ADDENDA

ASHRAE Addenda g, h, and i to
ASHRAE Guideline 13-2007

Specifying Building Automation Systems

Approved by the ASHRAE Standards Committee on June 22, 2013, and by the ASHRAE Board of Directors on June 26, 2013.

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FOREWORD

As the industry increasingly demands high-performing buildings, the need to measure and document their performance increases as well. This addendum adds an annex to Guideline 13 that describes performance monitoring, its benefits, and the implications to a building automation system if performance monitoring is desired in a building. In addition, the addendum provides guidance throughout the guideline to describe performance monitoring considerations when specifying a building automation system, as well as example specification language for performance monitoring if desired.

Note: *In this addendum, changes to the current guideline are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.*

Addendum g to Guideline 13-2007

Add Annex X, Performance Monitoring.

(This annex is not part of this guideline but is provided for information purposes only.)

ANNEX X— PERFORMANCE MONITORING

X1. WHAT IS PERFORMANCE MONITORING?

Performance monitoring is the capability to provide facility managers and operators with the means to easily assess the current and historical performance of the building/facility as a whole and its significant energy consuming systems and components. Performance monitoring requires not only the needed instrumentation and architecture but also the means to calculate, timestamp, display, and archive resultant parameters. The monitoring capability can be included within a building automation system (BAS) or implemented as a separate energy information system (EIS) or a combination of the two. Performance monitoring can be implemented as part of a new construction project or as part of a BAS installation or upgrade project in an existing building. This annex provides three levels of performance monitoring. Level 1 supports trending of data. Level 2 supports the collection of the data in the form of time-value trendlogs and provides data analysis. Level 3 uses the data collected by the Level 1 functionality and analyzed by the Level 2 functionality to predict equipment faults, energy consumption, and demand patterns.

X2. BENEFITS OF PERFORMANCE MONITORING

Monitoring main electricity and natural gas meter data enables building staff to track building electricity and natural gas use by time of day, facilitating management of peak loads and identification of unnecessary equipment operation during unoccupied periods. It also enables monitoring of power quality supplied to the building and the power factor of the building load if advance metering instrumentation is utilized. Monitoring of water use can provide information to help detect and diagnose unnecessary consumption.

Building monitoring can direct a building owner to additional energy savings potential at the plant or equipment level. For example, monitoring chilled-water plant equipment power meter data enables building staff to track and manage chilled-water plant contributions to peak load and monitor chiller health. Monitoring building chilled-water flowmeter and chilled-water supply and return temperature data enables the monitoring system to calculate the actual cooling delivered by plant chillers, allowing growth in chiller capacity requirements to be tracked and managed and aiding the detection of anomalous loads that increase operating costs. Monitoring of both plant power and thermal loads enables the tracking of chiller plant efficiencies, which allows the identification of more efficient operating strategies. It also enables the detection of degradations in performance that indicate the need for maintenance in order to minimize operating costs and maximize equipment life.

Use of a high-quality weather station provides reliable measurement of outdoor air dry-bulb and wet-bulb temperatures, which help in identifying more operating hours for air-side and water-side economizers, facilitating the most effective use of free heating and cooling resources, and minimizing central plant energy use. Reliable measurement of outdoor wet-bulb temperature enables proper cooling tower operation, maximizing chilled-water plant efficiency.

Advanced data calculations and automatically updated data displays provide operators with effective, standardized ways of viewing the performance of the building and the HVAC system, including comfort conditions. Careful grouping of plots puts all the information required to monitor and, if necessary, troubleshoot each different part of the HVAC system on a single screen. This makes it easier to spot and diagnose a fault before it becomes a problem, reducing hot and cold calls and operation and maintenance (O&M) costs and making it easier to operate the building, freeing up stationary engineers to meet other needs.

As utilities implement demand response plans and as the Smart Grid becomes a reality, owners will see the benefits of the Level 3 performance monitoring option. Specifiers are referred to the National Institute of Standards and Technology (NIST) website (www.nist.gov) for information on the Smart Grid. The local energy service provider serving the facility can provide information on current and future demand response programs.

Example calculations to determine end-to-end accuracy of a measurement can be found in ASHRAE Guideline 22, *Instrumentation for Monitoring Central Chilled-Water Plant Efficiency*, Annex C4.[X1]

This annex aligns with *Performance Measurement Protocols for Commercial Buildings: Best Practices Guide*[X2] in the following manner. There is limited alignment with the Basic Evaluation Level (Indicative) of *Performance Measurement Protocols for Commercial Buildings: Best Practices Guide*, as this level is largely a manual exercise to determine roughly how a building under review compares to another building or a group of buildings. Data needed for the Basic Evaluation Level, such as whole-building utility consumption and demand, are available from the BAS at Performance Monitoring Level 1 as outlined in this annex. The Diagnostic Measurement Level (Diagnostic) as outlined in *Performance Measurement Protocols for Commercial Buildings: Best Practices Guide* aligns with Performance Monitoring Annex Levels 2 and 3, as the Diagnostic Measurement Level uses more detailed energy data at hourly or shorter intervals than is available in electronic form from the BAS. The Advanced Analysis Level (Investigative) in *Performance Measurement Protocols for Commercial Buildings: Best Practices Guide* also aligns with Performance Monitoring Annex Levels 2 and 3. The main difference between the two levels described in *Performance Measurement Protocols for Commercial Buildings: Best Practices Guide* is that under the Advanced Analysis Level there may be a requirement for longer-term historical trends or detailed fault detection and diagnosis (FDD) information that is available at Performance Monitoring Annex Level 3. Readers wishing to make a more detailed comparison are referred to *Performance Measurement Protocols for Commercial Buildings: Best Practices Guide*.

X3. BAS REQUIREMENTS TO IMPLEMENT PERFORMANCE MONITORING

Table X.1 shows the requirements and architecture for specific BAS elements that are needed to implement performance monitoring.

X4. LEVELS OF PERFORMANCE MONITORING

This annex provides guidance on three possible levels of performance monitoring that can be implemented in a BAS. The specifying engineer, in concert with the owner or owner's representative, should include in the specification those requirements needed to meet specific Owner's Project Requirements.

X4.1 Level 1: Data Collection and Trending

Level 1 is a building block for the higher levels. This level assumes that the specified BAS manufacturer can meet the Level 1 performance monitoring requirements within the company's current product offering. The BAS must support trending, but the extent of the trending is based on the project requirements as defined by the specifier. Depending on the scope of the project, the specifying engineer may specify the long-term trending software module that BAS suppliers sell as part of their front-end software suite.

For purposes of this annex, a *trend* or *trendlog* is a collection of time-value pairs (e.g., the outdoor air temperature was 20°C [68°F] at 15:00 [3:00 p.m.]). The time interval, whether the value is a minimum, maximum, average, or instantaneous value, and the amount of the data to be collected are based on the project requirements. Most BASs do not support the creation of X-Y plots (e.g., outdoor air temperature vs. chiller kilowatt/ton), so this requirement is not included in Level 1. This level allows for the collection of the data for performance monitoring and the graphing of one or more trendlog values against time, but it does not require the support for any analysis of the trendlog time-value pairs.

Level 1 also applies to a BAS that is either controlling directly or monitoring other systems such as lighting and fire alarm systems. The principles outlined in the next two levels apply to such control implementations.

X4.2 Level 2: Trendlog Data Analysis

Level 2 includes the trendlog data of Level 1 and assumes that the data collected in the form of time-value trendlogs will be analyzed in some manner to meet the specifier's design intent for the project. BASs must either support the creation of X-Y plots natively or be able to export these data to a third-party graphing and analysis tool such as Microsoft® Excel®. The specifier must ensure that the plot requirements are clearly laid out in the specification so the BAS supplier has guidance on what work is expected for the project. There may also be a requirement for structured queries of energy and operational BAS data to assist in certification under the Leadership in Energy and Environmental Design (LEED) Green Building Rating System[X3] or other sustainable rating systems.

X4.3 Level 3: Equipment Fault Diagnosis and Event Response

Level 3 includes the functions of Level 1 and Level 2 and assumes that the data that are collected under Level 1 and analyzed under Level 2 can then be used to identify and predict mechanical, electrical, or other equipment faults or can provide analysis of data relating to operational issues, power quality, or other applications. One could use these data to predict energy consumption and demand patterns to prepare a demand response strategy based on a change to a real-time energy pricing request from the local energy service provider. A BAS at this level is not just a server responding to requests from a user but may also have the ability to act as a client, taking action to respond automatically to a real-time pricing signal. This demand response may implement fuel switching by starting building generators or shedding equipment loads, or it may make changes in local zone space conditions. The BAS would return the building equipment under its control to a normal operating condition once the demand response event ends. The BAS would then provide automated reports on the impact on building health (e.g., changes to temperature or carbon dioxide levels) once the demand event ends. Projects at this level may be eligible for LEED certification and such smart shedding strategies may give the specifier the opportunity to apply for the LEED Measurement & Verification or Innovation credits.

X5. IMPACT OF THE PERFORMANCE MONITORING LEVEL ON BAS DESIGN

The level of sophistication of the BAS design varies from Level 1 to Level 3. The various levels require differing considerations in the implementation of hardware, software, and system functionality, discussed as follows.

1. **Selection of Controlled Equipment.** Equipment with packaged controls on a BAS project at Level 1 may allow for enable/disable, setpoint changes, and a common alarm contact. This same equipment at Level 2 or Level 3 may require a network connection with interoperable communications that allow data access. For a chiller, these data might include bearing temperature, head pressures, revolutions per minute, faults, equipment metering data, etc.

