An Enhanced R-134a Climate System

Presented by:

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2002 SAE AUTOMOTIVE ALTERNATE REFRIGERANT SYSTEMS SYMPOSIUM
JULY 9-11 • SCOTTSDALE, ARIZONA

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Goals of the Project

- Improve the environmental friendliness of R-134a vapor-compression air conditioning systems
  - Improve the operating efficiency
    - Externally Controlled Swashplate Compressor
    - Oil Separator
    - Evaporator exit superheat
  - Reduce the refrigerant charge required
    - Condenser internal volume
    - Evaporator internal volume
    - 4mm I.D. liquid line

Test and Develop Enhanced R-134a Ideas

- Production system and vehicle needed for a benchmark
  - Small R-134a Charge
  - Good Front end airflow
  - Newly developed (not old carryover technology)
  - Good capacity and idle airflow characteristics
- 2003 Cadillac CTS was chosen
  - 590g R-134a
  - Very efficient cooling module and under hood airflow
  - Newly Launched
  - Very Good performing components and system

Total System Power Consumption Benefits of Externally Controlled Swashplate Compressors

Equivalent 3.9 kW A/C Cooling Capacities, Identical Operating conditions

Alternator Efficiency is Assumed to be 50%, 4% Oil concentration

Internally controlled comp

229 SCFM @ 4.3 deg C

Power Consumption at FEAD

Clutch (82W /0.5) = 164W

Blower (193W /0.5) = 386W

Blower Res. (37W /0.5) = 74W

Compressor = 2630W

Total Power = 3254W

Externally controlled comp

280 SCFM @ 10.5 deg F

Power Consumption at FEAD

Clutch (82W /0.5) = 164W

Blower (294W /0.5) = 588W

ECV Valve (9W /0.5) = 18W

Compressor = 1860W

Total Power = 2630W

19% Less Accessory Drive Shaft Power

Consumed by Externally Controlled System

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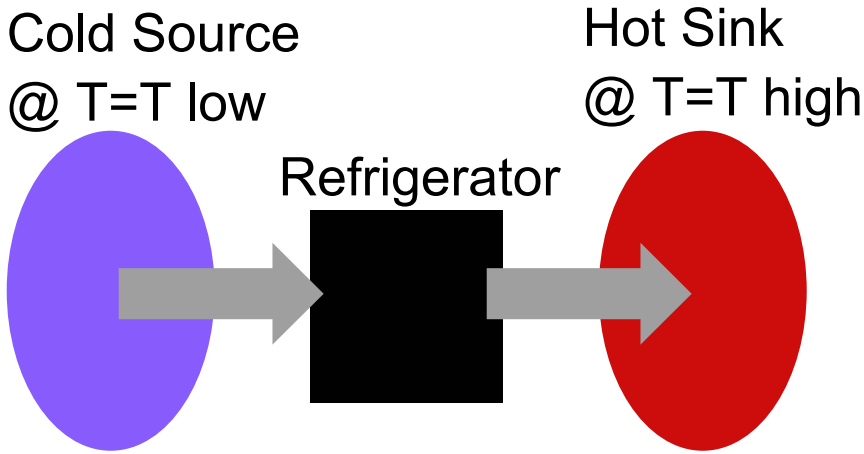
How Does Increasing the Evaporator Temperature Reduce The Power Consumption?

Consider the equations characterizing an ideal Carnot refrigerator.

(a refrigerator operating at the highest COP thermodynamically possible)



