



Scottish Health Technical Memorandum 2005

(Part 2 of 4)

Design considerations

Building management systems

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Executive summary

A building management system (BMS) is a computer-based centralised procedure that helps to manage, control and monitor certain engineering services within a building or a group of buildings. Such a system ensures efficiency and cost-effectiveness in terms of labour and energy costs, and provides a safe and more comfortable environment for building occupants.

The BMS has evolved from being a simple supervisory control to a totally integrated computerised control and monitoring system.

Some of the advantages of a BMS are as follows:

- a. simple operation with routine and repetitive functions programmed for automatic response;
- b. reduced operator training time through on-screen instructions and supporting graphic display;
- c. faster and better response to occupant needs;
- d. reduced energy costs through centralised control and energy management programmes;
- e. better management of the facility through historical records, maintenance programmes and automatic alarm reporting;
- f. improved operation through software and hardware integration of multiple sub-systems, for example direct digital control, security and access and lighting controls.

This part, 'Design considerations', considers general BMS technology and details the requirements and considerations that should be applied to the selection, design, tendering and installation stages of a project.

Management responsibilities in terms of compliance with statutory instruments are summarised in Chapter 2. The technology and potential benefits of a BMS are described in Chapter 3, 'Functional overview'. The fundamentals of BMS architecture are described in Chapter 4. Chapter 5 describes key BMS functions, including:

- a. monitoring routines such as digital, analogue and pulsed inputs and trend logs;
- b. control of environment, energy, lighting, plant and machinery.

Chapter 6 covers BMS inputs and outputs. Software applications in monitoring and targeting energy or consumption, and providing the basis of a planned preventive maintenance programme, are discussed in Chapter 7.

Chapter 8 covers communications and Chapter 9 deals with aspects of integrating the BMS with other systems such as fire detection, security, lifts etc.

Chapters 10, 11 and 12 provide guidance on project procurement, such as:

- a. initial feasibility studies;
- b. the briefing process;
- c. planning;
- d. assembling the specifications;
- e. the tendering procedure;
- f. presentation of information.

Definitions of selected staff functions and a glossary of terms are provided in Chapters 13 and 14 respectively.

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1. Scope

- 1.1 A building management system (BMS) is a management tool for the effective control of building engineering services, and can be applied equally to new and existing buildings.
- 1.2 A BMS can be used to manage the environmental conditions of all types of building. In healthcare premises, a BMS is particularly valuable in maintaining suitable conditions in critical areas, for example operating departments, intensive care units, isolation suites, pharmacies and sterile supply departments. A BMS provides alarm communication networks for the building services plant.
- 1.3 A properly installed and maintained BMS operated by fully trained staff offers considerable opportunities for “energy management”. A BMS can support separate software packages for energy monitoring and targeting.

NOTE: Other areas that can be monitored and targeted include water consumption, sewage and waste disposal.

- 1.4 A further use of the BMS is to help to establish the basis of the site’s planned preventive maintenance operations.
- 1.5 A BMS should be specified with care and detail, focusing on the functionality and required performance of the systems under control. The specification should detail the commissioning and handover requirements. When a BMS is specified, especially if it is replacing existing controls, consideration should be given to the appropriate level of user control.

NOTE: When a BMS is specified, the NHS Model Engineering Specifications with appropriate supplements for Scotland should be considered.

- 1.6 The commissioning of a BMS should be fully documented to ensure that all aspects of the system meet the specification. Adequate resources should be allocated to ensure satisfactory commissioning procedures are met.
- 1.7 To continue to meet specified environmental conditions and increase energy efficiency, a BMS should be regularly maintained and its performance tested.
- 1.8 It is important that BMS operators and maintenance staff receive adequate training.

- 1.9 The sophistication of building services in healthcare premises is increasing, and therefore BMS controls should be designed, installed, operated and maintained to standards that will enable the controls to fulfil the desired functions reliably and safely.

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2. Management responsibilities

- 2.1 It is incumbent on management to ensure that their BMS installations comply with all the statutory regulations applicable to a BMS on their premises. Other functional guidance in terms of standards and codes of practice should also be noted.

Statutory requirements

- 2.2 Safety regulations are as laid down in the:
- a. Health and Safety at Work etc (HSW) Act 1974;
 - b. Electricity at Work Regulations 1989;
 - c. The Building Standards (Scotland) Regulations 1990 (as amended);
 - d. Management of Health and Safety at Work Regulations 1999;
 - e. Provision and Use of Work Equipment Regulations 1998;
 - f. Manual Handling Operations Regulations 1992;
 - g. Workplace (Health, Safety and Welfare) Regulations 1992;
 - h. Personal Protective Equipment at Work (PPE) Regulations 1992;
 - i. Health and Safety (Display Screen Equipment) Regulations 1992;
 - j. Construction (Design and Management) Regulations 1994;
 - k. Electromagnetic Compatibility Regulations 1992;
 - l. Electromagnetic Compatibility (Amendment) Regulations 1994.

Functional guidance

- 2.3 Guidance is as laid down in:
- a. British Standards and Codes of Practice;
 - b. Health and Safety Executive Guidance;
 - c. NHS Model Engineering Specifications;
 - d. Scottish Health Technical Memoranda (SHTM);
 - e. Scottish Hospital Planning Notes (SHPN);
 - f. Scottish Hospital Technical Notes (SHTN);
 - g. Scottish Health Guidance Notes (SHGN);
 - h. NHS in Scotland – Firecode;
 - i. Health Building Notes and Health Technical Memoranda;

- j. The Technical Standards for compliance with the Building Standards (Scotland) Regulations 1998 (as amended).

For further details please refer to the 'References' section at the end of this document.

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3. Functional overview

Introduction

- 3.1 A BMS controls the plant and equipment creating the internal environment in healthcare premises. It typically consists of a **central station** connected via a communications network to a number of **outstations** (see Figure 1). Control actions can be determined by either the central station or outstations. The latter can operate independently of the network if necessary, hence the term “**distributed intelligence**”.

NOTE: The extent and geography of the site will determine the choice of the equipment and communications network to be used. Links from the central station to remote outstations can be achieved by, for example, hard wire, modem or radio communication. However, it is critical to ensure that sensitive medical electrical equipment is not affected by radio communication interference (refer to HEEU Report: Electromagnetic Compatibility of Medical Devices with Mobile Communications issued 9/5/97).

It is recommended that uninterruptable power supplies (UPS) are included for the central station, outstations and any communications network.

BMS technology

Central station

- 3.2 The central station of a BMS is usually a personal computer-based system which provides a user interface with the BMS by means of schedules or graphical schematics. These are dynamically updated with monitored values. The central station of a BMS provides:
- the ability to establish trend logs of various monitored parameters such as sensor values or control outputs. This feature can be invaluable when investigating the performance of plant;
 - the ability to receive plant alarms and abnormal conditions warnings which can be graded by degree of severity and required response;
 - the ability to alter control parameters such as programmed occupancy times or control set-points;
 - the ability to configure the system, including the outstations;
 - the use of management software for energy monitoring and targeting and for maintenance planning;

- f. the ability to monitor all connected plant. Hard copy reports can be generated and printed.

NOTE: The technical specification of the central station is of vital importance to enable it to operate additional management software for monitoring and targeting purposes.

Outstation

- 3.3 An outstation is a microprocessor device which uses programmable software to perform control functions. The outstation software provides control “blocks” which can be arranged (configured) to provide a control strategy. Once configured, the outstation is able to hold the control logic.
- 3.4 A number of inputs and outputs are connected to each outstation. Inputs include on/off status of plant, and data from sensors measuring temperature, humidity, pressure, velocity etc. Outputs include on/off signals to plant, along with control signals to actuators for valves and dampers etc.

NOTE: One or more outstations may be used to control the engineering services plant in a particular building.

- 3.5 Outstations are connected to a communications network. This enables data to be shared between outstations and provides a means of accessing and monitoring the system from a single point.