TABLE X.1 BAS Requirements for Performance Monitoring

Requirements related to:	Related Specification Sections	BAS Elements				
		Network	Sensor(s)	Building Controller or Custom Application Controller	Central Operator Workstation (OWS) or Enterprise Server	Historical Data Server
Sensor—Certification and O&M Requirements	1.5	—	NIST certified, with calibration data supplied as required.	—	—	—
Reporting Accuracy	1.9	Network should be selected to maximize system throughput. Ethernet is recommended for high speed and high performance.	Sensor accuracy selected to meet end-to-end accuracy requirements. See Table X.3 for detailed accuracy requirements.	analog to digital converter(s) in controller support end-to-end accuracy requirements for sensor readings. Minimum 12-bit A/D conversion is required.	The OWS or server may require additional database and structured query language (SQL) software in order to provide custom reports.	—
Accurate Records	There are no related specification sections for this item. The specifier must provide information on the objects to be trended. The specifier must also specify the amount of trending in the BAS panels as well as which trendlogs need to be long-term trends, as the data needs to be uploaded to the server when the BAS panel trendlog buffer is full.	Time sync by server to a standard time sync service. Access to the server clock is restricted by physical and software security measures. Time functions in BAS are synchronized to the system server.	—	Synchronized (interval) and event-driven trending. Adjustable trend buffer high threshold limit will notify workstation when to upload trend data records from field panel.	Upload trend data from BAS controllers when trend buffer limit reaches high threshold limit.	View data records stored on server. Create reports using historical data server report manager.
Protection of Records	The specifier must provide language on who is supposed to be backing up the records (i.e., is this a BAS responsibility or will this be done by the facility IT department?).	—	—	Battery backup of field panel application programs. Firmware program stored in Electrically Erasable Programmable Read-Only Memory (EEPROM).	Incremental backup of OWS software to designated server hard drive partition. Offload backup of server database to external media. Archiving records is normally done with a separate application provided by the BAS contractor.	Disable data purging. Incremental backup of each hourly transaction log file. Offload backup of server database to external media.

TABLE X.1 BAS Requirements for Performance Monitoring

System Security	The specifier must provide a security plan that specifies user access rights by categories such as guests, technicians, administrators, etc.	Access rights to system records and client applications are all controlled using Windows integrated security.	—	User account required to access building controller from control system front end.	Integrated security. Group policy permissions for files and directories are assigned to user groups. OWS user account required to access BAS.	Integrated security or equivalent. Group policy permissions for files and directories are assigned to user groups. Secured access to historical data.
Records—Length of Retention	Modern BASs with servers have virtually unlimited trending capability. Many BAS vendors have additional applications for archiving data. The specifier needs to specify which trendlogs are to be archived and for what length of time.	—	—	—	—	Historical data retention software locks down records in a secure database and retains them for a user-definable and/or indefinite time.
Written Procedures	The specifier must either specify these procedures or arrange for these procedures to be provided by others.	The specifier should recommend that the following Standard Operating Procedures (SOPs) be developed: backup procedures, calibration procedures, system security procedures, electronic records/data management procedures, incident management procedures, and disaster recovery procedures.				
Control Documents	The specifier must either specify these procedures or arrange for these procedures to be provided by others.	The customer needs to have the required documentation available and protected. Revision and change control procedures should be in place for all the required documentation. The list of required documentation includes, but is not limited to, operations and maintenance manuals, training records, calibration records, system acceptance and sign-off, and maintenance records.				
Training	The specifier must specify the training needed.	The customer will require additional training that is appropriate to the level of performance monitoring specified.				
Ongoing Support	The specifier must either specify these procedures or arrange for these procedures to be provided by others.	The specifier needs to determine if the owner requires ongoing support to maintain the infrastructure or to analyze the data generated by the performance monitoring system. The owner may decide to contract out these services instead of creating additional internal capacity in the facility management organization.				

2. **Server Requirements.** Projects at Level 1 may not require a server to collect data. It may be sufficient to trend the data in the BAS panels. Level 2 or 3 projects may require a server that supports web services or can act as a client to respond to Simple Object Access Protocol (SOAP) remote procedure calls that may be invoked, for example, as part of a real-time pricing request from an energy service provider.
3. **Software License Levels and Costs.** The data volumes increase as one goes from specifying a Level 1 to a Level 3 BAS. Most BAS vendors have front-end software licenses that are based on the object count. There is normally an increase in the software cost to handle greater volumes of data either from within the HVAC BAS or by bringing in (mapping) data from other building systems such as lighting, fire, or other systems.
4. **Interoperability Considerations.** BAS projects at Level 1 may only require one vendor's equipment on the project. Level 2 or 3 projects may require chillers, boilers, meters, or other equipment with networking capabilities, implying that these building devices communicate using one or more common protocols so they can respond collectively, for example, to a building-level strategy such as demand response.
5. **BAS Equipment Sophistication.** Performance monitoring is not restricted to measuring utility consumption and demand. The BAS may act as a "server" device to pass runtime or other information to other applications in the Enterprise such as the preventive maintenance (PM) program. The reporting capabilities may extend to generating runtime reports, alarm reports, tenant energy usage reports, etc., that provide management with timely information on the performance of the facility.
6. **Client/Server Capabilities.** BASs are normally designed so that the field panels respond to a request from the front end for information on the status of a point or to receive an update to a schedule. The field panel is called the "server" because it responds to a request for information. The front-end software is called the "client" because it generates the information request. Field panels installed as part of Level 1 or Level 2 monitoring can be strictly server devices. Field panels installed to meet Level 3 performance monitoring need client functionality as they need to generate a response to an event. An event in this case might be to report an alarm, a change of status, or excessive energy consumption.
7. **Event Response.** The client functionality required for Level 3 includes taking action in response to a trigger such as initiating a demand response to deal with a real-time pricing signal from an energy service provider. These "smart" devices may shed a load or start an alternative and less expensive source of energy so the owner of the facility does not have to pay the high price during a demand peak on the electric grid.

   The electric grid delivers electricity from points of generation to consumers, and the electricity delivery network functions via two primary systems: the transmission system and the distribution system. The transmission system delivers electricity from power plants to distribution substations, while the distribution system delivers electricity from distribution substations to consumers. The grid also encompasses myriads of local area networks that use distributed energy resources to serve local loads and/or to meet specific application requirements for remote power, village or district power, premium power, and critical loads protection.

   Historically, the energy service provider would only know that service was out if a customer called to report an outage. The Smart Grid is an initiative that uses the Internet and BASs in the facility to permit two-way communications to allow the energy service provider to report changes in price or the availability of electric power. The facility can report internal power quality problems or can tell the grid that alternative power sources in the facility are being brought on-line. The idea of two-way communications from the energy service provider to the facility to control residential appliances such as clothes dryers or air conditioners during peak demand periods is not new. Improvements in data communications and more sophisticated BASs will permit the facility to implement load shedding or to start alternative power sources automatically without human intervention.
8. **The BAS as an Ongoing Commissioning as well as a Performance Monitoring Tool.** BASs used for Level 3 performance monitoring may have the capability to undertake commissioning on a regular basis. Under this process, the BAS would report sensor faults or sensors out of calibration or would report when equipment is not performing to the original design intent. The BAS would use this information to generate an event notification. The BAS may also relay this information as a client to the Enterprise PM system server to raise a work order to have maintenance order a part or fix the problem. This will require support for data interaction from the BAS to other applications.
9. **The BAS as an Integral Component for Fault Detection and Diagnosis (FDD).** Building designs are becoming more complex to meet "green" or sustainability requirements such as those of LEED[X3], Go Green™[X4], or Green Globes™[X3]. BASs can help operators to optimize maintenance and equipment performance by using FDD techniques to identify causes of degraded equipment performance and impending equipment failures such as miscalibrated temperature sensors, excess outdoor air during heating mode, inadequate unit airflow, or refrigerant problems in chillers.

   FDD is a natural enhancement to monitoring the performance of an HVAC system. The rating systems referred to above require that the system can monitor indoor air quality, energy consumption, and thermal comfort. In order to sustain the air quality and energy targets over time, the HVAC systems must be properly maintained. Simple alarms will not catch subtle problems such as miscalibrated temperature sensors or refrigerant problems in chillers.

   FDD techniques have been refined based on research funded by ASHRAE and other organizations such as NIST. FDD is based on a set of rules for how a chiller, boiler, or air-handling unit is supposed to operate. Specifiers using FDD tools should specify the data requirements the BAS needs to provide in order to satisfy the needs of the FDD software tool. This tool would likely be provided by a third party that would take trend-log data from the BAS and then apply the rules for detecting the fault. The specifier should lay out the performance monitoring requirements and specify the FDD tool or tools to be used to meet the requirements.

Table X.2 lists the BAS characteristics required to meet the three levels of performance monitoring.

X6. REFERENCES

X1. ASHRAE. 2012. ASHRAE Guideline 22-2012, *Instrumentation for Monitoring Central Chilled-Water Plant Efficiency*. Atlanta: ASHRAE.

X2. ASHRAE. 2012. *Performance Measurement Protocols for Commercial Buildings: Best Practices Guide.* Atlanta: ASHRAE.

X3. USGBC. 2013. Leadership in Energy and Environmental Design (LEED) Green Building Rating System. Washington, DC: U.S. Green Building Council. www.usgbc.org/leed

X4. Redleaf Press. 2013. Go Green Rating Scale for Early Childhood Settings. St. Paul, MN: Redleaf Press. www.gogreenratingscale.org

X5. GBI. 2013. Green Globes. Portland, OR: The Green Building Initiative. www.greenglobes.com

X6. ASHRAE. 2006. *Sequences of Operation for Common HVAC Systems*. Atlanta: ASHRAE.

