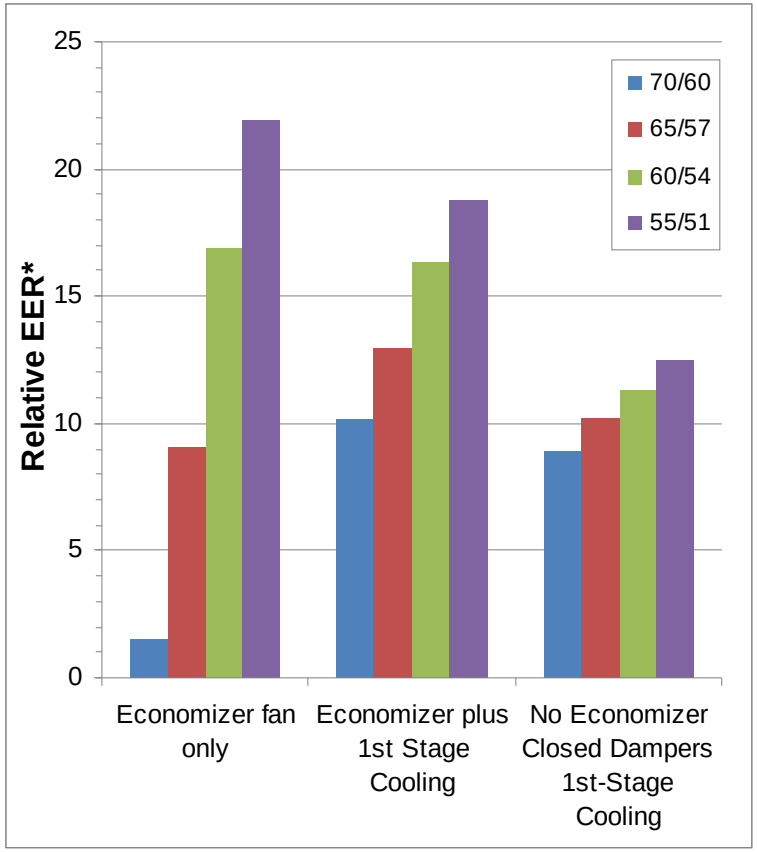
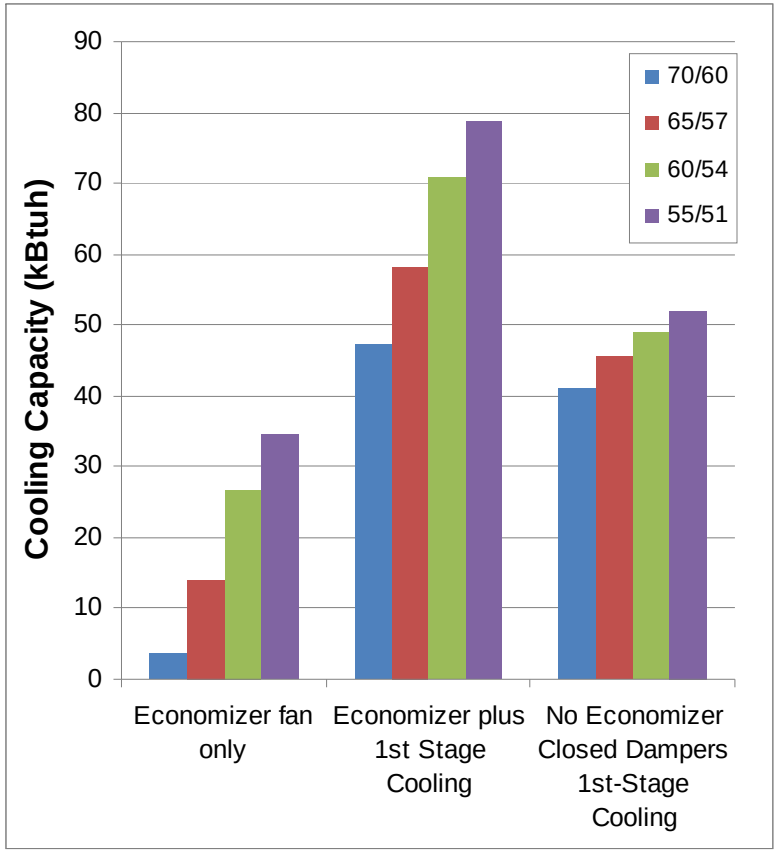
Economizer Damper Tests

- Tests show closed dampers leak 15%, 1-finger 20%, 2-fingers 23%, 3-fingers 30%, and fully-open 62% versus assumed 2% closed and 100% open
- Closed dampers are 36 to 51% less efficient than same unit without economizer
- Economizer dampers open from 10 to 30% (1 to 3 fingers) reduce efficiency by 5 to 62% compared to closed dampers
- Fully open dampers reduce efficiency by 24 to 139% compared to closed dampers