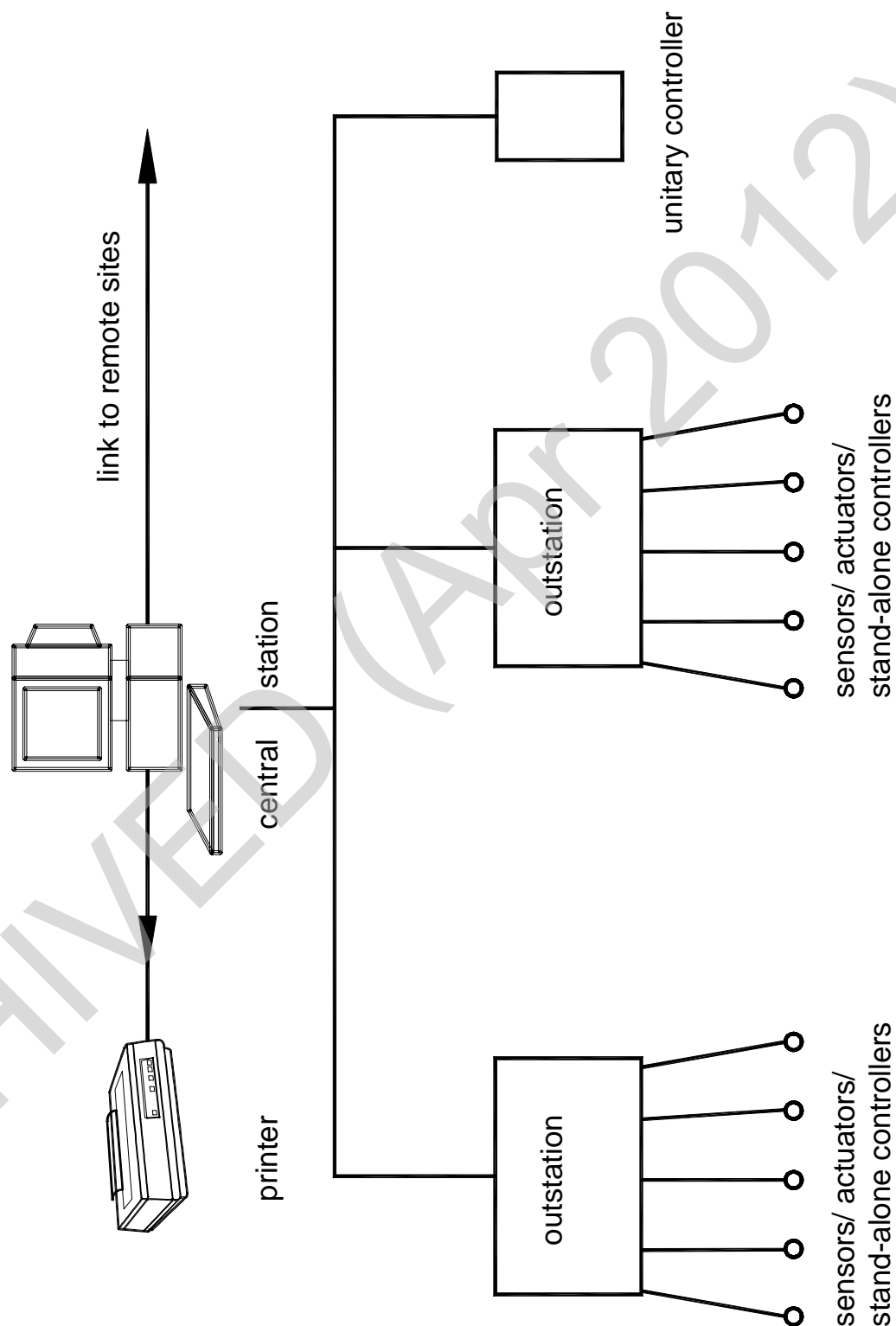
Unitary controllers

- 3.6 These are small outstations generally dedicated to one item of plant and are connected to the communications network.

Control functions

- 3.7 Control functions available for configuration depend on the make of outstation and typically include:
 - a. time/event schedules;
 - b. optimisers;
 - c. compensators;
 - d. proportional, integral and derivative control;
 - e. logic functions.

Figure 1: Building management system schematic



3.8 These various functions can be configured together to provide a tailored control strategy to suit the plant in question. Typical control applications include:

- a. heating;
- b. ventilation;
- c. air-conditioning;
- d. lighting;
- e. duty cycling;
- f. load shedding.

Potential benefits of a BMS

3.9 To maximise the energy-saving potential of a BMS, its ability to control plant should be fully exploited.

NOTE: Improved monitoring alone may not necessarily save energy.

3.10 A BMS can provide enhanced control of environmental conditions. This is achieved by the flexibility in configuration of programmes which can be tailored to provide optimum control solutions. The ability to record or log measured or calculated parameters over time provides a powerful auditing tool which can be used to check and refine the control settings.

3.11 The logging facility is invaluable for energy auditing and checking the control of an item of plant or space condition. A permanent record can be made of environmental conditions through the use of logs.

3.12 A BMS can be configured such that any monitored parameter can signal an alarm once a predetermined value has been exceeded. The type of abnormal condition can be specified, as can the nature of the associated alarm and required response. This facility gives the BMS a fault detection capability, which can be extended to other hospital equipment, for example fume cupboards, freezers and lifts.

NOTE: It is essential to ensure that the BMS interface with “lifts” processors is restricted to monitoring only. Any possibility of the BMS influencing the lift controls must be eliminated.

3.13 A BMS can be configured to log the hours run of a particular item of plant and the number of starts. This data and other information collected by a maintenance management software package can be used to schedule plant maintenance. Messages from the BMS can also be used to initiate repair and maintenance instructions.

- 3.14 Improved monitoring and control of plant with a BMS improves the life of the plant, reduces maintenance costs and enables better use of existing engineering labour resources.
- 3.15 Proprietary software for monitoring and targeting can be installed at the central station. This software can be a powerful tool in an energy-saving campaign, as it not only provides an analysis of energy use, but also highlights energy wastage and deviations from set targets.
- 3.16 A BMS can provide a central monitoring facility for a range of related systems such as:
- a. fire detection;
 - b. security detection systems, including burglar alarms, closed circuit television (CCTV) and access control systems;
 - c. telephone systems;
 - d. vertical transport systems (lifts).
- 3.17 At present a BMS performs no control role when integrated with any of the above; it merely acts as a single user interface, monitoring autonomous systems. There needs to be a clear technical break (isolation) between fire alarm/protection systems and the BMS to ensure the absolute integrity of the fire alarm systems. This level of integration is restricted at present due to the current standards and the advice of fire prevention and building control officers. It is also essential that the BMS interface with “lifts” processors is restricted to monitoring only. Any possibility of the BMS influencing the lift controls must be eliminated.

4. BMS architecture

Introduction

- 4.1 The architecture of a distributed intelligence BMS is illustrated in Figure 1. Outstations, the central station and other operator interfaces are linked together via a communications network.
- 4.2 The advantages of this type of architecture over a centralised system are:
- improved reliability: outstation failure will affect only a small part of the technical installation;
 - a reduction in cable costs, as the field devices are wired only to the local outstations;
 - information processing functions are distributed, hence a PC can be used as a central station, which lowers initial costs. The system response time is reduced;
 - the system can be expanded easily by the addition of extra outstations or central stations.

Central station

- 4.3 The communications network normally consists of a protected twisted-pair cable connecting the outstations. For practical or financial reasons other methods can be used, for example:
- telephone modem;
 - mains-borne signalling;
 - radio or microwave.

NOTE: It is critical to ensure that sensitive medical electrical equipment is not affected by radio communication interference.

- 4.4 Each of the BMS manufacturers implements different communications protocols at the various levels (field devices, outstation and central station), therefore special gateways are required to enable systems from different manufacturers to communicate with each other. This is described in more detail in Chapter 9.

Outstations

- 4.5 BMS field devices (analogue/digital inputs and outputs) are normally wired directly to outstations, but other forms of communication can be used as mentioned above.
- 4.6 Analogue input and output devices would include resistance thermometers, potentiometers and voltage - or current-operated devices, normally functioning in the range of 0-10V or 4-20 mA.

Stand-alone controllers

- 4.7 These controllers are not linked to a communications network. They are normally provided with strategies appropriate to their applications. An outstation can be used to switch a stand-alone controller (for example compensator or PID control) on and off according to a time schedule and input set-points. The outstation's digital outputs can enable the operation of the stand-alone units.

System expansion

- 4.8 BMS should be designed to be flexible. Outstation configuration software should enable control strategies to be modified as required. To enable outstations to expand provision should be made to incorporate additional input/output points in each outstation and to enable additional circuit boards to be installed.
- 4.9 Expansion of an existing system may be inhibited by the existing capacity of outstations and some outstations may require to be replaced. In replacing these, the possible need for further expansion in the future should be considered.

5. BMS functions - typical system description

Monitoring routines

- 5.1 BMS outstations can be configured for several different types of monitoring routine, for example:
- a. digital inputs;
 - b. analogue inputs;
 - c. pulsed inputs;
 - d. positive feedback;
 - e. run time totalisation; and
 - f. trend logs.

Digital inputs

- 5.2 BMS outstation software recognises the status of digital inputs and also enables associated events as defined by any logical relationships. The BMS also recognises the status of soft or internal points.

Analogue inputs

- 5.3 The outstation software processes analogue inputs (voltage or current signals). The software assigns scaling factors and upper and lower limits to each analogue input.

Pulsed inputs

- 5.4 Inputs from meters (for example gas, electricity or water) are pulsed. The outstation stores the pulsed input signals as cumulative totals, and the operator has the facility to reset the counter. The software scales the pulse rate to display totals in the required units.

Positive feedback

- 5.5 The outstation software provides positive feedback of plant operation by monitoring physically separate but functionally related sensors, transducers or internal “soft” points. The feedback strategy raises an alarm and operates standby plant if the expected response has not been established within a pre-set time.

Run-time totalisation

- 5.6 Run-time totalisation routines in the outstation software record the cumulative run-time for each item of plant. The outstation software signals an alarm when pre-set maximum levels are attained.

Trend logs

- 5.7 Logging routines in the software record any real or “soft” point in the system at regular specified time intervals. These can be set up to operate continuously or for predetermined periods.

