

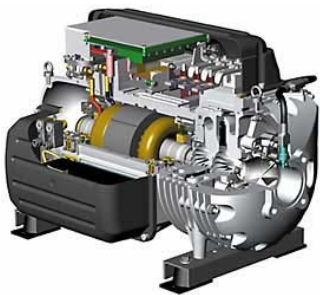
CASE STUDY

*Environmental  
Stewardship  
Combined with  
Good Economics.*



## **Turbocor® Compressor Retrofit of a 260 Ton Screw Chiller for Seattle-Based Hi-Tech Company**

<b>The Challenge</b>	Facility management group Grubb & Ellis enlisted UMC's assistance in a retrofit project involving a 260 ton roof-top screw chiller for their high-profile client. Several operating concerns initiated the need for a replacement/upgrade, including inefficient energy use, vibration and noise issues, and high maintenance costs.
<b>The Solution</b>	A custom UMC engineered retrofit solution with three 80 ton Turbocor compressors mounted in parallel on a new refrigerant discharge header.
<b>The Results</b>	Improvements in operation efficiencies resulted in dramatic savings in utility and maintenance costs.



### **Project Overview**

In January of 2007, Grubb & Ellis' facility manager contacted UMC concerning a potential Danfoss Turbocor retrofit for a 260 ton rooftop screw chiller. This unit had been an ongoing target for a replacement/upgrade for the facility management group due to several operating issues. The first issue concerned the chiller's energy usage. While not an old piece of equipment, the chiller operated in the 0.7 to 1.2 kw/ton range; certainly a number that could be improved upon. Another issue concerned noise and vibration. The unit operated at a high decibel level, necessitating the construction of a sound proof barrier around the unit to reduce the noise to a level that would be acceptable for the surrounding neighborhood. While successful at reducing the sound level, the barrier limited access to the equipment during servicing. In addition, the vibration of the chiller had previously required that the office space immediately below the unit be abandoned; and for a company needing every square foot of space available, this was not a minor issue. Finally, the cost of maintaining the chiller was becoming an issue primarily due to a problem with the circuit control board having to be replaced following interruptions in power due to relatively frequent power spikes. This cost approximately \$7,000 each occurrence.

The four buildings within this campus range in size from three to four floors each and house office space as well as software laboratories that require mechanical cooling year round. The cooling capacity requirements for the facility are driven primarily by the internal operating equipment and are only slightly effected by external temperature conditions.

The pre-retrofit cooling system consisted of four 260 ton water cooled rooftop screw chillers installed in 1998. Each of these chillers is located on a separate rooftop corner of the facility and all are interconnected so that any one chiller can serve the entire campus. Given that the cooling load of the facility is significantly less than the four chillers combined capacity, past operating practice has been to utilize only one chiller at a time to supply cooling to the entire campus. This provided an excellent opportunity to retrofit a single unit to serve as the lead campus chiller year round.

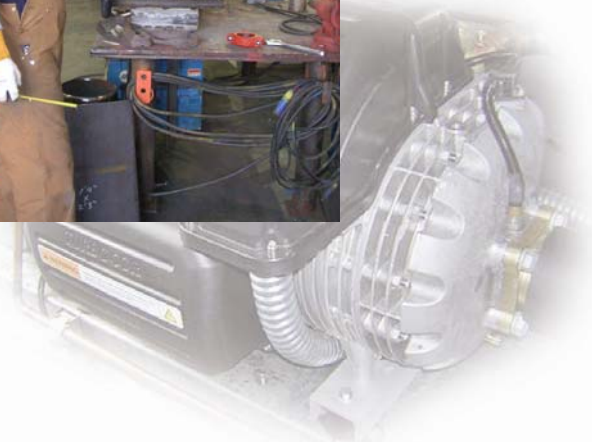
### **Project Implementation**

University Mechanical Contractors (UMC) worked directly with the Danfoss Turbocor compressor manufacturer to determine the best application of the available technology to suit this retrofit situation. This necessitated a custom UMC engineered retrofit solution. This custom design included removal of a single 260 ton screw compressor; to be replaced with three 80 ton Danfoss Turbocor compressors mounted in parallel on a new refrigerant discharge header. Keeping an eye on environmentally conscious upgrades, and with the help of eddy current tube analysis to insure the integrity of the equipment, the original chiller's evaporator & condenser bundles were found to be in excellent shape. So with



a little cleaning & upkeep they were retained for reuse with the newly retrofit chiller compressors. This not only reduced the implementation cost, but also due to the reuse of salvaged on site materials, provided a key sustainable element to the project corresponding to "LEED-EB Material & Resources Credit 2 – Optimize Use of Alternative Materials".