Economizer Tests

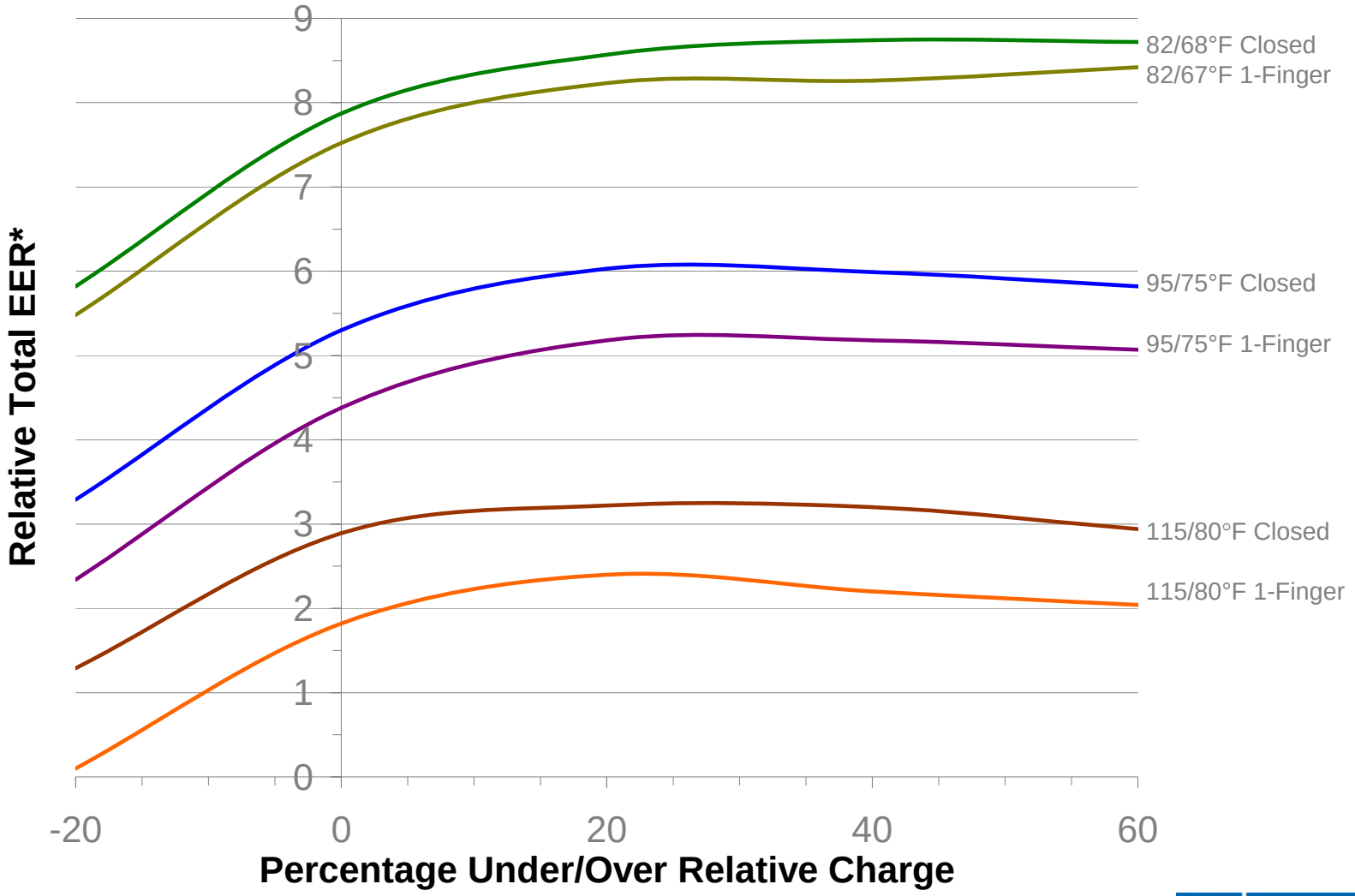




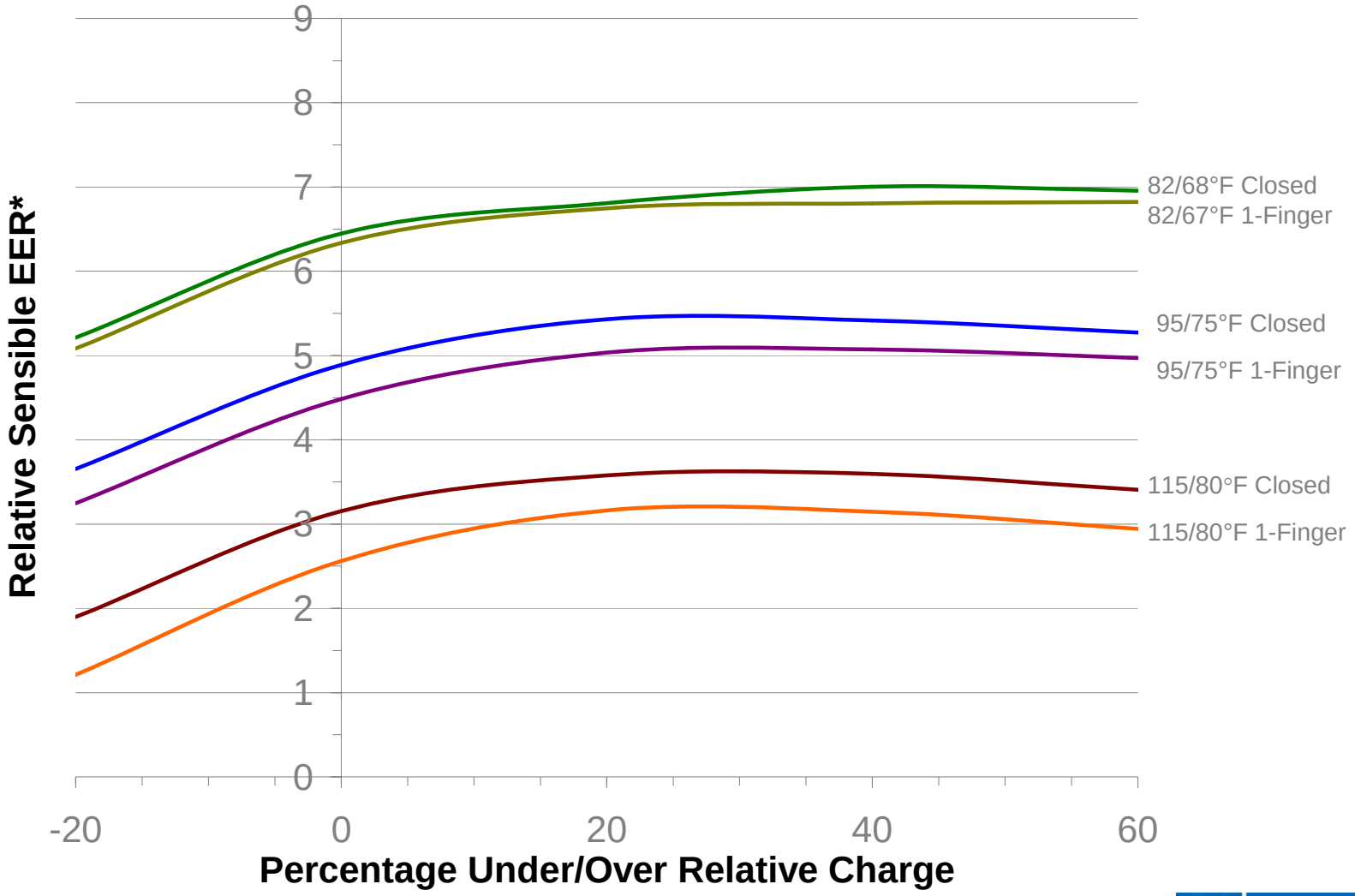
Economizer Test Results

- Economizer fan-only is less efficient than no economizer at 70/60F and 65/57F outdoor due to fan heat and less cooling capacity
- Economizer fan-only provides less cooling capacity at all outdoor temperatures
- Savings approach zero as economizer damper position increases from closed to 100% open
- One training video recommended 3-fingers open (30% outdoor air) which reduces efficiency by 10 to 62%, increases cooling and heating energy use, and reduces economizer savings by about 50%