$$COP_{\text{Re}\,frigerator,\text{Re}versible} = \frac{1}{Thigh/Tlow - 1}$$

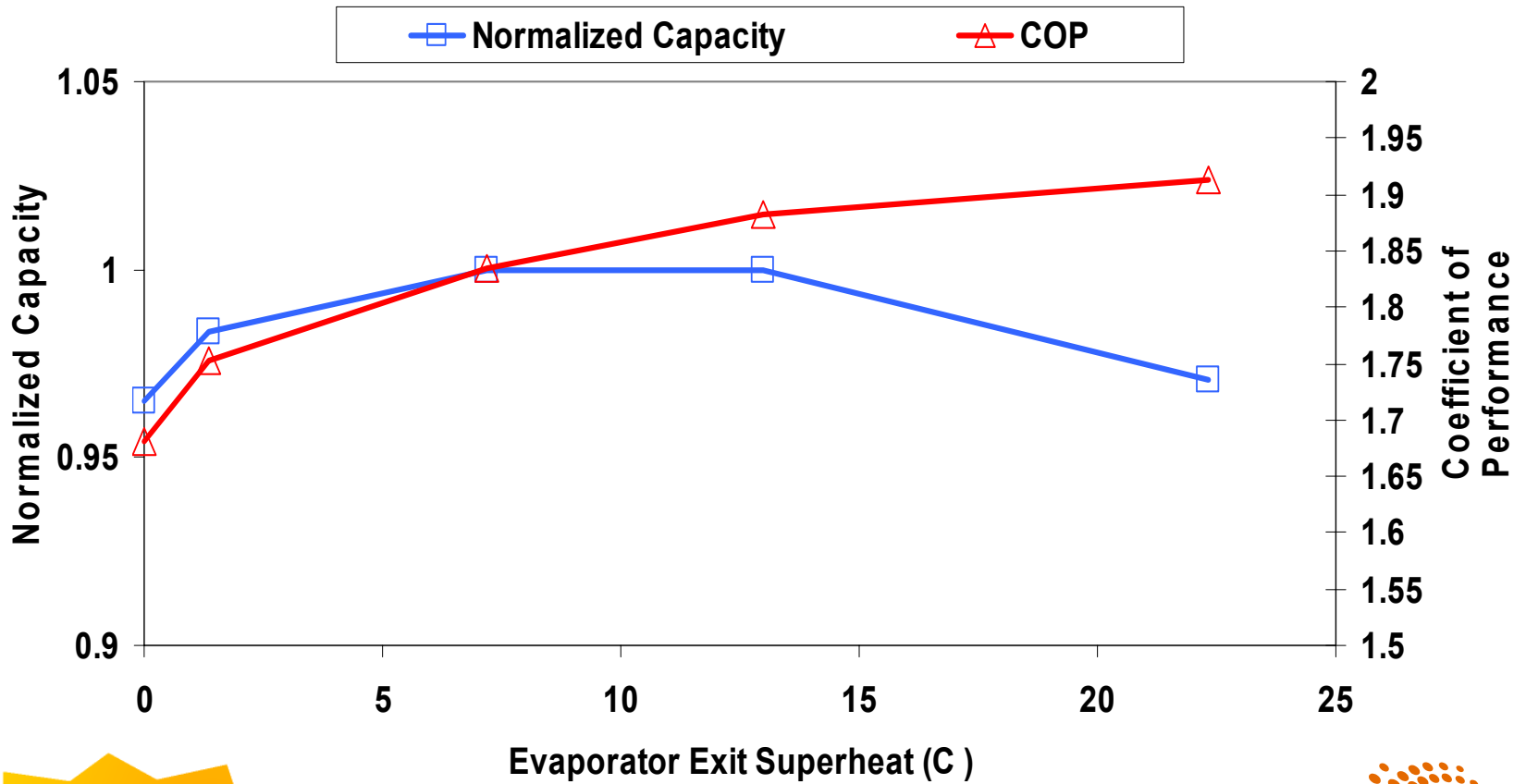
Assume T high is the same (43 deg C) and T low can be either 4 or 10 deg C