All custom prefab and welding was completed at the UMC shop prior to delivery to the site. A newly designed power panel and Kiltech control system were also included in the package. Following the installation and start up of the new Danfoss Turbocor retrofit chiller, final commissioning had to be completed to fine tune the operating conditions for optimum efficiency.



## Results

### Retrofit Overview

- ✓ Replaced a single 260 Ton Trane Screw Compressor with three (3) 80 Ton Danfoss Turbocor Compressors
- ✓ UMC provided all custom engineering design and construction requirements as needed
- ✓ Converted from R22 (which is an HCFC ozone depleting refrigerant) to more ozone friendly R134a (an HFC based refrigerant)
- ✓ Reviewed condition of evaporator & condenser tube bundles via eddy current analysis. Cleaned and re-used the existing equipment
- ✓ Installed a new Kiltech touchscreen chiller control system & interface panel
- ✓ Designed and installed a new power panel
- ✓ Making use of the existing chiller's compressor support brackets, a seismically rated compressor support stand was designed and certified prior to being fabricated in-house

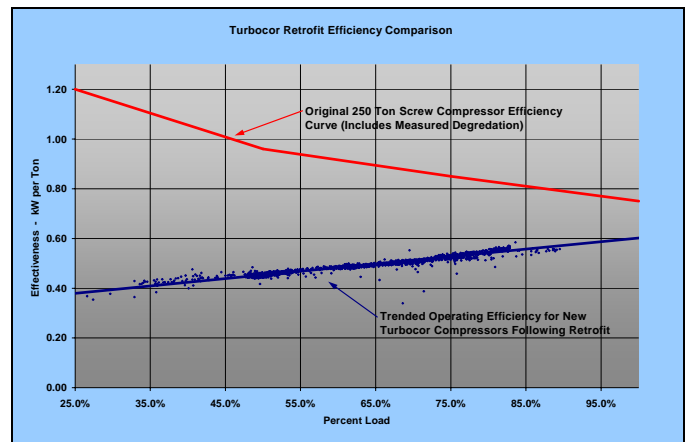
### Danfoss Turbocor Technology

Danfoss Turbocor technology consists of an oil-less centrifugal compressor that utilizes environmentally friendly R-134a refrigerant, magnetic bearings (no oil), and a direct drive system (no gears). The compressor's rotor shaft and impellers levitate during compression and float on a magnetic cushion. This system incorporates on-board digital control electronics and an integrated variable frequency drive to proactively manage compressor operation. This design provides for very efficient part load operation while eliminating the need for an oil management system. It also weighs 80% less than traditional compressors (about 265 pounds versus 1,300 pounds).



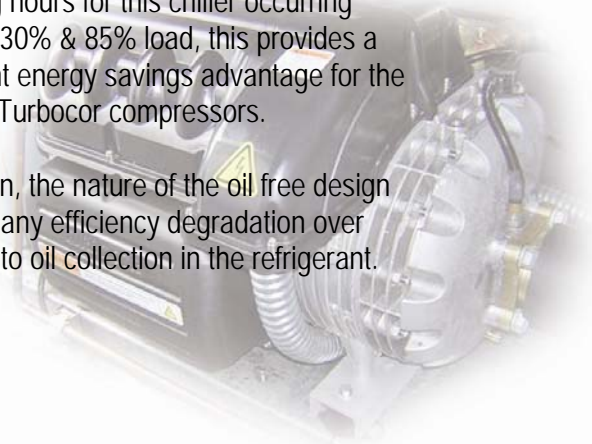
### Operating Efficiency

The operating efficiency of the newly retrofit chiller ranges from a design maximum of 0.67 kw/ton at 100% load to a minimum of 0.37 kw/ton at 25% load. The actual measured operating efficiency of the chiller was extremely close to this predicted efficiency, varying no more than 5% at any operating point (see chart below).



