BEMS Performance Specification

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Building Energy Management System overview

A building energy management system (BEMS), may also be known as Building Automation System (BAS), Building Management System (BMS) or other similar terms.

A BEMS may consist of a number of intelligent controllers located in control panels or equipment with factory fitted intelligent controls integrated to form an intelligent system. This system will control the heating, cooling and ventilation systems. Metering solutions may be integrated using communication protocols or by hard-wired connections.

Other third party devices should be connected to the BEMS using BACnet or other common protocols.

An appropriate user interface shall be incorporated so as to allow user interrogation, adjustment and display of system settings and conditions.

All peripheral devices shall be supplied by a reputable controls manufacturer and these will include sensors, OEM Manufactured equipment, valves, control actuators and variable speed drives.

The BEMS shall be supplied, configured and commissioned by a specialist controls company who are members of the Building Controls Industry Association. Membership of the BCIA means they have ready access to the latest standards, technology advancements and training.

It is recommended that the client's users be properly trained in the operation and use of the BEMS. A range of courses are available from the BCIA and the installer should offer suitable training of the user at hand-over upon project completion.

Most BEMS manufacturer's equipment today offers cloud based technologies that allow additional services to be provided such as Energy Analysis, Asset Management, Remote Fault Diagnosis, and Predictive Maintenance, etc.

Controls Overview & Operation

The controls system and BEMS shall be designed and installed to comply with the standards of EN15232. The EuBac System Certification can be used to prove compliance with the minimum requirements of this standard but systems awarded EuBac Class A Certification are proven to combine optimum occupant comfort and energy efficiency.

The BEMS system should be designed to operate the plant to ensure the most energy efficient operation of the connected building services whilst maintaining occupant comfort. The most energy efficient systems utilise demand control techniques to ensure services are only deployed when needed.

There are many studies that have proven maximum occupier comfort and productivity is best achieved if due consideration is given to human wellbeing during the design. The international Well Building Institute provides excellent guidelines on this topic.

Dependent upon the operational mode required and selected by the user, adjustable time zones which will run the required plant automatically in accordance with predetermined time schedules. Additionally or alternately, some operational modes will operate plant automatically (such as demand based control) to provide functions for the building & plant.

Frost/building fabric protection

Typically, multiple stages of frost protection will be employed and should always active outside of the occupied period or plant running condition. Examples could include:

1st Stage – outside frost protection

When the outside temperature is less than 2°C all pumps will be enabled and control valves will be opened. When the outside temperature is greater than 3°C the pumps will stop and the valves will close.

2nd Stage – plant protection

When the 1st stage frost protection is in operation and the LPHW return temperature is less than 25°C the lead boiler will fire until the return temperature is greater than 60°C. The boiler will continue to cycle until the 1st stage frost protection is not in operation.

3rd Stage – internal frost protection

When the average internal space temperature falls below 10°C out of occupancy the system moves into internal frost protection mode and activates an operational state until all the internal space temperature are above 12°C.

NOTE: All the safety interlocks above are hardwired and operate in all modes of control.

Plant exercise

Pumps

When any of the pumps are not in use they will be exercised for a minimum period of five minutes every 7 days to ensure plant operation and to prevent the build-up of contaminants.

Valves

When any automatic control valves are not in use they will be driven fully open (100%) for a minimum period of five minutes once a week (midnight, for example) to protect against seizure.

Summer/winter modes

Changeover

A summer/winter changeover state may be configured within the system to govern the economic use of the heating, cooling and ventilation systems to suit the prevailing seasons. This is intended to reduce unnecessary simultaneous operation of the heating and cooling systems when the outside air temperature is above a predetermined value.

Boilers

Conventional boiler system

Conventional boilers

When enabled the boilers will be modulated and sequenced by the BEMS to achieve a LPHW flow temperature of 80°C (user adjustable). The conventional boilers are enabled to assist the biomass boilers if they cannot meet the required LPHW demand. The boilers are duty rotated weekly, based on the hours run.

Each boiler is fitted with a 2-port back-end isolation valve.

