

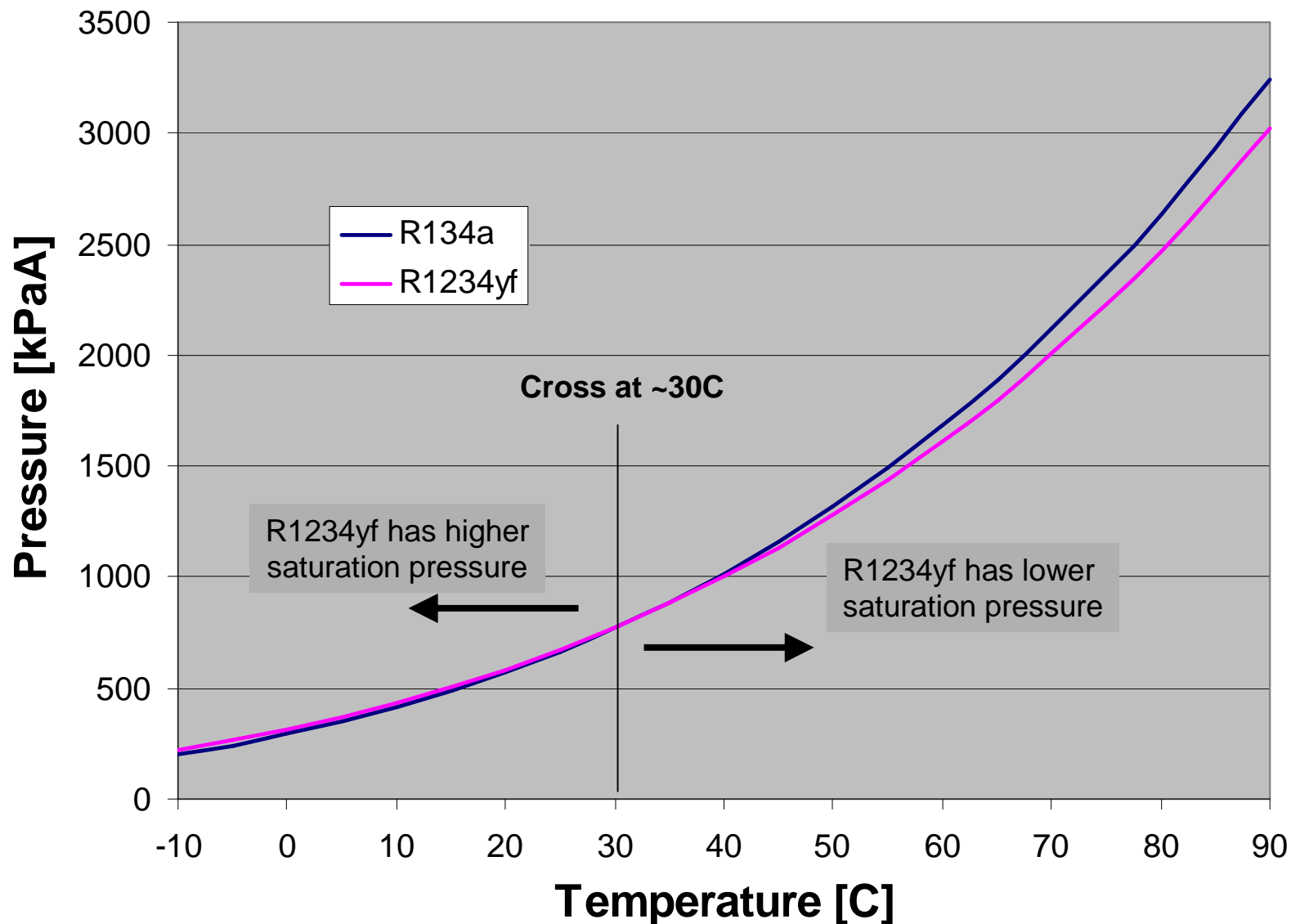


# **R1234yf System Enhancements and Comparison to R134a**

June 10, 2008

**John Meyer**

- ▶ System Performance Evaluation
  - TXV (Egelhof) and MCV (TGK) tuning
  - Baseline and enhanced system test results
    - » IHX
    - » Oil Separator
    - » High Effectiveness Evaporator
- ▶ Compressor Durability



- ▶ Production system used for analysis
- ▶ 160cc variable displacement compressor
- ▶ 16mm IRD condenser
- ▶ 2.0T cross-charged TXV
- ▶ 58mm plate-fin evaporator
- ▶ Slightly modified discharge and liquid line
  - Modified for installation on stand
- ▶ Slightly modified SL
  - To allow for *in situ* torque calibration



# R1234yf – Stand Evaluation



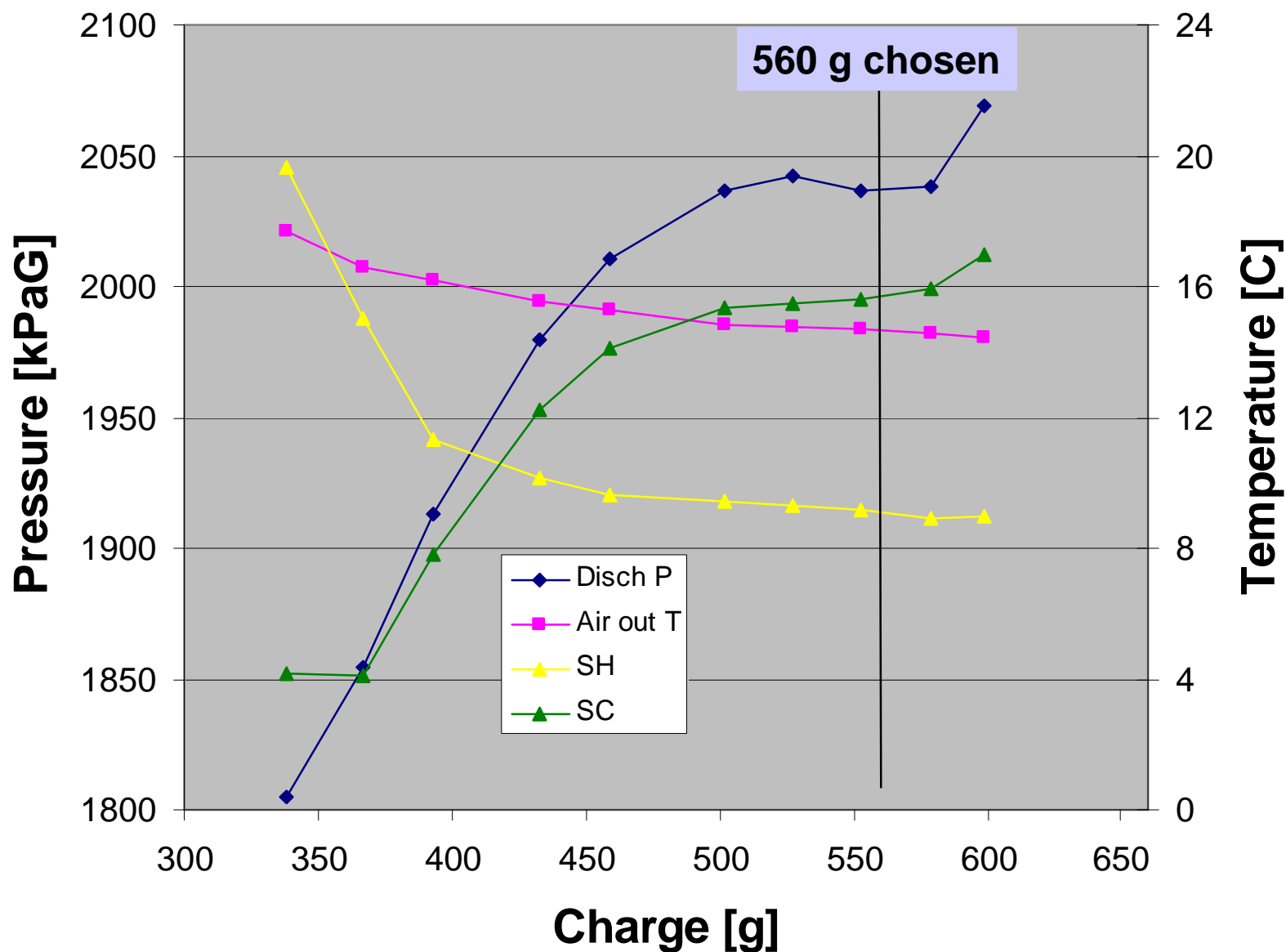
- ▶ Changes to R134a system hardware
  - Same 16mm IRD condenser
  - Same 58mm plate-fin evaporator
  - Same VS16 compressor, **new MCV set points**
  - Same 200 cc PAG
  - **2.0T, 2.5T, 1.75T TXVs at high & low SH settings evaluated**
  - Same slightly modified discharge and liquid line
  - Same slightly modified SL to allow for torque calibration

