Commissioning EXISTING HVAC Systems

Taking a holistic approach to identifying the root causes of system problems can provide improved comfort and energy efficiency.

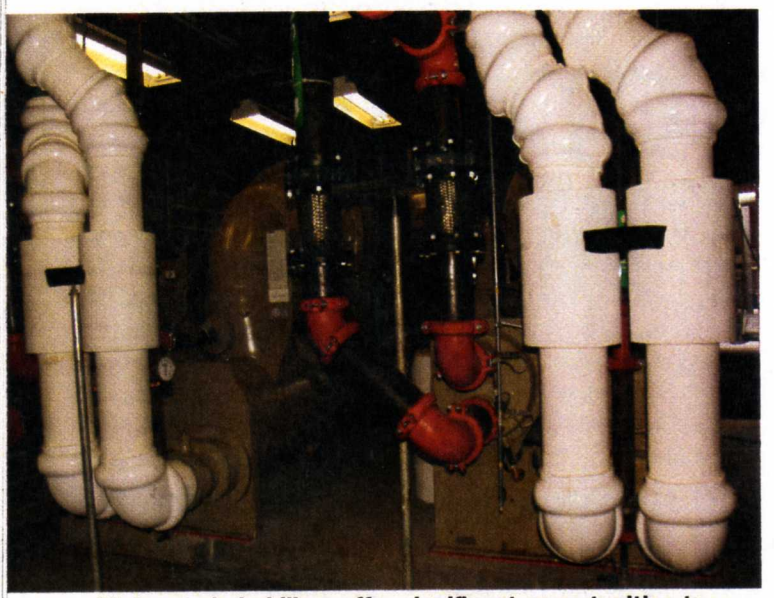
BY SCOTT GORDON, CM, CEM, CIAQP

In an ideal world, engineers design highly efficient HVAC systems that perfectly match a facility's varying outdoor and indoor conditions. These precisely designed systems are then flawlessly installed by contractors, integrated with other building systems and turned over to a thoroughly trained facility maintenance staff. The maintenance staff then implements a top-notch preventative maintenance program for the HVAC equipment as per the manufacturer's published specifications.

Unfortunately, we do not live in such a perfect world. Construction projects are often designed and installed under pressure, with a variety of demands placed upon architects, engineers and contractors. All too often, initial budgets for high-efficiency equipment and installation are cut, sacrificing long-term performance and operating costs. Once the mechanical systems are installed and the warranty period ends, the building's operation and maintenance staff is frequently left with a facility suffering from some serious issues. Issues such as unacceptably high-energy use, poor comfort levels, unsatisfactory Indoor Air Quality (IAQ) and a seemingly endless number of unsolved service calls—which all carry a potential for lawsuits and liability—are, unfortunately, more common than rare.

Service technicians often end up inheriting problems that are multifaceted and challenging to discover. A prescribed series of steps, however, can help technicians reach the root cause of such mechanical system problems.

Use of a digital hydronic manometer allows water flows to be set accurately through chillers. Use of proper instrumentation is an important part of the retrocommissioning process.



Water-cooled chillers offer significant opportunities to optimize system performance through retrocommissioning.

Commissioning

The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) defines the commissioning process as: "A quality focused process that focuses upon verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated and maintained to meet the Owner's Project Requirements (OPR)."

There are four types of commissioning:

1. **Commissioning:** Pertains to a new building during the construction process;
2. **Recommissioning:** Commissioning a project that was previously commissioned;
3. **Retrocommissioning (Rcx):** Commissioning an existing facility that was not previously commissioned; and
4. **Continuous Commissioning:** After a building is commissioned, an operational baseline is established, and automatic adjustments are made when operation goes outside of set parameters.

While this article focuses on commissioning HVAC systems in existing buildings that were not previously commissioned, other building systems—such as envelope, electrical and plumbing—can also benefit from going through the retrocommissioning process (Rcx). Due to the large inventory of existing buildings, coupled with the complexity of HVAC systems and their high-energy use, HVAC systems are the primary building system to utilize the retrocommissioning process.

Retrocommissioning

Retrocommissioning is a systematic process that helps resolve many of the problems previously stated. This is accomplished by analyzing all the related components within the context of the building design, to allow a building's HVAC system and integrated building controls to operate at peak performance.

The National Environmental Balancing Bureau (NEBB) is a leading authority of technical commissioning and retrocommissioning. The NEBB defines Rcx, as: "The systematic process by which the building owner ensures that the building and systems are optimized to perform interactively to meet the current operational needs as closely as possible. This may include remedial design and construction to accomplish this goal."

Retrocommissioning is a holistic process. An approach that leaves no stone unturned is necessary so that the root causes of any problems are discovered. In the mechanical service industry, treating symptoms without determining their cause only leads to ongoing problems and dissatisfied customers.