When enabled the relevant back-end valve will be opened. When the back-end valve is confirmed as open (end switch) and primary pump flow has been proved the boiler will be allowed to operate.

The LPHW flow and return temperatures to the low loss header are monitored by the BEMS.

Conventional boilers primary pumps

When a boiler is required to operate the duty boiler primary pump will be enabled.

The duty boiler primary pump will change over on a weekly basis. The change will be made at midnight every Sunday or when a BEMS software switch is activated.

The BEMS will monitor the duty boiler's primary pump operation. This may be done with for example an undercurrent relay or flow switch etc. If low flow is experienced while the pump is enabled a flow failure will be indicated and, after a short time delay, the pump duty will change over. The system will automatically reset to the duty pump every 24 hours or when a software switch on the BEMS is operated.

Biomass boiler system

Biomass boilers

When enabled the biomass boilers will be modulated and sequenced by the BEMS to achieve a LPHW flow temperature of 80°C (user adjustable). The boilers are duty rotated weekly if two or more boilers are installed, based on the hours run.

Each biomass boiler is fitted with a 3-port valve, biomass screw feed and duty and standby shunt pumps. A LPHW isolation valve is provided between the biomass boilers and the low loss header.

During initial start-up, the 3-port valve will circulate the LPHW around the biomass boiler until the flow temperature reaches 60°C. When this temperature has been achieved the 3-port valve and LPHW isolation valve will open, allowing the LPHW to circulate to the low loss header.

During a shut-down, the buffer isolation valve will close and the running biomass boiler(s) will be disabled. The relevant shunt pumps will then run on to dissipate any residual heat. Once the run on period has elapsed the duty shunt pump will stop and. the 3-port valve will close.

The biomass boiler fuel screw feeds are monitored for a running condition. The running signal is used to give an indication of screw feed hours run and biomass fuel usage.

The LPHW flow temperatures of the biomass boilers are monitored by the BEMS.

The biomass LPHW low loss header flow and return temperatures are monitored by the BEMS.

Biomass boiler shunt pumps

When a biomass boiler is required to run the associated duty shunt pump will be enabled.

The duty shunt pump will change over on a weekly basis. The change will be made at midnight each Sunday or when a BEMS software switch is activated.

The BEMS will monitor the boiler's shunt pump operation. This may be done with for example an undercurrent relay or flow switch etc. If low flow is detected while the pump is enabled a flow failure will be indicated and, after a short time delay, the pump duty will change over. The system will automatically reset to the duty pump every 24 hours or when a software switch on the BEMS is operated.

Boiler control

The lead boiler must be selected via the BEMS to provide the optimum energy performance.

Combined Heat and Power (CHP) operation

When enabled the CHP will be controlled via the BEMS to achieve a LPHW flow temperature of 80°C (user adjustable) and only if there is sufficient electrical power requirements in the building.

CHP boiler shunt pumps

When a CHP is required to operate the associated duty shunt pump will be enabled.

The duty shunt pump will change over on a weekly basis. The change will be made at midnight each Sunday or when a BEMS software switch is activated.

The BEMS will monitor the duty boiler's shunt pump operation. This may be done with for example an undercurrent relay or flow switch etc. If low flow is detected while the pump is enabled a flow failure will be indicated, and after a short time delay, the pump duty will change over. The system will automatically reset to the duty pump every 24 hours or when a software switch on the BEMS is operated. The status Information from the CHP should be monitored by the BEMS. This can be done with hardwired status signals or via a standard industry protocol e.g. Modbus or BACnet.

System control

The system control is to be finalised by a third party specified under the contract.

LPHW primary pump

The duty LPHW primary pump will change over on a weekly basis. The change will be made at midnight each Sunday or when a BEMS software switch is activated.

The BEMS will monitor the LPHW primary pump operation. This may be done with for example an undercurrent relay or flow switch etc. If low flow is detected while the pump is enabled a flow failure will be indicated and, after a short time delay, the pump duty will change over. The system will automatically reset to the duty pump every 24 hours or when a software switch on the BEMS is operated.

The pump motor speed is controlled to maintain a constant flow pressure in the LPHW heating circuit.

