



AIR-COOLED TURBOCOR

RETROFIT OF AN AIR-COOLED CHILLER WITH AN OIL-LESS CENTRIFUGAL COMPRESSOR

**EAST COUNTY FAMILY RESOURCE CENTER
COUNTY OF SAN DIEGO**

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Background

The County of San Diego's East County Family Resource Center is a 22,000 sq ft office facility served by one 88-ton York air-cooled chiller (230 Volt, R-22) with two reciprocating compressors. The chiller had been riddled with problems since installation: compressor failures, excessive noise, and significant oil in the refrigerant. Before the retrofit, the chiller was measured operating at 1.4 kW/ton (8.3 EER). In April 2005, one of the reciprocating compressors failed again; the replacement cost was estimated to be \$12,800. Rather than replace the compressor like for like, the chiller was retrofitted with one R-134a 80-ton oil-less centrifugal Turbocor compressor, a transformer to step the voltage from 230V to 480V, an electronic expansion valve (EXV), and a variable frequency drive to control the two condenser fans. Figure 1 below shows the chiller pre-retrofit.



Figure 1: York air-cooled chiller (model YCA288HE3)

Oil-less Compressor Technology

During the retrofit 32 ounces of oil were removed from the evaporator of the existing chiller. This amount of contamination severely degraded the heat transfer characteristics of the refrigerant and resulted in poor chiller performance. The Turbocor oil-less centrifugal compressor uses environmentally friendly R-134a refrigerant, magnetic bearings (no oil), and a direct drive system (no gears). It is currently manufactured in capacities of 60-150 tons. It weighs 80% less than traditional compressors and the direct drive system and magnetic bearings reduce noise and vibration. The compressor's rotor shaft and impellers levitate during compression and float on a magnetic cushion. The compressor has an integrated variable frequency drive (VFD) that provides an excellent part load efficiency.

Turbocor compressors have been commercially available since 2001 and there are more than twelve installations in San Diego. The Turbocor manufacturer claims 30% energy savings versus standard centrifugal compressors, 33% versus screw compressors, and 40% versus reciprocating compressors.

Chiller Retrofit

The installation required the following:

- Pump out refrigerant and remove existing compressors.
- Provide and install new Turbocor TT300 80-ton compressor.
- Provide and install transformer to step voltage to 480V.
- Provide and install new R134A chlorine free refrigerant charge (120 lbs).
- Provide and install a new network ready VFD on the condenser fans.
- Provide and install a new Electronic Expansion Valve to match system.
- Provide sequence of operation and necessary controls.
- Provide factory trained startup and commissioning and one year warranty.



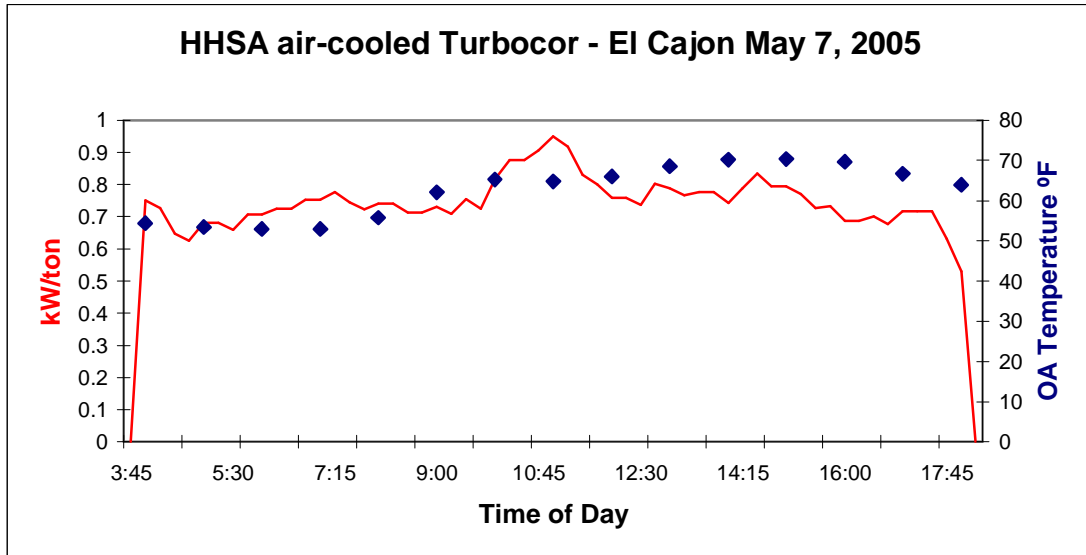
VFD controlling two 1 hp condenser fans. The VFD maintains a constant head pressure for the compressor.

80-ton Turbocor compressor.