NOTE: Management systems should be in place to analyse the recorded data and initiate any follow-up action.

Available control functions

Control modes

- 5.8 The outstations provide proportional control (P) or proportional and integral control (P+I) or proportional and integral and derivative control (P+I+D) modes individually for each controlled device. The proportional band, integral action time and derivative action time are adjustable for each control algorithm.

Time control

- 5.9 The BMS controls plant by switching it on or off according to multiple pre-set times or time intervals. The programmes usually allow for several operating periods per 24 hours.
- 5.10 The time programmes can accommodate variations such as:
- a. day/night;
 - b. weekends;
 - c. holidays;
 - d. seasonal;
 - e. clock changes, for example British Summer Time;
 - f. manual override, for example extended occupancy periods.
- 5.11 The time programmes can also be subject to pre-defined conditional parameters, for example minimum/maximum ambient conditions.

Event control

- 5.12 Control software can start and stop plant according to sequences or events detailed in the specification, including any conditional requirements for status of plant items, valves or dampers. For example, standby plant is required to operate automatically on the failure of duty plant. Starting routines can be delayed to provide sequential plant operations.

NOTE: Minimum on/off cycle times and/or the maximum number of starts per hour can be programmed to prolong plant life.

Plant protection during shut-down

- 5.13 During plant shut-down a plant protection routine can be used to automatically run items of plant for short periods. The normal seasonal sequence of plant operation overrides this routine.

Sequence control

- 5.14 Plant operations can be sequenced by monitoring load parameters and efficiently matching the plant to the load. Control options include:
- a. choice of different control strategies;
 - b. operator facility to override programmed sequence;
 - c. operator facility to vary and adjust the set-point values for each control action;
 - d. operator adjustment for switching control differentials to prevent short cycling;
 - e. automatic modification of schedule when maximum number of start/stop cycles is reached for a particular plant.

Keyboard control

- 5.15 This facility allows the BMS operator to directly control the plant. This operation usually overrides the programmes.

Boiler management

- 5.16 Separate boiler controls supplied by the boiler manufacturer normally supervise the safety and firing of boilers; however, the BMS provides the following boiler management routines:
- a. on/off command signal to the boiler controller;
 - b. selection of fuel in multi-fuel installations;
 - c. signalling of faults and alarms;
 - d. monitoring of the following parameters:
 - (i) burner status;

- (ii) fuel consumption;
- (iii) heating flow/return temperatures;
- (iv) hours run.

NOTE: Reference should be made to PM5 HSE Guidance Note, Automatically controlled steam and hot water boilers and HSE Programmable electronic systems in safety related applications.

Chiller management

- 5.17 Separate controls supplied by the chiller manufacturer normally supervise the operation of packaged chiller plant; however, the BMS provides the following chiller management routines:
- a. on/off command to the chiller controller;
 - b. signalling of faults and alarms;
 - c. monitoring of the following parameters:
 - (i) electrical load;
 - (ii) chilled water flow/return temperatures;
 - (iii) hours run.

Machinery management

- 5.18 Machinery installations, such as air compressors, lifts or pumping sets, can be supervised or monitored by the BMS providing the following routines:
- a. recording start/stop times;
 - b. counting number of starts in a predetermined period;
 - c. issuing test commands to demonstrate the operation;
 - d. fault and alarm monitoring.

Optimum start/stop

- 5.19 Optimum start routines for the heating and cooling systems compute the optimum daily minimum “on” period necessary to achieve target comfort conditions at occupation start time.
- 5.20 Optimum stop routines compute the earliest “off” time in order to retain minimum target comfort conditions in the space at the end of occupation. The control routines have a self-learning process which will seek to reduce any error in achieving the target conditions at the required time. The optimum start/stop routines include the following facilities:

- a. independent adjustment of the start and stop times;

- b. overriding compensation controls during pre-heat periods;
- c. application to both individual zone and overall operation.

5.21 The following parameters can be adjusted by the operator:

- a. target temperature for optimum start to achieve comfort conditions;
- b. maximum pre-heat/pre-cool period;
- c. target temperature for optimum stop;
- d. minimum space temperature for out-of-hours periods;
- e. separate time/temperature limits for optimum start and optimum stop;
- f. enable/disable the self-learning function;
- g. default time limit for handover to the weather compensation routines after the start of occupation.

Weather compensation

5.22 These routines control the heating/cooling systems in relation to the external temperature. There is often the option to adjust the temperature and flowrate settings for the system to redefine the weather compensation.

5.23 The weather compensation automatically adjusts the temperature when a significant difference occurs between the measured and required space temperatures.

NOTE: Care should be exercised in the location of the sensors recording temperatures to ensure that external influences (for example air extract discharges) do not cause any misrepresentation of the environment.

Frost protection

5.24 Frost protection software routines operate plant and pumps to protect building services systems and their components from frost damage. The protection can be provided in two stages:

- a. when the outside air temperature falls to the operator-set minimum frost protection temperature, the outstation software starts selected pumps;
- b. when the system temperature falls below the operator-preset minimum, the control routine initiates the full frost protection facility. For heating systems the control routine activates the heat source and maintains a minimum return temperature. For other liquid systems the BMS activates specified protective devices.

Building/plant protection

- 5.25 Building/plant protection routines operate the plant to protect the building fabric and its contents against the effects of low internal temperatures and condensation. If the room temperature falls below the pre-set protection temperature, the control routine activates the heating system and related plant.
- 5.26 The building/plant protection routine overrides other operating programmes unless otherwise specified. The routine operates whenever the normal heating is switched off.

Load cycling

- 5.27 A load cycling routine intermittently disconnects selected plant to make electrical energy savings. The periods of disconnection and the control limits are adjustable.

Electrical load and gas management

- 5.28 The BMS can manage electrical and gas demands using load shedding or diversification routines which include the following features:
- a. monitoring of demand during a set interval which coincides with the supply authority's metering tariffs;
 - b. predicting whether cumulative demand by the end of the metering interval is likely to exceed a definable limit;
 - c. shedding of loads and/or transfer to alternative energy sources to reduce cumulative demand during the metering interval to avoid exceeding the demand limit;
 - d. restoring loads which have previously been shed/transferred when the predicted cumulative demand falls sufficiently below the demand limit;
 - e. a two-stage alarm to indicate whether the demand limit is likely to be exceeded and whether it is exceeded.

NOTE: Adaptation of main and sub-metering would contribute to effective control of energy consumption. This in turn would greatly enhance savings.

- 5.29 The maximum demand limit and load shedding routines can be adjusted according to the supply authority's tariffs.
- 5.30 The BMS operator can allocate the loads to be shed into a number of priority groups, and can assign to each load or group a maximum off-time and/or a minimum on-time.

Fresh air control

- 5.31 A “fresh” outside air control routine optimises the proportions of fresh and recirculated air based upon the conditions of these two airstreams and the requirements of the controlled space. The proportions can be based on time, enthalpy and dry bulb temperatures. The fresh air proportion modulates between an operator-set minimum value and full fresh air as specified.

Air quality

- 5.32 The operation of the ventilating plant and the intake of fresh air is controlled in response to measured air quality, for example CO₂. If the air quality control is used in conjunction with the fresh air control, the demand for fresh air should have priority.

Lighting

- 5.33 Control routines for lighting can include the following:
- a. on/off switching of external and internal lights according to a time schedule;
 - b. dimming and switching of internal lights based on signals from external and internal photo sensors, incorporating a user-adjustable delay;
 - c. switching off internal lights according to occupancy detectors;
 - d. on/off switching of external lighting based on the signals from an external photo sensor.
- 5.34 Local switches and the central station operator can override the BMS lighting control. In the event of BMS failure the lighting system can be controlled manually. The BMS monitors the emergency lighting but performs no central function.

Occupancy

- 5.35 These routines enable the ventilation, temperature, lighting etc. to be controlled in response to the level of occupancy. The level of occupancy is determined by the level of carbon dioxide (CO₂) or access control data.

NOTE: Typically, signals from infra-red detectors indicate whether the space is occupied, but not the level of occupancy.

Other site alarms

- 5.36 The BMS can be used to monitor the status of other system alarms.

6. BMS inputs and outputs

General

- 6.1 The effectiveness of a BMS relies on the performance of the inputs and outputs. Sensors, detectors and associated meters should comply with relevant British Standards, and should also have a proven record of long-term precision and reliability.

Digital inputs

- 6.2 Digital inputs include plant status switches and inputs from other control, monitoring and alarm systems. The inputs should be compatible with the BMS outstation input interface.

Sensors

- 6.3 Many different sensors can be connected to a BMS. Suitable values of range and accuracy are shown in Table 1.