The LPHW flow and return temperature sensors are monitored by the BEMS.

The LPHW primary flow pressure sensor is monitored by the BEMS.

LPHW pressurisation unit

The pressurisation unit will be permanently powered from the control panel. The pressurisation unit runs under its own controls.

The status of the pressurisation unit will be indicated on the panel fascia and monitored by the BEMS.

Ventilation and air handling units

Start-up and operation

AHU

The AHU will provide tempered fresh air to the Building. The AHU will operate when the specific time zone is in occupancy.

When the AHU is called to operate the inlet damper will open. When the damper is confirmed as 90% open (by its end switch) then the supply fan will be energised. When airflow is proved for the supply fan then the extract damper will open. When the damper is confirmed as 90% open (by its end switch) the duty extract fan will be energised.

Undercurrent detectors or other flow proving devices monitors the supply and extract fans for airflow and an alarm condition will be raised on the BEMS if a flow failure occurs.

The supply and extract fans are fitted with Inverter variable speed drives. The fan speed is controlled to provide a constant pressure in the supply and extract ducts.

When the AHU is no longer required the fans will stop and all associated dampers will close.

The fans are interlocked with the fire system and will be disabled when the fire system is activated.

Access for maintenance shall be properly cater for within the design and installation.

Inverters and control equipment are not to be mounted on the roof but preferably located inside the building within allocated areas (not store cupboards, teaching space or cleaner's cupboards). If internal mounting cannot be achieved, suitable environmental protection shall be provided.

Temperature control

The frost battery control valve will modulate to give a constant 4°C off-coil temperature. The temperature after the frost battery will be monitored by a frost thermostat and will shut down the supply and extract fans and close the air inlet dampers if the temperature falls below 2°C. If the frost thermostat is activated an alarm will be raised on the BEMS. The frost battery control valve will modulate to the fully open position and the thermostat will reset itself when the temperature rises to a safe level.

The heating coil battery will be controlled to provide a constant supply air temperature of 20°C (user adjustable).

The thermal wheel is used to give free cooling and heating. If the air-handling unit is in a heating mode and the return air temperature is higher than the outside air temperature, the thermal wheel will use the return air to heat the supply air.

If the air-handling unit is in a cooling mode and the return air temperature is lower than the outside air temperature, the thermal wheel will utilise the return air to cool the supply air.

The frost, cooling coil, supply and extract air temperatures are logged by the BEMS.

Dirty filter monitoring

Differential pressure switches will monitor the panel, bag and extract filters. In the event of a high differential pressure being detected across the filter bank, the filter dirty lamp will be illuminated on the control panel facia and an alarm condition shown on the BEMS.

Fireman's switch

The AHU is provided with a 3-position fireman's switch. This can be utilised to run the extract fan during a fire alarm active situation to assist with smoke clearance. The operation of the switch is listed below:

- Auto – AHU runs under normal BEMS control
- Off – Supply and extract fans prevented from operation

- Manual – extract fan will operate.

Inverter control

All AHU fans shall be fitted with Inverters variable speed drive complete with communications cards to enable the monitoring of energy use and the following running conditions:

- Auto
- Run/off
- Hz control
- Kwhr.

Toilet ventilation

The building toilet ventilation will be enabled whenever the specific time zone is in occupancy.

The duty fan will change over on a weekly basis. The change will be made at midnight each Sunday or when a BEMS software switch is activated.

The BEMS will monitor the duty extract fan's operation. This may be done with for example an undercurrent relay or flow switch etc. If low flow is detected while the fan is enabled a flow failure will be indicated and, after a short time delay, the fan duty will change over. The system will automatically reset to the duty fan every 24 hours or when a software switch on the BEMS is operated.

Domestic Hot Water Supply system

DHWS

The DHWS circuit will be enabled when the specific time zone is in occupancy.

The DHWS secondary pump will run 24 hours a day, 7 days a week. An undercurrent relay will monitor the pump. If low current is experienced while the pump is running flow failure will be indicated on the BEMS.

The DHWS 3-port is modulated to control the DHWS flow temperature to 60°C (initially set).