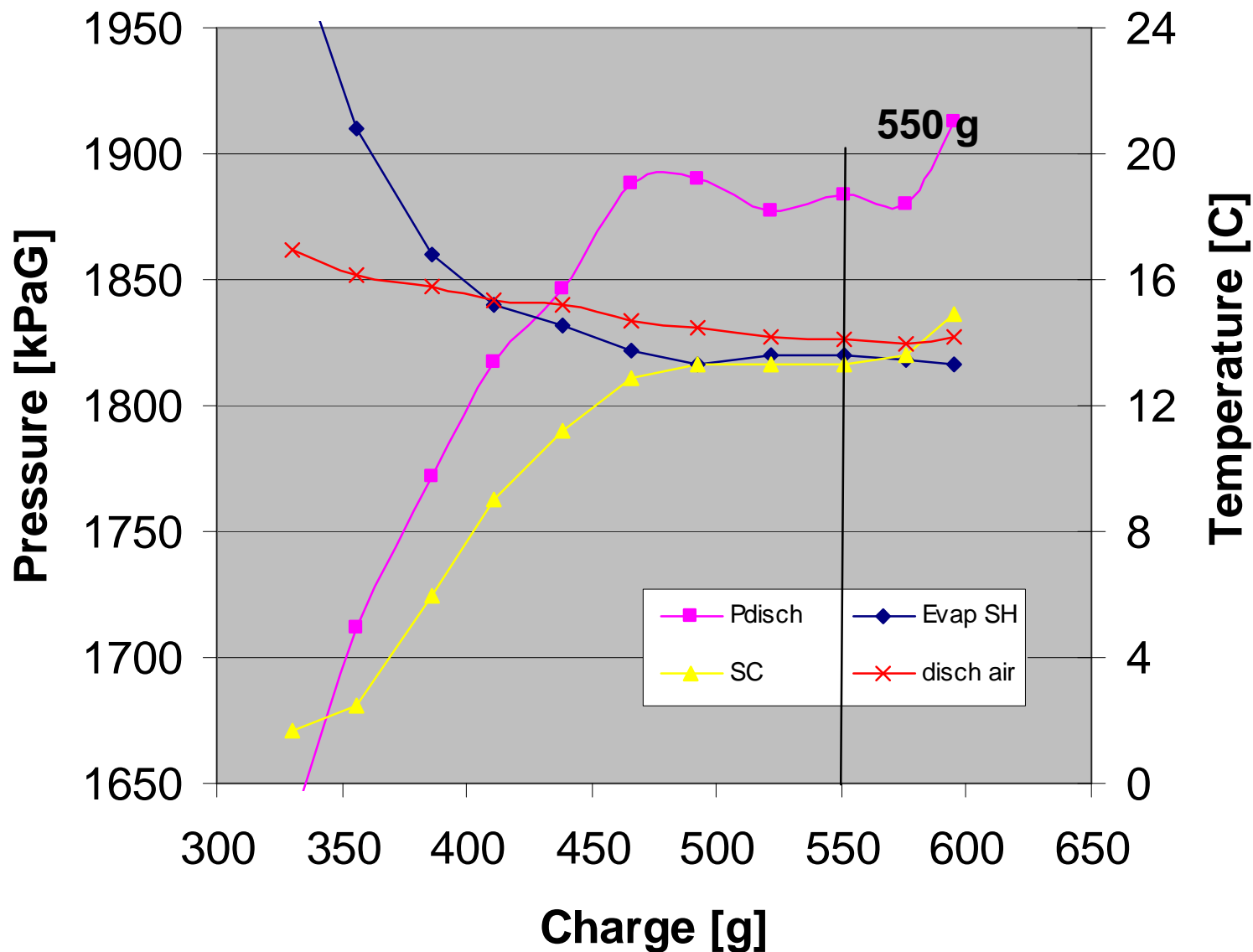


# Evaluation Matrix



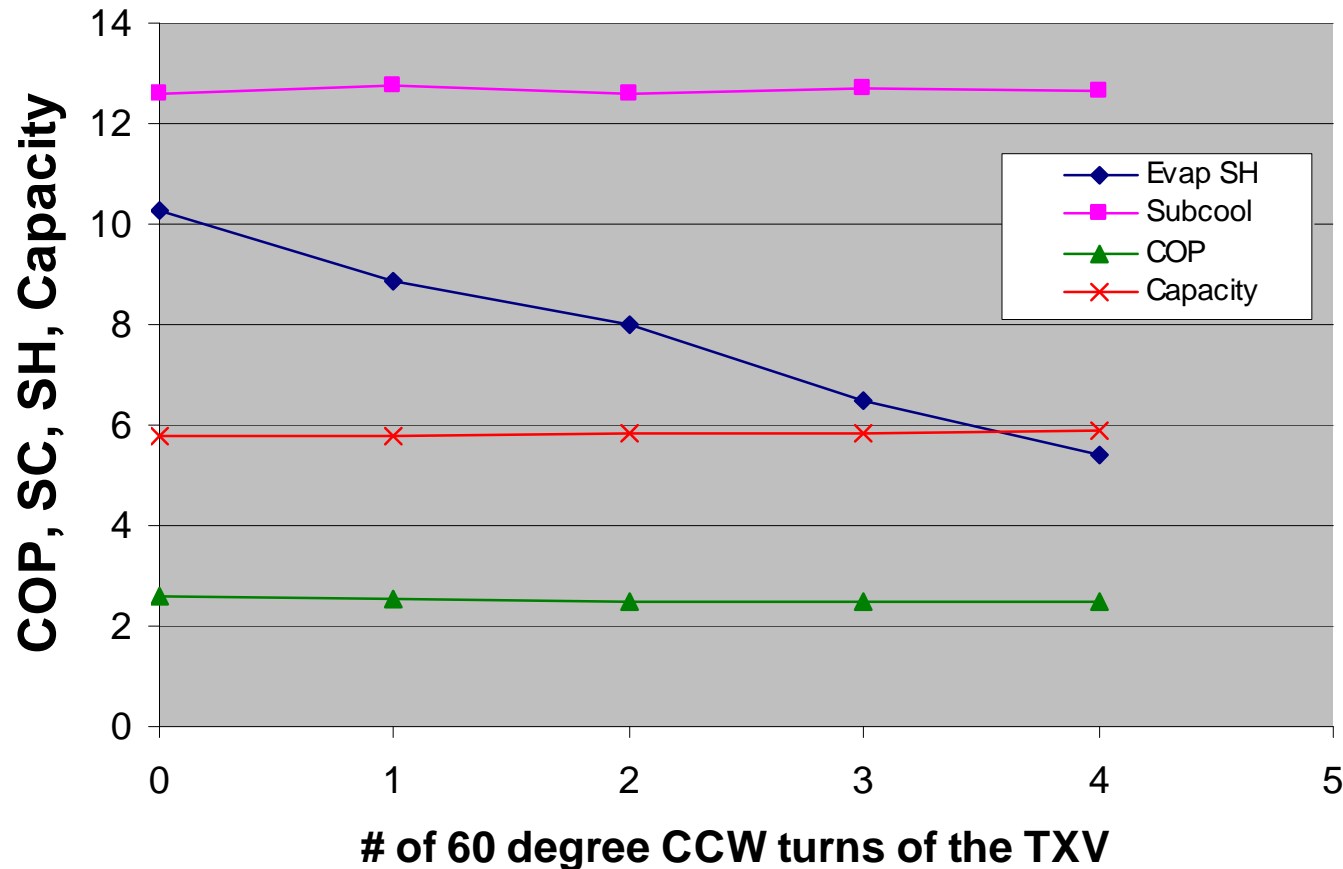
	Compressor	Condenser Airflow		Evaporator Airflow		
	RPM	l/s	Temp °C	Flow l/s	Temp °C	RH %
1	2500	700	45	140	43	40
2	1800	650	45	140	43	40
3	800	600	45	140	43	40
4	2500	700	37	140	35	40
