Refrigerants for Organic Rankine Cycle Systems: Properties, Efficiency, and Usage Notes

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https://infinityturbine.com/infinity-turbine-sco2-cluster-mesh-micro-supercritical-analysis.html

Explore refrigerants used in Organic Rankine Cycle systems, including maximum temperature, pressure in bar and psi, Carnot efficiency, condenser conditions, and regulatory notes.

This webpage QR code

PDF Version of the webpage (maximum 10 pages)

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Introduction

Organic Rankine Cycle (ORC) systems use refrigerants and other working fluids to convert low and medium grade heat into electricity. The choice of refrigerant impacts efficiency, safety, regulatory compliance, and equipment design. This article reviews common ORC refrigerants, their thermodynamic limits, Carnot efficiencies at those limits, and key use notes including environmental restrictions and optimal condenser conditions.

R-245fa (Honeywell Genetron)

Maximum Temperature: ~150 °C (302 °F)
Pressure at Max Temp: ~36 bar (~522 psi)
Carnot Efficiency at Max Temp (vs 30 °C / 86 °F condenser): ~29 percent
Condenser Temperature: Best performance near 30–35 °C (86–95 °F)
Usage Notes: Widely used in commercial ORC systems. Classified as an HFC with a high global warming potential (GWP ~950). Scheduled for phase down under the EU F-Gas Regulation with sunset dates already in place for new equipment in some applications.

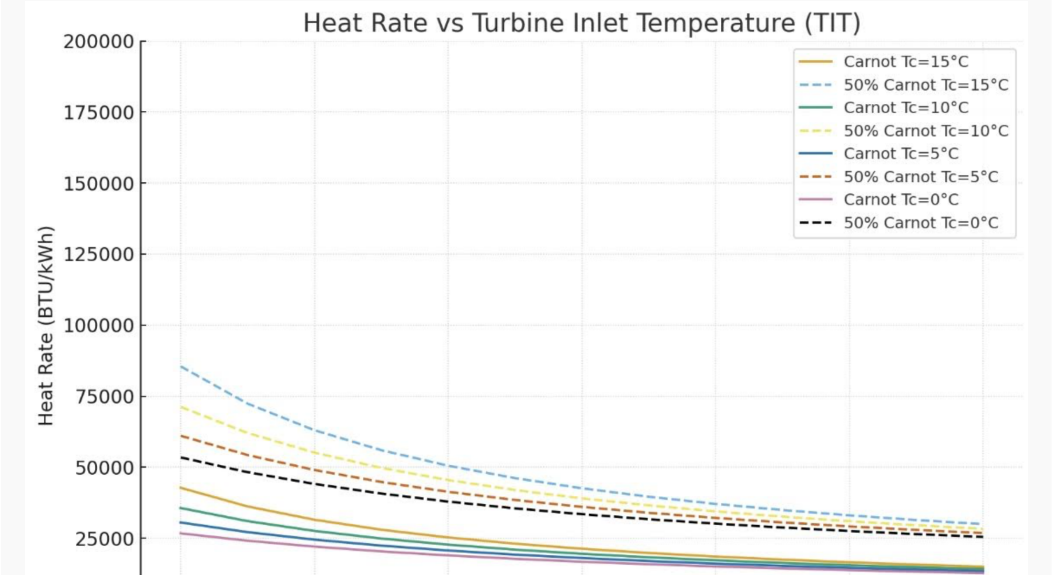
R-1233zd(E) (Hydrofluoro-olefin, HFO)

Maximum Temperature: ~180 °C (356 °F)
Pressure at Max Temp: ~19 bar (~276 psi)
Carnot Efficiency at Max Temp (vs 30 °C / 86 °F condenser): ~33 percent
Condenser Temperature: Performs well with 25–35 °C (77–95 °F) condenser
Usage Notes: Low GWP (~1) HFO refrigerant marketed as a replacement for R-245fa. Accepted under EU and US regulations with no near-term sunset date. Increasingly popular for high-temperature ORC and centrifugal chiller systems.

R-123 (HCFC, historical use)

Maximum Temperature: ~130 °C (266 °F)
Pressure at Max Temp: ~14 bar (~203 psi)
Carnot Efficiency at Max Temp (vs 30 °C / 86 °F condenser): ~26 percent
Condenser Temperature: Typically 25–30 °C (77–86 °F) for best performance
Usage Notes: Older ORC fluid, phased out due to ozone depletion potential. Banned in the EU and being phased out globally under the Montreal Protocol. Not suitable for new systems.

R-600 (n-Butane)


Heat Rate vs Turbine Inlet Temperature (TIT)
Heat Rate (BTU/kWh)
200000
175000
150000
125000
100000
75000
50000
25000
Carnot Tc=15°C
50% Carnot Tc=15°C
Carnot Tc=10°C
50% Carnot Tc=10°C
Carnot Tc=5°C
50% Carnot Tc=5°C
Carnot Tc=0°C
50% Carnot Tc=0°C