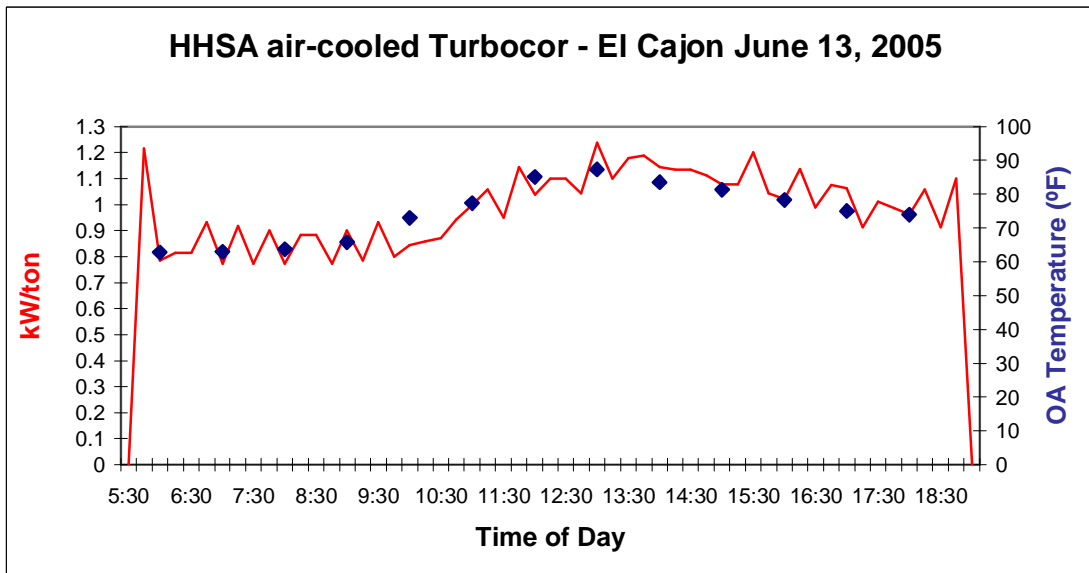
Transformer to step voltage from 230V to 480V.

Compressor Performance

With the temperate climate in San Diego, chillers run at part load for all but 1% of the year. The figures below show the energy consumption of the retrofitted chiller collected at the Family Resource Center in the months of May and June of 2005. Metering equipment was installed to capture the chilled water flowrate, entering and leaving chilled water temperature, and overall chiller power consumption. Outside air temperature was also recorded to monitor the performance of the compressor as the condensing conditions changed.



As shown above, the retrofitted chiller operated between 0.65 to 0.95 kW/ton on May 7th. On this day, the unit averaged 0.74 kW/ton or 45% more efficient than the pre-retrofitted chiller with reciprocating compressors.



The higher ambient temperatures in June resulted in chiller energy consumption ranging between 0.77 and 1.2 kW/ton. The average efficiency of 0.90 kW/ton during June 2005 still resulted in 35% savings over the pre-retrofit machine.

HHS Building Chiller Efficiency	
Month	kW/Ton
Jun-05	0.90
Aug-05	1.04
Sep-05	0.98
Oct-05	0.98
Nov-05	0.95
Dec-05	0.82
Average	0.99

Savings Analysis

The 88-ton York air-cooled reciprocating compressor consumed 1.4 kW/ton according to multiple spot measurements taken before the retrofit (readings taken between March and May 2005). Based on 15 minute interval data collected between June and December 2005, the new variable speed chiller with an oil-less Turbocor compressor consumes an average of 0.99 kW/ton. In the last 6 months of operation the County has saved \$4,907 from the energy upgrade. In the end, it is estimated the Family Resource Center stands to benefit from \$7,500 to \$8,500 in annual energy savings.

The variable speed oil-less Turbocor compressor keeps the East County Family Resource Center comfortable while consuming approximately 35% less energy over the pre-retrofit reciprocating unit (based on 6 months of data). With SDREO's Local Government Energy Efficiency Program (LGEEP) incentive, the energy savings will allow the County to recoup their investment of \$22,485 in less than 3 years.

Implementation Costs	
Compressor Retrofit	\$ 50,000
Reciprocating Compressor Cost	\$ (12,800)
Incentive	\$ (14,715)
Total Installed Cost	\$ 22,485
Est. Annual Energy Savings	\$ 8,000
Simple Payback (yrs)	2.8

Conclusion

Based on the test results, 30-40% energy savings over reciprocating air-cooled compressor technologies are realistic. Additional benefits and points of interest include:

- Existing refrigerant (R-22) was replaced with environmentally friendly R-134a
- Noise was greatly reduced
- Oil is no longer an issue (in regards to refrigerant contamination, oil return problems, oil replacement costs, and oil recycling)
- Installed cost averages about \$45,000-\$50,000 per compressor (60-90 ton units)

For more information about this retrofit please contact Ben Erpelding, P.E. (SDREO's Engineering Manager) at 858-244-1177.