5	1800	650	37	140	35	40
6	800	600	37	140	35	40
7	2500	700	27	100	25	40
8	1800	650	27	100	25	40
9	800	600	27	100	25	40



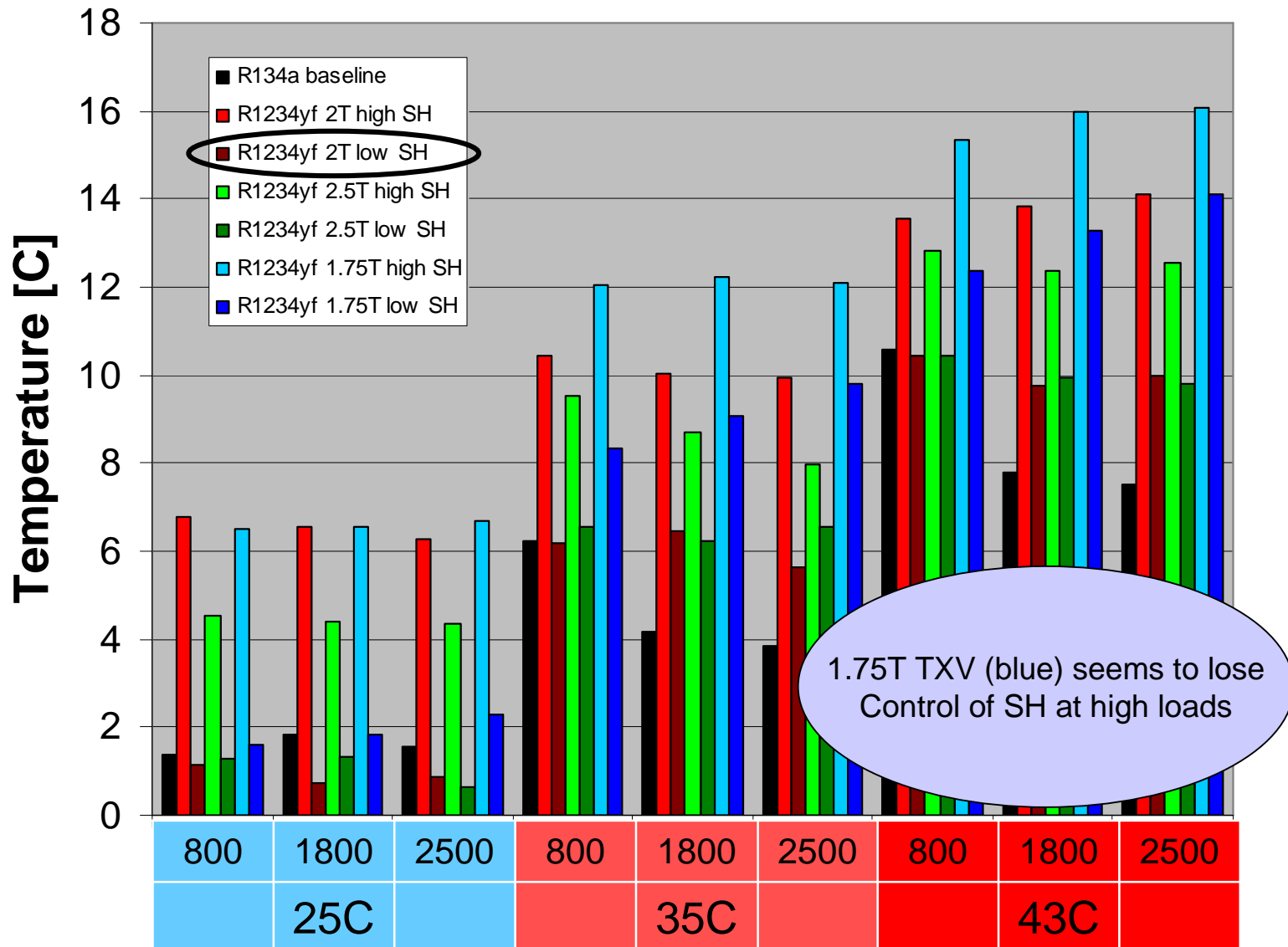


- ▶ TXVs have a “set screw” to adjust SH setting
  - ▶ Each valve was evaluated at a high and low SH setting
- SH setting