TABLE X.2 BAS Requirements for Performance Monitoring Levels 1, 2, and 3

Requirement	**Level 1:** **Data Collection and Trending**	**Level 2:** **Level 1 plus Trendlog Data Analysis**	**Level 3:** **Levels 1 and 2 plus Equipment Fault Diagnosis and Event Response**
Data Displays			
Software Requirements The specifier needs to determine if the BAS supplier can provide the software or if it has to come from another supplier.	Level 1 is specifically designed so that a specifier does not have to add additional software. The standard BAS front-end software package will be able to meet Level 1 data display requirements.	The BAS may permit the analysis of the trendlog data from the equipment graphic directly. Otherwise the user may have to launch a separate application and then import the trendlog data as time-value pairs into this application.	It is likely that to meet the Level 3 requirements the specifier will have to specify software from third parties that specialize in automated commissioning, FDD, sophisticated metering, and event responses.
Equipment/System Graphic Most BASs can present data on a floor plan or equipment graphic.	Floor plan with zone temperatures; system graphic with performance data from trendlogs only that may be accessed from a link on the equipment graphic.	Add performance data to the equipment graphic.	Level 2 graphics would meet the requirements for Level 3. Additional graphics to meet Level 3 would be provided by the third-party software tools required for the project.
Data Tables Most BASs can present real-time data in tabular form.	Building air handler summary table as described in Figure 5.	Expand building air handler summary table, add floor zone table, expand metrics results table to include additional metrics such as energy targets.	Expand metric results table to include additional metrics such as the performance of specific pieces of equipment or the demand response sequence (e.g., starting a generator or increases in space temperature setpoints).
Trendlogs System performance trendlogs over a time series that is specified by the specifier.	Collect the following trendlogs (instantaneous, average over the interval, maximum during the interval, minimum during the interval) with a common time interval (e.g., from 1 to 30 min): • Chilled-water-plant delta-T • Chilled-water-plant tons • Outdoor air temperature (dry-bulb temperature) • Outdoor air wet-bulb temperature • Outdoor-air-temperature fraction • Outdoor-air-damper fraction • Meter data (gas, water, electricity, steam, chilled-water flow, etc.)	Add equipment performance plots and third-party software to create these plots	Add system and equipment diagnostic plots as well as software to permit interoperable responses to these events.

TABLE X.2 BAS Requirements for Performance Monitoring Levels 1, 2, and 3 *(Continued)*

Requirement	**Level 1:** **Data Collection and Trending**	**Level 2:** **Level 1 plus Trendlog Data Analysis**	**Level 3:** **Levels 1 and 2 plus Equipment Fault Diagnosis and Event Response**
X-Y Group Trend Plots This functionality is normally not part of a standard BAS software package. The specifier may require BAS trendlog data to be exported in a format that can be consumed by software to be provided by the BAS supplier via a subcontract or from a third party. Alternatively, the specifier can require X-Y plots to be built using a spreadsheet tool such as Microsoft Excel.	Not available at this level.	Add X-Y plots (X-Y plots plot data from one trendlog against another trendlog collected at Level 1): • Chilled-water-plant delta-T and chilled-water-plant tons vs. outdoor air temperature • Chilled-water-plant power vs. chilled-water-plant tons • Chilled-water-plant kilowatts per ton vs. outdoor air temperature, outdoor air wet-bulb temperature, and chilled-water-plant tons • HVAC power vs. outdoor air temperature, outdoor air wet-bulb temperature, and chilled-water-plant tons • Total gas flow vs. outdoor air temperature • Outdoor-air-temperature fraction vs. outdoor-air-damper fraction • Whole-building electric energy-use intensity, whole-building HVAC electric energy-use intensity, whole-building natural-gas energy-use intensity, and whole-building water-use intensity vs. average daily outdoor air temperature • Chiller kilowatts per ton vs. condenser entering-water temperature and chiller tons • Chiller power vs. chiller tons • Whole-building HVAC electric energy-use intensity, total boiler gas energy-use intensity, whole-building lighting energy-use intensity, and whole-building plug energy-use intensity vs. average daily outdoor air temperature	Add X-Y plot diagnostics: • Average daily chilled-water supply temperature, daily chilled-water-plant efficiency, and daily total chilled-water-plant electricity use vs. average daily outdoor air temperature, when at least one chilled-water pump is running • Average daily boiler efficiency, daily total boiler-heating-system thermal output, daily total HVAC gas use, and daily total HVAC gas energy vs. average daily outdoor air temperature, when at least one hot-water pump is running • Daily total air-handler volume, average daily air-handler efficiency, and daily total air-handler electricity use vs. average daily outdoor air temperature, when at least one air handler is running • Average daily building power vs. average daily outdoor air temperature • Daily HVAC energy-use intensity vs. average daily outdoor air temperature • Average building air-handler variable-frequency-drive frequency and average building duct static pressure vs. outdoor air temperature
Points (Objects)			

TABLE X.2 BAS Requirements for Performance Monitoring Levels 1, 2, and 3 *(Continued)*

Requirement	**Level 1: Data Collection and Trending**	**Level 2: Level 1 plus Trendlog Data Analysis**	**Level 3: Levels 1 and 2 plus Equipment Fault Diagnosis and Event Response**

Measured
The specifier needs to include these points (objects) in the project Points List Schedule.
	• Outdoor air temperature
	• Outdoor air wet-bulb temperature
	• Main power
	• Main natural-gas flow
	• Main water flow
	• Chiller power
	• Other chilled-water-plant equipment power
	• Plant chilled-water supply temperature
	• Plant chilled-water return temperature
	• Plant chilled-water flow rate
	• Air-handler mixed air temperature, return air temperature, and supply air temperature
	• Air-handler supply-fan and return-fan power
	• Air-handler flow rate
	• Zone temperatures; air-handler duct static pressure; supply air hot duct static pressure, if dual duct
	• Terminal unit supply-air flow, supply air temperature; if dual duct, supply air heating-duct flow and supply air heating-duct temperature
	• Lighting-circuit power
	• Plug-circuit power
	• Rooftop-unit power
	• Other HVAC-equipment power
	• Chiller chilled-water supply temperature
	• Chiller chilled-water return temperature
	• Chiller chilled-water flow rate
	• Boiler gas flow
	• Boiler hot-water supply temperature
	• Boiler hot-water return temperature
	• Boiler hot-water flow rate
	• Air-handler supply-fan variable-frequency-drive frequency
	• Plant condenser-water supply temperature
	• Plant condenser-water return temperature
	• Plant condenser-water flow rate
	• Rooftop-unit gas flow rate
	• HVAC-heater gas flow rate
		Add:
		• Information from devices such as chillers that can only be obtained by making a network connection to the chiller control panel:
		  • Chiller bearing temperature
		  • Chiller effective setpoint (this is the value that the chiller is using based on a setpoint signal from the BAS)
		  • Boiler carbon monoxide (CO) percentage
		  • Boiler stack gas temperature
		  • Internal equipment faults
			It is assumed that all data needed for diagnostic or event triggers is available at Level 1 or Level 2.

TABLE X.2 BAS Requirements for Performance Monitoring Levels 1, 2, and 3 *(Continued)*

Requirement	Level 1: Data Collection and Trending	Level 2: Level 1 plus Trendlog Data Analysis	Level 3: Levels 1 and 2 plus Equipment Fault Diagnosis and Event Response
Virtual These are software points (objects) that are listed in the Points List Schedule or are determined by the BAS contractor from the sequence of operations.	• Air-handler outdoor-air-damper percentage • Return-damper percentage • Supply-fan mode (per *Sequences of Operation for Common HVAC Systems*[X6]) • Supply-fan status • Chilled-water-valve percentage • Supply air temperature setpoint • Supply air hot deck temperature, supply air hot deck temperature setpoint, hot-water valve position, if dual duct	• Chiller chilled-water supply temperature setpoint • Air-handler duct static pressure setpoint, variable-frequency-drive speed setpoint, and supply air hot duct static pressure setpoint, if dual duct • Terminal unit cooling temperature setpoint, heating temperature setpoint, cooling control signal, and heating control signal	—
Calculated—Whole Building	• Average daily outdoor air temperature • Whole-building peak power • Whole-building electric energy-use intensity • Whole-building natural gas energy-use intensity • Whole-building water-use intensity	Add: • Average building static pressure • Total HVAC electric power • Whole-building lighting power • Whole-building plug power • Whole-building HVAC electric energy-use intensity • Whole-building lighting energy-use intensity • Whole-building plug energy-use intensity	Add: • Average daily outdoor air temperature, when at least one chilled-water pump is running • Average daily outdoor air temperature, when at least one hot-water pump is running • Average daily outdoor air temperature, when at least one air handler is running • Average daily building power; total HVAC electric demand; whole-building HVAC energy-use intensity
Calculated—Chilled Water	• Chilled-water-plant delta-T • Chilled-water-plant power • Chilled-water-loop tons • Total chilled-water-plant tons • Chilled-water-plant efficiency	Add: • Chiller tons • Chiller efficiency • Total chiller power • Total chilled-water-plant heat rejection • Chilled-water-plant heat balance	Add: • Average daily chilled-water supply temperature • Daily total chilled-water-plant electricity use • Daily chilled-water-plant energy • Maximum daily chilled-water-plant energy • Average daily chilled-water-plant efficiency
Calculated—Natural Gas Equipment	—	Add: • Total boiler gas flow • Total boiler gas energy-use intensity • Boiler output • Boiler efficiency • Total boiler output • Total boiler efficiency	Add: • Total roof top unit gas flow rate • Total HVAC gas flow rate • Daily total HVAC natural gas use • Daily total HVAC natural gas energy • Maximum daily HVAC natural gas energy • Total HVAC natural gas energy-use intensity • Average daily boiler efficiency

TABLE X.2 BAS Requirements for Performance Monitoring Levels 1, 2, and 3 *(Continued)*

Requirement	**Level 1:** **Data Collection and Trending**	**Level 2:** **Level 1 plus Trendlog Data Analysis**	**Level 3:** **Levels 1 and 2 plus Equipment Fault Diagnosis and Event Response**
Calculated —Supply Air	• Air-handler outdoor-air-temperature fraction • Air-handler outdoor-air-damper fraction • Total air-handler power • Total air-handler volume • Air-handler specific power	Add: • Instantaneous average building air-handler supply fan variable-frequency-drive frequency	Add: • Daily total air-handler electricity use • Daily total air-handler volume • Maximum daily air-handler volume • Average daily air-handler specific power
Event Response Initiation	None	None	Initiate a runtime report or a demand response request based on a real-time pricing signal.