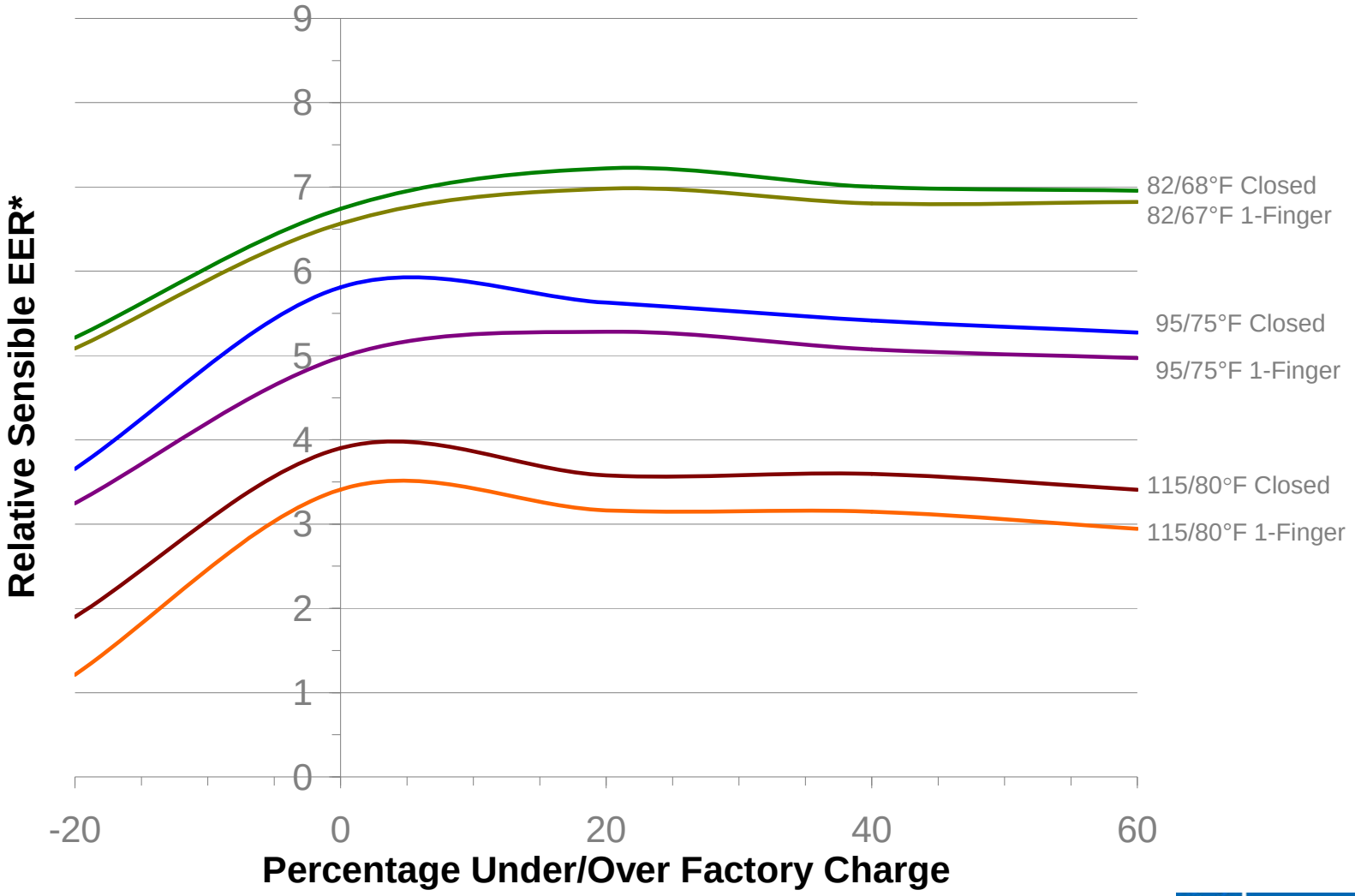
% Relative Charge vs Total EER*



% Relative Charge vs Sensible EER*



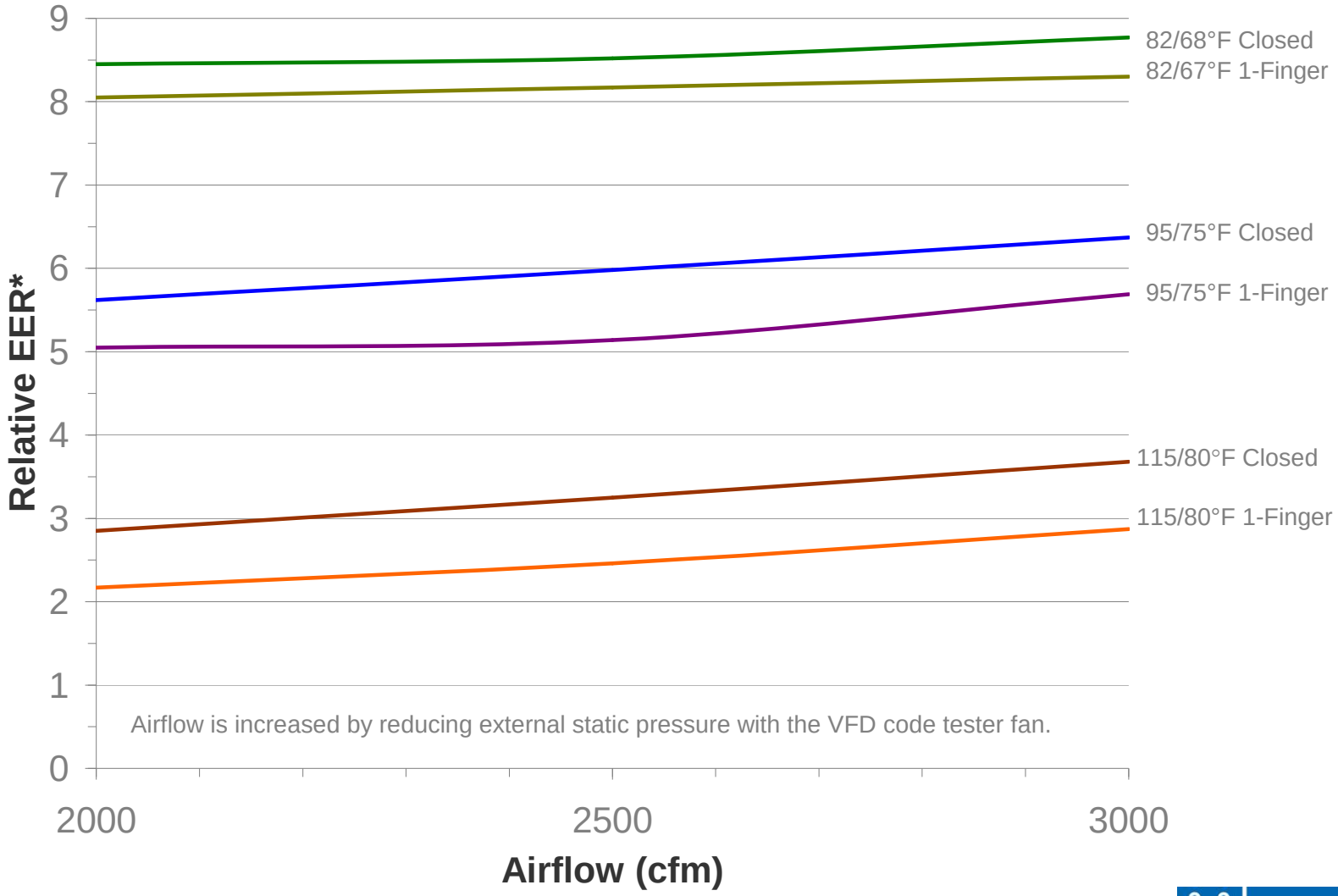
% Factory Charge vs Sensible EER*



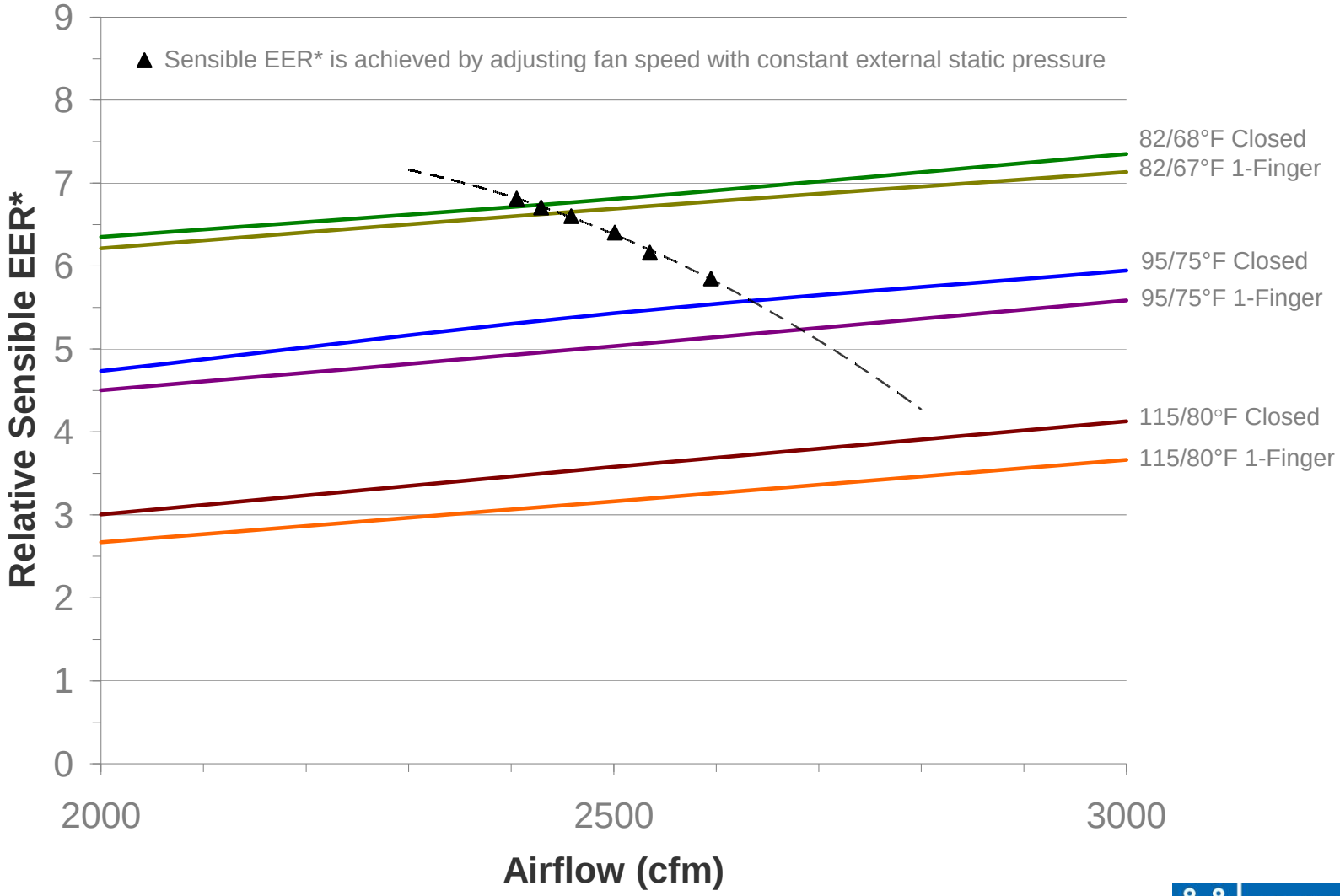
Refrigerant Charge Results

- Recent tests show factory charge is generally 2 to 65% more efficient than over/under charging
- Factory charge might not provide diagnostic values within manufacturer specifications
- Overcharging to achieve manufacturer specifications can reduce efficiency
