ASHRAE Guideline 13-2015
(Supersedes ASHRAE Guideline 13-2014)
Includes ASHRAE addenda listed in Annex G

Specifying Building Automation Systems

See Annex G for ASHRAE approval dates.

This guideline is under continuous maintenance by a Standing Guideline Project Committee (SGPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the guideline. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Senior Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

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Includes Web-based access to Example Specification for Building Automation Systems
(Requires Microsoft® Word®)
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NOTE
Approved addenda, errata, or interpretations for this guideline can be downloaded free of charge from the ASHRAE Web site at www.ashrae.org/technology.
FOREWORD

This guideline is intended to provide a designer of building automation systems (BASs) with background information, recommendations for good practice, project considerations, and detailed discussion of options with respect to the design of a BAS.

The reader should be aware that the technologies available in BAS products change more rapidly than those in the rest of the HVAC industry. A careful review of suppliers’ offerings should be made before proceeding with creation of any BAS design. The creation of a BAS specification is a process similar to that used to design the rest of a facility’s systems. This guideline attempts to guide the reader through this process. Informative Annex E provides guidance for specifying various levels of performance monitoring.

This guideline includes online access to an example specification, presented as excerpted parts and embedded throughout the document and also available as a separate file in Microsoft Word® format. Its function is to illustrate the concepts described in the body of the text. The example should be used as it was intended—as an example only. The example is not a guide specification; it does not include exhaustive options for every conceivable project system architecture, requirement, or configuration. It does not fit all applications, nor is it the best way to proceed on every job.

The example is protocol neutral, and refers the BAS designer to the cognizant organization for the selected protocol. Many of these organizations have guide specification language based on their protocol.

The excerpted parts of the example are presented in a typeface different from the text of the guideline, with lines above and below. An outline of the example specification is included as an annex to this guideline to allow the reader to see how its sections fit together.


1. PURPOSE

The purpose of this guideline is to provide recommendations for developing specifications for building automation systems (BASs) in heating, ventilating, and air-conditioning (HVAC) control applications.

2. SCOPE

This guideline covers building automation systems (BASs) for HVAC control, monitoring, and management functions. The guideline specifies hardware performance, installation, and training. It also addresses system architecture, input/output structure, communication, program configuration, system testing, and documentation. The guideline only includes examples of how to integrate to fire, life safety, lighting, and other systems. The design and specification of these non-HVAC systems is not part of this document. There is also no specification of facility management functions, as this is beyond the scope of this document.

3. PREAMBLE

3.1 Intent of this Document. This guideline provides building automation system (BAS) designers of BAS with a tool to help them create and edit specifications for projects of virtually any size, scope, or complexity. It is the result of industry consensus obtained from the controls and equipment manufacturers, users, consulting engineers, installation contractors, and testing contractors who composed ASHRAE Standing Guideline Project Committee (SGPC) 13.

This guideline discusses the options, considerations, perceived benefits, and concerns associated with each part of an installed system. The authors chose specific configurations, components, and methodology. One such selection decision was the architecture or topology of the system. These selections are not the only way to build a system, nor are they necessarily the best for each project. The information provided should assist the reader in understanding why these selections were made and how to make these decisions for his/her project.

This guideline represents a standardization of approach to the design, documentation, and specification of BAS for HVAC control and energy management applications. This standardization should improve both the quality and value of BAS for building owners and users. The guideline should not be used as a statutory standard for compliance. The examples are not an exhaustive representation of all types and features of BAS. This guideline and its annexes require substantial editing and customization for the particular requirements of any given project.

3.2 Use of this Guideline. This guideline is to be used when preparing written and drawn specifications of BAS control and energy management systems and can be a reference for the design of these BAS as well. The term direct digital control is only used when referring to the process of controlling equipment directly with digital controllers.

The terms BAS designer, contractor, subcontractor, and owner are used throughout this document. These terms are used for clarity—they are not intended to define contractual or legal requirements of any party.