Commissioning team

Commissioning existing HVAC systems is a team effort that requires the skills of various technical specialists, including mechanical service contractors and technicians; test and balance technicians; control technicians and programmers; electricians; and other specialty trades. A knowledgeable commercial-service technician who has direct digital controls' (DDC) expertise is worth their weight in gold on a retrocommissioning team. If design problems are discovered, then a mechanical engineer is another essential member of the team.

The Retrocommissioning Authority (RCxA) leads the commissioning team.[1] The RCxA can be viewed as the general contractor of a construction project. The RCxA is ultimately responsible for the outcome of the commissioning process, and therefore, must be well-versed in mechanical and control system design; construction; test and balance; analyzing mechanical system problems; operational and maintenance; procedures; and training.

Retrocommissioning process

Retrocommissioning is not a simple step-by-step process that flows from one completed step to the next. Often, there are times during the process when it is necessary to reinvestigate an issue that was previously assessed. As new discoveries are made and questions arise through the analysis phase, the iterative nature of Rcx often demands taking this step back.

Technical retrocommissioning requires significant knowledge of HVAC and control systems, coupled with practical field experience and the ability to effectively work with instruments normally used by test and balance technicians. Flow hoods for measuring air quantities from diffusers; tachometers for recording fan speed; digital manometers for verifying air and water pressures; digital thermometers for checking dry and wet bulb air temperatures; and ultrasonic water flow meters for measuring direct water flow in a pipe are commonly used instruments.

Guided by NEBB procedures, the retrocommissioning

[1]NEBB Retrocommissioning Seminar, Tempe AZ, October 2007

Retrocommissioning is a holistic process. An approach that leaves no stone unturned is necessary to discover the root causes of problems.

process is broken down into the six phases below, followed by a brief explanation of each phase.

Contract phase

An initial walk-through of the facility is required to inspect the overall condition of the building and mechanical systems and determine the level of complexity. The RCxA provides a project proposal detailing the scope of the retrocommissioning work.

During the initial walk through, general items to look for are:

- Whether the building is under positive or negative pressure;
- Level of current maintenance and any deferred maintenance issues;
- Condition of air filters and their Minimum Efficiency Reporting Values (MERVs);
- Outdoor air dampers that are either stuck or frozen closed or wide open;
- Airside economizer dampers, actuators and linkages that are disconnected or otherwise not operational;
- Variable Frequency Drives (VFDs) that are in the bypass position;
- Balancing valves on pumps that are significantly throttled down; and

Duct and pipe modifications that reduce system pressure and increase horsepower inefficiencies.

Also during the walk through, spot readings are often obtained for such factors as temperature and relative humidity (r/h) as well as carbon dioxide (CO_2) and carbon monoxide (CO) levels. These "snapshot" readings can help identify potential problem areas to assess more deeply, and establish what additional data logging and trending might be needed.

Read about the investigating, analyzing and correcting phases of the commissioning process in part two of "Commissioning Existing HVAC Systems," featured in the February 2008 issue of RSES Journal.

Scott Gordon is general manager of Existing Building Services for HVAC Inc. He can be contacted at sgordon@hvac-inc.com.

Commissioning EXISTING HVAC Systems

Taking a holistic approach to identifying the root causes of system problems can provide improved comfort and energy efficiency.

BY SCOTT GORDON, CM, CEM, CIAQP

Editor's Note: Last month (January 2008), in part one of this feature, Gordon introduced commissioning, retrocommissioning (Rcx) and continuous commissioning of building HVAC systems, about which he states: "While this article focuses on commissioning HVAC systems in existing buildings that were not previously commissioned, other building systems—such as envelope, electrical and plumbing—can also benefit from the retrocommissioning process (Rcx). Due to the large inventory of existing buildings, coupled with the complexity of HVAC systems and their high-energy use, HVAC systems are the primary building system to utilize the retrocommissioning process."

In part two, Gordon provides the final stages of the Rcx process of an existing HVAC building system. Part one left off with the details of the contract phase, where Gordon mentions that "Also during the walk through, spot readings are often obtained for such factors as temperature and relative humidity (RH) as well as carbon dioxide (CO_2) and carbon monoxide (CO) levels. These 'snapshot' readings can help identify potential problem areas to assess more deeply, and establish what additional data logging and trending might be needed."

And without further ado, the stages to complete an Rcx project:

Calibrating Controls is a low-cost retrocommissioning procedure that offers an immediate benefit to your customer.

Presite investigation phase

The RetroCommissioning Authority (RCxA) team reviews existing construction drawings, specifications, submittals, control diagrams, and test and balance reports, to understand what type of system and equipment was supposed to be installed. Sequence of operation for the control system is reviewed to understand how the system was designed to operate. When faced with missing documentation, experience should be used to fill in the gaps of missing information until field verification is made to finalize what is actually installed.