Table 1: Range and accuracy of sensors

Sensor	Range	Accuracy
Temperature		
Air	-10 to +40°C	± 0.5°C
Flue gas	+30 to +850°C	± 3.0°C (0.75% of FSD > 450°C)
Chilled water	-10 to +30°C	± 0.5°C
Water	-10 to +150°C	± 2.0°C
Humidity	10 to 90% RH	± 5% RH
Pressure	–	± 2%
Air flow	–	± 5%
Fuel flow	0 to 10Hz	± 3%
Water flow	> 5:1	± 2%
Electricity	–	± 1.5%
Light		
Internal	0 to 1000 lux	–
External daylight	1000 to 30,000 lux	–
External security	0 to 100 lux	–

Digital outputs

- 6.4 Digital outputs in BMS outstations are used to switch equipment on or off, usually via contactors.

Actuators

- 6.5 The analogue outputs of a BMS are often connected to actuators to convert the electrical signal to a physical movement. To achieve good control, the control device (for example valve or damper) must be correctly sized for its application. The actuator must be matched to the control device.

Valve actuators

- 6.6 Control valves should have authorities relevant to the required application: diverting and throttling, mixing or on/off, and they should be sized accordingly.

Damper actuators

- 6.7 Control dampers should be sized to give the required control authority; failure to do so may lead to a system being uncontrollable.
- 6.8 Actuators can incorporate position feedback devices. BMS use this feedback either to provide closed loop control of position or to give independent information on achieved positioning.

7. Software

Application software (outstation)

- 7.1 The control, monitoring and alarm functions of a BMS are undertaken via the application software within a BMS outstation. The application software is configured to provide the required control routines or algorithms.
- 7.2 The control routines are created by linking together separate control function “building blocks”. Larger outstations have more inputs and outputs and hence a greater number of each of the different “building blocks” used to write the control routines.
- 7.3 Outstations have the ability to store logged data for subsequent analysis. Outstations can be connected together to expand the number of control functions available for a particular application.

Management software (central station)

- 7.4 Operator access to a BMS is normally via the central station running management software. The software is normally “Windows” - based and has evolved to become much more user-friendly, with many graphical features.
- 7.5 The primary functions of the central station software are to allow the operator to view the operation of the plant and building under control, to alter the control settings and algorithms, and to provide manual override.
- 7.6 Software can include a package for handling mathematical formulae. These will include the full range of algebraic functions such as:
 - a. addition;
 - b. subtraction;
 - c. multiplication;
 - d. division;
 - e. powers and root extraction;
 - f. maximums, minimums and means;
 - g. calculation of enthalpy;
 - h. trigonometrical functions;
 - i. functions of Boolean algebra, that is, NOT, AND, NAND, NOR, XNOR, as well as relational operators.

Automatic operation

- 7.7 The central operator facility should automatically:
- a. monitor system status and report faults;
 - b. allow the execution of commands issued by an operator whose authority has been confirmed in accordance with security codes;
 - c. process and store data received;
 - d. annunciate alarms;
 - e. maintain a real-time clock and calendar;
 - f. operate an adjustable “time out” facility to log off the operator between 1 and 10 minutes after use of the facility ceases.

Operator actions

- 7.8 Suitably authorised operators should be able to undertake the following from the central station:
- a. acknowledge alarms;
 - b. add or delete points from the system;
 - c. inhibit alarms;
 - d. alter alarm level limits;
 - e. re-schedule plant operation times;
 - f. adjust and synchronise all real-time clocks on the BMS;
 - g. prepare a calendar for plant operation;
 - h. alter plant control parameters;
 - i. obtain and display data from the BMS on command or at selected time intervals;
 - j. set up trend logging facilities;
 - k. archive, condense and/or delete logged data;
 - l. interrogate system protocols.

- 7.9 The management software should have a clearly accessible help facility which is comprehensive for all routine operations.

Data handling

- 7.10 The central station software should be equipped for the on-line storage, retrieval, processing and display of logged data. The format of the data should be such that it can be exported into other software packages.

Alarm handling

7.11 Operator alarm handling facilities should include the following:

- a. alarm status should include a high priority level that is annunciated regardless of any other activity, and a low priority or information status that is only annunciated on demand;
- b. a visual, audible and printed annunciation of the alarm or any combination of these as selected by the operator;
- c. a requirement for all alarms to be acknowledged;
- d. a time programme for annunciation of alarms to different destinations;
- e. operator-supplied text message associated with alarm condition.

7.12 The alarm handling system should provide for:

- a. alarm processing and annunciation of priority alarms to take precedence over other activities;
- b. distinction between active alarms whose condition is not yet cleared and unacknowledged alarms;
- c. an alarm review facility;
- d. storage of alarm data in order that alarms can be analysed together with other data either by the BMS software or by other software;
- e. alarm data which should include:
 - (i) condition identity;
 - (ii) condition value;
 - (iii) alarm time and date;
 - (iv) acknowledgement status.

NOTE: Where alarms are sent to a printer, any printer malfunction should not inhibit the operation of the BMS.

Third-party management software

7.13 The computer which hosts the BMS central station management software should have the capacity to run third-party management software. This third-party software uses the data collected by the BMS sensors to provide additional management information.

7.14 Energy monitoring and targeting (M&T) and planned preventive maintenance (PPM) are the two major types of third-party program associated with the BMS central station.

7.15 Management packages that have the necessary protocols can communicate with the BMS and load data directly from the outstations. For packages

lacking the protocols the data has to be transferred within files created by the BMS. The former type of package operates faster and more efficiently because of its direct link with the BMS.

- 7.16 The compatibility of management packages and BMS should be examined carefully to ensure the optimum solution is provided. It also follows that there may be difficulties in transferring data between different packages. This implies that suitable interfaces may be required for third-party software.

NOTE: Details of the Works Information Management System (WIMS) interface is given in Model Engineering Specification (MES) C54 (Building management systems).

Energy monitoring and targeting software

- 7.17 Energy monitoring and targeting systems have been promoted as an effective means of achieving reductions in the annual energy cost. The software is usually spreadsheet-based, and actual energy consumption figures are recorded and compared with pre-defined targets.
- 7.18 The algorithms within the software can normalise the energy consumption data with respect to degree days, units of production or other figures. Energy consumption data, targets and savings can be displayed graphically using the M&T software.
- 7.19 Typically, M&T packages read energy meter data on a regular basis (from half-hourly to monthly), and possibly degree-day or temperature data from the BMS outstations.

Planned preventive maintenance software

- 7.20 Instead of scheduling plant maintenance on a fixed time basis, the work can be planned according to the total equipment hours run or number of starts made. Plant data on hours run and number of starts can be recorded by the BMS and accessed by a planned preventive maintenance package. The software will then issue works maintenance orders as and when required. Plant alarm messages sent to the PPM software can be used to produce breakdown maintenance requests.

8. Communications

Protocols

- 8.1 For a BMS to function effectively, data must be transferred around the system and in many cases, to and from other systems. To provide a means for the transfer of data, communication protocols are implemented. These protocols permit the physical connection, transfer and interpretation of data between various points in the system.
- 8.2 Major BMS companies implement different communication protocols, resulting in equipment from different companies being unable to communicate directly. This can result in several problems, including:
- a. a system provided by a single supplier may not include the most suitable features/functionality for specific applications;
 - b. the building owner may not receive best value for money by being tied to a single supplier;
 - c. the building owner is faced with separate user interfaces if autonomous systems are implemented.
- 8.3 At the sensor and actuator level, a number of control manufacturers are developing bus systems which allow a range of control devices to be connected to the same cabling circuit.

European standards on BMS communications

- 8.4 European standards to address the issue of communication protocols are initiated by the European Standardization Committee (CEN), technical committee (TC) 247, 'Control for Mechanical Building Services'. A working group (WG4) is responsible for 'System Neutral Data Transmission for HVAC Applications'.
- 8.5 WG4 attempted to select one standard protocol for each of the following "levels":
- a. central station to central station;
 - b. outstation to central station (and outstation to outstation);
 - c. sensors/actuators to outstation.
- 8.6 Due to the difficulties experienced in selecting a single protocol at each level, WG4 announced that it will select up to three protocols for each level. Further information should be sourced from the reference section of this SHTM.

Gateways

8.7 Gateways are used to transfer data between different systems. Essentially a gateway can be thought of as a “black box” which is placed between dissimilar systems to give a degree of interconnection and to enable a certain amount of interaction. Currently gateways present several potential problems, for example:

- a. high cost of engineering the gateway;
- b. loss of functionality;
- c. gateway maintenance;
- d. accommodation of protocol variations;
- e. contractual issues, that is, determining who has ultimate responsibility for the communications.

Modems

8.8 Modems are devices which allow the use of the telephone network for data transmission between remote devices and the BMS central station. These are particularly appropriate to remote or dispersed sites.

8.9 Modems should have auto-dialling facilities with safety features to prevent unnecessary use of the telephone network. Judicious choice of the telephone tariff structure/network circuit used for modem links can result in considerable reductions in operating costs.

NOTE: Modems can avoid the higher costs of using dedicated telephone lines.

