

Evaluation of R290 and R600a as Sustainable Substitutes for R22 in Refrigeration Systems: Performance, Safety, and Environmental Impact

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Abstract: *As sustainable alternatives to traditional HCFC and HFC refrigerants, this study compares the thermodynamic performance of the hydrocarbon refrigerants R290 (propane) and R600a (isobutane). Assuming quasi-equilibrium compression, the analysis was conducted at condensing temperatures between 30 to 50 degrees Celsius and evaporating temperatures between -10 to 10 degrees Celsius. The results show that R600a required 2 to 3.5% less compressor power input and consistently produced a 2 to 4 percent higher coefficient of performance (COP) than R290. Additionally, R290 maintained a lower pressure ratio, especially at high condensing temperatures, whereas R600a demonstrated 6 to 9 °C lower discharge temperatures, improving compressor reliability. As the condensing temperature rose from 30 to 50 degrees Celsius, both refrigerants displayed a ~44% decrease in COP. From an environmental standpoint, both R290 and R600a demonstrated zero ozone depletion potential (ODP = 0) and ultra-low global warming potential (GWP < 3), providing a drastic improvement compared with R22 (GWP ≈ 1810) and R134a (GWP ≈ 1430). These findings confirm the technical viability and environmental superiority of R290 and R600a, supporting their broader adoption in energy-efficient and eco-friendly refrigeration systems.*

Keywords: R290, R600a, hydrocarbon refrigerants, vapor compression system, COP, energy efficiency