COP @ 4 deg C = 7.1

COP @ 10 deg C = 8.6

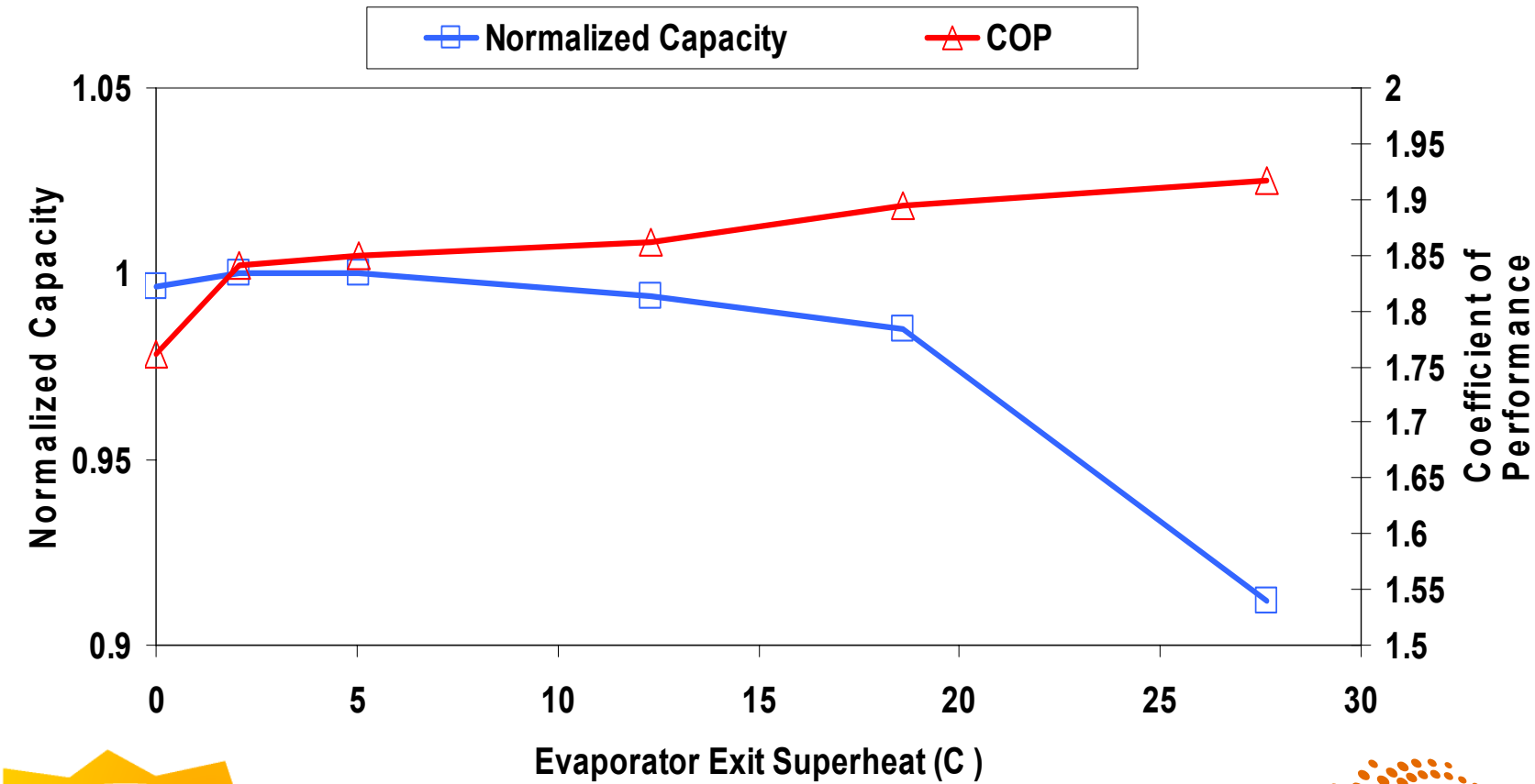
R-134a System Performance as a Function of Evaporator Superheat

160cc Compressor, 2000 RPM, 1000 SCFM, 43C Condenser Flow,
280 SCFM, 43C, 11%RH Evaporator Flow (No Condensate),
3% PAG Oil Concentration by Mass