BAS designer: the creator of the work or the author of the specification. The BAS designer may be a consulting engineer, a licensed professional engineer, a facility master system integrator, or other. It is possible that with the need to have Internet connectivity and sharing of control-point data, there could be more than one party involved in the specification of the work.

contractor: the performer of the work defined in the specification; the person or company who enters into contractual agreement to execute the work and the entity responsible for its completion in accordance with the contract documents.

subcontractor: the performer of the work defined in the specification; this person or company is contracted by the contractor—not the owner—to perform some or all of the work defined by the specification in accordance with the contract documents.
owner: the person or company that executes the contract for the work; this entity will assume ownership of the completed work in accordance with the contract documents.

3.3 Organization of the Guideline. This guideline is organized into 14 chapters, called clauses, each with a main heading. Also, appendices, called annexes, are attached. The document is divided into eight major parts:

a. Introduction: Purpose (Clause 1), Scope (Clause 2), Preamble (Clause 3).
b. A general introduction of the principles of design and documentation (Clauses 4 and 5).
c. An article-by-article discussion of the content of a written specification for a BAS (explanation of each specification article has been included to help the BAS designer). (Clauses 6 through 9)
d. Information about the BAS that will be important to other subcontractors (Clause 10).
e. Additional information regarding valves and dampers (Clause 11).
f. Annexes: Outline of example specification, BACnet® discussion, interoperability case studies, and performance monitoring.
g. IP networking requirements (Clause 12). This section contains information about graphics, submittals, training, etc., that is found in Clauses 6 through 9 that is specific to the IP networking and integration of the BAS device network into enterprise.
h. Legacy systems (Clause 13). This section discusses various options for managing legacy systems and the relationship to a modern control system.
i. References (Clause 14). This section provides additional references and resources for designers and specifiers.

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 specification is divided into three parts (“General,” “Products,” and “Execution”), each consisting of articles, paragraphs, and subparagraphs. Under the 2004 CSI Master Format™, control specifications are in Division 23, “Heating, Ventilating, and Air Conditioning.” Section 23 09 00, or in Division 25, “Integrated Automation.” The electronic version of the sample specification is applicable to both the 1995 and 2004 formats.

4. BUILDING AUTOMATION SYSTEM (BAS)
OVERVIEW

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 comprises 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/IES Standard 90.1 and ASHRAE/USGBC/IES Standard 189.1. Controls strategies such as night setback, optimum start/stop and demand limiting, and setpoint reset for variable-air-volume (VAV) systems require a BAS, as these strategies cannot realistically be accomplished using pneumatic or 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 Informative Annex E.
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 through Saturday), as well as scheduling for nonbusiness days (i.e., holidays) for years in advance. The BAS can also permit occupied and unoccupied setpoints to meet energy savings targets. Scheduling can be further modified using optimized start/stop algorithms.
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, system, device type, unit, or panel to allow the building operator to observe the order in which 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. Maintenance of a separate network infrastructure can be performed by the Information Technology (IT) department, not necessarily by the facilities department. The IT department can secure BAS assets and the informa-
tion 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 BAS designer must evaluate the suitability of wired versus wireless solutions or a hybrid of both. 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 through 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 specifications of 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 that energy savings are maintained over the long term, and it can be used as a measurement and verification tool.

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, as well as 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 installation or upgrade project in an existing building. With the advent of initiatives such as ASHRAE 189.1, LEED, Net-Zero, and ASHRAE 201P SmartGrid interoperability, 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. Many BAS device 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, in the future the owner may install lighting, security, or fire-alarm systems and will expect interoperability with the original HVAC system.

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

1. 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 a building network or directly to the Internet to permit remote monitoring and control. With energy and servicing costs rising and the cost of onboard networkable controls becoming commonplace, it makes good sense to utilize these onboard controls.

2. 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.

3. 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 BAS designer should consider providing BAS controls to monitor these nonelectronic control interlocks. Some BAS suppliers offer UL or cUL 864 (UUKL7) listed DDC devices specified 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.

4. 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.

5. Unit heaters in shops or mechanical rooms often use simple line voltage controls, which may not require a BAS. Even in this case, the BAS designer should not rule out the option for controlling this equipment via the BAS so as to permit remote monitoring and control. The BAS is a tool, a powerful one, but requires skilled system operators to provide a properly operating system.

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 BAS technology is not a solution to all building problems. A BAS should not be installed before a proper needs assessment 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 BAS designer must make the owner aware of these issues, or the BAS, once installed, may be unfairly blamed for these pre-existing problems.