9. Integration of BMS with other systems

Integrated systems

- 9.1 The control room of a modern building will often house the central processors and display units for a range of non-energy related systems as well as a BMS. To reduce the number of displays monitored by the operator, the separate systems can be integrated with the BMS, providing a central monitoring facility for a range of non-energy related systems, for example (this list is not exhaustive):
- a. fire detection systems;
 - b. security detection systems:
 - (i) intruder alarms;
 - (ii) access control systems;
 - (iii) closed-circuit television (CCTV);
 - (iv) watchman's rounds;
 - c. vertical transportation systems;
 - d. medical gas alarms;
 - e. blood banks;
 - f. fixed temperature storage;
 - g. telephone systems.
- 9.2 At present, BMS perform no control role when integrated with any of the above; the BMS merely acts as a single user interface, linking autonomous systems. There needs to be a clear technical break (isolation) between fire alarm/protection systems and the BMS to ensure the absolute integrity of the fire alarm systems. This level of integration is restricted at present due to current standards and the advice of fire prevention and building control officers. It is also essential that the BMS interface with "lifts" processors is restricted to monitoring only. Any possibility of the BMS influencing the lifts controls must be eliminated.
- 9.3 In principle, fire alarm systems can be integrated into the BMS; however, current regulations and codes of practice restrict this level of integration.
- 9.4 Integrated systems should comply with the relevant standards, codes of practice and guidance documents shown in the 'References' section.

Advantages of integration

9.5 Integrated systems have the following potential advantages:

- a. an integrated system may be easier to standardise and co-ordinate. For each installation, alarms and controls can be effectively prioritised;
- b. one central annunciator or group of annunciators may allow the adoption of a rational and coherent format for the presentation of information. The operation of the entire system can be monitored by one operator, and one recording medium used to log all the system events;
- c. one system for several functions will be easier to administrate by the user.

Limitations of integration

9.6 Integrated systems can have a number of limitations compared with separate systems, for example:

- a. each installation may have different requirements despite the priorities for the various alarms and other annunciators being readily co-ordinated and allocated. The site specific operation configuration should be carefully prepared;
- b. the alarm annunciations should be effectively prioritised to avoid an operator missing critical alarms while attending to other alarm signals;
- c. integrated systems are dependent on their software, which tends to be more complex. During the design phase, much more skill and care is therefore needed;
- d. there is the possibility of potentially adverse interactions between the different functions, which will require resolution during the design of the system;
- e. the dependence of an integrated system on a single piece of equipment or wiring common to several functions could make it vulnerable to faults;
- f. engineers involved in the installation, operation and maintenance of the system may require a higher level of training and skill, and an appreciation of the interactions between the system functions;
- g. the user of a multi-function integrated system will require a higher level of training.

Detailed design

- 9.7 The detailed design of an integrated system should give careful consideration to the following:
- a. definition of the specific objectives of the BMS;
 - b. how these objectives are to be achieved;
 - c. what information is required to support (a) and (b);
 - d. how this information is to be accessed, including:
 - (i) the display/output of information at all times and for all scenarios;
 - (ii) the required priority of alarms and information;
 - (iii) the delay, storage, annunciation and subsequent display of lower-priority alarms initially masked by high-priority alarms;
 - (iv) the likely consequences of all alarm and information scenarios.
- 9.8 Designers with expertise in each integrated system should be employed, and one organisation should be appointed with overall responsibility to co-ordinate the design.
- 9.9 Each integrated system should meet the relevant standards with respect to design, installation, commissioning and maintenance.
- 9.10 The power supply requirements of each integrated system should be considered separately, and stand-by power supplies specified when necessary.
- 9.11 The integrated system should be designed so that a fault in one system will not affect the other systems unless it affects common equipment.

Operations

- 9.12 Particular attention should be given to the maintenance of integrated systems. Specialists should only work on systems for which they have been trained. If maintenance of one system affects another, maintenance specialists for both systems should attend site together.
- 9.13 Special care should be taken when making modifications to any part of an integrated system to ensure that the changes do not affect other systems. When changes affect more than one system, engineers responsible for the other systems should be present for testing.

10. Projects

Feasibility studies

Purpose

- 10.1 BMS can be beneficial for large healthcare sites, buildings or complex plant to provide a high level of control and monitoring. It may be advantageous to replace existing control systems with a BMS. This can be demonstrated by feasibility studies.

NOTE: Stand-alone controls may be more appropriate for smaller buildings or buildings with simple plant. For a widely dispersed estate, the BMS may offer advantages.

Objectives

- 10.2 A feasibility study should include:
- a. review of control and monitoring requirements;
 - b. review of any existing BMS on site;
 - c. review of the condition of any existing controls;
 - d. required interface with existing controls;
 - e. review of need for energy monitoring, targeting and planned preventive maintenance third-party software;
 - f. estimate of energy savings;
 - g. estimate of manpower savings;
 - h. estimates of annual maintenance and support costs;
 - i. cost estimate of new BMS;
 - j. cost estimate of traditional control system;
 - k. cost estimate of manpower requirements;
 - l. cost estimates for future expansion;
 - m. estimates of payback periods.

Potential users of BMS

- 10.3 Potential applications of BMS (subject to the result of a feasibility study) include:
- a. large hospitals or healthcare premises;
 - b. highly serviced buildings, for example:
 - (i) laboratories;
 - (ii) operating theatre suites;
 - (iii) intensive care units;
 - c. widely dispersed estate.
- 10.4 On sites where there is an existing BMS, the system can be extended to cover major energy users to maximise the savings potential. These include:
- a. boilerhouse;
 - b. refrigeration;
 - c. combined heat and power;
 - d. sterile services departments;
 - e. incinerators;
 - f. laboratories;
 - g. wards and clinical areas;
 - h. offices;
 - i. staff accommodation;
 - j. catering departments;
 - k. laundries.

Client's brief

Pre-tender brief

- 10.5 The purpose of the pre-tender brief is to introduce potential suppliers to the project and to obtain from them an interest in tendering and, via a questionnaire, company information relevant to the undertaking of the work. This information should enable a shortlist of suitable tenderers to be produced, thereby avoiding abortive tendering.

NOTE: Where an extension to an existing BMS is being considered, a full pre-tender brief may not be appropriate.

- 10.6 The pre-tender exercise will produce qualitative judgements, whereas the tender reveals a quantitative result.

10.7 The pre-tender brief should contain the following:

- a. objective;
- b. project description;
- c. project management and form of contract;
- d. building and plant schedules;
- e. questionnaire.

Objective

10.8 The purpose of the pre-tender brief should be stated: to allow the tenderer to both register an interest in the work and quickly decide whether they wish to be considered.

Project description

10.9 The project description should contain the following four main elements:

- a. a general description of the building(s) to be controlled and monitored by the BMS, for example location, building types, use, floor areas and also layout plans of the sites;
- b. a general description of the building services systems and plant to be controlled and monitored, and any special requirements;
- c. an outline of the general BMS requirements, for example the location of the control facility, control facilities required at outstations, the extent of any user programming of control algorithms, likely future extensions of the BMS etc;
- d. special considerations such as required interfaces to other data networks, computers and software.

Building and plant schedules

10.10 The building and plant schedules should contain the minimum essential information on the building plant which is to be controlled/monitored by the BMS, such that the supplier or installer may appreciate the scale and complexity of the proposed BMS and the suitability of their equipment.

Questionnaire

10.11 A questionnaire should be used to obtain details about the company and approximate costs and timescales for the proposed system. A sample questionnaire is provided in Appendix 1.

Planning the project

Overview

- 10.12 The design of the BMS should be undertaken from the top down, starting with the corporate policy of the client or end-user as expressed in the design brief, and working towards a functional specification.
- 10.13 The BMS installation can be a stand-alone project in its own right. For major construction work, the BMS project should be an integral part of the building scheme and not considered in isolation.
- 10.14 The client should produce a design brief, including any particular requirements and restrictions on the cost or scope of the BMS, which is then developed in conjunction with the design consultant. The design consultant will produce a conceptual design for the project including an economic appraisal which will be agreed by the client and form the basis of the specification process.
- 10.15 A pre-tendering exercise is recommended to shortlist potential suppliers; this is discussed in Chapter 11.

Planning considerations

- 10.16 In new buildings the design of the BMS should be integrated with the design of the building services plant.
- 10.17 Consideration should be given to the availability of the BMS when commissioning other plant.
- 10.18 In the retrofit case, incorporation of existing control systems may be required in the design. Plant modifications may be necessary to accommodate this.
- 10.19 End-users (potential operators and building occupiers) should be involved in the project from the beginning. Potential operators with “local knowledge” can contribute to resolving problems and avoiding loose ends during commissioning and handover. The experience they gain is invaluable for the long-term maintenance and optimisation of the system.

Assembling the full specification

- 10.20 The full specification should describe the scope of the contract. It should state unambiguously what is to be done and the standards and performance to be achieved.
- 10.21 A full specification for contract documentation (as indicated in the Model Engineering Specifications (MES), inclusive of Scottish supplements) will usually contain:

Part A – Standard general conditions of contract with amendments, special conditions and preliminary clauses;

Part B – General clauses common to building services, plant and equipment;

Part C – Standard engineering specifications;

Part D – Detailed description of extent and nature of the works.

10.22 It is the designer's responsibility to provide part D of the specification. NHS Model Engineering Specification C54, 'Building management systems' is recommended for BMS projects. The specification should be complemented by drawings and schematics.