R-134a System Performance as a Function of Evaporator Superheat

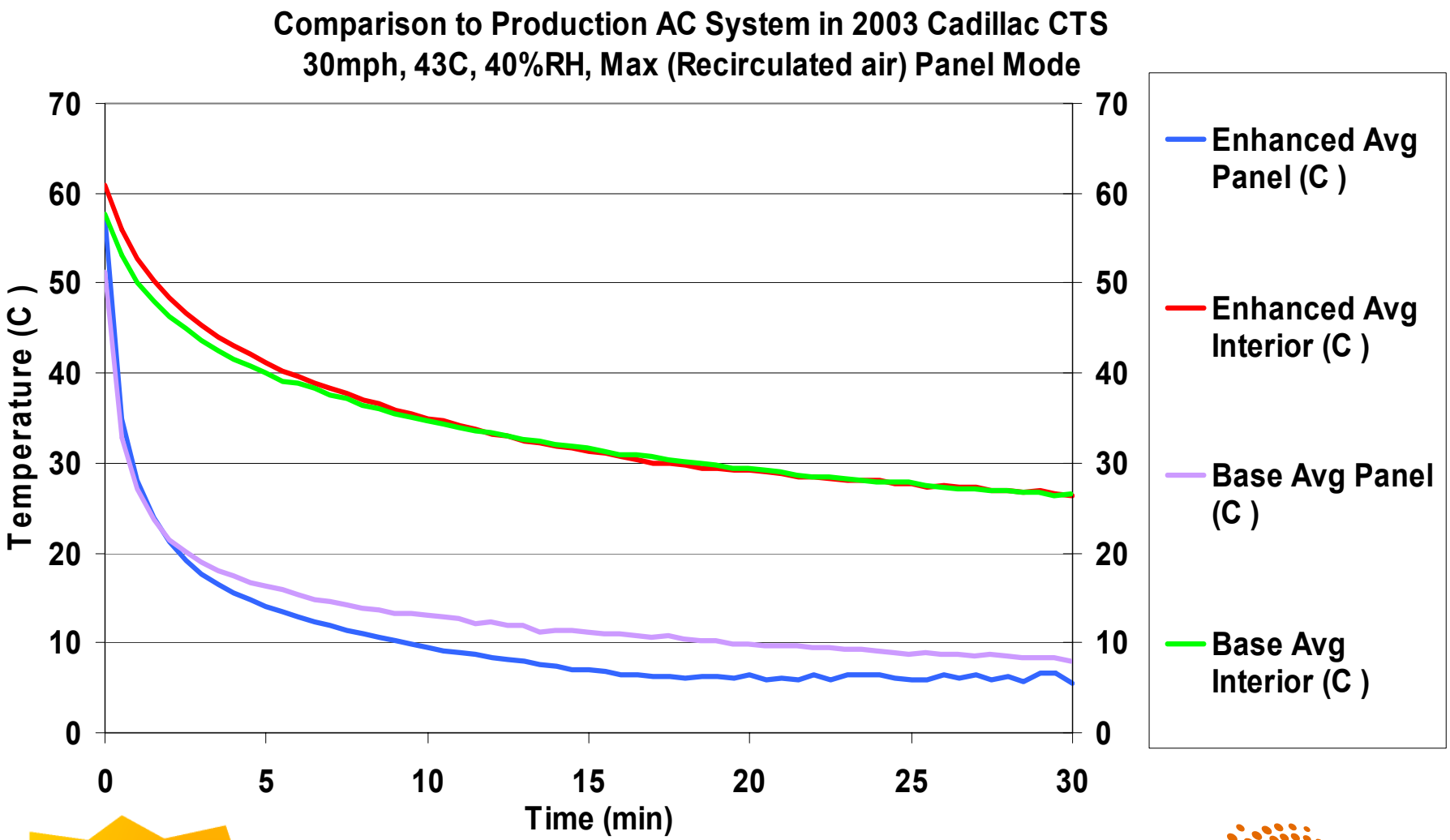
160cc Compressor, 2000 RPM, 1000 SCFM, 43C Condenser Flow,
280 SCFM, 43C, 8%RH Evaporator Flow (No Condensing),
PAG Oil Separated in Discharge Line, Returned to Suction Line



2003 Cadillac CTS
Enhanced R-134a Demonstration Vehicle

- 16mm thick Subcooled IRD Condenser
- 45mm thick, 33 plate Evaporator
- 160cc Externally Controlled Variable Swashplate Compressor
- Humidity sensor for Compressor Control Algorithms
- Oil Separator
- 4mm I.D. Liquid Line
- 590g R-134a Charge (same as production system)

