Satisfaction Through Six Sigma

Originally developed for Motorola's production line, the Six Sigma approach translates to one message for all facilities: Before throwing money at new HVAC equipment, take steps to understand precisely what is going on in the current system and how it is failing to meet goals. More thorough evaluation using measurable parameters can lead to smarter solutions through wiser spending, or sometimes simply through better practices.

BY JOSEPH J. WATSON, P. E.

I recently had an opportunity to attend a conference titled "Best Practices in Facility Management." The attendees consisted of facility managers from Fortune 500- and large government-owned facilities in excess of 1 million sq ft. The agenda included presentations on a wide range of issues including building maintenance, utilities, outsourcing, space utilization, and custodial best practices. I was impressed with the importance placed on the feedback ratings from the building occupants, using the results of customer satisfaction surveys to help identify the best methods and techniques in facility management.

As the featured speaker on HVAC issues, I was looking forward to hearing how a group oriented to maximizing occupant satisfaction would deal with the complex issues of HVAC design, operation, and maintenance. I asked the audience how they defined HVAC system effectiveness. A large majority stated that as long as the temperature was maintained between 72° and 76°F, that the system was effective. When asked how they knew if their system was achieving this goal, most talked about maintaining and tracking a log of customer complaints over time. My response to that was that I wasn't sure if they were measuring HVAC effectiveness or their occupants' tolerance for pain!

A savvy facility manager realizes the need to develop strategies that can maximize occupant satisfaction while lowering energy costs. The goal in this article is to consider the application of the principles of Six Sigma to help identify the best methods and techniques to achieve these goals.

DEFINING HVAC SYSTEM EFFECTIVENESS

For those of you that measure your experience in decades, rather than years, it is not too hard to recall a time when HVAC controls consisted of a series of electromechanical devices or pneumatic-powered systems sequenced by time clocks. Any effort to provide control beyond the simple maintenance of space temperatures resulted in highly complex and inflexible systems that were difficult to design and often more difficult to maintain.

It wasn't until the early 1990s that the cost of microprocessors dropped enough to allow their use on individual HVAC components. The state of technology today allows for sophisticated control strategies to be implemented at each component, with operating information accessible over local area network-based (LAN) systems.

With the advent of these high-tech DDC systems, facility managers need to increase dramatically the expectations of their HVAC systems. Whether you are designing an HVAC system in a new facility or looking to improve the operation of an existing one, there are improved methods that can be used to define an effective HVAC system.

The primary benchmark of HVAC effectiveness continues to be temperature. Most systems are designed to maintain setpoint temperatures in numerous zones within the building. The setpoint is maintained by varying the temperature or the volume of air being delivered into the space. Most systems do an adequate job of maintaining acceptable space temperatures.

Another important parameter is rh. Unlike temperature, it is much more difficult to maintain zonal differences in rh. Depending on application and climate, HVAC systems may need to be designed to provide both humidification and dehumidification.

In typical designs, it is assumed that the temperature will rise as the humidity increases, ensuring that cooling will be energized to provide dehumidification. In my experience, this is not always the case, especially in low-lying or coastal regions. Excessively high indoor humidity levels are often the major culprits in creating IAQ problems.

Another factor which has become much more important in recent years is the introduction of fresh air, especially in newer, airtight buildings. ASHRAE provides recommendations for the amount of fresh air that should be introduced based on the number of occupants in any given zone.

One measure of the quality of the indoor air is the amount of CO_2 it contains. CO_2 is particularly useful to monitor because it is easily measured, and can be considered a trace gas. This means that other, more dangerous, indoor air contaminants typically vary in direct proportion to the amount of CO_2 in the air. By maintaining good CO_2 levels through the introduction of fresh air, other sources of indoor air contamination can also be minimized.

Temperature, humidity, and CO_2 levels are all measurable parameters that can help define an effective HVAC system. Only after these factors have been satisfied, should the issue of "energy savings" be considered. There is a tendency among property managers to seek funding for energy-saving projects first because they have a payback associated with them that can be used to justify the expenditure. However, that can be a false sense of savings because one can't know the true cost of operating the building if your current system fails to perform effectively. This approach can also siphon funds away from other HVAC projects that may be more important to improving environmental quality but which are without a quantifiable savings.