In Section 3.3, Organization of the Guideline, modify the fifth bullet describing the parts of the document as follows.

- Annexes: outline of example specification, BACnet discussion, interoperability case studies, performance monitoring.

Add the following paragraph to the end of section 5.2, Defining Project Scope.

Once the facility's needs have been defined in terms of the number of HVAC systems, user requirements, number of points, and criteria, the system designer can complete the design of the DDC system.

If an owner desires to include performance monitoring as part of the project requirements, the specification will need to define the functional capability that is desired. This includes the required monitoring points and performance metrics, system accuracy, network throughput and enhanced data management, and graphical data displays. Detailed example specifications can be found in Annex X.

In the first paragraph of Section 7.5, Description of DDC System, add a new sentence as follows.

This section should contain a narrative description of the system. This description could include the type of architecture, communication technology, panel layout, use of DDC vs. conventional controls, operator interfaces, and any special or unusual hardware or operating features. In addition, if performance monitoring or event response are to be included as described in Annex X, descriptions of these capabilities should be included. The purpose is to provide the reader with insight into the design intent. This section should be an overview of the project, highlighting any special requirements associated with its implementation. It is not meant to describe every detail of the control system design and installation.

Edit the Project Considerations for Section 7.5, Description of DDC System, to include performance monitoring and event response in the system descriptions and example specification language for each of the three examples.

Project Considerations: This first example is generic and may or may not result in a Web-based interface, *but includes performance monitoring and event response capability.*

1.5 DESCRIPTION

A. General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers and an operator workstation. The operator workstation shall provide for overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.

B. Performance Monitoring: The BAS will provide the specified performance monitoring functionality, including required monitoring points and performance metrics, improved through system accuracy, data acquisition and data management capabilities, and required graphical and data displays.

C. Event Response: The BAS will provide the specified operational changes based on event response from the energy service provider.

This second example is for a full Web-based interface with performance monitoring and event response.

1.5 DESCRIPTION

A. General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers, a control system server, and an operator workstation.

B. System software shall be based on a server/thin-client architecture, designed around the open standards of web technology. The control system server shall be accessed using a Web browser over the control system network, the Owner's local area network, and remotely over the Internet (through the Owner's LAN).

C. The intent of the thin-client architecture is to provide operators complete access to the control system via a Web browser. No special software other than a Web browser shall be required to access graphics, point displays, and trends, configure trends, configure points and controllers, or to edit programming.

D. Performance Monitoring: The BAS will provide the specified performance monitoring functionality, including required monitoring points and performance metrics, improved through system accuracy, data acquisition and data management capabilities, and required graphical and data displays.

E. Event Response: The BAS will provide the specified operational changes based on event response from the energy service provider.

This third example is for a Web-compatible interface with performance monitoring and event response.

1.5 DESCRIPTION

A. General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers, a control system server, and/or an operator workstation.

B. The control system server and/or operator workstation shall provide for overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.

C. The system shall support web browser access to the building data. A remote user using a standard web browser shall be able to access the control system graphics and change adjustable setpoints with the proper password.

D. Performance Monitoring: The BAS will provide the specified performance monitoring functionality, including required monitoring points and performance metrics, improved through system accuracy, data acquisition and data management capabilities, and required graphical and data displays.

E. Event Response: The BAS will provide the specified operational changes based on event response from the energy service provider.

In Section 7.9, System Performance, move the paragraphs on reporting accuracy and control stability and accuracy, along with the associated items in the guide spec language, to their own section. Provide specific guidance and tables for reporting accuracy and control stability for a typical BAS.

~~*Reporting Accuracy*: Reporting accuracy per application is listed for end-to-end performance. These include the effects of device accuracy, A/D (analog to digital) conversion in the controller, and any loss in data transmission. The values shown in Table 1 of the system performance excerpt below are shown for typical HVAC applications. Industrial and process applications may require higher accuracy. For example, the typical accuracy listed for a relative humidity sensor is ±5% in a comfort cooling and monitoring application. This can be met with a standard commercial grade device. However, a printing plant application may require humidity control of ±1%. Specifying this greater accuracy will result in the selection of an industrial grade device that may cost five to ten times more than the commercial sensor used for space monitoring.~~

~~*Control Stability and Accuracy*: The stability and accuracy of the controlled variable (e.g., temperature, pressure, humidity) is a function of the programming and tuning of the control loops of the working system. The stability is also dependent on properly sized and installed mechanical components.~~

Project Considerations: All of the performance values (e.g., times and accuracy) should be reviewed and possibly edited for a given project. In particular, the performance values may not be achievable by the product lines that are listed in Part 1, "Approved Control System Subcontractors and Manufacturers," or the products in Part 2. Even if they are achievable, the system required may be more expensive than a typical DDC system or that covered by the project budget.

1.9 SYSTEM PERFORMANCE

A. Performance Standards. System shall conform to the following minimum standards over network connections:

1. Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 s.
2. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 s.
3. Object Command. Devices shall react to command of a binary object within 2 s. Devices shall begin reacting to command of an analog object within 2 s.
4. Object Scan. Data used or displayed at a controller or workstation shall have been current within the previous 6 s.
5. Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 45 s.
6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 s. Select execution times consistent with the mechanical process under control.
7. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per second. Select execution times consistent with the mechanical process under control.
8. Multiple Alarm Annunciation. Each workstation on the network shall receive alarms within 5 s of other workstations.
9. ~~Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in Table 1.~~
10. ~~Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.~~

~~**TABLE 1 Reporting Accuracy**~~

~~**Measured Variable**~~	~~**Reported Accuracy**~~
~~Space temperature~~	~~±0.5°C (±1°F)~~
~~Ducted air~~	~~±0.5°C (±1°F)~~
~~Outside air~~	~~±1.0°C (±2°F)~~
~~Dew point~~	~~±1.5°C (±3°F)~~
~~Water temperature~~	~~±0.5°C (±1°F)~~
~~Delta-T~~	~~±0.15°C (±0.25°F)~~
~~Relative humidity~~	~~±5% RH~~
~~Water flow~~	~~±2% of full scale~~
~~Airflow (terminal)~~	~~±10% of full scale (*see Note 1*)~~
~~Airflow (measuring stations)~~	~~±5% of full scale~~
~~Airflow (pressurized spaces)~~	~~±3% of full scale~~
~~Air pressure (ducts)~~	~~±25 Pa (±0.1 in. w.g.)~~
~~Air pressure (space)~~	~~±3 Pa (±0.01 in. w.g.)~~
~~Water pressure~~	~~±2% of full scale (*see Note 2*)~~

Electrical (A, V, W, power factor)	±1% of reading (*see Note 3*)
Carbon monoxide (CO)	±5% of reading
Carbon dioxide (CO2)	±50 ppm

Note 1: Accuracy applies to 10%–100% of scale
Note 2: For both absolute and differential pressure
Note 3: Not including utility-supplied meters

TABLE 2 Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
Air pressure	±50 Pa (±0.2 in. w.g.) ±3 Pa (±0.01 in. w.g.)	0–1.5 kPa (0–6 in. w.g.) –25 to 25 Pa (–0.1 to 0.1 in. w.g.)
Airflow	±10% of full scale	
Space temperature	±1.0°C (±2.0°F)	
Duct temperature	±1.5°C (±3°F)	
Humidity	±5% RH	
Fluid pressure	±10 kPa (±1.5 psi) ±250 Pa (±1.0 in. w.g.)	0–1 MPa (1–150 psi) 0–12.5 kPa (0–50 in. w.g.) differential

Reporting Accuracy: Reporting accuracy per application is listed for end-to-end performance. These include the effects of device accuracy, A/D (analog to digital) conversion in the controller, and any loss in data transmission. The values shown in Table 1 of the system performance excerpt below are shown for typical HVAC applications. Industrial and process applications may require higher accuracy. For example, the typical accuracy listed for a relative humidity sensor is ±5% in a comfort cooling and monitoring application. This can be met with a standard commercial-grade device. However, a printing plant application may require humidity control of ±1%. Specifying this greater accuracy will result in the selection of an industrial-grade device that may cost five to ten times more than the commercial sensor used for space monitoring.

Control Stability and Accuracy: The stability and accuracy of the controlled variable (e.g., temperature, pressure, humidity) is a function of the programming and tuning of the control loops of the working BAS. The stability is also dependent on properly sized and installed mechanical components.

9. Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in Table 1.
10. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 1 under "Accuracy Required for Control."