Enhanced R-134a System Windtunnel Pulldown Performance



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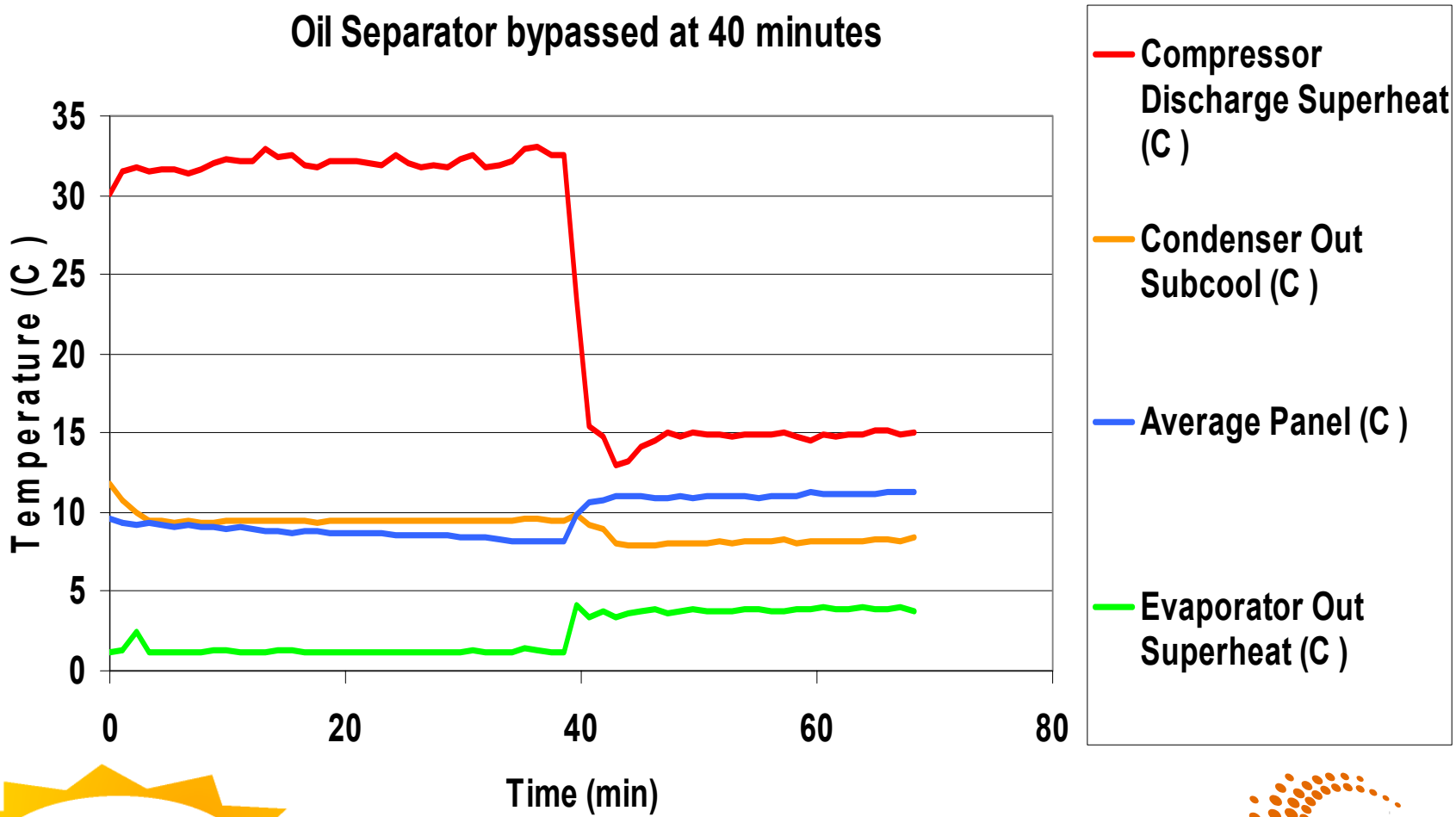
Enhanced R-134a System Windtunnel Oil Separator Comparison

40mph, 43C ambient, <5%RH, Recirculated Air, Full Cold, Panel Mode, Windows Down Oil Separator bypassed at 40 minutes



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Conclusions, Future Steps

- Condenser header volume needs to be further reduced to reduce the R-134a charge level in the vehicle
- Better system sealing is needed for R-134a to be environmentally competitive with CO2 systems
  - Lower TEWI
  - Smaller leakage reserve in receiver
- Oil separators might allow for downsizing of some system components