- Overcharging can cause liquid refrigerant to flood compressor during normal operation and start-up which dilutes oil causing inadequate bearing lubrication and premature failure

Airflow vs Total EER*



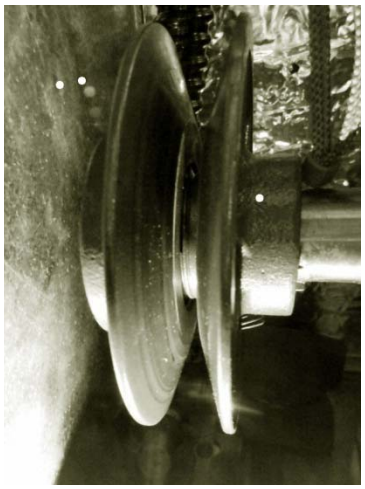
Airflow vs Sensible EER*



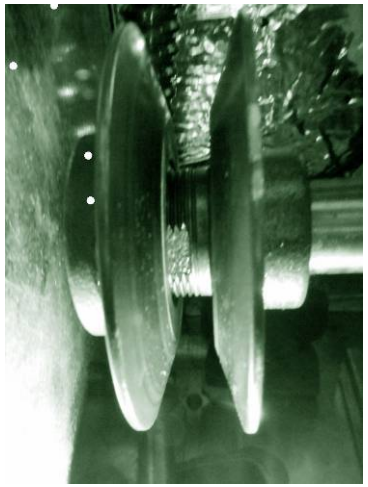
Airflow Test Results

- Airflow of 67% to 83% (267 to 333 cfm/ton) can reduce total efficiency by 2 to 27% and sensible efficiency by 6 to 24% depending on OA damper position
- Increasing airflow by increasing fan speed (RPM) reduces efficiency by 2 to 14% due to increased static pressure depending on OA damper position
- Tests of Pitot-tube arrays used in the field indicate 9 to 11% greater airflow than laboratory measurements (±7% manufacturer accuracy)

Efficient Fan Speed (EFS)



- Lab test of Standard Fan Speed 935 RPM (3 turns) produces 0.86" total static, -0.49" inlet static, 2629 cfm, 61,537 $Btuh_s$, 7.2 EER_s, and fan power of 1510 W