10.23 The description, extent and nature of works is contained in part D. This part of the specification will detail any amendments to the Model Engineering Specifications so as to customise the design. Any additional information/requirements should be provided to enable the full design intent of the project to be realised.

11. Tendering process

Pre-tendering process

- 11.1 The pre-tender brief can be used in assessing the suitability of potential suppliers or installers for the project.
- 11.2 The pre-tendering process enables a shortlist of suitable tenderers to be selected.

NOTE: Reference should be made to PROCODE for additional information.

Tender documentation

- 11.3 Typically, documents required for the tendering process are:
 - a. invitation to tender;
 - b. instructions to tenderers;
 - c. form of tender;
 - d. full specification;
 - e. drawings and schematics;
 - f. tender details and summary;
 - g. additional information required from tenderers.

Assessment of tenders

- 11.4 If all the tenderers meet all the requirements in the full specification, the preferred supplier may be decided on cost. Ambiguities in the specification and/or the form of tender can lead to difficulties in directly comparing tenders.
- 11.5 The options are to reject tenders which do not completely conform to or accept the tender as presented. Expert opinion may be required to assess the tenders with their discrepancies, with regard to whether they meet the functional specification for a successful and cost-effective project.

12. Collection and presentation of information

General

- 12.1 Using the top-down design approach, the conceptual design of the project leads on to functional statements and functional descriptions.
- 12.2 The sections in this chapter describe the format and presentation of project information required to define the project and eventually construct the specification.

Functional statements

- 12.3 These define how the BMS will operate in strategic terms, for example, "Optimum start will be applied to the heating system".
- 12.4 The level of detail employed in functional statements will vary according to the conceptual design and requirements of the buildings and plant. In general, functional statements will imply particular capabilities of the BMS.
- 12.5 Specific low-level requirements, such as the interaction between particular items of plant, are dealt with in the operational schedules.

NOTE: A sample functional statement is shown in Appendix 2.

Future expansion

- 12.6 The need for the system to accommodate future expansion should be fully defined.

Maintenance requirements

- 12.7 Initial maintenance is particularly important. Responsibility for this can be effectively focused by including the initial 12 months' maintenance in the supply contract. If maintenance is to be provided by the supplier/installer, it will be advantageous to detail the costs in the initial tenders.

NOTE: This approach should reduce the potential for disputes during the contract defect liability period.

Maintenance arrangements should commence at handover.

Schematics

- 12.8 One of the purposes of the specification is to allow the tenderer to understand fully the functional requirements of the project and its implications in terms of BMS equipment. The form of the schematics is usually some physical representation of a building services system or part of it.
- 12.9 Schematics communicate control and monitoring requirements, particularly the relative locations and correspondence of points, and can also be used as the basis for graphics for the eventual operator interface. A sample schematic is shown in Appendix 3.

The role of the schedules

- 12.10 The schedules provide the means to incorporate specific detailed requirements within the specification. They include the points schedule, which defines the physical scope of the BMS, and schedules for detailed operational requirements such as plant start-up sequences.

The points schedule

- 12.11 In the points schedule the requirement for a point is described in terms of its function. The parameters to be monitored or controlled are described, together with the operating range. A sample points schedule is shown in Appendix 4.

Operational schedules

- 12.12 The operational schedules describe the way in which the buildings and plant are to be controlled. They will determine the required BMS monitoring and control routines, its logical configuration and some of its physical characteristics.

12.13 Specific schedules may include the following areas:

- a. zoning;
- b. environmental parameters;
- c. alarm limits, priority and routing;
- d. initial time programmes;
- e. plant operating sequences;
- f. load shedding sequences;
- g. actions on start-up;
- h. actions on daily shut-down;
- i. actions on seasonal shut-down;
- j. actions on communications failure;
- k. actions on BMS failure;
- l. actions on total power failure.

12.14 These schedules may be subdivided for particular plant areas or zones as required. A sample operational schedule is shown in Appendix 5.

Equipment schedules

12.15 There will be the occasional requirement for a particular piece of equipment or capability (for example the number of operator facilities), and these should be detailed in the equipment schedules.

Report schedules

12.16 There may be a requirement for the BMS to produce reports containing very specific information, in addition to the manufacturer's standard reporting formats. This information should be detailed as a schedule or a prototype report.

Graphics schedules

12.17 The graphics schedules contain details of particular graphics to be provided, with reference to the schematics included in the specification as appropriate.

- 12.18 General features of the graphics such as the use of animation, real-time display of parameters, images and interactivity should be detailed as functional statements. However, there may be additional detailed operational requirements which should be presented within the graphics schedules. There may be a requirement for a flexible graphics user interface to meet the needs of different levels of staff use.

Drawings and documents

- 12.19 Particular requirements for drawings and documentation, numbers of copies, form of presentation etc. should be specified.
- 12.20 The information concerning the BMS installation to be supplied at handover should be identified. Details of this are given in the 'Validation and verification' part of this SHTM.

Training

- 12.21 The training requirements associated with the project should be identified. Details of this are given in the 'Operational management' part of this SHTM.

Commissioning

- 12.22 The commissioning requirements associated with the project should be identified. Details of this are given in the 'Validation and verification' part of this SHTM.

13. Designated staff functions

- 13.1 Only trained and competent persons should be appointed by management to operate and maintain the BMS.
- 13.2 **Management:** the owner, occupier, employer, general manager, chief executive or other person who is accountable for the premises and who is responsible for issuing or implementing a general policy statement under the HSW Act 1974.
- 13.3 **Employer:** any person or body who:
- a. employs one or more individuals under a contract of employment or apprenticeship;
 - b. provides training under the schemes to which the Health and Safety (Training for Employment) Regulations 1990 (SI No 1990/1380) apply.
- 13.4 **Designated person (electrical):** an individual who has overall authority and responsibility for the premises containing the electrical supply and distribution system and who has a duty under the HSW Act 1974 to prepare and issue a general policy statement on health and safety at work, including the organisation and arrangements for carrying out that policy. This person should not be the authorising engineer.
- 13.5 **Duty holder:** a person on whom the Electricity at Work Regulations 1989 impose a duty in connection with safety.
- 13.6 **Authorising engineer (low voltage):** a Chartered Engineer or Incorporated Electrical Engineer with appropriate experience and possessing the necessary degree of independence from local management who is appointed in writing by management to advise on and monitor the safety arrangements for the low-voltage electrical supply and distribution systems of that organisation to ensure compliance with the Electricity at Work Regulations 1989, and to assess the suitability and appointment of candidates in writing to be authorised persons (see SHTM 2020; *Electrical safety code for low voltage systems*).
- 13.7 **Authorised person (LV – electrical):** an individual possessing adequate technical knowledge and having received appropriate training, appointed in writing by the authorising engineer (LV) to be responsible for the practical implementation and operation of management's safety policy and procedures on defined electrical systems (see SHTM 2020).

- 13.8 **Competent person (LV – electrical):** an individual who in the opinion of an authorised person has sufficient technical knowledge and experience to prevent danger while carrying out work on defined electrical systems (see SHTM 2020).
- 13.9 **Commissioning specialist (BMS):** an individual or organisation authorised to carry out commissioning, validation and routine testing of BMS.
- 13.10 **Maintenance person (BMS):** a member of the maintenance staff, BMS manufacturer or maintenance organisation employed by management to carry out maintenance duties on BMS.
- 13.11 **BMS operator:** any authorised individual who operates a BMS.

14. Definitions

Actuator: an electromechanical device that positions control devices (such as valves or dampers) in relation to a supplied control signal.

Alarm: the annunciation of an event that the system operator needs to be aware of.

Analogue: pertaining to data that consists of continuously variable quantities.

BAS – building automation system: synonymous with BMS.

BEMS – building and energy management system: synonymous with BMS.

BMS – building management system: a system comprising electronic equipment and software with the prime function of controlling and monitoring the operation of building services within a building, including heating, air-conditioning, lighting, and other energy-using areas.

BMS contractor: the organisation responsible for the supply and/or installation of the BMS. The contractor may be either the manufacturer or a systems house. It is often the case that the BMS contractor will commission the BMS.

Bus: a means of connecting a number of different devices, sensors, controllers, outstations, etc. to act as a means of data exchange.

Central station: the primary point of access to a BMS; the usual point from which all operations are supervised.

Client: the individual or group of individuals ultimately responsible for paying for and using the BMS.

Commissioning: the advancement of an installed system to working order to specified requirements.

Commissioning specialist: the individual responsible for the commissioning of the BMS. He/she may be employed by the BMS contractor or a specialist commissioning company.

Communications network: a system of linking together outstations and a central station to enable the exchange of data. Usually a dedicated cable system, but radio or mains-borne signalling may be used.

Compensator: a control device whose control function is to either:

- a. reduce heat supply with decreasing building heat load; or
- b. reduce cooling energy supply with decreasing building cooling load, in response to outside and (sometimes) inside temperatures.

Completion: the state of being finished in its entirety, according to the specification, ready for use by the owner.

Configuration software: software (in the form of “building blocks”) resident in an outstation which can be configured to create different control strategies.