TABLE 1 Sensors, Meters, Calculated Values, and Required Accuracies

#	Object Description and Location if Applicable	Sensor or Value Type	Sensor Type or Calculation Method	Expected Range	Required End-to-End Accuracy	Display Resolution	Refresh Interval, min	Trend Interval, min	Accuracy Required for Control
S1	Ambient Dry-Bulb Temperature	AI	Locate in weather station or ventilated enclosure in fully shaded location away from thermal mass bodies	–29°C to 40°C (–20°F to 120°F)	±0.5°C (±0.1°F)	±0.25°C (±0.5°F)	1	10	±1.0°C (±2°F)
S2	Ambient Wet-Bulb Temperature	AI	Locate in weather station or ventilated enclosure in fully shaded location away from thermal mass bodies	–29°C to 40°C (–20°F to 120°F)	±1.5°C (±3.0°F)	±0.25°C (±0.5°F)	1	10	±1.5°C (±3°F)
S6	Building Main Meter Power	AI/BI (pulse)	True RMS	—	±1.0% of reading	1.0 kW	1	1	1.0 kW
S8	Zone (Space) Temperatures	AI	10000 ohm thermistor or 1000 ohm RTD	–1°C to 38°C (30°F to 100°F)	±0.5°C (±0.1°F)	±0.25°C (±0.1°F)	1	1	±0.5°C (±1°F)
S9	Carbon Dioxide	AI	Nondispersive infrared sensor technology	0 to 2000 ppm	±50 ppm	50 ppm	1	1	50 ppm
S10	Carbon Monoxide	AI	Electrochemical sensor	0 to 100 ppm	±5ppm	50 ppm	1	1	50 ppm
S11	Air Pressure (Ducts)	AI	Variable capacitance	0 to 2 kPa (0 to 8 in. w.g.)	±25 Pa (±0.1 in. w.g.)	125 Pa (±0.5 in. w.g.)	1	1	25 Pa (0.1 in. w.g.)
S12	Air Pressure (Space)	AI	Variable capacitance	–25 to 25 Pa (–0.1 to 0.1 in. w.g.)	±3 Pa (±0.01 in. w.g.)	3 Pa (±0.01 in. w.g.)	1	1	1.3 Pa (0.005 in. w.g.)
S13	Water Pressure	AI	—	0 to 1 kPa (0 to 150 psi)	±2% of full scale	7 kPa (1 psi)	1	1	3.5 kPa (0.5 psi)
S14	Water Temperature	AI	—	(0°C to 107°C) (32°F to 225°F)	±0.5°C (±1°F)	±0.5°C (±1°F)	1	1	±0.5°C (±1°F)
S15	Delta-T	AI	10000 ohm thermistor or 1000 ohm RTD matched pair	—	±0.15°C (±0.25°F)	±0.25°C (±0.5°F)	1	1	±0.15°C (±0.25°F)
S16	Relative Humidity	AI	—	0% to 100%	±5% RH	5%	1	1	±5% RH
S17	Water Flow	AI	—	—	±2% of reading	1000 L/s (5 gpm)	1	1	
S18	Ducted Air Temperature	AI	10000 ohm thermistor or 1000 ohm RTD	7°C to 60°C (45°F to 140°F)	±0.5°C (±1°F)	±0.5°C (±1°F)	1	1	±0.5°C (±1°F)

S19	Electrical (A, V, W, Power Factor Not Specified Elsewhere)	AI/BI (pulse)	True RMS, three-phase, stand-alone analog or pulse output or networked meter; use maximum resolution if pulse output	—	±1% of full scale	0.1	1	1	—
S28	Airflow Rate (Measuring Stations)	AI	Electronic or differential pressure	—	±5% of reading down to 0.75 m/s (150 ft/min)	0.05 L/s (0.1 cfm)	1	1	±5% of reading down to 0.75 m/s (150 ft/min)
S30	Airflow (Terminal)	AI	Electronic or differential pressure	—	±10% of reading	47 L/s (100 cfm)	1	1	±10% of reading
S31	Airflow (Pressurized Spaces)	AI	Electronic or differential pressure	—	±3% of reading	24 L/s (50 cfm)	1	1	±3% of reading

AI = analog input; BI = binary input; calculated = value calculated by the DDC hardware or BAS software

Add a paragraph on performance monitoring, along with a table that could be used to specify Level 2 or 3 performance monitoring as described in the new Annex X.

Performance Monitoring. Specifying higher-quality sensors may be required when implementing a performance monitoring system in order to obtain desired accuracy and repeatability of measured and calculated performance metric indices. Levels 1 and 2 as described in Annex X can be accomplished with the instrumentation typically installed in a BAS, as shown in Table 1 in the example above. In the example below, Table 1 reflects the required reporting accuracy for a Level 3 system as described in Annex X. Special consideration should also be given to communication for performance monitoring applications, due to the additional bandwidth that may be required to provide the required sampling rate for all objects.

11. Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in Table 1.
12. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 1 under "Accuracy Required for Control."

TABLE 1 Sensors, Meters, Calculated Values, and Required Accuracies

#	Object Description and Location if Applicable	Sensor or Value Type	Sensor Type or Calculation Method	Expected Range	Required End-to-End Accuracy	Display Resolution	Refresh Interval, min	Trend Interval, min	Accuracy Required for Control
S1	Ambient Dry-Bulb Temperature	AI	Locate in weather station or ventilated enclosure in fully shaded location away from thermal mass bodies	–29°C to 40°C (–20°F to 120°F)	±0.2°C (±0.35°F)	±0.01°C (±0.02°F)	1	10	±1.0°C (±2°F)
S2	Ambient Wet-Bulb Temperature	AI	Locate in weather station or ventilated enclosure in fully shaded location away from thermal mass bodies	–29°C to 40°C (–20°F to 120°F)	±0.3°C (±0.5°F)	±0.01°C (±0.02°F)	1	10	±1.5°C (±3°F)
S3	Dew Point	AI	Chilled mirror, infrared, capacitive	–12°C to 38°C (10°F to 100°F)	±1.5°C (±3°F)	±0.05°C (±0.1°F)			±1.5°C (±3°F)
S4	Building Main Natural Gas Meter	BI	Positive displacement—pressure compensated; continuous output		±1% of reading, > 10:1 turndown	0.05 L/s (0.1 scfm)	1	1	—
S5	Natural Gas Flow Rate (e.g., boiler)	AI/BI (pulse)	Positive displacement—pressure compensated; continuous output		±2% of reading, > 10:1 turndown	0.05 L/s (0.1 scfm)	1	1	—
S6	Building Main Meter Power	BI	True RMS to 50th harmonic		±1.0% of reading	0.1 kW	1	1	0.1 kW
S7	Electric Power Submeter (e.g., Lighting Circuits)	AI/BI (pulse)	True RMS to 50th harmonic		±1.0% of reading	0.001 kW			—
S8	Zone (Space) Temperatures	AI	10000 ohm thermistor or 1000 ohm RTD	–23°C to 38°C (30°F to 100°F)	±0.3°C (±0.5°F)	±0.05°C (±0.1°F)	1	1	±0.5°C (±1°F)
S9	Carbon Dioxide	AI	Nondispersive infrared sensor technology	0 to 2000 ppm	±3% of reading, ±40 ppm	50 ppm	1	1	40 ppm

S10	Carbon Monoxide	AI	Electrochemical sensor	0 to 100 ppm	±5 ppm	50 ppm	1	1	50 ppm
S11	Air Pressure (Ducts)	AI	Variable capacitance	0 to 2 kPa (0 to 8 in. w.g.)	±25 Pa (±0.1 in. w.g.)	125 Pa (±0.5 in. w.g.)	1	1	25 Pa (0.1 in. w.g.)
S12	Air Pressure (Space)	AI	Variable capacitance	–25 to 25 Pa (–0.1 to 0.1 in. w.g.)	±3 Pa (±0.01 in. w.g.)	3 Pa (±0.01 in. w.g.)	1	1	1.25 Pa (0.005 in. w.g.)
S13	Water Pressure	AI		0 to 1 kPa (0 to 150 psi)	±2% of reading	7 kPa (1 psi)	1	1	3.5 kPa (0.5 psi)
S14	Water Temperature	AI		–5°C to 107°C (32°F to 225°F)	±0.5°C (±1°F)	±0.05°C (±0.1°F)	1	1	±1.5°C (±3°F)
S15	Delta-T	AI	10000 ohm thermistor or 1000 ohm RTD matched pair		±0.15°C (±0.25°F)	±0.25°C (±0.5°F)	1	1	±0.15°C (±0.25°F)
S16	Relative Humidity	AI		0% to 100%	±5% RH	5%	1	1	±5% RH
S17	Heating Hot-Water Flow	AI			±2% of reading	1000 L/s (5 gpm)	1	1	
S18	Ducted Air Temperature (Not Specified Elsewhere)	AI	10000 ohm thermistor or 1000 ohm RTD	7°C to 60°C (45°F to 140°F)	±0.5°C (±1°F)	0.5°C (1°F)	1	1	±0.5°C (±1°F)
S19	Electrical (A, V, W, Power Factor Not Specified Elsewhere)	AI/BI (pulse)	True RMS, three-phase, stand-alone analog or pulse output or networked meter; use maximum resolution if pulse output		±1% of full scale	0.1	1	1	—
S20	Chiller Power	AI	True RMS, three-phase, integrated equipment, stand-alone analog or pulse output or networked power meter; use maximum resolution if pulse output		±1.5% of reading	0.01 kW	1	1	—
S21	Primary Chilled-Water Pump Power	AI/BI (pulse)	True RMS, three-phase, integrated equipment, stand-alone analog or pulse output or networked power meter; use maximum resolution if pulse output		±1.5% of reading; ±3.0% of reading if from VFD	0.01 kW	1	1	—