4.2 System Overview. The BAS comprises both hardware and software that combine to produce a seamless architecture that provides complete integration of a building’s HVAC systems and may include control over, or monitoring of, lighting, security, and fire systems in the building. The BAS can continuously and automatically monitor and — through control of the HVAC mechanical and refrigeration systems — maintain desired ambient temperature, static pressure, relative humidity, indoor air quality, and energy management.

The control system normally consists of several microprocessor-based controllers that have electronic sensors connected to measure temperatures, pressures, electrical current, status, and other environmental variables. These inputs can be either binary (on/off), such as fan status, or analog (variable), such as static pressure. The signals from the analog inputs are digitized for further processing. The controllers run a program to compare the measured values to the desired results and, using proportional-integral-derivative (PID) algorithms, determine how the system outputs should be controlled. This is the essence of DDC. In addition to control, BAS devices also provide coordination, monitoring for out-of-normal or alarm situations, scheduling, graphics, and other functions. Each BAS manufacturer has a slightly different approach to providing the same solution, as well as a slightly different architecture.

Several types of local area networks (LANs) are used by BAS vendors to allow information sharing between controllers. These LAN types include Ethernet (ISO 8802-3) and ARCNET (ASTM 878.1), LON TP/FT-10 (ANSI 709.3/ISO 14908.2), and EIA-485. Communication over these LANs may involve a proprietary communication protocol or may involve an open protocol, such as ASHRAE’s building automation and control network (BACnet) protocol or the ISO/AIDS Local Operating Network (LON) Standard protocol developed by LonMark International.

4.3 Impact of the Internet on the BAS Design and Specification Process. The Internet has changed how BASs are designed and specified. Before the advent of the Internet, BASs were isolated systems that were accessible only by dialup modems. The Facilities Department was normally the only user of BAS trendlog and alarming information. BASs can now be designed and specified to co-exist with computers, tablets, smartphones, and other IP-based devices now connected to measure temperatures, pressures, electrical current, status, and other environmental variables. These inputs can be either binary (on/off), such as fan status, or analog (variable), such as static pressure. The signals from the analog inputs are digitized for further processing. The controllers run a program to compare the measured values to the desired results and, using proportional-integral-derivative (PID) algorithms, determine how the system outputs should be controlled. This is the essence of DDC. In addition to control, BAS devices also provide coordination, monitoring for out-of-normal or alarm situations, scheduling, graphics, and other functions. Each BAS manufacturer has a slightly different approach to providing the same solution, as well as a slightly different architecture.

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At one time it was common for each BAS supplier to provide his or her own network infrastructure. There can now be a cabling contractor who provides all IP network cabling. This change is similar to how firestopping work is now handled. Firestopping used to be provided by each individual trade. As firestopping work became more specialized and difficult, it is normally performed by one trade. The firestop contractor provides this service for mechanical, electrical, architectural, and other trades.

In the case of non-IP networks, it is normal practice that the division providing the devices is also responsible for the non-IP network connectivity. Examples of this include VAV boxes, lighting, security, and fire alarm. It is certainly possible in a contract that the IP network contractor could provide the network wiring for fire alarm devices but this would blur responsibilities and create problems. The more likely inter-relationship is that all non-IP cable is identified using unique identifiers and cable colors that are set for the facility as a whole. Identification and tagging standards would also be set in this manner. The non-IP network could be run using plenum cable, run in conduit, or sharing a common cable tray.

The BAS can be set up as a physically separated IP network or can be on the enterprise network and then separated by creating a virtual local area network (VLAN). BAS devices are now designed to operate on the enterprise network. These devices must coexist on the Intranet, or the owner’s IT department will not allow them to be added to their network. Someone must take responsibility for managing the unique IP addresses for all devices on the Ethernet backbone and ensure no duplicates and no communication issues. This is typically an IT department responsibility, or it can be managed by assigning a block of addresses to the BAS contractor and letting them perform installation. A good check-and-balance system is required in order to ensure reliability.