An understanding of the original design intent and potential problem areas will start to surface and provide a rough game plan of conditions to assess during the site investigation. Management and maintenance staff interviews, followed by occupant interviews, are performed to discover any additional problem areas requiring focus during the site investigation.

Site investigation phase

With the game plan developed during the first two phases, a detailed investigation of the building conditions can now take place. Inspections are made by appropriate team members in search of issues such as installation defects, deferred maintenance, control problems and building pressurization

problems. HVAC and control systems are surveyed to determine current operating conditions.

Total air- and water-flow rates of primary equipment components—such as air handlers, pumps and variable air volume (VAV) boxes—are measured and recorded to compare actual values with design. Quick fixes are made at this time, such as calibrating thermostats and sensors, connecting damper linkages and replacing defective actuators. This is an excellent time to work with the building's maintenance staff to provide hands-on training, if warranted.

The site investigation must be holistic in approach; there is seldom only one problem present. Often, three or four problems are discovered and resolved, and then another two or three may surface. Data loggers are invaluable at this phase, because their strategic placement establishes a baseline of system performance. Data—such as equipment hours of operation, zone temperatures, RH, CO and CO_2 levels, lighting schedules, chilled- and hot-water temperatures and static pressure—are critical to determining the level and complexity of performance issues.

Portable data loggers are easy to set up, store a lot of data and provide the flexibility of obtaining data that may not be available from the building automation system (BAS). As with any test instrument, it is essential to annually calibrate all loggers in order to maintain a high degree of data reliability.

Do not trust existing BAS readings due to sensors that may not be calibrated properly. If BAS readings are used, the sensors need to be calibrated prior to data trending. Independent data readings also can provide verification of BAS sensor and system performance.

Analysis phase

At this point in the process, the RCxA studies problems identified and data recorded during the site investigation phase to unearth the root cause of problems. Data-logger findings and field-test results must be reviewed to support the conclusions made during the analysis process. Analysis results may make it necessary to go back and perform additional testing at the site. The final part of the analysis phase is to recommend solutions along with estimated costs to implement them and any associated energy/operational savings that the solutions will provide.

Corrective action phase

The recommended solutions developed during the analysis phase are implemented and commissioned during the corrective action phase. Commissioning in this sense means verifying the effectiveness of the solutions—meaning that what has been designed as a corrective action is in fact what was done, and that the given solution is producing the desired result.

Functional performance testing (FPT) is a key component of the commissioning process. Utilizing the BAS control system—which provided sensor calibration and system integrity checks that took place during site investigation—to check the functional performance of equipment and systems, FPT is the final step in verifying that the HVAC system now performs per its intended design.

Follow-up phase

A "lessons-learned workshop" provides an opportunity for the retrocommissioning team to meet with building owners and personnel to discuss the project and recognize areas for enhancement in the future. This is the time to provide any final training that the operations and maintenance staff requires, particularly in the areas of BAS operation and general preventative-maintenance guidelines. The final commissioning report is provided, and any off-season testing that may be required is noted.

Utilizing the DDC system

A properly functioning direct digital controls (DDC) BAS is crucial to the efficient operation of a building's HVAC system. During the retrocommissioning process, programming changes are often made to improve system efficiency and functionality. Control strategies and algorithms—such as static pressure reset on VAV systems, demand controlled ventilation, optimized economizer operation, optimized start/stop, pressure reset on variable-flow pumping systems, as well as air- and water-temperature reset—when properly employed, help ensure optimal comfort and energy utilization as originally designed.

The DDC BAS is a powerful facility management tool that is generally underutilized. However, when properly calibrated and operated by trained personnel, the BAS can more reliably realize its design potential to monitor and control mechanical system performance. Employing higher-level control strategies, significant energy savings can be achieved, thus why it is a major area of focus during the retrocommissioning effort.

Conclusion

It is well documented that the majority of existing buildings in the United States have significant problems with comfort, IAQ and high-energy usage. HVAC industry organizations—such as American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the Mechanical Contractors Association of America (MCAA)—have embraced sustainable construction and green building practices as the most important issues of this century. ASHRAE defines sustainability as: "providing for the needs of the present without detracting from the ability to fulfill the needs of the future." Every opportunity to curb energy inefficiencies contributes to sustainable practices.

The United States Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) program requires commissioning services for new buildings (LEED-NC), and retrocommissioning for existing buildings (LEED-EB) to achieve such efficiency levels.

RSES members and the mechanical service industry have the expertise necessary to provide sustainable solutions to the huge inventory of existing buildings across America.

Commissioning existing buildings is an important step in providing a sustainable future for our children and generations to come.◆

Scott Gordon is general manager of Existing Building Services for HVAC Inc. He can be contacted at sgordon@hvac-inc.com.