Control function: a term used to describe a specific, discrete form of control, for example compensation, optimisation etc. These can be linked together in a control strategy.

Control loop: proportional, or proportional + integral, or proportional + integral + derivative control strategy where the output is related to a function of the input signal.

Control strategy: a description of the engineered scheme to control a particular item of plant or perform a series of control functions.

Data: a representation of information or instruction in a formalised manner suitable for communication, interpretation, or processing by humans or computer.

Derivative control: a control algorithm in which the control output signal is proportional to the rate of change of the controlled variable.

Direct digital control (DDC): a term used to define products that are based on microprocessor control.

Distributed intelligence: a description of a system where data processing and control is carried out at outstations, not at a central point.

Duty cycling: a control function that rotates the use of items of plant so that each item undergoes equal usage.

EMS – energy management system: synonymous with BMS.

Field device: the controls that are placed in the field level, that is, switches, sensors, actuators, etc.

Gateway: software written to enable data to be exchanged between two different communications protocols.

Handover: the transfer of ownership of all or part of a building or system, usually to the client.

Integral control: a control algorithm in which the output signal is proportional to the integral of the error.

Load cycling: a control method where management of plant energy demand is achieved by means of fixed on/off periods of operation.

Load shedding: the function of switching off electrical equipment if the load exceeds a limit. This function therefore reduces the risk of maximum demand penalty charges.

Optimiser: a control device whose function is to vary the daily on and off times of heating, ventilation and air-conditioning (HVAC) plant in order to produce an acceptable environment with lowest energy usage.

Outstation: a device to which sensors and actuators are connected, capable of controlling and monitoring building services functions. It also has the facility to exchange information throughout the BMS network.

Performance tests: tests carried out to demonstrate that the system functions according to specification.

Point: a physical source or destination for data in the form of analogue or digital signals.

Pre-commissioning checks: systematic checking of a completed installation to establish its suitability for commissioning.

Proportional control: a control algorithm in which the output signal is proportional to the error in the controlled variable.

Proportional and integral control: a control algorithm in which the output signal is proportional to the error plus the integral of the error in the controlled variable.

Proportional and integral and derivative control: a control algorithm in which the output signal is proportional to the error plus the integral of the error and the rate of change of the controlled variable.

Protocol: a set of rules governing information flow in a communication system.

Sensor: a hardware device which measures, and provides to a control strategy, a value representing a physical quantity (for example temperature, pressure etc); or activates a switch to indicate that a preset value has been reached.

Soft point: a point that can be referenced as if it were a monitoring or control point in a BMS, although it has no associated physical location. It may have a set value or be the result of a given calculation or algorithm.

Stand-alone control: during normal operation, an item of equipment which can operate normally when isolated from the remainder of the system.

Testing: the evaluation of the performance of a commissioned installation tested against the specification.

Witnessing: the observation (by the client or his/her representative) of tests and checks of BMS hardware and operation prior to completion.

ARCHIVED (Apr 2012)

References

NOTE:

Where there is a requirement to address a listed reference, care should be taken to ensure that all amendments following the date of issue are included.

Publication ID	Title	Publisher	Date	Notes
Acts and Regulations				
SI 2179 & 187	The Building (Scotland) Act	HMSO	1959	
	Clean Air Act	HMSO	1993	
	Electricity Act	HMSO	1989	
	Health and Safety at Work etc Act	HMSO	1974	
	Registered Establishments (Scotland) Act	HMSO	1998	
	The Water (Scotland) Act	HMSO	1980	
	The Building Standards (Scotland) Regulations (as amended)	HMSO	1990	
SI 2092	The Building Standards (Scotland) Regulations: Technical Standards Guidance	HMSO	1998	
	Carriage of Dangerous Goods (Classification, Packaging & Labelling) and Use of Transportable Pressure Receptacles Regulations	HMSO	1996	
SI 1460	Chemicals (Hazard Information and Packaging for Supply) Regulations (CHIP2)	HMSO	1997	
SI 3140	Construction (Design and Management) Regulations	HMSO	1994	
SI 437	Control of Substances Hazardous to Health Regulations (COSHH)	HMSO	1999	
SI 635	Electricity at Work Regulations	HMSO	1989	
SI 1057	Electricity Supply Regulations (as amended)	HMSO	1988 (amd 1994)	
SI 2372	Electromagnetic Compatibility Regulations (as amended)	HMSO	1992	
SI 2451	Gas Safety (Installation and Use) Regulations	HMSO	1998	
SI 917	Health & Safety (First Aid) Regulations	HMSO	1981	
SI 682	Health & Safety (Information for Employees) Regulations	HMSO	1989	

Publication ID	Title	Publisher	Date	Notes
SI 2792	Health and Safety (Display Screen Equipment) Regulations	HMSO	1992	
SI 341	Health and Safety (Safety Signs and Signals) Regulations	HMSO	1996	
SI 1380	Health and Safety (Training for Employment) Regulations	HMSO	1990	
SI 2307	Lifting Operations and Lifting Equipment Regulations (LOLER)	HMSO	1998	
SI 3242	Management of Health and Safety at Work Regulations	HMSO	1999	
SI 2793	Manual Handling Operations Regulations	HMSO	1992	
SI 1790	Noise at Work Regulations	HMSO	1989	
SI 3139	Personal Protective Equipment (EC Directive) Regulations (as amended)	HMSO	1992	
SI 2966	Personal Protective Equipment at Work (PPE) Regulations	HMSO	1992	
SI 128	Pressure Systems Safety Regulations (PSSR)	HMSO	2000	
SI 2306	Provision and Use of Work Equipment Regulations (PUWER)	HMSO	1998	
SI 3163	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR)	HMSO	1995	
SI 3004	Workplace (Health, Safety and Welfare) Regulations	HMSO	1992	
British Standards				
BS 4737	Intruder alarm systems	BSI Standards		
BS 5445	Components of automatic fire detection systems	BSI Standards		
BS 6238	Code of practice for performance monitoring of computer-based systems	BSI Standards	1982	
BS 7671	Requirements for electrical installations. IEE wiring regulations	BSI Standards	1992	16 th edition
BS 7807	Code of practice for design, installation and servicing of integrated systems incorporating detection and alarm systems and/or security systems for buildings other than dwellings	BSI Standards	1995	
BS EN 55011	Specification for limits and methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment	BSI Standards	1998	

Publication ID	Title	Publisher	Date	Notes
BS EN 55014-1	Electromagnetic compatibility. Requirements for household appliances, electric tools and similar apparatus. Emission. Product family standard	BSI Standards	1997	
BS EN 55014-2	Electromagnetic compatibility. Requirements for household appliances, electric tools and similar apparatus. Immunity. Product family standard	BSI Standards	1997	
BS EN 55015	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment	BSI Standards	1996	
BS EN 50065-1	Specification for signalling on low-voltage electrical installations in the frequency range 3 kHz to 148.5 kHz. General requirements, frequency bands and electromagnetic disturbances.	BSI Standards	1992	
BS EN 60529	Specification for degrees of protection provided by enclosures (IP code)	BSI Standards	1992	
BS EN ISO 9000	Quality management and quality assurance standards	BSI Standards		
Scottish Health Technical Guidance				
SHTM 2007	Electrical services: supply and distribution	P&EFEx	2001	
SHTM 2011	Emergency electrical services	P&EFEx	2001	
SHTM 2014	Abatement of electrical interference	P&EFEx	2001	
SHTM 2015	Bedhead Services	P&EFEx	2001	
SHTM 2020	Electrical safety code for low voltage systems (Escode – LV)	P&EFEx	2001	
SHTM 2024	Lifts	P&EFEx	2001	
SHTM 2025	Ventilation in healthcare premises	P&EFEx	2001	
SHTM 2035	Mains Signalling	P&EFEx	2001	
SHPN 1	Health service building in Scotland	HMSO	1991	
SHPN 2	Hospital briefing and operational policy	HMSO	1993	
SHPN 48	Telecommunications	HMSO	1997	
SHTN 1	Post commissioning documentation for health buildings in Scotland	HMSO	1993	
SHTN 4	General Purposes Estates and Functions Model Safety Permit-to-Work Systems	P&EFEx	1997	
	NHS in Scotland – PROCODE	P&EFEx	2001	Version 1.1