As can be seen in the efficiency curve, the Danfoss Turbocor compressors actually improve operating efficiency at lower loads. This is not the case for a typical screw compressor. With the majority of the annual operating hours for this chiller occurring between 30% & 85% load, this provides a significant energy savings advantage for the Danfoss Turbocor compressors.

In addition, the nature of the oil free design prevents any efficiency degradation over time due to oil collection in the refrigerant.



### Sound Attenuation

One side benefit that resulted from the retrofit was the significant reduction in sound levels emanating from the chiller compressors. With the original screw compressor operating at approximately 90 db, the rooftop installation had previously been modified with sound attenuating devices to reduce noise pollution transfer to the surrounding residential neighborhood. The Danfoss Turbocor chiller operates at about 72db; eliminating the need for the attenuating devices; thereby freeing up space while eliminating any potential noise related issues.

Typical Sounds	Typical Music	SPL, dB
Chest wall vibrates, choking, giddiness		150
Jet taking off, 25 meters		140
Threshold of pain		130
Artillery, 100 yards	Cannon (peaks)	130
Riveter, nearby		120
Loud car horn, nearby	Very loud rock (peaks)	110
	Very loud classical (peaks)	110
Inside N.Y. subway	Very loud classical (avg.)	100
Screw Compressor	Loud classical music	90
Heavy truck		90
Inside motor bus	Moderately loud classical	80
Noisy traffic, corner		80
Newy office	Soft popular music	70
<b>TURBOCOR</b>	TT300 Refrig. compressor	70
Business office	Soft classical music	70
Conversational speech		60
Private office	Very soft music	50
Background noise, city home		40
Background noise, suburb		40
Library		30
Background, country night		20
Whisper, leaves rustling		20
Good recording studio		10
Threshold of hearing		0

### Chiller Controls

The world's first truly "smart" compressors, Danfoss Turbocor utilizes on-board digital control electronics to proactively manage compressor operation while providing external control and web-enabled monitoring access to a full array of performance and reliability information. It also provides many of the control functions that have been previously performed by the power and

control panels of the chiller or rooftop package, saving product costs.

These internal control functions of the installed compressors were tied directly into a local Kiltech touch control screen for control and monitoring of the chiller. In addition, this system was tied directly into the Building Automation System for remote access.



## Utility Savings Analysis

Utilizing actual system operating data to determine the facility cooling load curve and the chiller operating efficiency at various loads, the estimated annual utility cost savings and payback information is shown in the following table.

Annual Utility Savings (kWh)	Monthly Demand Reduction (kW/month)	Utility Incentive (\$)	Simple Payback
546,560 kWh	50 kW/month	\$198,000	Less than 2 years

## Conclusion

Based on the lessons learned during the development, implementation and performance monitoring of this project, several conclusions have been reached.

- ✓ A Danfoss Turbocor retrofit of an existing screw chiller can be extremely cost effect, given the appropriate operating load curve and operating hours.
- ✓ Noise reduction proved to be a significant benefit given the rooftop installation and residential neighborhood location. Previously installed noise abatement equipment was removed after installation, opening up more of the surrounding space.
- ✓ Operating efficiencies and resulting utility savings estimates are real; as was proven by careful monitoring and measurements performed by the local utility (Puget Sound Energy).
- ✓ The depth of operational information and system parameters immediately available at the unit (via the Kiltech touchscreen chiller control panel) provides a great deal of value for operators and engineers.
- ✓ The potential for sustainable re-use of chiller evaporator & condenser bundles is an environmentally friendly retrofit construction practice that can help achieve LEED-EB credit.
- ✓ The inherent design of the Danfoss Turbocor compressors provides minimal vibration; which, in this case, allowed the office space directly below the chiller to be re-occupied.
- ✓ Another sustainable attribute associated with this compressor technology is the potential for converting to an environmentally friendly, non CFC refrigerant – R-134a. This also can help to achieve LEED-EB credit.



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