MUSEUM OF SCIENCE & INDUSTRY

CASE STUDY

Over eighty years has passed since the German U-505 submarine was captured during World War II, but you would never know it by looking at her, and curators at the Museum of Science & Industry in Chicago would like to keep it that way.

Since her capture in 1944, the U-boat has survived a near sinking, a treacherous tow from the Atlantic to the Great Lakes, and 50 years of turbulent Chicago weather as an outdoor exhibit. The years had certainly taken their toll, but in 1997 the Museum launched a massive restoration project to preserve the U-505 and then move her indoors to a climate-controlled environment. Today, the U-boat resides in a specially constructed 75 ft. x 42 ft. underground exhibit space at the Museum of Science and Industry where visitors of all ages can come aboard to see this painstakingly restored artifact.

To make sure that the U-Boat retains her youthful appearance, the exhibit space was engineered for the utmost in temperature and humidity control. Primera, a leading engineering and design management firm in Chicago, was charged with the task of designing a space and mechanical system that would protect the sub indefinitely from environmental wear and tear and provide a comfortable, healthy indoor space for museum patrons.

It was not an easy task given Chicago's broad spectrum climate and the limitations of the existing chilled water system, which could only provide a 44 degree supply temperature. Because Chicago summers can be quite hot and humid, this supply temperature was not low enough to provide adequate cooling and dehumidification. Furthermore, the traditional method of overcooling the air and then heating it back up would be terribly inefficient. Designers considered active dehumidification options typically associated with natatorium applications, but the heat energy required to regenerate the desiccant was too cost prohibitive.

Humidity and temperature weren't the only challenges. Space was also limited for a system that would ultimately have to deliver 20,000 CFM of conditioned outdoor air to the exhibit space. Noise was another concern since the exhibit would include both sound effects and interactive options.

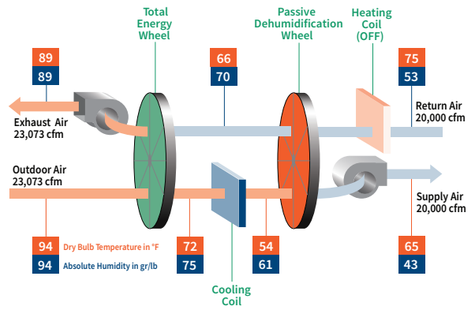
COMFORT, FRESH AIR, & ENERGY OPTIMIZATON

The solution to these and other problems was found in a Pinnacle® Primary Ventilation and Energy Recovery System made by SEMCO. The key to the Pinnacle's effectiveness is its unique passive dehumidification wheel. This wheel uses a desiccant material that is optimized to remove moisture from a saturated air stream without an active regeneration source. Other components included a cooling coil, heating coil, total energy recovery wheel, and a humidifier for wintertime operation.

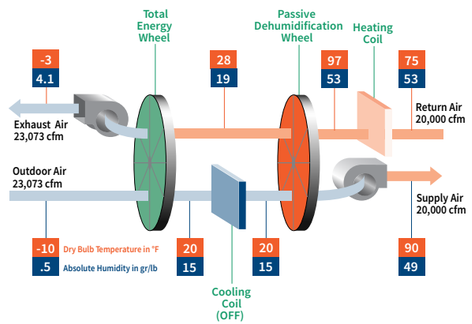
HOW IT WORKS

The Pinnacle system pre-cools and dehumidifies outdoor air during the cooling season; it also preheats and humidifies the outdoor air during the heating season. Pre-tempering and dehumidification are both accomplished by recovering (or rejecting) heat from the exhaust air stream via the heat wheels. The Pinnacle system responds to variations in temperature and humidity by modulating the rotational speed of the passive dehumidification wheel, and/or adjusting the energy input to the cooling coil. The rotational speed control may be adjusted to control the level of temperature and moisture exchanged by the passive dehumidification wheel.

Latent Cooling Mode



Peak Heating Mode



The chilled water coil is sequenced on when the space requires cooling and when the chillers are in operation, which is May through October. The heating coil is used only during wintertime operation to boost the supply air temperature. The heat wheels provide approximately ¾ of the heat required for wintertime operation.

To further maximize efficiency but still maintain fresh air, the system is controlled to operate with 100% outdoor air during operating hours when the air can be used for cooling. When outdoor weather is extreme, the system uses just enough outdoor air to maintain proper ventilation. When the museum is closed, the system operates on 50% outside air. The end result is a system that works in perfect harmony with the museum's central chilled water system without any of the energy penalties associated with conditioning 100% outside air in an area with diverse climate conditions.

$150K+ SAVINGS OVER TRADITIONAL SYSTEM

Primera's design modeling demonstrated that the SEMCO system would provide an annual energy saving of over $150K annually over a conventional system utilizing over-cooling and reheat. (See table on **PAGE 3**) Note that these savings are based on 2002 utility rates, which were much lower and therefore do not reflect the full amount of savings.

	Pinnacle Approach	Over-cooling Reheat Approach
Cooling Season Energy Cost	$2,568	$34,287
Heating Season Energy Cost	$1,433	$112,310
Demand Charges (cooling season only)	$3,229	$10,929
Total Annual Energy Cost	$7,230	$157,525

NOTES:
1. Supply air 20,000 cfm; exhaust air 20,000 cfm.
2. Electric cost is $0.050/kWh; gas at $1.47/therm.
3. Based on 24 hour/day, 7 day/week operation.
4. Electrical demand charges are $16.41.

In addition to savings, SEMCO was able to accommodate the museum's space limitations.

"An exhibit decision dropped a section of the floor just adjacent to the mechanical room that forced some redesign to get the SEMCO unit into the available space," said Bill Vanderbilt, Facilities Director for the Museum. "SEMCO was able to alter the width of the unit to make it fit into the space."

After several years of operation, Vanderbilt is please to say that comfort has been "ideal" with "no report of any noise issues." Equally important, the U-505 hasn't aged a bit and should continue to educate many future generations.

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