Publication ID	Title	Publisher	Date	Notes
NHS in Scotland Fire Safety Management				
SHTM 81	Fire precautions in new hospitals	P&EEx	1999	CD-ROM
SHTM 82	Alarm and detection systems	P&EEx	1999	CD-ROM
SHTM 83	Fire safety in healthcare premises	P&EEx	1999	CD-ROM
SHTM 84	Fire safety in NHS residential care properties	P&EEx	1999	CD-ROM
SHTM 85	Fire precautions in existing hospitals	P&EEx	1999	CD-ROM
SHTM 86	Fire risk assessment in hospitals	P&EEx	1999	CD-ROM
SHTM 87	Textiles and furniture	P&EEx	1999	CD-ROM
SFPN 3	Escape bed lifts	P&EEx	1999	CD-ROM
SFPN 4	Hospital main kitchens	P&EEx	1999	CD-ROM
SFPN 5	Commercial enterprises on hospital premises	P&EEx	1999	CD-ROM
SFPN 6	Arson prevention and control in NHS healthcare premises	P&EEx	1999	CD-ROM
SFPN 7	Fire precautions in patient hotels	P&EEx	1999	CD-ROM
SFPN 10	Laboratories on hospital premises	P&EEx	1999	CD-ROM
UK Health Technical Guidance				
EH 40	HSE Occupational Exposure limits	HSE	Annual	As required
MES	Model Engineering Specifications	NHS Estates	1997	
C54	Model Engineering Specification – Building Management Systems	NHS Estates	1997	
HTM 2050	Risk management in the NHS estate	HMSO	1999	Use with caution – See SHPN 48
HTM 2055	Telecommunications (Telephone exchanges)	HMSO	1994	
	HSE programmable electronic systems in safety related applications	HSE	1987	
Miscellaneous				
PM5	HSE Guidance Note; Automatically controlled steam and hot water boilers	HSE		
	HSE programmable electronic systems in safety related applications	HSE	1987	
	CIBSE commissioning codes: Series C: Automatic control systems	CIBSE	1973	

Publication ID	Title	Publisher	Date	Notes
GVA	CIBSE guides: Volume A: Environmental Design	CIBSE	1999	5 th edition
GVBS	Volume B: Installation and equipment data		1986	
GVC	Volume C: Reference data		1986	
AM1	Automatic controls and their implications for systems design (Application manual)		1985	5 th edition
GVH	CIBSE Guide GVH: Building control systems	CIBSE	2000	
BAH01/01	Applications handbook volume 1: Guide to BEMS centre standard specification	BSRIA	1990	
BAH01/02	Applications handbook volume 2: Standard specification for BEMS version 3.1	BSRIA	1990	
AH2/92	Commissioning of BEMS: a code of practice	BSRIA	1992	
AG2/94	BEMS performance testing	BSRIA	1992	
SMG 90c	Standard maintenance specification for mechanical services in buildings. Vol. III: control, energy and building management systems.	HVCA	1992	
9/5/97	Electromagnetic compatibility of medical devices with mobile communications	EEF	1997	

Appendix 1: Questionnaire for prospective tenderer

1. Company details.
2. Project management details.
3. Company history and organisation.
4. Financial history.
5. Technical history.
6. Order book status.
7. Project planning system in use.
8. Applications to trade and research organisations.
9. Supply and/or installation services offered.
10. Software, operational and maintenance support.
11. Quality control procedures.
12. Specific standards employed in design, manufacture and installation of equipment.
13. Details of installations completed.
14. Outline details of equipment suggested for the proposed project.
15. Budget cost of the system (hardware, cabling, installation and commissioning).
16. Provisional installation programme and completion dates.
17. Details and costs of standard maintenance arrangements.
18. Guarantees on equipment, system performance, savings etc.
19. Compatibility with other BMS suppliers' equipment.
20. Expansion potential of the system.
21. General comments.

Appendix 2: Sample functional statements

Sample only

Functional statements describe the overall control strategy to be adopted. They are arranged in logical order by building or services system, individually numbered, and cross-referenced to drawings and other relevant documentation. Detailed parameters such as times and temperatures should be listed in the Operational Schedules.

There should be three groups of selected plant and circuits available for electrical load shedding as described in the Operational Schedules.

Heating, cooling and ventilating systems should be operated under time programme control including the use of optimum start/stop control and free cooling.

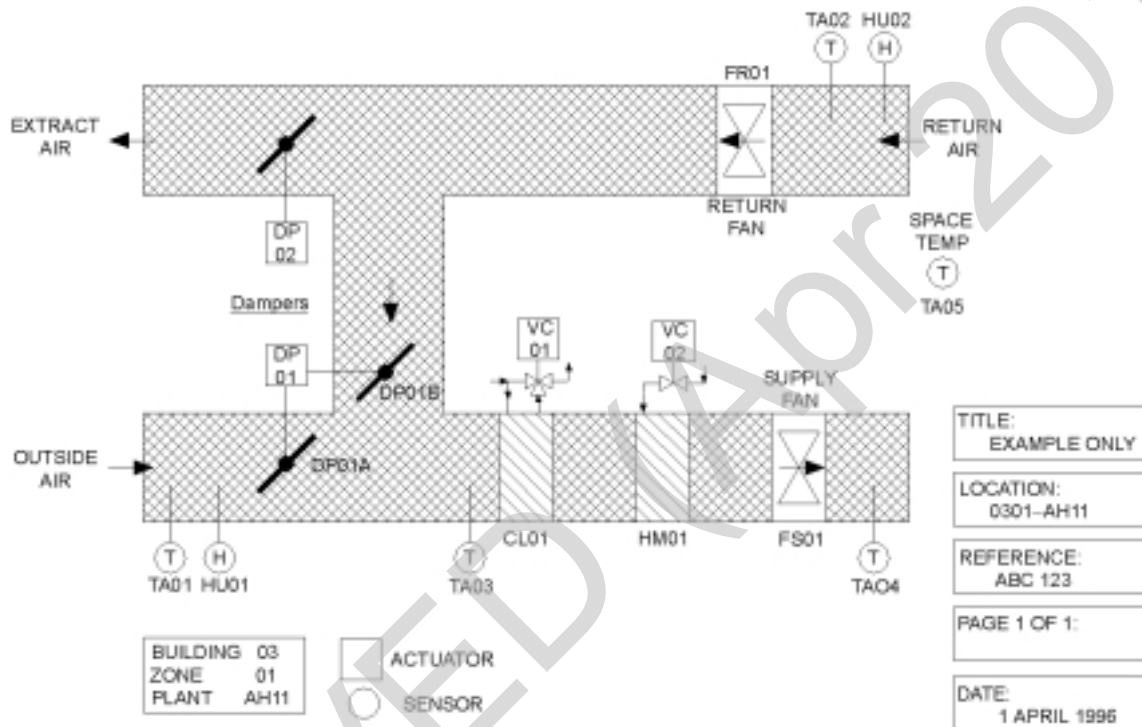
Main boilers should be loaded in sequence to maximise efficiency and equalise operating periods for each boiler.

The BMS should interface with packaged chiller plant in Plant Room C to provide supervisory monitoring and control.

Lighting in corridors and open-plan offices should be operated under timed and illumination level control.

The BMS should be capable of initiating paging of the duty engineer for out-of-hours priority alarms.

Appendix 3: Sample schematic diagram



Appendix 4: Sample points schedule

Page 1 of 1 Contract No. 123456 Date 1 April 1996
Building 03 Ref SCHEMATICS ABS 123
Zone 01 Ref DRAWINGS LP-0301 MCC-AH11 PD-AH11
Plant AH11 Ref SCHEDULES CS-AH11

Reference	Point name	Type	Parameter range	Ref docs	Comment
TA01	Outside air temp	Input	Air temp Std	LP0301	See location plan
TA02	AH11 Return air temp	Input	Air temp Std		
TA03	AH11 Mixed air temp	Input	Air temp Std		
TA04	AH11 Supply air temp	Input	Air temp Std		
TA05	Zone 1 Space temp	Input	Air temp Std		
HU01	Outside air humidity	Input	Humid Std		
HU02	AH11 Return air humidity	Input	Humid Std		
FR01L	AH11 Return fan low speed	Output	Relay On/Off	MCC-AH11	
FR01H	AH11 Return fan high speed	Output	Relay On/Off	MCC-AH11	
FR01A	AH11 Return fan tripped	Input	Status On/Off	MCC-AH11	
FS01R	AH11 Supply fan run	Output	Relay On/Off	MCC-AH11	
FS01A	AH11 Supply fan tripped	Input	Status On/Off	MCC-AH11	
FS01I	AH11 Access door interlock	Input	Status On/Off		Contacts available
DP01	AH11 Fresh air damper	Output	Actuator	PD-AH11	
DP02	AH11 Extract damper	Output	Actuator	PD-AH11	
VC01	AH11 Cooling coil valve	Output	Actuator 1/4 turn	PD-AH11	Supply actuator
VS01	AH11 Humidifier steam valve	Output	Actuator 1/4 turn	PD-AH11	Supply actuator

Appendix 5: Sample operational schedule

Operational schedules describe the detailed control strategy, and relationships between plant items and control parameters. They are arranged in logical order by building, zone or services systems, individually numbered, and cross-referenced to drawings schematics, schedules and other relevant documentation.

Plantroom B – example only

Chiller plant will operate under timed control.

At designated “on” time, switch on chilled water pumps via a signal to MCC4.

After delay of 5 minutes and confirmation of chilled water flow from FS04, switch chiller to “RUN” via contact on chiller control panel. Control chilled water temperature flow temperature at 6°C.

Set chilled water high temperature alarm to 10°C but mask alarm during initial operation.

Inhibit chiller operation when:

- outside air temperature less than 12°C;
- no air handling units running (AH6-10).

Alarm when:

- no chilled water flow;
- fault indication on chiller control panel;
- chilled water temperature high.

Include chiller in Group 2 load shedding.