The DHWS temperature is monitored for a high-limit condition (>65°C). Should a high-limit condition occur then the 3-port valve will be closed. The secondary pump will continue to run to dissipate heat. When activated the high-limit will require a manual reset to re-enable the DHWS system.

The DHWS flow and return temperature is monitored by the BEMS.

Operation of the de-stratification pump must comply with ACOPS L8 recommendations.

Direct fired HWS system

The DHWS circuit will be enabled when the specific time zone is in occupancy.

The DHWS secondary pump will run 24/7. An undercurrent relay will monitor the pump. If low current is experienced while the pump is running, flow failure will be indicated on the BEMS.

The DHWS Heater is modulated to control the DHWS flow temperature to 60°C (initially set).

The DHWS temperature is monitored for a high-limit condition (>65°C).

Once the high-limit condition is activated, the system must be reset manually to re-enable the DHWS system. The DHWS flow and return temperature is monitored by the BEMS.

Air conditioning units

Air Conditioning Units are usually supplied with their own internal, factory-fitted control system and shall be integrated to the 'house' BEMS. A/C Units will be connected and interfaced such that enable signals and fault alarms will be generated on the BEMS via a Modbus or other common communications protocol interface.

The BEMS will provide enable signals to the A/C unit with consideration to relevant time schedules, maximum demand energy control and to avoid conflict with any competing services (i.e. avoid simultaneous heating and cooling).

IT server room

The server room ventilation will be enabled 24 hours a day, 7 days a week. The A/C Units will be monitored and fault alarms generated on the BEMS via a Modbus or other common communications protocol interface.

IT Server room high temperature sensor will generate an alarm on the BEMS.

Chilled Water System (CHW)

CHW system will be enabled whenever there is a demand for CHW. The status information from the Chiller will be via a Modbus or other common communications protocol interface.

Chillers

When enabled the chillers will be operate and be sequenced via the BEMS.

The chillers will operate via their own integral controls. The chillers are duty rotated weekly based on the hours run.

When a chiller is required to run the duty chiller shunt pump will be enabled. The duty chiller shunt pump will change over on a weekly basis. The change will be made at midnight each Sunday or when a BEMS software switch is activated.

The BEMS will monitor the duty chiller shunt pump operation. This may be done with for example an undercurrent relay or flow switch etc. If low flow is detected while the pump is enabled a flow failure will be indicated and, after a short time delay, the pump duty will change over. The system will automatically reset to the duty pump every 24 hours or when a software switch on the BEMS is operated.

The CHW flow and return temperature sensors are monitored by the BEMS.

The CHW low loss header temperature sensors are monitored by the BEMS.

Chilled water pumps

The duty CHW system primary pump will change over on a weekly basis. The change will be made at midnight each Sunday or when a BEMS software switch is activated.

The BEMS will monitor the duty CHW system pump's operation. This may be done with for example an undercurrent relay or flow switch etc. If low flow is detected while the pump is enabled a flow failure will be indicated and, after a short time delay, the pump duty will change over. The system will automatically reset to the duty pump every 24 hours or when a software switch on the BEMS is operated.

The pump motor speed is controlled to maintain a constant flow pressure in the LPHW heating circuit.

The CHWS flow and return temperature sensors are monitored by the BEMS.

The CHWS primary flow pressure sensor is monitored by the BEMS.

Heat exchanger

When enabled the heat exchanger will be operated and sequenced by the BEMS and duty rotated weekly based on the hours run.

Control points to monitor include:

- High temperature alarm
- Low temperature alarm
- Flow and return pressure sensors
- Pumps.

CHW pressurisation unit

The pressurisation unit will be permanently powered from the control panel. The pressurisation unit runs under its own controls. The pressurisation unit status will be indicated on the panel fascia and monitored by the BEMS.

Heat source - under floor heating (UFH)

A cascade control technique should be employed to suit the energy efficient and occupant comfort requirements of the controlled areas. The controls shall minimises the recovery time of the under floor heating system by controlling the slab temperature. This allows the heating medium to be circulated at 80°C and mixed locally.