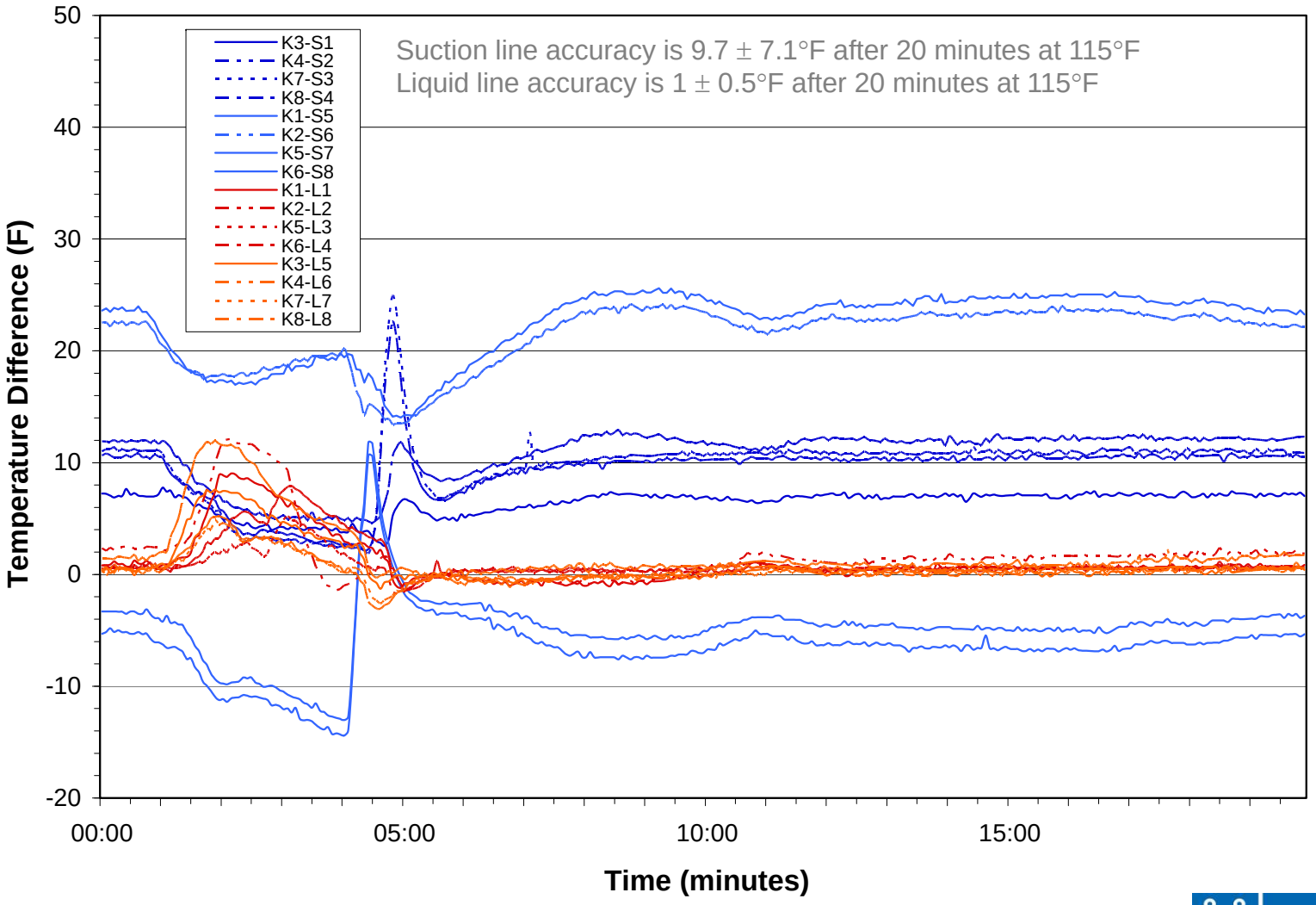


- Lab test of Efficient Fan Speed 756 RPM (6 turns) produces 0.37" total static, -0.27" inlet static, 2473 cfm, 62,368 $Btuh_s$, 7.8 EER_s, and fan power of 1015 W