S22	Chiller Condenser Water Pump Power	AI/BI (pulse)	True RMS, three-phase, integrated equipment, stand-alone analog or pulse output or networked power meter; use maximum resolution if pulse output		±1.5% of reading; ±3.0% of reading if from VFD	0.01 kW	1	1	—
S23	Cooling Tower Fan Power	AI/BI (pulse)	True RMS, three-phase, integrated equipment, stand-alone analog or pulse output or networked power meter; use maximum resolution if pulse output		±1.5% of reading; ±3.0% of reading if from VFD	0.01 kW	1	1	—
S24	Secondary Chilled-Water Pump Power	AI/BI (pulse)	True RMS, three-phase, integrated equipment, stand-alone analog or pulse output or networked power meter; use maximum resolution if pulse output		±1.5% of reading; ±3.0% of reading if from VFD	0.01 kW	1	1	—
S25	Chilled-Water Plant Chilled-Water Supply Temperature	AI	10000 ohm thermistor or 1000 ohm RTD (matched with S26)		±0.05°C (±0.1°F)	±0.005°C (±0.01°F)	1	1	±0.5°C (±1°F)
S26	Chilled-Water Plant Chilled-Water Return Temperature	AI	10000 ohm thermistor or 1000 ohm RTD (matched with S25)		±0.05°C (±0.1°F)	±0.005°C (±0.01°F)	1	1	±0.5°C (±1°F)
S27	Chilled-Water Plant Chilled-Water Flow Rate	AI	Full-bore magnetic flowmeter (preferred) Hot tapped insertion flowmeter (alternate if location permits)		±0.75% of reading ±2.0% of reading	0.005 L/s (0.1 gpm)	1	1	±0.75% of reading ±2.0% of reading
S28	Air-Handling Unit Supply Fan Airflow Rate	AI	Vortex shedding sensor on fan inlet		±5% of reading down to 0.75 m/s (150 ft/min)	0.05 L/s (0.1 cfm)	1	1	±5% of reading down to 0.75 m/s (150 ft/min)
S29	Airflow (Measuring Stations)	AI	Electronic or differential pressure		±5% of reading	47 L/s (100 cfm)	1	1	±5% of reading
S30	Airflow (Terminal)	AI	Electronic or differential pressure		±10% of reading	47 L/s (100 cfm)	1	1	±10% of reading

S31	Airflow (Pressurized Spaces)	AI	Electronic or differential pressure		±3% of reading	24 L/s (50 cfm)	1	1	±3% of reading
S32	Air-Handling Unit Supply Fan Power	AI/BI (pulse)	True RMS, three-phase, integrated equipment, stand-alone analog or pulse output or networked power meter; use maximum resolution if pulse output		±1.5% of reading; ±3.0% of reading if from VFD	0.1 kW	1	1	—
S33	Air-Handling Unit Return Fan Power	AI/BI (pulse)	True RMS, three-phase, integrated equipment, stand-alone analog or pulse output or networked power meter; use maximum resolution if pulse output		±1.5% of reading; ±3.0% of reading if from VFD	0.1 kW	1	1	—
S34	Air-Handling Unit Supply Air Temperature	AI		7°C to 49°C (45°F to 120°F)	±0.2°C (±0.35°F)	0.01°C (0.02°F)	1	10	±0.5°C (±1°F)
S35	Air-Handling Unit Mixed Air Temperature	AI	Locate in air handler's mixed air section; to minimize effects of stratification use averaging sensor if possible	4°C to 38°C (40°F to 100°F)	±0.2°C (±0.35°F)	0.01°C (0.02°F)	1	10	±0.5°C (±1°F)
S36	Air-Handling Unit Return Air Temperature	AI	Locate upstream of air handler's return air damper	16°C to 32°C (60°F to 90°F)	±0.2°C (±0.35°F)	0.01°C (0.02°F)	1	10	±0.5°C (±1°F)
S37	Air-Handling Unit Outdoor Air Demanded Damper Position	AI	Virtual point that commands the damper position	0% to 100%	N/A	0.1%	1	10	—
S38	Air-Handling Unit Return Air Demanded Damper Position	AI	Virtual point that commands the damper position	0% to 100%	N/A	0.1%	1	10	—
S39	Whole-Building Total Water Flow Rate	AI	Hot tapped insertion flowmeter		±2% of reading, > 20:1 turndown	0.005 L/s (0.1 gpm)	1	1	—

M1	Whole-Building Peak Power	AI/BI (pulse)	Maximum of measured value S6 over a given time interval		±1%	0.1 kW	1	10	1 kW
M2	Whole-Building Area-Normalized Electric Energy-Use Intensity	Cal-culated	Measured value S6 integrated over a given interval divided by a constant #C1 = building area, m^2 (ft^2)		±1%	1.8 kWh/m^2 (0.1 kWh/ft^2)	1	10	—
M3	Whole-Building Natural Gas Heat Rate	Cal-culated	Measured value S4 divided by a constant #C2 = 0.01 therm/standard cubic feet		±1.5%	1.8 kW/s (0.1 therms/ min)	1	10	—
M4	Whole-Building Area-Normalized Gas Energy-Use Intensity	Cal-culated	Calculated value M3 integrated over a given interval divided by a constant #C1 = building area, m^2 (ft^2)		±1.5%	315 kW/m^2 (0.1 therms/ft^2)	1	10	—
M5	Average Daily Outdoor Ambient Temperature	Cal-culated	Average of instantaneous measured values (S1)		±0.2°C (±0.35°F)	±0.01°C (±0.02°F)	1	10	—
M6	Chilled-Water Plant Chilled-Water Supply-Return Temperature Difference	Cal-culated	Calculated difference of two measured values (S25 – S26); sensors should be a matched pair		2% of reading or ±0.08°C (±0.15°F)	±0.005°C (±0. 01°F)	1	1	±0.08°C (±0.15°F)
M7	Chilled-Water Plant Power	Cal-culated	Sum of measured values S20, S21, S22, S23, S24		±1.5%	0.1 kW	1	10	±1 kW
M8	Chilled-Water Loop Thermal Cooling Output	Cal-culated	Calculated value M6 multiplied by measured valued S27 multiplied by a constant #C3 = 1.0 kW (500 min-tons/°F·gal)		±3%	0.3 kW (0.1 tons)	1	10	—
M9	Chilled-Water Plant Efficiency	Cal-culated	Calculated value M7 divided by calculated value M8		±4%	0.03 COP (0.01 kW/ton)	1	10	—
M10	Total Air-Handling Unit Power	Cal-culated	Sum of calculated values S32x		±1.5%	0.1 kW	1	10	—
M11	Total Air-Handling Unit Flow	Cal-culated	Sum of measured values S28x		±5%	0.05 L/s (0.1 cfm)	1	10	—
M12	Total Air-Handling Unit Specific Power	Cal-culated	Calculated value M10 divided by calculated value M11		±6%	0.0002 kW/(L/s) (0.0001 kW/cfm)	1	10	—

M13	Air-Handling Unit Percentage Outdoor Air	Calculated	Instantaneous difference of two measured values (S35 – S36)/(S1 – S36); this can be used as an estimate of outdoor air percentage of total airflow, provided that the air temperature difference between the outdoor air and the return air is at least 5°C (11°F)	0% to 100%	N/A	0.001	1	1	—

AI = analog input; BI = binary input; calculated = value calculated by the DDC hardware or BAS software

In Section 7.10, Submittals, in guide spec items A and C.1, delete "AutoCAD 2004 compatible." Also add a new item 7 to item A.

1.10 SUBMITTALS

A. Product Data and Shop Drawings
Meet requirements of Section 01xxx on Shop Drawings, Product Data, and Samples. In addition, the contractor shall provide shop drawings or other submittals on all hardware, software, and installation to be provided. No work may begin on any segment of this project until submittals have been successfully reviewed for conformity with the design intent. Six copies are required. Provide drawings as ~~AutoCAD 2004 compatible~~ files on optical disk (file format: .dwg, .dxf, .vsd, or comparable) with three 11 × 17 in. prints of each drawing. When manufacturer's cutsheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawing shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Submittals shall be provided within 12 weeks of contract award. Submittals shall include:

1. DDC System Hardware

...

7. Instrumentation and Data Point Summary Table. Contractor shall submit in table format with the following information for each instrument and data point. The table is to be reviewed and approved by the owner's representative prior to hardware and software installation and programming.
   a. Point name
   b. Point description: provide building designation, system type, equipment type, engineering units, and functionality; include a description of its physical location
   c. Expected range (upper and lower limit)
   d. Instrumentation (as applicable): manufacturer, model number, range, and accuracy specification
   e. Type
      1. AI: analog input
      2. BI: binary input
      3. NAI: network analog input
      4. NBI: network binary input
      5. P: programmed (e.g., soft or virtual point in control sequence such as a PID input or output)
      6. C: calculated value; a soft or virtual point. If calculated value, provide logic diagrams or code and any constants used in formula. If time-based integrated values are required, provide time periods: minutes, daily, weekly, monthly, and yearly. Also indicate if it is a running average.
   f. Input resolution
   g. Graphic display resolution
   h. Data trend interval
   i. Number of samples stored in local controller before transfer to host computer/server database
   j. Data point address

...

C. Project Record Documents. Upon completion of installation, submit three copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and shall include:

1. Project Record Drawings. As-built versions of the submittal shop drawings provided as ~~AutoCAD 2004 (or newer) compatible~~ files on optical media and as 11 × 17 in. prints.

Add the indicated text to Section 7.11.3, Warranty Period.

The warranty period will vary with the type of project and the owner's requirements. A typical warranty period is one year after system acceptance, although some owners may desire up to five years. After the first year of acceptance, each additional year may increase the cost of the project. It is generally observed that malfunctions and problems in electronic equipment occur in the first year after installation. Thus, the economic value of extending the warranty may not be justified. However, an owner may have other financial considerations that justify an extended warranty. If the BAS capabilities include performance monitoring, additional calibration or sensor warranty services outside of the standard manufacturer's warranty may be required. Consider the number of years following substantial completion required to achieve and sustain the performance goals of the BAS.

In Section 7.11.9, Periodic Preventive Maintenance Service, in guide spec Section 1.11, WARRANTY, add Section B.

1.11 WARRANTY

A. Warrant work as follows:

...

B. Special warranty on instrumentation:
   1. All instrumentation shall be covered by manufacturer's transferable [one-year] "No Fault" warranty. If manufacturer warranty is not available, the BAS installer shall provide the same.

Add a Project Considerations section to Section 8.2.6, Communication Performance.