The slab is controlled to 26°C during normal occupancy, which offers the benefit of self-regulation, and the room sensor is used to protect against over- or under-heating. The UFH system is designed to operate with a maximum surface temperature of 29°C to comply with BS/EN 1264.

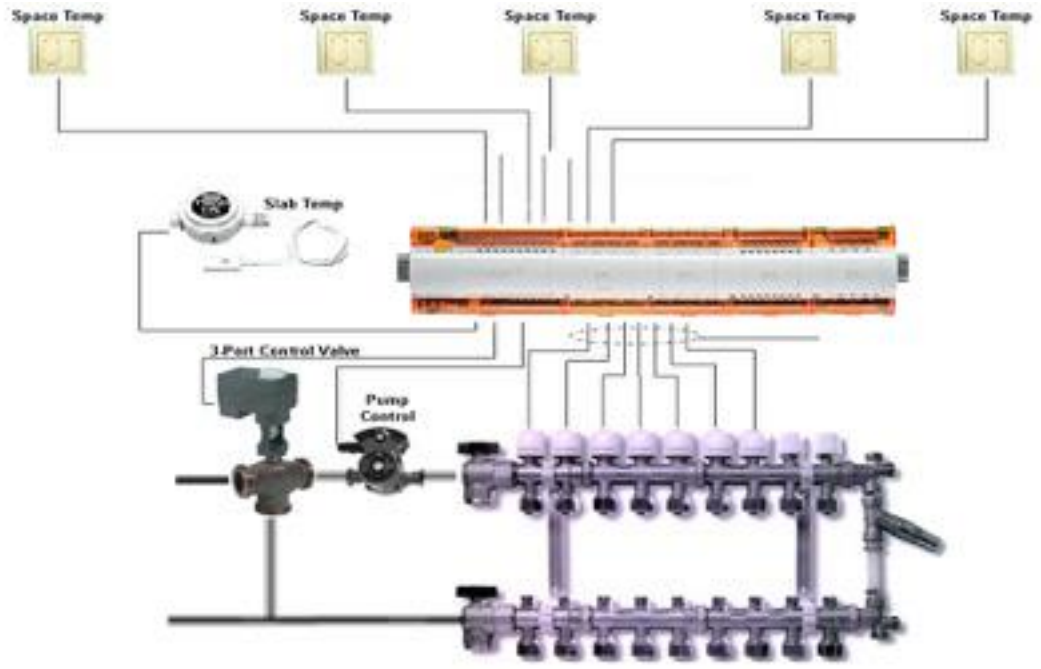

FIGURE 1: UNDER FLOOR HEATING LAYOUT

Cold Water Supply System

CWS tank

The CWS tank will have low and high water level monitoring and will create an alarm on the BEMS if the set low or high levels are reached. Tank temperature sensors are to be fitted and logged by the BEMS.

Should a low water level occur then the booster set will be inhibited and an alarm condition will be indicated on the control panel fascia. Should a high water level occur an alarm condition will be indicated on the control panel fascia.

CWS booster set

The booster set is controlled via its own packaged controls. The booster set will be inhibited from operation if a low water level condition is detected.

The booster set is monitored for common alarm conditions that will be indicated on the control panel fascia and the BEMS.

Gas safety circuits

Gas valves

The solenoid valve feeding the kitchen gas supply will close should any of the following occur:

- Fire alarm activated
- Emergency knock off operated
- Kitchen AHU air flow failed (supply or extract).

The solenoid valve feeding the boiler gas supply will close should any of the following occur:

- Fire alarm activated
- Emergency knock off operated
- Boiler thermal link operated
- Biomass boiler thermal link operated
- CHP thermal link operated.

Gas valve position monitoring

Fault lamps situated in the local control panel will indicate that the local gas valve is in the closed position and an alarm will be generated on the BEMS. **NOTE:** All the safety interlocks above are hardwired and operate in all modes of control.

Utility & energy metering

The BEMS will monitor and log utility meters (capturing 1/2 hour, 24 hour, weekly totals, monthly totals, accumulative total and 15min usage rate). Energy meters shall be provided for all plant items rated above 50kW and shall communicate with the BEMS via a common communications protocol.