One concern for IT departments is that the BAS devices must not consume excessive bandwidth. This is usually not a problem as BAS devices are normally designed to run on a stand-alone basis, so bandwidth usage is minimal. If network communications fail, the BAS devices will run based on the last known values for occupancy or outdoor air temperature. In a campus of buildings, each building may have its own occupancy schedule and either its own outdoor air sensor or sensors shared by multiple buildings. Losing network connectivity means that alarms cannot be reported centrally or trend data may be lost, but the chiller, boiler, air-handling unit (AHU), pumps, lights, etc., operate on a stand-alone basis until network connectivity is restored. Prolonged network outages were common in the early days of the Internet. This is not the case now, as IP switches and routers are designed to
be fault tolerant. These devices are backed up by uninterruptible power supply (UPS) and may have a generator to provide backup power to the BAS network until commercial power is restored. In mission-critical facilities there are redundant IP networks and redundant power sources. These provisions result in fewer power or communications outages in practice.

Security is a significant concern presents ever increasing issues regarding authorized/unauthorized access to BAS networks. Clause 12 identifies the key elements of a control network specification for network security. However, local project requirements must enforce owner and local code security requirements. Fundamentally, BAS control networks should follow standard IT best practices and enforce strong pass phrases, lockdown of devices that provide outside access, blocking of unauthorized access, and properly managed firewalls. Balancing security and reliability/access is of significant importance to the BAS designer, and one should coordinate with the relevant IT professional before mandating certain components, access, and tools. For example, providing the ability for a controls contractor to install their own cellular modem gateway for remote access should be strongly scrutinized for security issues before adopting.

The level of connectivity to the Internet began with large building controllers. Now, it is not unusual for a chiller, a boiler, a meter, or even a thermostat to be an IP device. As IP network connectivity costs fall, more larger devices such as chillers are IP-based. Devices such as VAV boxes are usually non-IP based. The issue for the BAS designer is to resolve the responsibility for who does what work.

4.3.1.3 BAS Design Option 3—Mixture of IP and non-IP Devices in a Building. This option (Figure 4.3.1.3) is now the most common design approach. Most BAS equipment suppliers and device suppliers (chillers, meters, etc.) offer both IP and non-IP connections. The BAS designer must weigh the benefits and costs of IP connectivity at the device level. A chiller supplier might want IP connectivity so that the technician can make a direct network connection to a service and configure the device. It is not unusual for the manufacturer to have proprietary software for this purpose. These proprietary data points may not be exposed on the BAS device network. If the device is part of a BAS contractor’s device network, the BAS contractor will have to give access to the chiller manufacturer and effectively assume responsibility for the security of the device. IP connections are usually more expensive than non-IP connections. The IT department may have a limited number of addresses available for BAS use. Once the chiller is on the enterprise network, IT has to secure the device. While IP connections are now reasonably stable and robust, if the BAS contractor relies on the owner’s network for controlling the device, then the principle of stand-alone control is not being followed.

One issue for the BAS designer is that in a public bidding situation, where the procurement rules require a minimum of three acceptable products, it may be difficult to find enough device suppliers able to offer a device with an IP connection. If these networking requirements are not specified correctly, one might end up with a meter with a Modbus connection, chiller with a BACnet/IP connection, and a boiler with a LON.

The first solution is to structure the contract so that there is a single FMSI. The FMSI is an umbrella position within standard construction divisions to help oversee the specification and implementation of BASs. The FMSI is usually accountable for assuring interoperability between subsystems and different buildings, for providing a common graphical user interface, and for assuring products from multiple bidders and vendors meet the intent of a specification as well as the letter of a specification, and for acting as a technical go-between for the various involved trades (controls, electrical, and mechanical, etc.). The FMSI would either report to the general contractor or the owner. This role could also be performed by a well-qualified BAS contractor.

The second solution is to have the network communications information built into the equipment specification (integral solution). Under this option, networking requirements are specified as for any other requirement, such as the correct voltage or phasing. If the device exceeds the allowed weight or height requirements, or if the device is too big to fit into the mechanical room, it is not acceptable. Similarly, if the device cannot support IP connectivity or a specific protocol, it is not allowed in the project.

Choosing which solution to follow is up to the BAS designer and the owner. The FMSI solution has a single source of responsibility for device communications. The FMSI solution also adds an additional reporting layer to the construction process that adds cost to the job. Building the network requirements into the equipment specification does
FIGURE 4.3.1.3 BAS design option 3—mixture of IP and non-IP devices in a building.