35C, 1800RPM (pt 5)



## SH comparison





# R1234yf TXV and MCV Evaluation



- ▶ Cross charge TXVs from Egelhof
- ▶ 2.0, 2.5, and 1.75T valves tested
- ▶ 1.75T TXV is undersized
- ▶ TXV at low SH
  - Although no strong indication that low SH leads to improved performance:
    - » Low SH facilitates IHX integration
    - » Improved evaporator discharge air stratification
- ▶ MCVs from TGK
- ▶ Initial MCV calibration slightly off
- ▶ Gen II MCVs better tuned for this system



# R1234yf Evaporator Stratification

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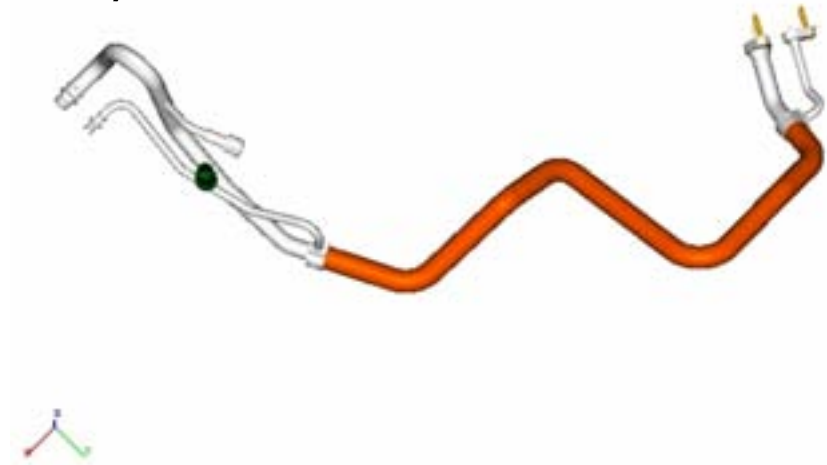


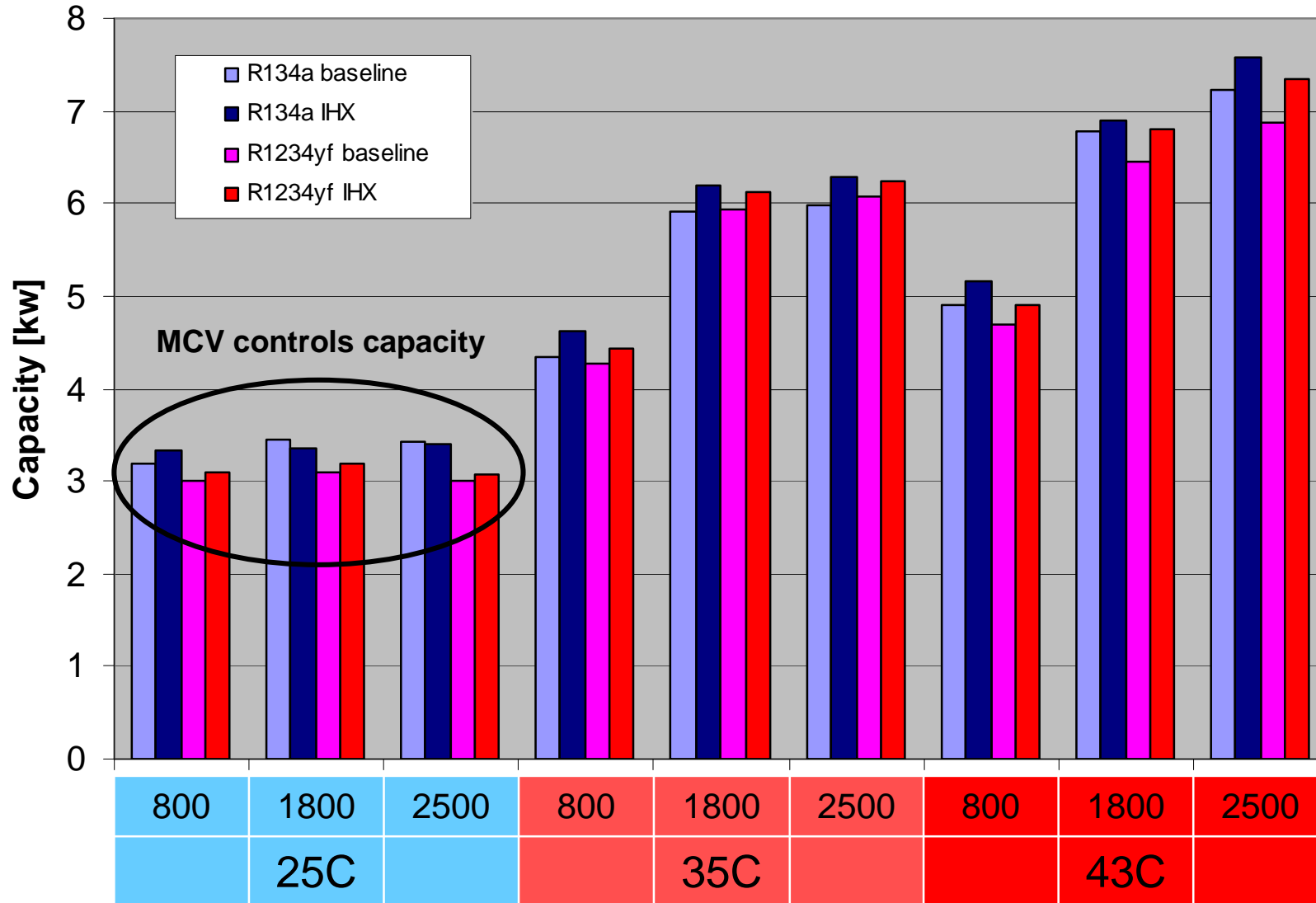
- ▶ 4x4 thermocouple matrix on evaporator outlet
  - Stratification =  $T_{\max} - T_{\min}$
- ▶ With similar SH settings, R1234yf shows slightly improved stratification