Meter details

- Heat Meters
- LPHW heat meters if required
- HWS heat meter if required
- CHWS heat meters if required
- Gas utility meters via M-Bus
- Main incoming meter (m^3)
- Boiler supply
- Kitchen supply Gas
- Kitchen Electrical power (AHU supply & extract, Lighting, Small Power
- Kitchen Water consumption (Hot & Cold)
- CHP supply
- Water utility meters via M-Bus
- Main incoming water meter (m^3)
- Kitchen water meter (m^3)
- Electric utility meters via Modbus or M-Bus
- Main incoming meter
- All LV distribution boards electric meters

Local Energy Display Screen

A Display Screen should be located in a central area as part of the BEMS Installation to show building utility meter readings and energy consumption, situated in the main reception area.

Energy Management and utility monitoring

The BEMS shall be capable of display, recording, and computing information about energy metering and environmental conditions. This will allow the effects of plant operation, maintenance and use to be recorded as agreed with Client. All sensors are to be set up with trend logs/plots.

Fire alarm

A fire alarm activated signal will be provided at each control panel by an addressable relay installed by the electrical contractor. The addressable relay will be configured such that it only operates on evacuation and not on test. In event of the fire alarm being activated all plant will be disabled immediately.

Sprinkler system

Sprinkler system monitoring

The sprinkler system will be monitored by the BEMS. This will include:

- Main pump status
- Jockey pump status
- Panel healthy
- All fault signals.

Lighting Control

External lighting control and monitoring

The external lighting will enabled whenever the specific time zone is in occupancy and when the outside light level falls below a user adjustable value (nominally 500 lux).

The external light level and lighting enabled signal will be displayed on the BEMS.

Internal Lighting Control

Recent advances in technology of lighting and their control systems has brought about their common use in modern buildings. These should be integrated into the BEMS such that they may benefit from occupancy, time and external condition information to ensure energy efficient operation.

Photo voltaic panels

Electrical panels

The BEMS will monitor and record the Electrical Power produced by the Photo Voltaic Panels and monitor any fault signals.

Heating panels

The BEMS will monitor and record the heat output from the Panels and monitor any fault signals.

The system should be controlled so the internal heat medium cannot heat the external system when used within DHW system; and at no point can a condition occur which will promote the growth of bacteria within the DHW system.

Wind turbine

Wind turbine electrical power

The BEMS will monitor and record the electrical power produced by the wind turbines and monitor fault signals.

Natural Ventilation Control Specification

Automated Windows/Natural Ventilation

To facilitate proper control and interface with energy consuming plant, the BEMS sub-contract is to include system design, delivery, wiring diagrams, programming parameters, and commissioning of the entire installation of controlled Natural Ventilation.

The control system is to incorporate the following Operation Modes:

- Full Daytime Temperature Control during the Summer periods
- Night Cooling according to individual day and zone requirements
- Demand CO2 control during winter periods
- Pulse ventilation during winter periods
- “Morning Fresh Air” flush functions
- Local user control functions with keypads.

The control system must be fully integrated with the BEMS via BACnet interface or other common communication protocol. The integration will be under the control of the BEMS system and this

should account for the operation of all other items of plant under its control to minimise energy wastage through overlap of control operation and maximise energy savings from night cooling.

The control system must divide the building into zones, each zone having its own sensors and parameters to facilitate local control by the BEMS system. The zones should be configured to operate independently from each other depending upon the external conditions acting on the zone façade as well as the internal usage and conditions within that particular zone.

The control system must monitor the wind speed to provide accurate optimised control of the windows and solar gain detection shall compensate for heat generation. The system shall protect against operation during rain, high wind or other dangerous external conditions.

The control system must provide absolute incremental control of the motors to provide the optimum position of the windows for user comfort and air change. This reduces the risk of draughts and overcooling, but maintains the acceptable indoor and optimises airflow rates.

The BEMS must provide two-way communication between the control system and the individual window motors/actuators and offer feedback of the window status and position.

