Study Verifies Coil Cleaning Saves Energy

By **Ross D. Montgomery, P.E.,** Member ASHRAE; and **Robert Baker,** Member ASHRAE

1500 Broadway in NYC is the site of a coil cleaning study.

Although it's known theoretically that cleaning a coil can result in energy savings, little actual testing data and research exist to prove the point. As a result, building managers often ignore or reduce resources devoted to air-handler maintenance when faced with budget constraints. If proper maintenance is an important consideration in overall energy costs, conserving in that budget area can be self defeating.

Through our privately funded testing, monitoring and analysis, we believe we found a methodology and regimen that proves maintaining air-handler components in a clean condition can save energy dollars and improve other building parameter changes and efficiencies such as improved dehumidification and comfort, along with less mold and bacteria. Thus, we are encouraging IAQ environmental parameter improvements, better tenant satisfaction, and increased worker effectiveness.

It is difficult to find a building where such a study can be held. Fortunately, the owner and managers of a landmark 34-floor building on Times Square in New York City wanted to see what impact a dramatic change in coil cleaning nature and frequency might have. This building has only four large air handlers (SF-6, SF-7, SF-8, SF-9; 250 [880 kW], 123 [433 kW], 121 [425 kW] and 81 tons [285 kW], respectively) to service its 1.2 million ft^2 (111 500 m^2) of air-conditioned and heated space throughout the year.

The test project was performed at the building July through September 2005 to monitor and analyze the HVAC energy use before and after restoration of two air handlers, SF-8 (121 tons [425 kW]) and SF-9 (81 tons [285 kW]), which are similar in their constant volume operation to the other two air handlers in the building, and are located on the 34th floor mechanical room. This total of four air handlers interact by providing heating and cooling to the tenants of the 34 floors of the building. Periodic

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future data readings will measure and document an ongoing O&M program designed to maintain the enhanced level of performance.

No direct way of measuring energy use or demand savings exists because instruments cannot measure the absence of energy or demand. However, the absence of energy use or demand can be calculated by comparing measurements of energy use and/or demand before and after an energy conservation measure (ECM) (see ASHRAE *Guideline 14-2002, Measurement of Energy and Demand Savings* for details and more specific testing criteria and methods).

The ECM data collection was started on approximately Aug. 21, 2005. The ECM cleaning of the coils occurred on Aug. 27 and 28. During the study, specific operational parameters on SF-8 and 9 were monitored with energy balance and temperature/humidity data points being recorded for one week prior to the ECM. The recording was resumed for an additional week following the ECM. Several critical data points such as coil differential pressure, air and water temperatures before and after the coil, condensate temperature, supply air velocities, outside air temperatures, humidity's before and after the coil, were monitored on SF-8 and 9 and both units were properly and completely cleaned.

To add reliability in our instrumentation calibration and accuracy, a certified and independent testing, adjusting and balancing (TAB) firm was used to test and calibrate the instrumentation that logged pressure, temperature, humidity, air velocity and volumetric flow rates, voltage and amps, during the course of our study period. In all, some 54 data points were continuously logged throughout the study period.

The daily variation in outside air temperature was nearly the same in the time span of this ECM (*Figure 1*). (As can be observed in the various charts, the building HVAC systems are operated in this building only during 6 a.m. to 6 p.m. Monday through Friday.)

The study has yielded the following overall results and conclusions:

- Restoration of the one air handler resulted in improvements that will lead to energy savings of up to $40,000 this year, in accordance with the results and assumptions of this study. (The coil is 30 years old, and its last cleaning was one year ago, so the coil was in a dirty state.)
- Restoring the air handler resulted in a decrease in the pressure drop across the coil, of approximately 14%. This has resulted in a corresponding increase in airflow. The result is that the fan is producing that much more work in the form of cooling.
- Restoring the air handler resulted in an increase of 19 tons to 22 tons (67 kW to 77 kW) of cooling added to SF-9. We estimate that 100 tons (352 kW) of cooling capacity will be added to the building once all four air handlers in the building are restored in a similar manner. (Building has a total of 1,800 [6330 kW] tons available capacity.)
- Restoring the air handler increased the thermal efficiency of the cooling coil 25% with respect to its ability to transfer its energy to its sensible loads.
- Restoring the air handler increased the thermal efficiency of the cooling coil 10% with respect to its ability to transfer its energy to its latent loads. (This is especially significant as it helps to cure the only IAQ-related complaint from building occupants, which was elevated humidity levels in certain interior locations.)
- Restoring the air handler will continue to save energy by decreasing the load on the chiller plant, and making the heat transfer of this loading more efficient. It reduces the time of multiple chiller operation and its associated pumps, cooling towers, chemical costs, wear and tear, etc. It also increases the awareness and practice of scheduling of plant operations and optimization techniques.

On SF-9, the *measured* flow rate (by TAB contractor), using the velocity across the cooling coil and the measurement of the coil area, was 30,609 cfm (14 444 L/s) before cleaning, and 34,980 cfm (16 507 L/s) after cleaning. (As shown, the ECM coil cleaning occurred on Aug. 26 to Aug. 28, and the velocity started to increase after that.) On SF-9, the *calculated* flow rate using pressure differences across the fan inlet and discharge were 27,125 cfm (12 800 L/s) before cleaning and 31,173 cfm (14 710 L/s) after cleaning. (For informational purposes only, the original specified cfm of this AHU-9 is 39,150 cfm [18 475 L/s], and this value is not used in any of our calculations. This unit is 30+ years old, and is not operating up to its original design values.) As you can see, the calculated vs. the measured values have a difference of 13%, but for the purpose of this article, we will use the measured values. The increased airflows and delivery of conditioned air to the space can increase tenant satisfaction and decrease complaints. *Figure 2* shows the graph of the increase in velocity after cleaning.

