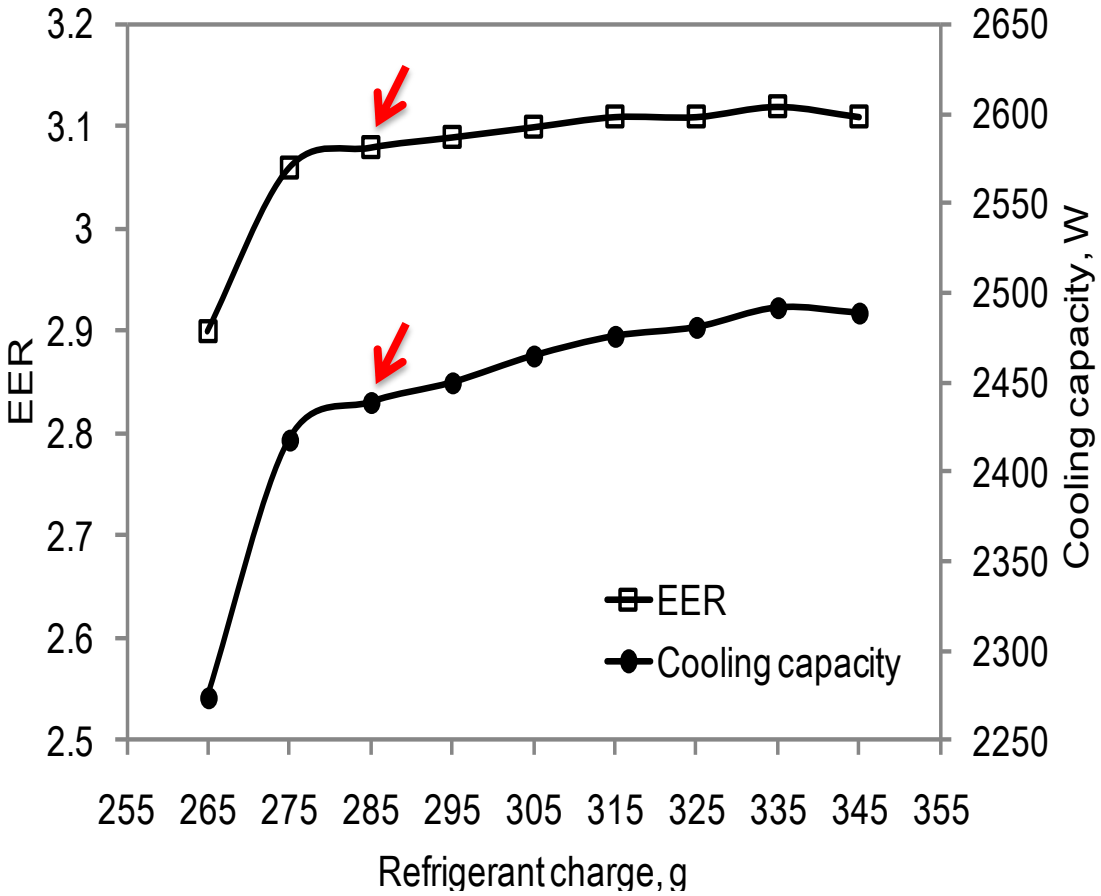

Performance (W) & Efficiency (EER) vs. Refrigerant Charge (g)

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Items	Simulation	Experimental data
Refrigerant charge	275 g	285 g
Cooling capacity	2403 W	2439 W
EER	3.05	3.08
Indoor unit heat capacity	2403 W	2439 W
Outdoor unit heat capacity	3183 W	3117 W
Condensing temperature	46.5 ℃	45.8℃
Evaporating temperature	7.9 ℃	7.8℃

Experimental Data – Design Validation

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Conclusions

- Reducing tube diameters in room air conditioners can significantly reduce refrigerant charge while maintaining system performance.
- Lower refrigerant charges resulting from small diameter tubes can reduce fire hazards and increase the safety of systems using R290 refrigerant.
- Comparing air conditioners of equal performance, units with small diameter tubes can be produced at lower costs than units with larger tubes.
- The physical properties of R290 refrigerant are well suited for air conditioner designs in North America.

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Thank You!

Additional information on small diameter copper tubes can be found at:
www.microgroove.net

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