Software Maintenance: A Must for Energy Management Programs

Yousef Abouzelof, M.S., C.E.M.
Director of Facilities & Energy Management

ABSTRACT

There are many reasons for implementing a preventive maintenance (PM) program: to lower power consumption, extend the life of equipment, and to maintain or improve tenants' thermal comfort. However, all the efforts to service and improve the performance of the HVAC system may be promoted or hindered by the building automation system (BAS). While the PM program may provide a certain level of assurance that the HVAC system is working at optimal performance, the BAS is the one dictating the load level as well as the duration of operation, thus impacting the entire cost of operation of the facility. For that reason, I suggest including software maintenance as an integrated part of the PM program. This article will discuss the various aspects of software maintenance and its impact on the power consumption of facilities and their operating cost. I will also present a list of critical BAS items to be included in the software maintenance program.

DEFINITIONS

The PM program is usually associated with the maintenance of the physical aspects of facilities: air handlers, chillers, boilers, cooling towers, air compressors, pumps, valves, dampers, etc. The tasks include brushing tubes, changing air filters, greasing pumps, and calibrating dampers. A software maintenance program, on the other hand, deals primarily with the auditing and upkeep of the BAS software programs. Since the BAS is the one controlling the equipment schedule and water

and air temperature set-points, and has the ultimate power over the tenants' individual cooling or heating variable air volume (VAV) boxes, it is of utmost importance to maintain the system at optimal efficiency.

MAIN REASON FOR SOFTWARE MAINTENANCE

The main reason for implementing a software maintenance program is to reduce the operating costs of the facility. It is good to remember that not long ago, the BAS used to be called an energy management system. The push for integration, speed, and colorful graphics all but obscured the fundamental reason for building controls, which is to operate the building efficiently and reduce the power consumption of the facility while maintaining good thermal comfort for the tenants. The BAS is being integrated into building access systems, life and safety equipment, etc. However, the integrity and accuracy of BAS programs will ultimately be the one impacting the operation of the HVAC system, power consumption, and the cost of operating the facility.

START WITH A GOOD PM PROGRAM

Software maintenance is a supplement to the facility's PM program and should not be considered a substitute. A comprehensive and effective PM program is needed to get the best performance and response out of the BAS. The basic requirements for a good PM program are:

- **Complete inventory of the equipment to be serviced**. This inventory should include all the facility's main systems, as well as their components. Chillers, boilers, cooling towers, air handlers, fans, pumps, dampers, air compressors, roof top units, VAV boxes, fan coils, exhaust fans, water treatment equipment, etc. should be included in this inventory.

- **Provide O&M manuals for all equipment**. The manuals will provide the level of maintenance and frequency as required by the equipment manufacturer.

- **Supply all necessary tools**. The maintenance staff should be provided with the necessary and required tools to perform the various aspects of the PM program.

- **Purchase energy efficient equipment**. Using first cost as the only qualification to purchase a piece of equipment is not the most economical way to operate a facility. Life cycle cost, measuring the cost of purchase and the cost of operation of the equipment over its expected life, is a much more effective measure than first cost.

- **Proper training of the maintenance staff**. The in-house maintenance staff should be trained and qualified to operate and maintain the equipment they are trying to service. Training cannot be overemphasized. Handing an untrained maintenance staff member a grease gun will not guarantee that the person will use the correct type of grease. Staff members are the only ones able to maintain or extend the life of equipment, or cut that life by half.

- **Outsource maintenance**. Many facilities are outsourcing part or the entire PM program. There are many advantages and disadvantages to outsourcing based on the size of the facility, staff expertise, and operating budget. Some facilities utilize partial outsourcing in which the maintenance staff performs lower-level maintenance while highly technical or specialized pieces of equipment are handled by outside vendors. It is worth remembering that outsourcing may solve your training issues; however, you get what you pay for. The lowest bid may not provide the level of maintenance that you would like to have in your facility.