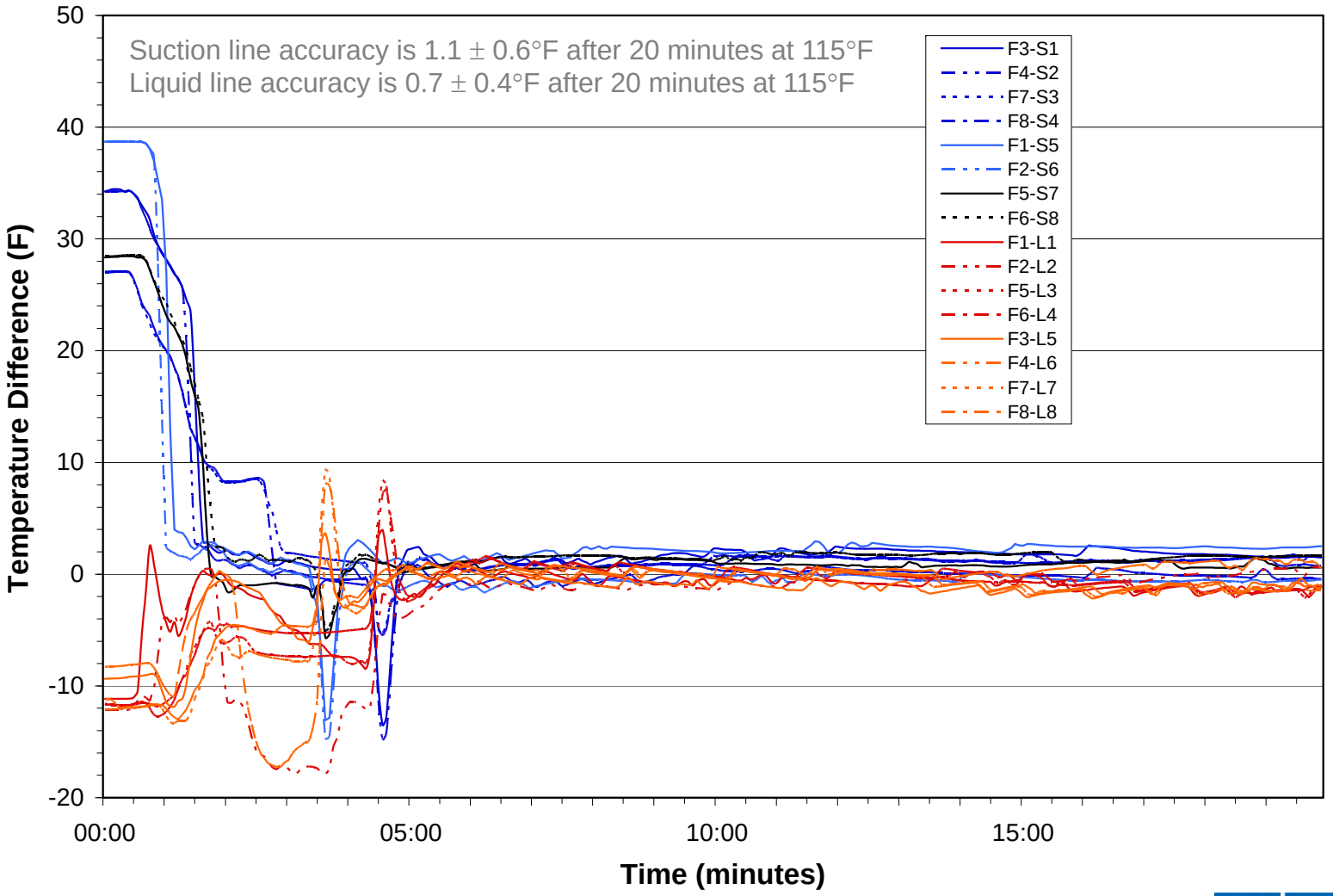
EFS Applicability

- Most packaged RTUs have higher fan speed than necessary which increases pressure, wastes power, increases noise, and causes occupant discomfort/complaints
- Lab tests of two 7.5-ton RTUs show that EFS improves EER* by 9 to 13%, reduces total kW by 6%, fan kW by 31%, and airflow by 6%
- Field tests of 5, 7.5, 10, and 12.5 ton RTUs indicate EFS improves EER* by 7% to 12%, reduces total kW by 7%, fan kW by 34%, and airflow by 12%

Cylindrical Thermistors



Type-K Clamp Probes



Measurement Instruments

- It takes 5 to 10 minutes for sensors to accurately measure temperatures
- Type-K clamp suction accuracy is 1.1 ± 0.6°F and liquid accuracy is -0.7 ± 0.4°F at 115°F outdoor
- Other Type-K clamp suction line accuracy is 6.8 ± 1.0°F and liquid accuracy is 1 ± 0.5°F at 115°F
- Insulated cylindrical thermistor suction accuracy is 9.7 ± 7.1°F, and clamp thermistor suction line accuracy is 5.4 ± 2.1°F at 115°F outdoor

Conclusions

- ACCA 180 is a maintenance check list with no instructions about how to improve energy efficiency
- Technicians do not understand how to properly detect and diagnose faults and make repairs to save energy
- In one program more than 70% of economizer repairs are not working 12 months year later and 100% are not working 3 months later
- Observations and lab tests indicate issues with tools, procedures, and damper leakage causing FDD errors
- Combination of FDD errors and refrigerant charge incentives can cause overcharging which reduces efficiency and compressor life

Conclusions

- EM&V study found 55% of units with dampers open from 10 to 30% and 9% with dampers fully-open
- Lab/field tests and other studies show open dampers can increase cooling/heating energy by 8 to 50%
- Problem appears to be with program design and implementation and not with technicians
- Recommend program redesign to improve training tools, protocols, measures, and data collection
- Lab/field tests indicate potential of Efficient Fan Speed as a simple low-cost maintenance measure that can provide measureable energy and peak kW savings

Thank you!

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