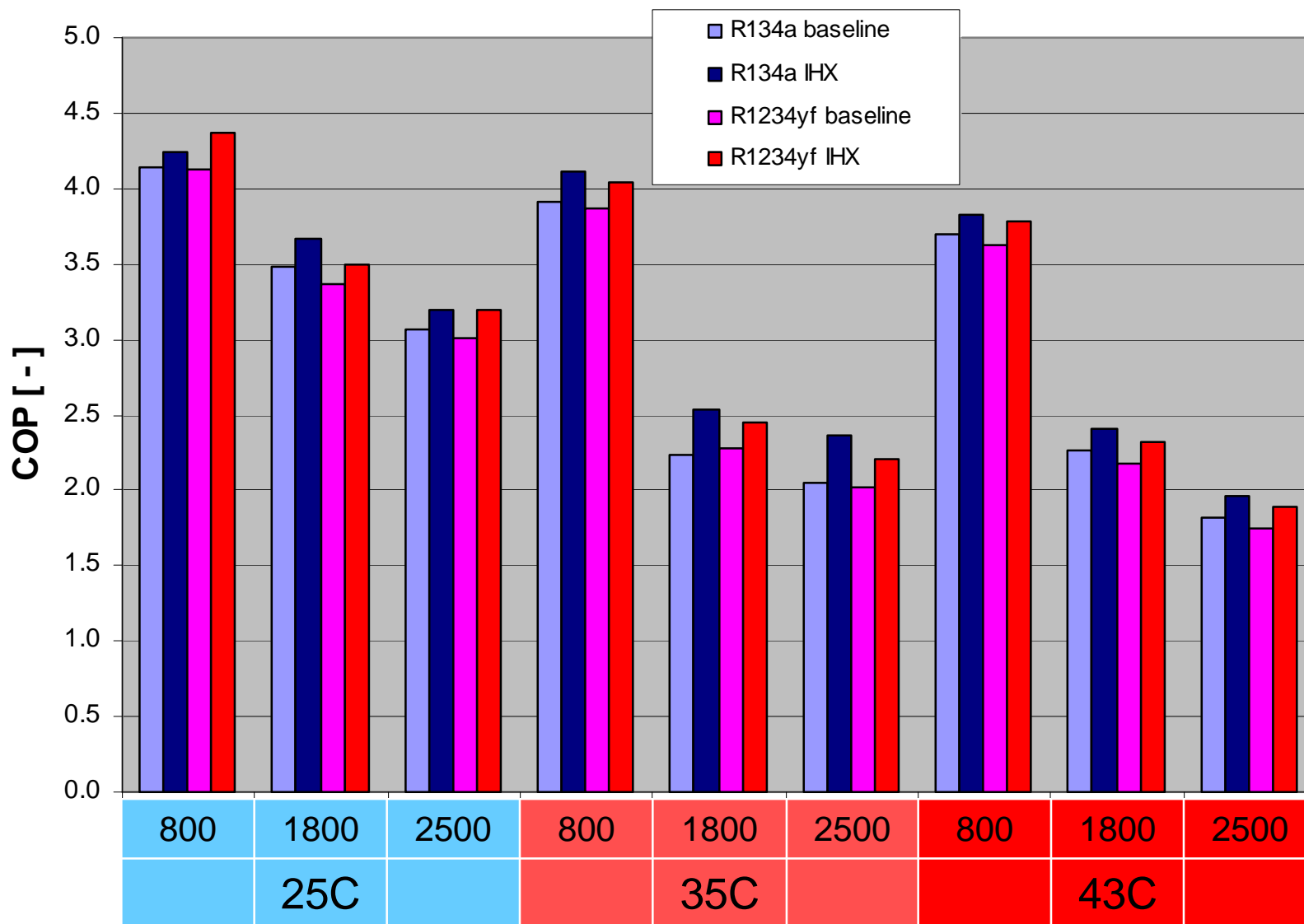


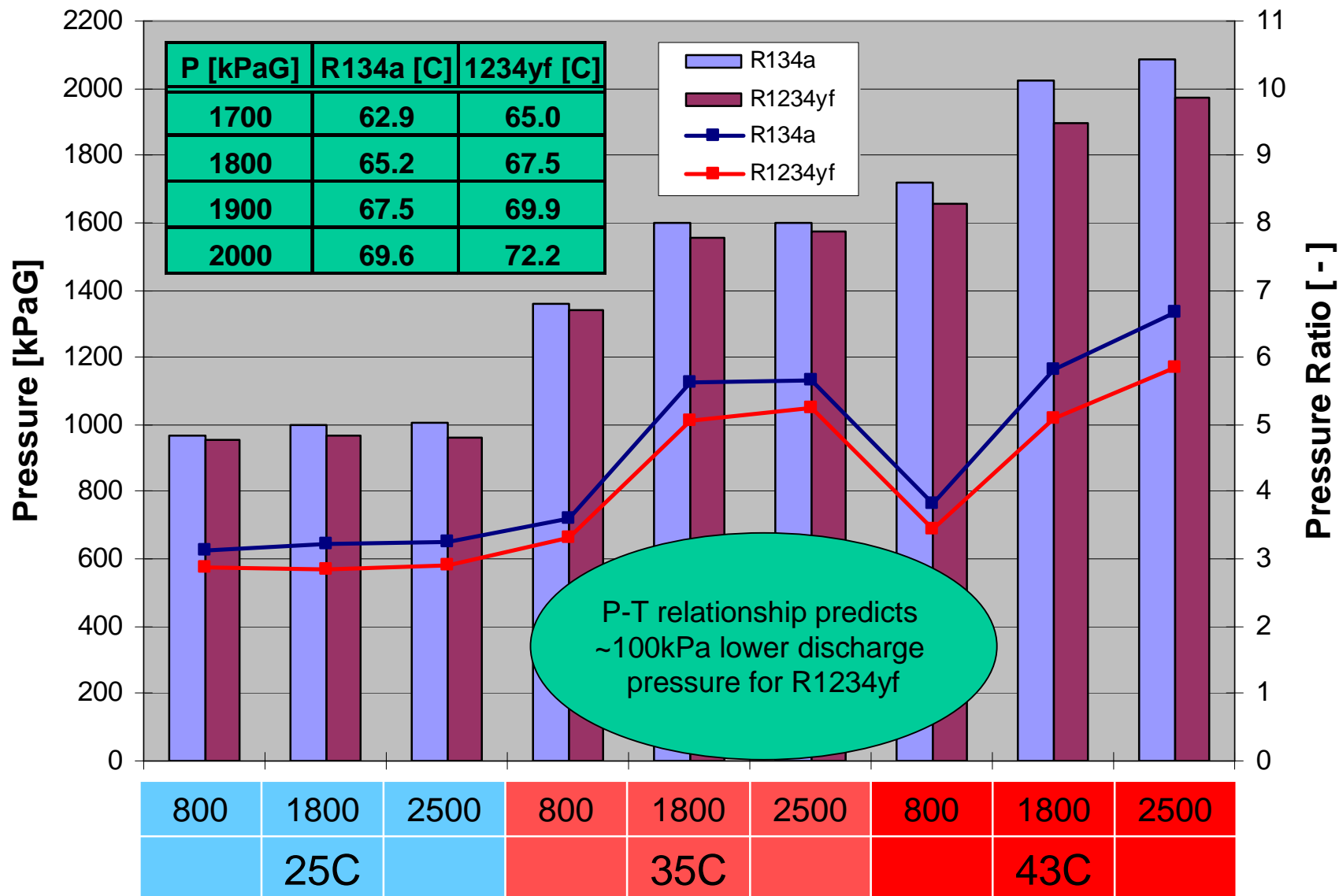
- ▶ Same compressor, heat exchangers, lines, lubricant
- ▶ 2.0T TXV from Egelhof at “low” SH setting
- ▶ “GEN II” MCV from TGK

- ▶ Internal Heat Exchanger (IHX)
  - Production Intent (SOP '09)
  - Fully validated with R134a
- ▶ Oil Separator
- ▶ High efficiency evaporator
  - Tube-fin
  - Same package
  - Lower air-side pressure drop