On SF-8, the coil differential pressure decreased by 14% (*Figure 3*). Using a similar analysis as we did for SF-9, this resulted in a flow rate increase of 53,475 cfm (25 234 L/s) × 1.14 = 60,961 cfm (28 767 L/s).

On SF-9, the condensate water temperature, as shown below in Figure 4 approached the chilled water supply temperature from 6°F to 8°F (3°C to 4°C) before cleaning, to 2°F to 4°F (1°C to 3°C) after cleaning. (As shown, the ECM coil cleaning

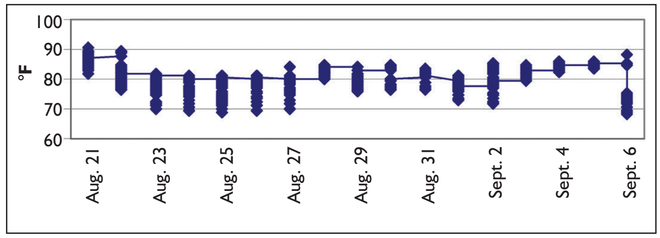

Figure 1: Outside air temperature (ECM period Aug. 21 to Sept. 6).

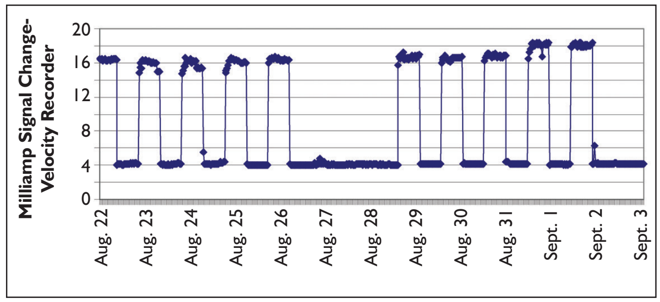

Figure 2: SF-9 air velocity increase before/after cleaning.

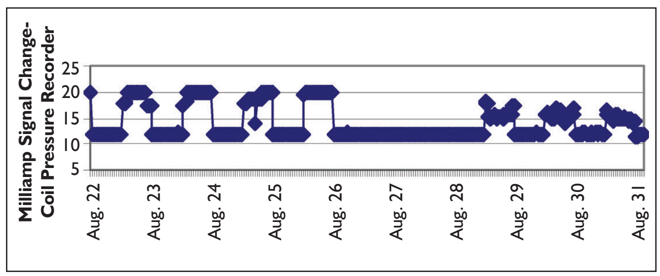

Figure 3: SF-8 differential pressure across coil change before/after cleaning.

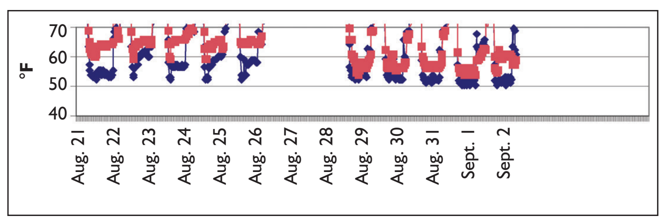

Figure 4: SF-9 supply water vs. consendate temperature differences.

occurred Aug. 26 to 28). This represents a significant increase in latent heat transfer ability of the coil in the range of 10%. This indicates the ability of this coil "after cleaning" to being able to provide for *better* building dehumidification capacity control by delivering sub-dew-point air temperatures across the cooling coil.

In addition to the hard results presented in this article, many other "soft" positive results come out of cleaning and normal maintenance operations and its resultant energy savings and airflow increases. The HVAC system performance is increased and can more closely perform to its original intended specified operation (39,150 cfm [18 500 L/s] design data from 30 years before). After coil cleaning and regular maintenance, the HVAC systems are cleaner, and do not provide an environment for fungal, bacterial and microbial growth in their coils, ducts, and pipes. IAQ and the awareness of good IAQ are increased in the building, and the overall comfort and work effectiveness can be greatly enhanced. Overall tenant satisfaction with the building environment has been improved as evidenced by the property manager's communications and positive feedback.

Furthermore, not only will the owner benefit from the obvious energy savings and comfort increase, we also were able to help optimize some other building maintenance and operation processes and help enhance energy and maintenance effectiveness for years to come.

The building management had considered upgrading the environmental control systems to a modern building management system but could not clearly demonstrate an economic value to that investment. The data developed during this study allowed them to more accurately calculate a payback, so they scheduled this upgrade. In addition, consideration had not been given to conversion of the controls over the building supply and return fans from constant speed operation to VFD. The economic analysis allowed through this data has suggested that such a conversion might have significant economic value.

Good maintenance and operation practices including coil cleaning can significantly improve energy efficiency and IAQ performance of the HVAC&R systems in a building, such as reported here of 10% to 15%. More importantly, this study identified several key monitored and adjusted data points, such as pressure, humidity, and temperature, that can quickly and affordably provide a prediction of the potential for energy savings in any building. It is anticipated that such measurements will become a valuable tool for managing the economic impact of various building maintenance strategies.

A rich set of this study's data remains to be fully analyzed. It is possible that full analysis of all of this data will lead to even more additional opportunities for operational economy and improvements in this and other similar buildings.

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Acknowledgments

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