DDC system communication is tied most directly to the "Communication" article of the example specification but also deals with other areas of the specification, most notably the "System Performance" article.

Project Considerations: Special consideration should be given to performance monitoring applications, due to the additional bandwidth that may be required to provide the desired sampling rate for all objects.

Add performance monitoring to the Project Considerations and guide spec language in Section 8.4.4.5.

Project Considerations: What events should go into these logs? The answer depends on the application. If the DDC system primarily provides comfort conditioning and has little operator interaction, then few objects should be designated for the log. Only a serious event occurrence, such as an equipment failure, should be recorded and then followed by notification of the operator (typically by dial-out or pager). On the other hand, a building that requires extensive record keeping and traceability—such as a hospital, computer operations center, correctional facility, or pharmaceutical manufacturing plant—should have all control actions and alarms recorded. Care should be taken to clearly indicate these requirements to the controls subcontractor in the sequences of operation or object list. The information should include the number of samples and the interval between samples—or change-of-value requirements—for each object to be logged. In addition, if required for performance monitoring, the specifier should include that the data should be exportable and in what format.

10. Trend Logs. The operator shall be able to define a custom trend log for any data object in the system. This definition shall include interval, start time, and stop time. Trend data shall be sampled and stored on the building controller panel, be archivable on the hard disk, and be retrievable for use in spreadsheets and standard database programs. Trend data shall be exportable in a standard electronic format [(.xls, .csv, .xml)] for analysis external to the BAS.

Add a new Section 8.4.4.6, Trend Graph Display, with new guide spec items 12 and 13 and renumber subsequent guideline and guide spec sections as required.

8.4.4.6 Trend Graph Display

In addition to trendlog data, visualizing trend data over time on a graph can be a useful diagnostic tool for a BAS operator. Such graphical displays can reveal unnecessary equipment operation during unoccupied hours, control instability over time, unexpected deviations from setpoint, and energy savings opportunities. Viewing multiple data points on a single graph can identify relationships between system components. For example, viewing space temperature with applicable space temperature setpoints (unoccupied or occupied heating or cooling) over time can provide valuable insight into the equipment performance and space comfort. This capability is a standard feature of most BASs.

12. Group Trend Time Series Plots
    a. Provide user-selectable Y points.
    b. Provide user-editable titles, point names, and Y axis titles.
    c. Individual trended points shall be able to be grouped in groups of up to four points per plot with up to four plots per page.

X-Y trend graphs can provide an additional level of data visualization by allowing the relationship between two variables to be viewed directly. For example, viewing outdoor air temperature against natural gas consumption may not only show that gas consumption generally increases as outdoor air temperature drops but also show interesting features of the mechanical system operations, mechanical system degradation, the building envelope, and occupancy patterns. These types of trend graphs may not be included as part of a BAS standard offering but may be available as special features of a BAS or as third-party add-ons to a BAS. These graphs should be included to perform Level 2 or Level 3 performance monitoring as described in Annex X.

13. X-Y Trend Plots
    a. User-selectable X and Y trend inputs.
    b. User-editable titles, point names, and X and Y axis titles.
    c. User-selectable time period options: (1) a 1-day 24-hour period; (2) a 1-week 7-day period; (3) a 1-month period, with appropriate days for the month selected; or (4) a 1-year period. The user shall be able to select the beginning and ending period for each X-Y chart, within the time domain of the database being used.
    d. User-selectable display of up to 6 plots per screen in 2 columns.

In Section 8.4.4.9.2 (previously 8.4.4.8.2), Electrical, Gas, and Weather Reports, add to guide spec item 19.d (previously 17d) language to clarify that weather station information is preferable to that from the BAS. Also add a new guide spec item 20.

19. Electrical, Gas, and Weather Reports
    a. Electrical Meter Report: Provide a monthly report showing the daily electrical consumption and peak electrical demand with time and date stamp for each building meter.

...

    d. Weather Data Report: Provide a monthly report showing the daily minimum, maximum, and average outdoor air temperature, as well as the number of heating and cooling degree-days for each day. Provide an annual (12-month) report showing the minimum, maximum, and average outdoor air temperature for the month, as well as the number of heating and cooling degree-days for the month. If there is a weather station within 25 miles of the facility, provide real-time weather information via SOAP/XML. Otherwise, use weather values from the BAS.

20. Electrical, Gas, and Weather Graphic Display
    a. Provide a graphic display for each electrical meter and gas meter and weather data point(s) with a data table and a current 24-hour trend plot. Include data values for the following time periods; today, previous day, week to date, previous week, month to date, previous month, year to date, previous year.

In Section 8.9.4, add natural gas flow rate to the table of input devices and engineering units. Also add "rate" to liquid flow and airflow for consistency with the rest of the guideline.

Device	Engineering Unit
Duct temperature sensor	°C (°F)
Liquid flow rate	L/s (gpm)
Airflow rate	L/s (cfm)
Humidity	% RH
Dew point	°C (°F)
Light level	Lux (foot-candles)
Natural gas flow rate, standardized	std. L/s (scfm)

In Section 8.11.9.3, add an input resolution bullet to the characteristics that should be considered when specifying power-monitoring devices.

The following characteristics should be considered when specifying power-monitoring devices:

- Required accuracy (non-revenue or revenue grade). For most submetering applications, an acceptable accuracy is ±1%.
- Input resolution of each pulse
- Three-phase (wye or delta) or single-phase system
- Voltage (120-600 V)

...

In Section 9.11, Installation of Sensors, add a new sentence to the Project Considerations section.

Project Considerations: A display of the temperature or pressure of the air or liquid is often useful for the operator, and in some cases, the display is used to ensure that the device is functioning correctly. Providing gauges at pressure and differential pressure sensors is especially useful—but often expensive. Some owners will be interested in having this level of instrumentation. In that case, decide whether the gauges should be located at the device or on a panel face at a central location. Piping water to a gauge in a panel is usually not practical. In all cases, test ports should be added to the piping or tubing to allow test and calibration of the devices. Particular attention should also be paid to sensor location and potential thermal stratification, as it can impact the quality of the measurement.

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

This addendum makes the guideline and example specification language non-specific to a particular version of the CSI masterFormat™ by eliminating references to a specific format designation.

Note: *In this addendum, changes to the current guideline are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.*

Addendum h to Guideline 13-2007

In Section 3.3, remove the clause that indicates that the guideline is based on the 1995 CSI format.

The example specification follows the format determined by the Construction Specification Institute (CSI). Under the 1995 CSI MasterFormat™, a controls specification will typically be placed in Division 15 for mechanical systems, usually in Section 15900 or 15950, although the exact placement varies. The section is divided into three parts (General, Product, and Execution), each consisting of articles, paragraphs, and subparagraphs. Under the 2004 CSI MasterFormat™, control specifications are typically in Division 23 Heating Ventilating and Air Conditioning Section 23 09 00, or in Division 25 Integrated Automation. ~~This Guideline is currently based on the 1995 CSI format, but the~~ The electronic version of the sample specification is available in both 1995 and 2004 formats.

Revise the last paragraph of Section 5.3.5 so that the paragraph applies to either CSI format.

It is important to note that the specification created for DDC systems will need to be well coordinated with the other sections. For example, Division 0 specifies how the contracts will be administered, along with general terms and conditions. This language also will apply to the systems and contractors addressed in ~~Section 15950~~ the relevant section. Work provided in other sections also requires coordination. For a more complete discussion, refer to Clause 7.

In Section 7.1, revise the Project Considerations section and Guide Spec language so that they apply to either CSI format.

Project Considerations: The paragraph should be stricken for projects in which the controls subcontractor may be the prime contractor (e.g., a controls upgrade project). Also, the specifier ~~needs to~~ must complete the ~~listed~~ CSI section numbers (shown below as "~~15xxx~~xxxxx") and edit the titles to match the actual sections used within the remainder of the specification.

7.1 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section ~~15xxx~~xxxxx—Hydronic Piping
  1. Control Valves
  2. Flow Switches
  3. Temperature Sensor Wells and Sockets
  4. Flow Meters
- B. Section ~~15xxx~~xxxxx—Refrigerant Piping
  1. Pressure and Temperature Sensor Wells and Sockets
- C. Section ~~15xxx~~xxxxx—Ductwork Accessories
  1. Automatic Dampers
  2. Airflow Stations
  3. Terminal Unit Controls

In Section 7.2, revise the Project Considerations section and Guide Spec language so that they apply to either CSI format.

Project Considerations: This specification paragraph should be edited to list only those other specification sections that include products for installation under this section. The paragraph should be stricken for projects in which the controls subcontractor is the prime contractor (e.g., a controls upgrade project). Finally, the specifier ~~needs to~~ must complete the ~~listed~~ CSI section numbers (shown below as "~~15xxx~~xxxxx") and edit the titles to match the actual sections used within the remainder of the specification.

7.2 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Section ~~15xxx~~xxxxx—Refrigeration Equipment
  1. Refrigerant Leak Detection System
- B. Section ~~15xxx~~xxxxx—Rooftop Air-Handling Equipment
  1. Thermostats
  2. Duct Static Pressure Sensors

In Section 7.3, revise the Project Considerations section and Guide Spec language so that they apply to either CSI format.

Project Considerations: The following specification paragraph should be edited to include only the other specification sections that apply to the integration involved. Also, the specifier ~~needs to~~must complete the ~~listed~~ CSI section numbers (shown below as "~~15xxx~~xxxxx") and edit the titles to match the actual sections used within the remainder of the specification. Finally, a detailed discussion of the integration required should be included in Part 3, "Sequences of Operation."