APPLYING THE PRINCIPLES OF SIX SIGMA

Six Sigma is a cost-cutting, quality control program developed by Motorola in the late 1980s and brought into widespread use by Jack Welch at GE in the mid-1990s. It is an analytical method aimed at achieving near perfect results. In statistics, the Greek letter sigma represents the variation in a standard bell curve. Originally used to improve performance on the manufacturing line, Six Sigma is a process aimed at reducing defects to three per million, saving significant dollars by eliminating waste.

Devotees of the methodology have recently expanded the programs into all facets of their business including accounting, sales, and R&D. The results have been impressive. GE spent $600 million on Six Sigma projects in 2002, rooting out inefficiencies that resulted in savings of over $2 billion. In addition, GE has sent out Six Sigma teams to their customers, helping them identify nearly $1 billion of cost savings.

The basic principles of the Six Sigma program can be applied to HVAC system performance. First, the process is reviewed to define areas where performance is below the acceptable standards. This first step requires the building owner or facility manager to clearly define an acceptable level of performance based on the measurable parameters of HVAC system effectiveness.

A method must then be developed to measure the performance of the system, either by continuously monitoring through the DDC control system, or by providing spot checks of performance using portable devices. In most cases, it would be impossible to continuously measure all parameters, so statistical sampling can be used to define "typical" operation.

Once the initial data collection is performed, the systems are evaluated based on the criteria established for the acceptable level of performance for each parameter. Those systems that are operating

HVAC SYSTEM EFFECTIVENESS
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Occupied Hours = 202   Hours: M-F 8:00-5:00

			TEMPERATURE (74 MAX, 70 MIN)		HUMIDITY (60 MAX, 40 MIN)		CO_2 LEVELS (‹ 1000 MAX)	
	OPERATING HOURS	OVERALL % IN RANGE	TEMP % IN RANGE	TEMP AVERAGE VARIANCE	HUM % IN RANGE	HUM AVERAGE VARIANCE	CO_2 % IN RANGE	CO_2 AVERAGE VARIANCE
AHU 1	396	32%	57%	3.1	38%	26	91%	166
AHU 2	355	82%	92%	2.6	84%	15	96%	85
AHU 3	246	85%	94%	3.0	88%	21	97%	99
AHU 4	320	90%	96%	3.3	90%	31	96%	88

FIGURE 1. A monthly performance report that shows the results of a typical analysis performed on four AHUs. As noted, one of the AHUs is performing at a significantly lower level than the other three.

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below expectations should be identified, and measured in greater detail to determine the cause of their subpar performance.

Figure 1 is taken from a recent monthly performance report. It shows the results of a typical analysis performed on four AHUs. As can be seen, one of the AHUs is performing at a significantly lower level than the other three.

This data will be analyzed to identify the causes of the subpar performance of AHU 1. System changes will then be identified to improve the process and eliminate the errors. These changes may be as simple as changing a setpoint or modifying the operating schedule. Or, it may require a significant modification or retrofit, using the latest technologies to improve the system performance. This process helps define the areas of greatest need when capital dollars become available.

Finally, controls will be put into place to prevent future problems. This feedback is a critical step to ensure that the changes that were made accomplish the goal of improving the system performance.

The time has come for building owners and facility managers to shift their paradigms and take a fresh look at the issues of designing, operating, and maintaining HVAC systems. Applying the Six Sigma principles for quality control to the parameters affecting HVAC system effectiveness can help to define a process for improving indoor environmental quality and, ultimately, customer satisfaction. **ES**

Watson is a professional engineer with over 25 years of experience in all facets of the HVAC industry. He is a recent chairman of the ASHRAE Technical Committee on Building Owning and Operating Costs. He is currently a senior project engineer with E3 Designs in Kitty Hawk, North Carolina. This month's National Facilities Management and Technology show in Baltimore will include his presentation, "Applying the Six Sigma Principles to HVAC Design." He can be reached via e-mail at **jwatson@e3designs.com***, and would welcome any feedback.* **ES**