The control system must have the ability to provide protection against potential entrapment on specified windows and be capable to detect if an object becomes trapped in the window or damper to protect against further damage.

The control system must provide night cooling of the building and must be able to operate with limited window openings if required, for safety and security reasons.

Terminal Units

All Fan Coil Units (FCUs), Variable Air Volume (VAV) boxes, Induction Units, Over-door Heaters, and Zone Re-heat Plant shall be fitted with their own intelligent controller. These units shall be capable to can communicate with other devices over the BACnet or other common communications protocols over a local network and the main BEMS by way or communications controllers.

These unit can be supplied either in fully programmable option or with a fixed strategy and have (EUBAC approved) Energy Efficient strategies available if required.

Integration solutions

To achieve an EN15232 Class A Certificate, all building services shall be integrated such that they combine to function as a single intelligent entity. All stand-alone intelligent systems should therefore be fully integrated into the BEMS to allow intelligent operation of the building from a single command source.

Integration of various non BEMS systems should use a standard protocol solutions. These can be lighting systems using DALI communication protocol, metering solutions using Modbus or MBUS protocols and other third party devices using the BACnet protocol.

Standard control panel specification

Drawings

All control panel equipment shall be labelled with a dedicated reference. All wire and terminal numbers are to be shown.

The control panel drawings for external layout and wiring diagrams shall be issued with drawing numbers that refer to the particular contract using industry standard formats.

A full set of 'as manufactured' drawings shall be provided with the panel housed in an internal drawing pocket.

Safety

Panels shall be constructed with components that meet IP20 standards to allow safe live testing with the door open.

All control circuits will be 24VAC.

All phases, including incoming isolator terminals, must be fully shrouded.

Terminals having live feeds from external equipment shall be shrouded and carry a warning label.

Enclosure

Control panel enclosures shall be designed to meet IP54 protection standards at minimum.

Control panels shall be manufactured to Form 2 or 'wardrobe' type construction with separate starter and controls sections. Each individual starter will be covered by transparent plastic and fitted with an interlocked isolator.

Panel body and doors will be of sufficient thickness (1.5 - 2.0mm) and braced to form a rigid structure. Doors will be braced as necessary to prevent flexing. The equipment mounting plates will be of 2.5mm galvanised sheet steel and equipment mounting will be by screws into tapped holes to enable replacements to be made from the front only.

Wall mounting panels shall not exceed 1200mm in height. Panels exceeding 1200mm in height will be of the floor standing type.

Floor standing panels shall be manufactured and delivered to site as a single item. Panels can be split into sections if required for site access.

Floor standing panels shall have provision for lifting eyes and for fixing to a concrete plinth.

All panel doors shall be lockable in the closed position and all locks will use the same key.

The controls section door shall not be interlocked unless specified.

Natural or forced ventilation shall be provided to prevent the internal temperature exceeding a maximum of 40°C.

Finishes and labelling

Panels shall be finished in corrosion resistant coatings. Internal mounting plates shall be galvanised steel.

Panel fascia labels for plant control and indication shall be white traffolyte with black lettering. Standard sizes for labels shall be 100mm wide by 200mm high or 200mm wide by 200mm high and

shall cover the entire area taken up by the relevant equipment (e.g. switches and associated lamps). All fascia labels shall be fixed with bright finish pan head screws.

Warning labels shall be yellow self-adhesive type with black lettering.

Internal labels shall be clear self-adhesive type with black lettering fitted to the grey trunking lids.

Wiring, identification and labelling

All internal panel wiring shall be in accordance with IEE wiring regulations.

Power wiring shall be tri-rated (stranded) in phase colours with a minimum size of 2.5mm² and a maximum size of up to 6.0mm².

Power wiring 10.0mm² and above shall be black cables with terminal sleeves in phase colours.

Control circuit wiring shall be kept physically separated from other circuits within the panel and shall be tri-rated cable (stranded), with a minimum size of 1.0mm².