LEVEL OF BAS INTENSITIES

The level of automation and investment in BAS varies between facilities. Some facilities incorporate direct digital controls (DDC) to the latest integration methods to upgrade and optimize their BAS system. On the other hand, many facilities are still trying to enter the DDC world very carefully. Here is a list of the different levels of automation being experienced by various facilities:

- **Single BAS system for the entire facility**. The facility's BAS utilizes one control company or is being integrated into one master system. Most, if not all, of the facility's equipment is connected to the BAS. This includes chillers, boilers, central air handlers, and VAV boxes. All set points and alarms report back to a central control room PC computer with a graphics user interface monitor. Acknowledging alarms, changing set points, and updating time schedules can be accomplished with ease at the graphics monitor. This is the most comprehensive and automated BAS that a facility can install.

- **Multiple BAS systems**. Economic realities make it very difficult to upgrade the BAS in all facilities at the same time. Older but operable systems are maintained as long as possible. The conversion to new BAS is usually based on capital budget requirements, high operating costs, and tenants' thermal comfort. System integration between old multiple BAS systems is not widely practiced.

- **In-between BAS upgrades**. A new BAS is being installed in the facility. The upgrade may impact one system at a time—chiller plant, VAV boxes—or may impact an entire building. There are many energy saving opportunities during this upgrade.

- **Partial BAS and manual operation**. Economic and investment reasons may dictate such a system. New BAS is being installed on a particular system, i.e. chiller plant, while the rest of the building will maintain time clocks and stand-alone systems.

SOFTWARE MAINTENANCE BASIC TOOLS

The basic tools needed to initiate a software maintenance program are as follows:

- **Master point list**. Every facility should have a master point list, either a hard copy or on a CD disk. The list will include all the original set points that the BAS engineers have programmed to the system. Some of these points may have been changes to correct for any operating difficulties. However, these points will serve as a reference for the software maintenance program.

- **Sequence of operation**. Each facility should have a clearly defined sequence of operation. This sequence will describe the mechanical engineer's design specification for the equipment. The sequence of operating will state the operating set points of the mechanical system as well as the operating parameters of the chillers, boilers, and air handlers.

- **As-built drawings for VAV boxes locations**. As-built drawings showing the correct locations and addresses of VAV boxes are very important documents to keep and update if needed. The temperature set points of VAV boxes influence the temperature and the load of the central air handler, and indirectly the chiller and boiler plant loads, thus impacting the power consumption of the entire facility.

- **Training**. Since the introduction of PC computers during the mid-1980s, more and more BAS vendors are selling the concept that BAS is so intelligent that operator intervention is rarely required. The color graphics are so easy to understand that minimal training is all it takes to operate the BAS, hence the HVAC system. Nothing could be further from real life day-to-day operation of the HVAC system. Understanding the basic concepts of the HVAC operation and the BAS terminology is very critical in the operation of the BAS system, as well as controlling the energy consumption and cost of the facility. It is important to remember that the operating staff will raise or reduce the capabilities of any BAS to their level of understanding. If the facility lacks the trained personnel to conduct software maintenance, paying an outside vendor is highly recommended.

- **Accessibility and security of the BAS system**. There are four aspects of accessibility and security of the BAS. **First**, outside hackers, especially if the BAS is a web-based system. Internet firewall and security passwords should be utilized to prevent any access to the system. **Second**, maintenance staff members with limited BAS experience. This group should have limited access to the programming portion of the BAS; however, access to the graphics interface points should be granted. This group will have the most impact on the operation of the facility because of their ability to modify the

set points. Changing the set points on the central air handler, chiller, or boiler plant will directly impact the load on the equipment, and thereby the power consumption of the facility. Third, trained BAS technicians should have total access and the tools needed to connect remotely to the system. Fourth, the BAS system provider may have access to the system using a modem to remotely connect to the BAS and troubleshoot any problem. It is of utmost importance that the facility manager approves such an arrangement. For security reasons, this arrangement should be evaluated on regular basis.