7.3 PRODUCTS NOT FURNISHED OR INSTALLED UNDER BUT INTEGRATED WITH THE WORK OF THIS SECTION

A. Section ~~15xxx~~xxxxx—Heat Generation Equipment
  1. Boiler Controls
B. Section ~~15xxx~~xxxxx—Refrigeration Equipment
  1. Chiller Controls
C. Section ~~15xxx~~xxxxx—Rooftop Air-Handling Equipment
  1. Discharge Air Temperature Control
  2. Economizer Control
  3. Volume Control
D. Section ~~15xxx~~xxxxx—Unit Ventilators and Fan Coil Units
  1. Setpoint Reset
  2. Day and Night Indexing
E. Section ~~15xxx~~xxxxx—VAV Terminal Units
  1. Cross-Flow Velocity Sensor
F. Section ~~15xxx~~xxxxx—Variable Frequency Drives

In Section 7.4, revise the Project Considerations section and Guide Spec language so that they apply to either CSI format and are consistent with the rest of the Guideline.

Project Considerations: The specifier must ~~This section needs to be edited~~edit this section to list the actual CSI sections and their titles used within the remainder of ~~in~~ the project specification.

7.4 RELATED SECTIONS

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.
B. The following sections constitute related work:
  1. Section ~~01xxx~~xxxxx—Submittal Requirements
  2. Section ~~01xxx~~xxxxx—Commissioning
  3. Section ~~13xxx~~xxxxx—Security Access and Surveillance
  4. Section ~~13xxx~~xxxxx—Detection and Alarm
  5. Section ~~15xxx~~xxxxx—Basic Mechanical Materials and Methods
  6. Section ~~15xxx~~xxxxx—Heat Generation Equipment
  7. Section ~~15xxx~~xxxxx—Refrigeration Equipment
  8. Section ~~15xxx~~xxxxx—Heating, Ventilating, and Air Conditioning Equipment
  9. Section ~~15xxx~~xxxxx—Air Distribution
  10. Section ~~15xxx~~xxxxx—Testing, Adjusting, and Balancing
  11. Section ~~16xxx~~xxxxx—Basic Electrical Materials and Methods
  12. Section ~~16xxx~~xxxxx—Wiring Methods
  13. Section ~~16xxx~~xxxxx—Electrical Power
  14. Section ~~16xxx~~xxxxx—Low-Voltage Distribution

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

This addendum revises and updates Section 4.1 to include benefits that are available in today's systems. This addendum also brings the language into alignment with the revised (September 2011) title, purpose, and scope of the guideline, which addresses Building Automation Systems more comprehensively than just HVAC and DDC.

Note: *In this addendum, changes to the current guideline are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.*

Addendum i to Guideline 13-2007

Delete the current Section 4.1 in its entirety and replace it with the following.

4.1 Benefits of a Building Automation System (BAS)

A BAS provides the technology platform by which the owner's project requirements for energy efficiency, sustainability, and occupancy conditions can be monitored, controlled, and tracked over the life of the building. A BAS provides the following benefits:

a. A BAS is comprised of microprocessor controls that provide a flexible platform onto which one or all of the following can be applied: control algorithms, scheduling events, event notification, trend data collection, and network communications. Combinations of these applications are not possible with pneumatic or electric control systems.

b. A BAS can incorporate the algorithms for energy conservation and system optimization specified in ASHRAE Standards 90.1 and 189.1. Controls strategies such as night setback, optimum start/stop and demand limiting, and setpoint reset for variable air volume systems require a BAS, as these strategies cannot realistically be accomplished using pneumatic nor electric controls.

c. With the advent of networked lighting systems, the BAS can also read the state of the occupancy or vacancy sensors on the lighting system and can have the terminal equipment controllers reduce the airflow when the space is unoccupied for a specified period (e.g., 30 minute timeout per California Title 24 rules).

d. A BAS provides the ability to match control performance to control application requirements. Sensors, control devices, and DDC controllers must be selected to meet control performance goals in order to meet end-to-end accuracy requirements for control application performance monitoring requirements. The issue of accuracy to meet control performance goals is discussed in detail in the Performance Monitoring Annex.

e. A BAS provides advanced scheduling features. A BAS allows building equipment and systems to be scheduled to operate under different time-of-day schedules for seven different day-types (i.e., Sunday thru Saturday), as well as scheduling non-business day (i.e., Christmas, Labor Day, etc.), for years in advance. The BAS can also permit occupied and unoccupied setpoints to meet energy savings targets.

f. A BAS provides event notification for alarms, system, and operator events. BAS activities such as event notification can provide a time/date stamp to allow the building operator to track and monitor events. System activities can be sorted by time/date, point name, or panel to allow the building operator to observe the order that events occur. BAS software also comes with built in audit trail functions that will log the operator's identity as well as the time/date of changes the operator made, such as changes to a setpoint or manually stopping a fan.

g. A BAS provides the ability to collect trend data from any controller that resides on the BAS network. Trend data may be collected by change-of-value (COV) or by synchronized time interval. The ability to collect trend data from the BAS is a valuable tool for commissioning and performance monitoring of building systems.

h. One of the barriers to BAS use was that older systems required their own separate network infrastructure. BASs can now co-exist on the enterprise Local Area Network (LAN) along with desktop computers, servers, and other devices. A separate network infrastructure and the maintenance of that infrastructure can be done by the Information Technology (IT) department, not necessarily by the Facilities department. IT can secure BAS assets and the information they contain and grant access rights in the same manner as other computing devices on the enterprise LAN.

i. A networked BAS can utilize both hardwired and wireless network protocols. The specifier must evaluate the suitability of wired versus wireless solutions. Some owners prohibit the use of wireless for security reasons. Wireless does have the advantage of not requiring more cabling infrastructure. A wireless solution is particularly advantageous in existing buildings or buildings with high ceilings, like hotel ballrooms or arenas.

j. Integration of other building systems (such as weather station, lighting, security, fire, submeters, emergency generators, etc.) into the BAS provides the opportunity for global optimization of building systems for energy conservation, occupant comfort, and safety. Integration of other building systems is accomplished by the use of different industry standard communication protocols. This guideline specification does not cover the specification of these other non-HVAC systems. This guideline does provide guidance on the integration of these systems into a BAS.

k. A BAS reduces labor and energy costs through remote monitoring and troubleshooting. The response time for correcting building system problems can be minimized though the use of remote monitoring and commissioning services. In many cases, on-site operations can be eliminated or reduced through the use of remote monitoring as a central monitoring service or an off-site technician with a cellular phone or tablet device that provides remote access to the BAS.

l. A BAS is often necessary to meet sustainability guidelines such as LEED™, Green Globes™, and Go Green™. The BAS allows the user to commission the systems to meet these sustainability guidelines. A BAS will also monitor the various systems to ensure compliance to these standards so the energy savings are maintained over the long term.

m. A BAS offers a viable platform for implementing performance monitoring, which can provide facility managers and operators with the means to easily assess the current and historical performance of the building/facility as a whole and of its significant energy consuming systems and components. Performance monitoring can be implemented as part of a new construction project or as part of a BAS system installation or upgrade project in an existing building. With the advent of initiatives such as ASHRAE 189.1, LEED™, Net-Zero, and the SmartGrid, a BAS must now respond in a dynamic fashion to changes in price signals from the local utility (called demand response), weather events, or power outages.

n. Virtually all BAS manufacturers offer product that conforms to worldwide interoperability standards at no extra cost over a proprietary communications protocol. Unless an owner is making an extension to a proprietary protocol installation or has a specific requirement that necessitates the use of a proprietary protocol system, it makes no sense to design and specify a proprietary protocol BAS. While the current project may be only an HVAC project, there may be future lighting, security, or fire alarm system installations that the owner will install and will expect that the original HVAC system can interoperate with these other systems.

o. When is a BAS not required, or when is the BAS not the primary means of control?

   i. In the past, it was common not to install a BAS for small buildings with one or more rooftop units. This is often not the case today as rooftop units, heat pumps, or other packaged equipment come with their own built-in automation controls that allow this equipment to be connected to the Internet to permit remote monitoring and control. With the cost of energy and servicing costs rising and the cost of onboard networkable controls becoming commonplace, it makes good sense to utilize these onboard controls.

   ii. There will be cases such as high hazard buildings where electronic controls that could generate a spark are not allowed. In this case, pneumatic controls or intrinsically safe electric controls may be the only solution.

   iii. UL, cUL, or other codes may necessitate the use of hardwired interlocks between the fire alarm and the corridor pressurization fans in the facility. The specifier should consider providing BAS controls to monitor these non-electronic control interlocks. Some BAS suppliers offer UL or cUL 864 (UUKL7) listed DDC devices that are listed for smoke control. Such devices maintain the UL chain of continuity between the fire alarm panel and BAS smoke control algorithms. The use of such listed BAS devices may reduce or eliminate hardwired interlocks and will allow for more sophisticated monitoring during operation. The suitability of such devices needs to be evaluated during the project design stage.

   iv. Hardwired interlocks may also be required by the equipment supplier. It is common practice to wire a flow switch through the chiller starter circuit rather than making a software interlock between these two devices with the BAS.

   v. Unit heaters in shops or mechanical rooms often use simple line voltage controls, which may not require a BAS. Even in this case, the specifier should not rule out the option for controlling this equipment via the BAS so as to permit remote monitoring and control.

In summary, BASs provide tangible savings in both energy conservation and maintenance. More importantly, the technology gives the owner better control over the building and can save labor and energy costs through remote diagnosis and troubleshooting. Pneumatic or electronic controls cannot provide the sophisticated alarm and trending features that are available as standard items on most commercially available BASs.

In making a decision on controls, property owners and managers need to understand that use of BAS technology is not a solution to all building problems. A BAS should not be installed before a proper assessment of needs is made. A BAS cannot correct problems with mechanical systems that are under capacity, poorly designed, or do not meet current codes. This is of concern primarily in retrofit projects. In this case, the specifier must make the owner aware of these issues, or the BAS, once installed, may be unfairly blamed for these preexisting problems.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

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