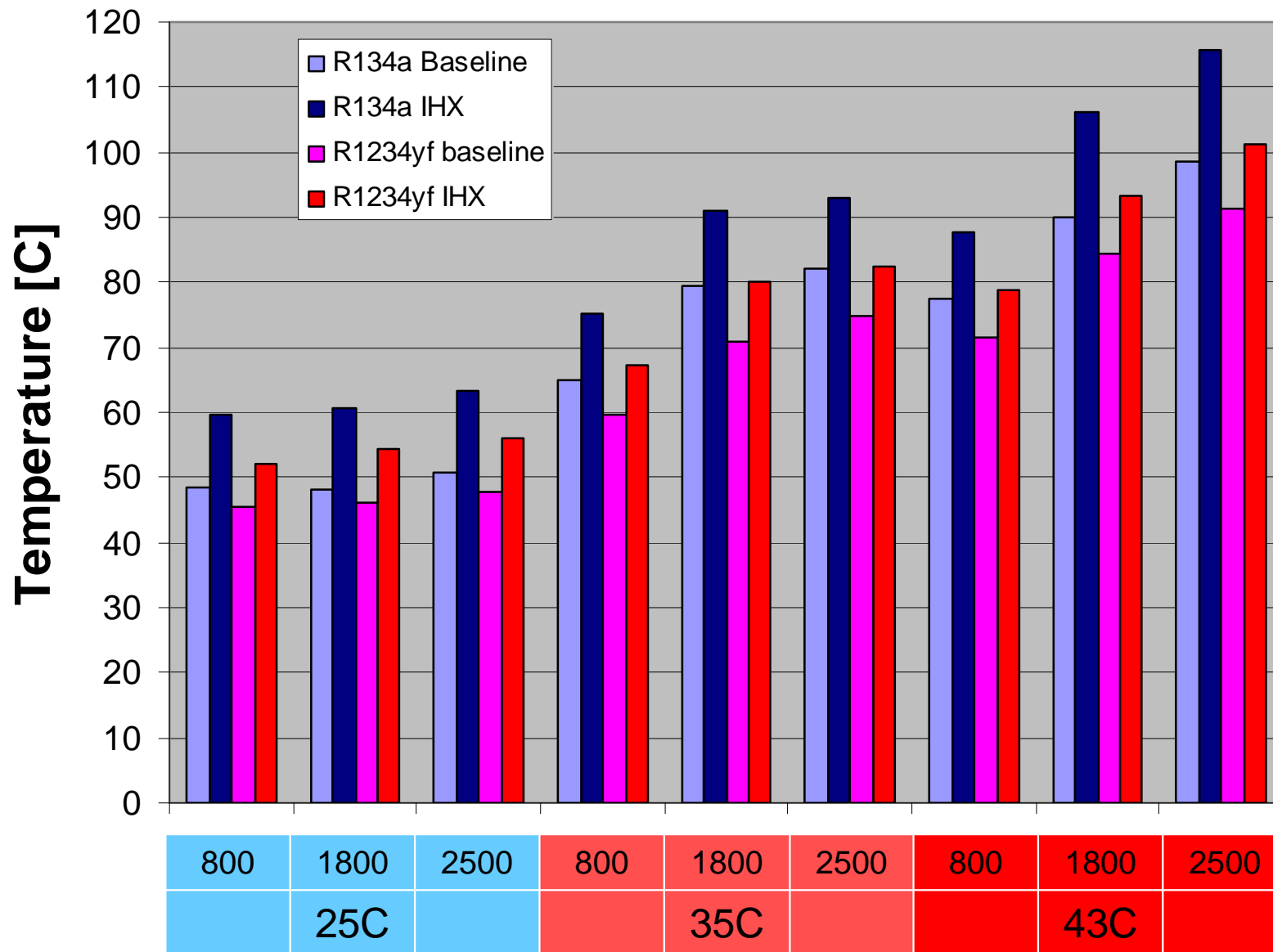






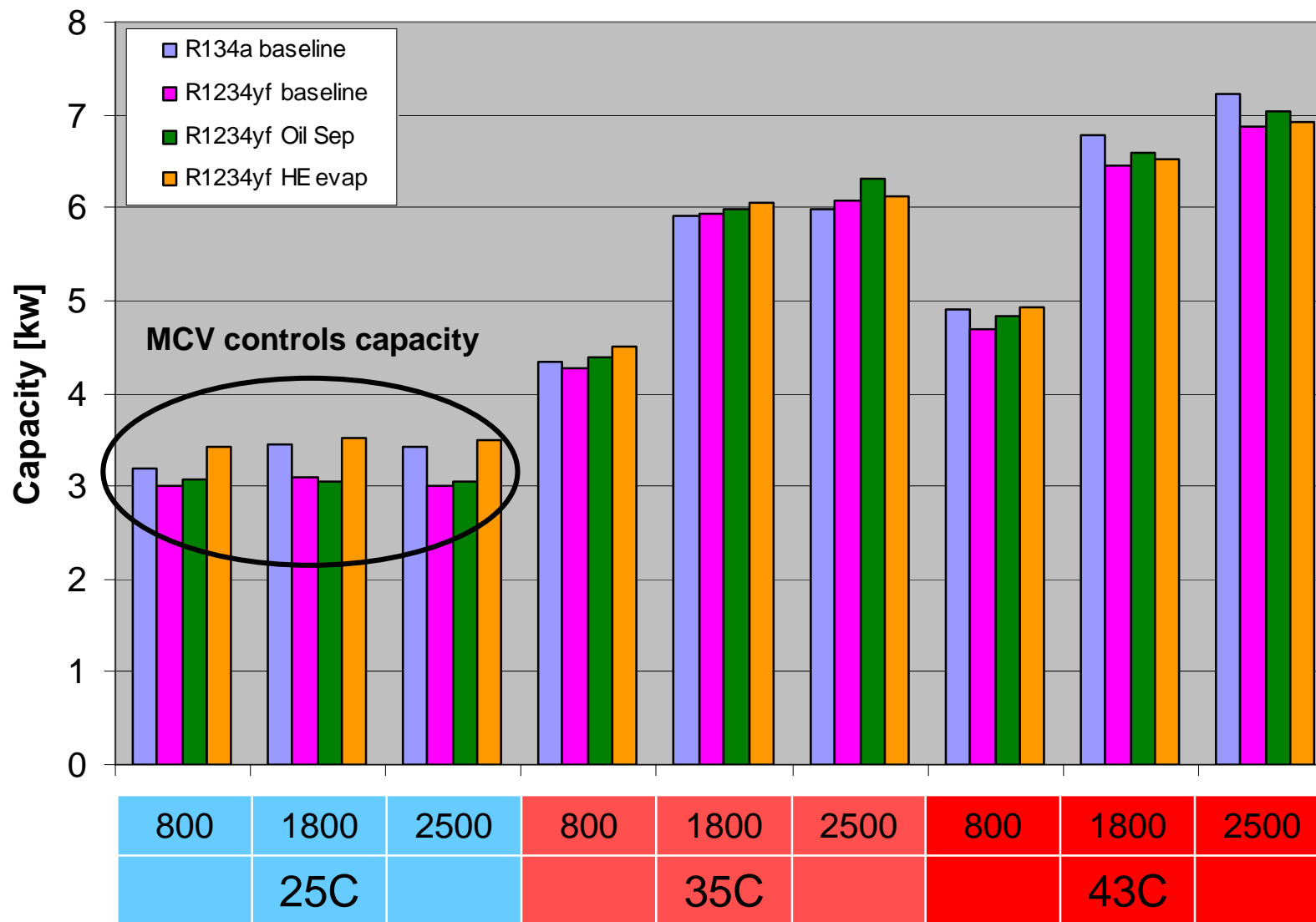


# R134a vs 1234yf – IHX; Compressor Discharge Temperature



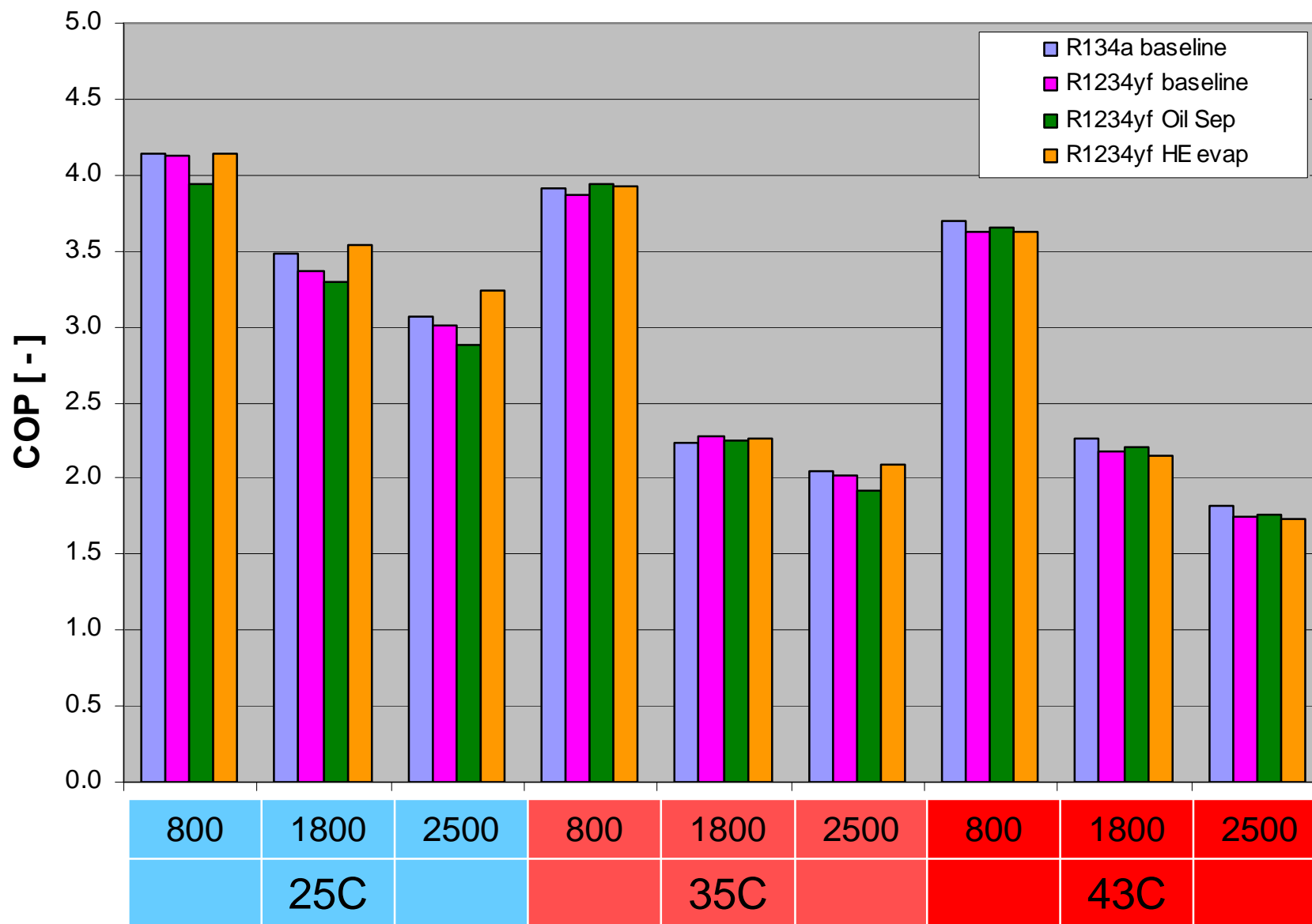


# R134a vs 1234yf – Oil Separator & High Efficiency Evaporator; Capacity

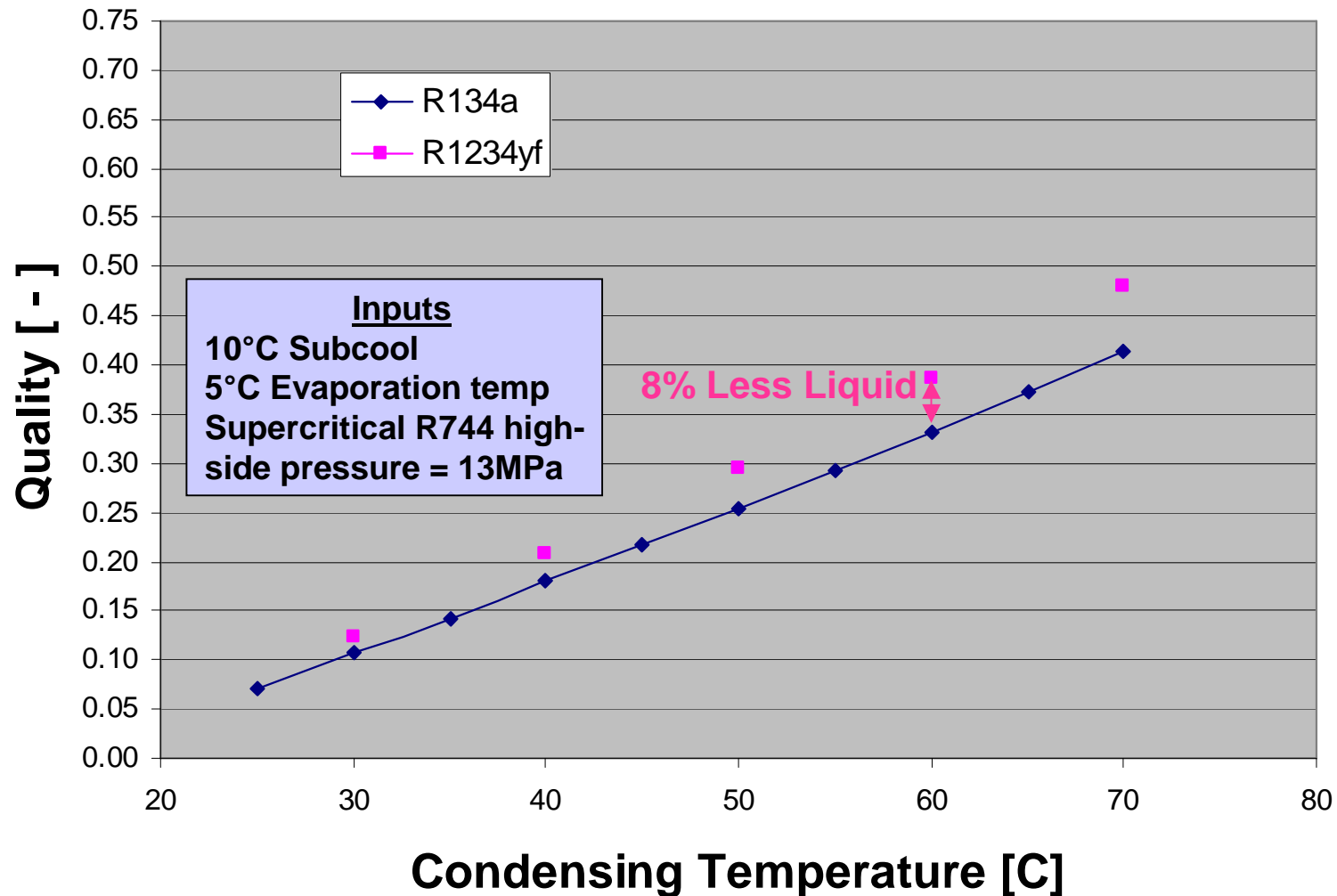




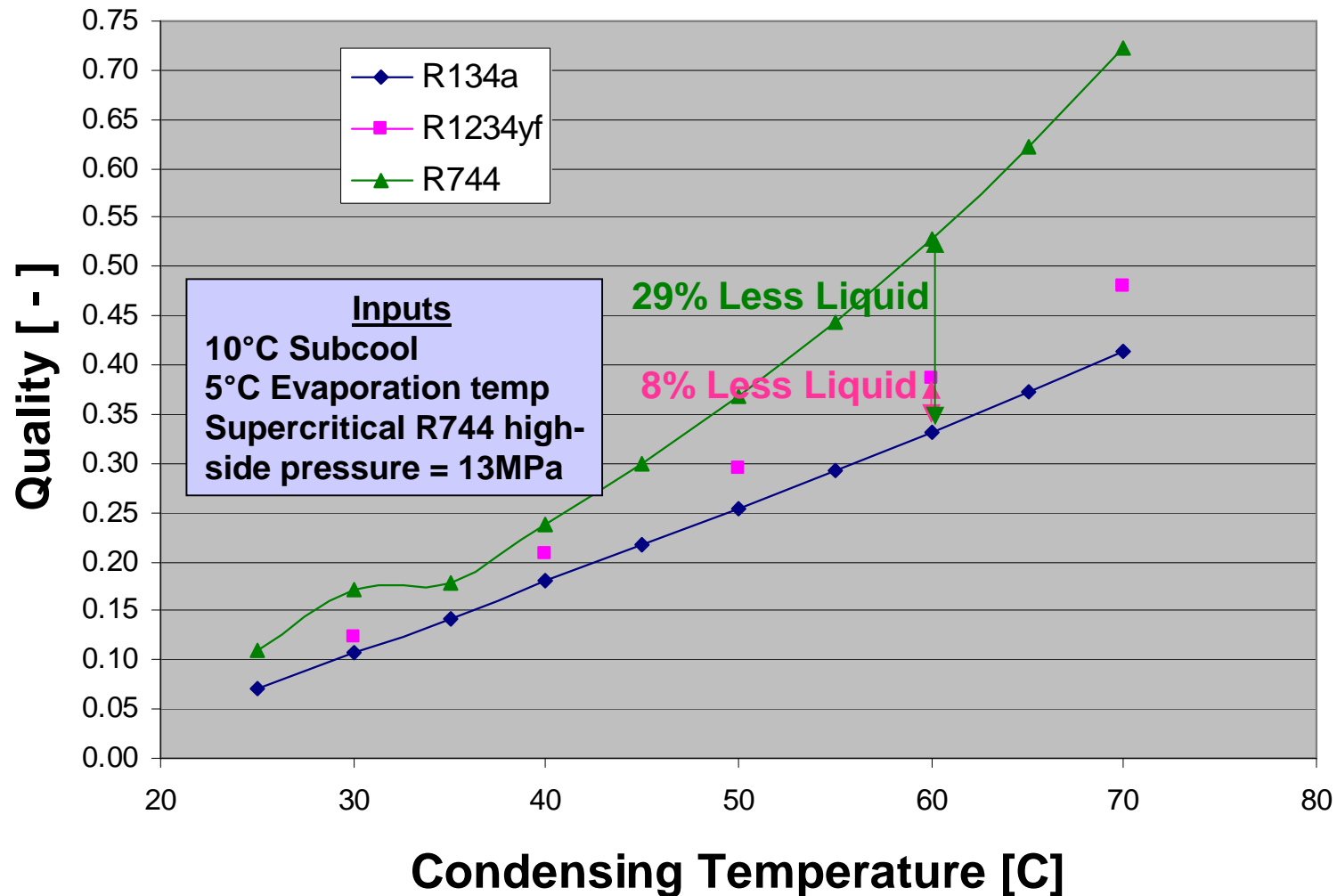
# R134a vs 1234yf – Oil Separator & High Efficiency Evaporator; Efficiency



- ▶ Higher quality = less liquid = lower capacity



- ▶ Higher quality = less liquid = lower capacity





# R1234yf Performance Summary



- ▶ Baseline R1234yf system used same tonnage TXV with modified bulb charge and adjusted MCV
- ▶ R1234yf has approximately 8-10°C cooler compressor discharge temperature vs R134a
- ▶ As near drop-in, capacity and efficiency fall slightly short of R134a



# R1234yf Performance Summary (cont)

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- ▶ R1234yf with IHX
  - ~Matches/exceeds R134a baseline capacity
  - Has slightly higher average efficiency than baseline R134a across all points
  - ~Matches R134a compressor discharge temperature
- ▶ R1234yf with Oil Separator
  - Small increase in capacity and efficiency
  - Falls short of baseline R134a at high ambient
- ▶ R1234yf with High Efficiency Evaporator
  - Small increase in capacity and efficiency
  - Falls short of baseline R134a at high ambient



# R1234yf Compressor Testing

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## ▶ Initial Compressor Durability

- High Pressure Low Charge – high load and temperature test
  - » Completed initial testing - No issues
- High Speed – high friction and high temperature test
  - » Completed initial testing – No issues



# Durability Teardown Results



- ▶ Thanks to....
  - **TGK** for prototype MCVs
  - Egelhof for prototype TXVs
  - JCS for tube-fin evaporator
  - Honeywell and DuPont for R1234yf