MAIN ELEMENTS OF THE SOFTWARE MAINTENANCE PROGRAM

An energy management-based software maintenance program should include all the programs and set-points that would impact the energy consumption of the facility, as well as the wear and tear on equipment, and finally the tenants' thermal comfort.

- **Time schedule**. This is one of the easiest programs to modify and at the same time the most expensive if abused. Facilities may utilize this program to control the HVAC system as well as lighting schedule. The HVAC time schedule controls the operation of the central air handlers, chillers, boilers, VAV boxes, and so on. The cost penalty of using the wrong time schedule can be obtained by multiplying the kW consumption of all equipment that is running, but not needed, by the extra hours, days, or weeks to obtain the total kWh. This total kWh should be multiplied by the facility's cost per kWh to obtain the total cost of the wasted energy. The time schedule should be evaluated and reviewed on a regular basis, no less than twice a year, especially at the beginning of the cooling and heating seasons.

- **Set points**. The set points of the central air handler's discharge and mix air temperature, and the air duct static pressure, should be evaluated and reviewed. Also, set points for VAV boxes, occupied and unoccupied temperatures as well as the cfm settings, should be checked regularly.

- **Reset schedule**. Most BAS utilize a reset schedule for air handler discharge air temperature as well as chilled and hot water temperatures. The reset schedule will change the parameters of the hot, chilled water or the discharge air temperature of the central air handler supply fan whenever full cooling or heating is not needed. For example, if the outside air temperature is 30°F or lower, the hot water supply from the boilers can be set at 180°F. However, if the outside air temperature is 50°F or above, the hot water supply will be reset down to 140°F. The reset schedule should be evaluated and reviewed at least twice a year at the beginning of the heating and cooling seasons. The cost associated with the wrong reset schedule is that the air handler, chiller, and coiler plants will end up producing cooler or hotter water temperature than required by the space, creating higher energy consumption and costs to the facility.

- **Alarms**. All BAS provide the ability to assign a numeric priority to each alarm event for which notification is desired. This includes change of status, change of value, command failure, and out-of-range alarms. Excessive or nuisance alarms are a clear indication of low tolerance between assigned values. All efforts should be made to adjust or correct the assigned values, and all nuisance alarms should be eliminated. There are two costs associated with nuisance and false alarms. First, the labor time required to check these false alarms, and second, the more alarms received at the control room, the less likely a true and serious alarm will be caught in time. Regular evaluation and review of the alarms' points and their priority levels should be conducted and corrected at least twice a year at the beginning of the heating and cooling seasons.

- **Notification Classes**. The ability of the BAS system to direct alarms to different destinations based on the type of alarm, the day of week, and time of day. Most facilities will distribute alarms by specifying the recipient of each type of alarms. Some alarms may be specified to go to BAS PC computer, audible or visual signal, an emergency printer, or to certain technicians' phones or pagers. This program should be evaluated, and all phone numbers and pagers should be evaluated for accuracy. The notification program should be checked against changes in maintenance staff assignments and/or responsibilities.

- **Message updates**. Many facilities utilize the messaging file as an instruction media source for the operating staff. These messages may instruct the staff to check on a piece of equipment, call a vendor for service, or call a technician for help. Review the message file and be sure that all the information is correct, that the vendor is still responsible to respond to call, or the technicians listed are still employed by the facility.

- **After-hours accounting**. Most commercial facilities provide after-hours service such as HVAC and lighting at a predetermined cost. After hours are defined as any time after the normal business hours, usually between 6:00PM and 7:00AM, Saturday, Sunday, and holidays. This service is provided at the tenant's request, and is accomplished by pushing a button or turning a switch connected to a VAV box in the tenant's own space. The length or duration of the after-hours service is usually two or three hours of service. The hourly cost of this service is based on the facility's operating costs, plus any markup and administrative fees. This program could be considered as an added revenue source to an owner or a cost reduction program for a facility. Review the duration time and the cost per hour at least once a year.