The cable colour coding shall be as follows:

400VAC	Brown/black/grey/blue
230VAC	Brown/blue
24VAC	Red/orange
12/24VDC	Violet
Controls cables (ELV)	White

Analogue signal cable shall have an overall screen of either braiding or foil and a PVC sheath. Foil-screened cables shall contain a 'drain wire', running the entire length of the cable, which shall be used for terminating the screen. Conductors shall be of the flexible (stranded) type and shall be individually sheathed in PVC.

Wiring shall be carried on the front surface of the mounting plate neatly strapped in suitably sized, ventilated, plastic cable trunking.

Cable and trunking sizes shall comply with the IEE Wiring Regulations with regards to grouping, bunching and enclosing factors. There shall be 25% spare capacity within the trunking.

Wiring to movable doors shall be loomed and protected with spiral wrap.

Wiring outside the trunking or loom shall be neatly set for connection to terminals or equipment.

All control wires shall carry numbered ferrules at both ends.

Each incoming and outgoing cable shall be separately terminated with an approved crimped terminal to suit the terminal use.

Terminals for differing voltages and circuit types shall be segregated and labelled accordingly.

No more than two wires shall be connected to any one terminal.

Insulating barriers shall be fixed between adjacent terminals for power wiring to give adequate protection while allowing easy access to terminals.

Cable entries

Removable gland plates shall be provided for terminating incoming cabling. All plates shall be sealed against the ingress of dirt, dust and moisture.

All entries for cables shall be easily accessible and marked to correspond with the panel-wiring diagram of external connections.

Controls section

The controls section will house the BEMS controllers and any power supplies, interface relays and terminals as detailed on the drawings.

An internal, shrouded on/off switch shall be provided to allow isolation of the controls section.

The power supply to the controls section should be taken from the live side of the main incoming isolator.

Controller input cables will be screened and a terminal will be provided for each cable's screen. The cable from the incoming terminals to the controller will continue screened with the screens grounded to clean earth bars adjacent to the controllers

A 13A socket shall be provided within the controls section for supplying test equipment. The socket shall be labelled "For computer use only".

Panel equipment

Isolators

Main isolating switches and fuse switches shall be capable of opening and closing on-load and shall be suitable for 50Hz, three phase, four wire operation.

Miniature circuit breakers

All protective devices will be miniature circuit breakers (MCBs) and shall be selected in accordance with manufacturer's recommendations to suit the application.

The circuit breaker mechanism shall be of the current limiting type to ensure interruption of a fault current during the 'rise' of the first half cycle, thus limiting the let-through energy.

The operating mechanism shall be completely trip-free and it shall not be possible to prevent the breaker tripping by holding or wedging the handle in the 'ON' position.

Contactors

Contactors shall be suitable for use on three phase, four wire 400/230V, 50Hz supplies and fitted with 24VAC coils, unless otherwise detailed.

Motor overload protection

Motor protection will be provided by breakers with combined magnetic (short circuit) and thermal overload releases. Also, protection against phase loss will be provided by a differential trip. The device will be suitable for providing isolation and will accept a padlock.

Motor protection devices above 37.5kw shall be of the electronic type.

All motor protection devices shall be arranged for hand resetting.

Interlocking relays

Plug-in type relays shall be interchangeable with equal numbers of 'N/O' and 'N/C' contacts. Relays operating on different control voltages shall be grouped and labelled with coil voltage.

All relays shall have an integral status indication and manual override.

Switches

Control switches shall be of the rotary type, comprising a switch handle fixed to the panel fascia and the required number of contacts fitted to the rear of the bezel. Control switches shall have black handles unless specified as key-operated and shall have a minimum protection index of IP54.

Indicator lamps

Indicator lamps shall be multi-cluster LED type and generally operate on 24vAC. 230vAC lamps shall only be used for mains supply status indication. A lamp test button will be fitted to each panel.

Colours of lamp lenses shall be as detailed in BS4099.

Green	Motor running
Red	Motor tripped, alarm
White	Power on, control circuit live
Amber	Flow fail, filter dirty

Inspection and testing

All control panels shall undergo a final inspection and test procedure where each control panel shall have its own unique test certificate and serial number.

Dispatch

Control panels shall be dispatched with a set of 'as manufactured' drawings and with a copy of the test certificate.