- **Trending**. Trending is the accumulation of time and value pairs at specified rates for a specified duration. A trending program can be used to track a zone temperature, a chilled water supply temperature, frequency of chiller start-ups, or any other point in the system. Trending is a valuable tool; however, it is allocated a certain memory size in the BAS PC computer. Most technicians will initiate the program and watch it for a week, then leave it running for months. When trending information reaches its allocated memory size, it starts replacing the oldest information with the most recent. Twice a year, check and disable all unnecessary programs from the computer.

- **Lead-lag program**. This program will allow multiple equipment to back each other up and alternate at a predetermined value. For example, if the facility has two boilers, and one of the boilers fails, the other boiler will start and carry the load. This is especially important during the winter season when freeze protection is of

utmost importance. This feature also allows multiple equipment to alternate at a predetermined value, i.e. the first of the month or every 300 hours, thus equating the run time and wear and tear on equipment. Creating a failure condition by turning the power to a pump or a boiler off, and watching the backup pump or boiler starting, is the simplest way to test the program. A lead-lag program on a heating system should be tested annually.

EXAMPLES OF SOFTWARE MAINTENANCE

My interest in software maintenance came as a by-product of retro or re-commissioning of building systems. I re-commissioned two office towers totaling 650,000 sq/ft. One building was in the process of upgrading the BAS, thus both BAS systems were active. The second building had one BAS. The following are examples of what was discovered.

- **Changing of static pressure settings**. The building engineer changed the set points on the main air duct of the air handler from 1.5 to 3.0 inches. The change in the static pressure caused the VFD to operate close to 60 Hertz, thus converting a VAV fan system to a constant speed. The set-point change was done on 13 of 22 air handlers. All static pressure set points were adjusted back to 1.5 inches and the VFDs backed off to the mid 40s Hertz.

- **Changes in the cfm set points of the VAV boxes**. The building engineer, who had very limited experience with VAV boxes, handled all of the tenants' thermal comfort complaints by changing the cfm settings of the VAV boxes. Thus a max 1,200 cfm VAV box was changed to 2,000 cfm, even though the box was fully open at 1,200 cfm with no possible increase in the amount of airflow. So many VAV boxes were changed up and down that the entire floor had to be reset back to its original balancing report set points.

- **Time schedule changes**. Even though one office tower has 22 air handlers (one air handler per floor), the time schedule for many air handlers was different. The normal business hours of the office tower were 7:00 AM to 6:00 PM; however, some of the fans started as early as 1:00 AM while others did not start until 6:30 AM. Some

were running seven days a week while others ran Monday through Friday. Once again, there is no logical reason for this difference in the time schedule. After reviewing the time schedule with the building management and the tenants, the time schedule was corrected.

CONCLUSION

The main purpose of any energy management program is to reduce energy consumption and cost while maintaining the highest level of tenants' thermal comfort. Checking and maintaining the BAS software programs at an optimal level will result in lower power consumption, less wear and tear on equipment, and improve tenants' thermal comfort. Combining a PM program with a software maintenance program will greatly improve the life cycle cost of all controlled equipment.

ABOUT THE AUTHOR

Yousef Abouzelof is the director of Facilities & Energy Management for Zions Securities Corporation in Salt Lake City, Utah. Mr. Abouzelof has a Master's degree from the University of Utah. He is a member of the Association of Energy Engineers and a Certified Energy Manager. Mr. Abouzelof has 24 years experience in operation, maintenance, building commissioning, and energy management.

Zions Securities Corporation
10 East, South Temple, Suite 1500
Salt Lake City, Utah 84133
E-mail: abouzelofy@zsc.com
Phone: (801) 321-7562
Fax: (801) 320-4653