FORM: **BROOKSBY VENTILATION SYSTEM OVERPRESSURE - SAFETY REQUIREMENT SPECIFICATION**

AUTHOR(S): **ANDRIAN HARSONO**

The Pirbright Institute

Brooksby Ventilation System Over-pressure Scenario Safety Requirement Specification (SRS)

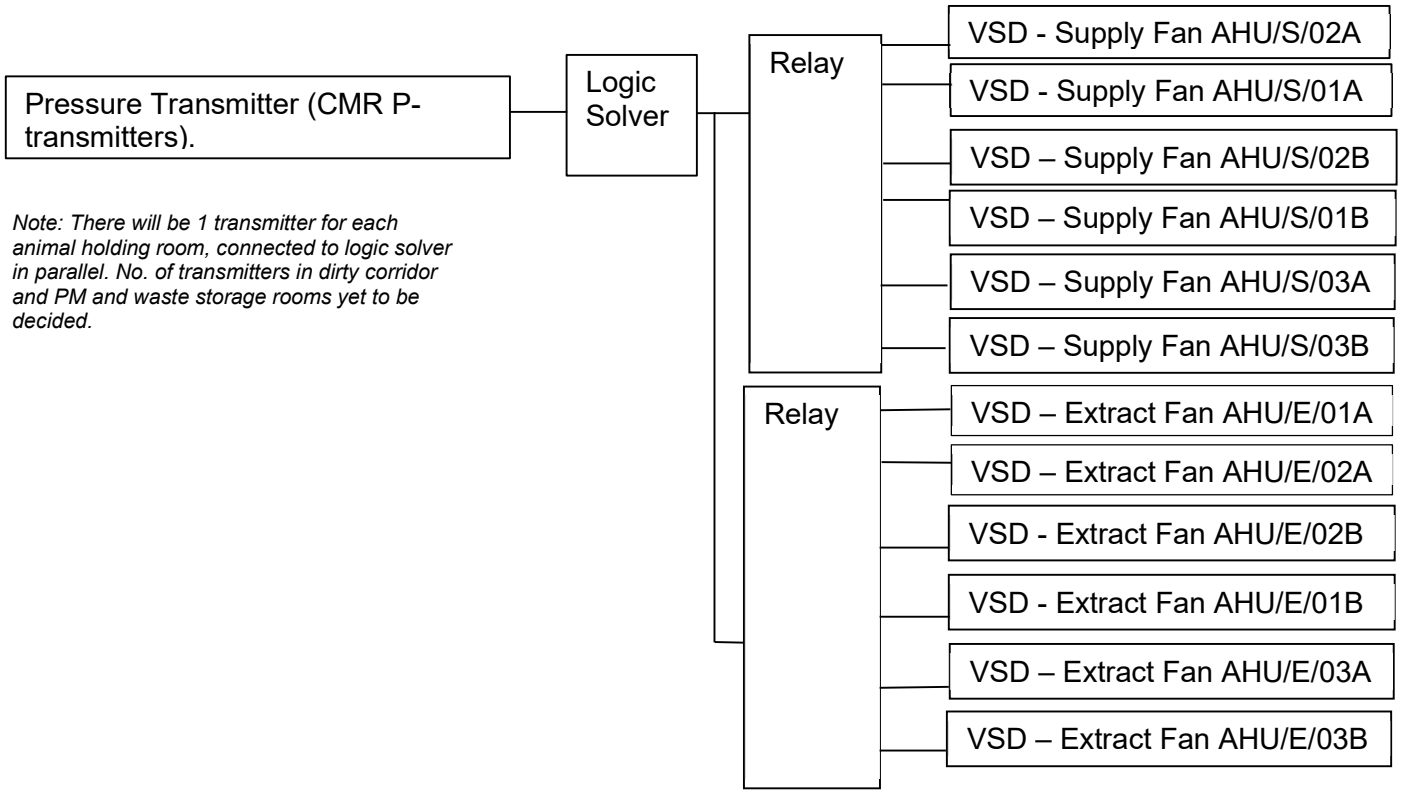
Rev.	Date	Author	Checked by	Approved by
1	23-MAY-2023	Andrian Harsono – Functional Safety Manager	Jason Tearle – Biosafety Technical Lead	Andy White – Director of Risk and Assurance
Signed:				

CHANGE HISTORY

Revision	Date of Issue	No. of Pages	Reasons for Change
1	23-MAY-2023	5	SRS is ready for FSA Stage 1. This document is a live document and as more information is available (e.g., tag numbers, FAT and SAT procedure numbers), this document will be updated again. The Institute should review the current proposal to shut down all 3 AHU systems when as few as one space i.e., an animal room, could trigger the safety function or whether a more local response would be preferable.

Safety Instrumented Function (SIF) Information	
Tag	To be confirmed (TBC)
Process Unit	Brooksby Ventilation System
Documents	LOPA Report – L308_ST001Rev. 2 FDS (AHU 1) - P800-SCH-92-ZZ-SP-XX-0011 FDS (AHU 2)- P800-SCH-92-ZZ-SP-XX-0012 FDS (AHU 3)- P800-SCH-92-ZZ-SP-XX-0013 SMS FDS - P800-SCH-92-ZZ-SP-XX-0022 Air System 2 Local Controls FDS - P800-SCH-92-ZZ-TS-XX-0041 Air System 1 Local Controls FDS - P800-SCH-92-ZZ-TS-XX-0049 Air System 3 Local Controls FDS - P800-SCH-92-ZZ-SP-XX-0016
Safety Function Description	High pressure detection which causes trip of the air handling unit (AHU) supply and extract fans for Systems 1, 2, and 3.
Hazardous Scenario	Over-pressure in an animal holding room, Dirty Corridor, or the "-140 Pa" space (i.e., Waste Storage, PM Room, and PM Euthanasia Room) resulting in a loss of containment of SAPO4 pathogen from the Brooksby building into the atmosphere resulting in a potential national outbreak.

SIF Logic/Architecture (Part 1)



Note: There will be 1 transmitter for each animal holding room, connected to logic solver in parallel. No. of transmitters in dirty corridor and PM and waste storage rooms yet to be decided.

SIF Components	Pressure Transmitter Analogue Input (AI) Card Logic Solver Central Processing Unit (CPU) Digital Output (DO) Card Relays Supply and extract Fans Variable Speed Drive (VSD)

SIF Logic/Architecture (Part 2)			
Architecture	**Voting**	**Limitations/Constraints**	**CCF Potential**
Pressure detection	1oo8 (TBC) – No. of transmitters in dirty corridor and PM rooms to be decided.	N/A	N/A
Logic Solver	1oo1	N/A	N/A
Final element (i.e., Relay) action	2oo2	N/A	N/A

SIF Requirements			
SIL Target	SIL 1	**Demand mode**	Low Demand
Final Element Response Time	~2 minutes[1]	**Process Safety Time**	~24 hours[2]
Proof Test Interval	12 Months[3]	**PFD Required**	0.012
Trip Condition	De-energise to trip	**Max. Spurious Trip Rate**	0.1 / year[4]
Expected MTTR	48 hours	**Mission Time**	20 years[3]

SIF Process Measurement Requirements				
Component	**Range**	**Accuracy**	**Trip Point**	**Validation Criteria**
Pressure detection	-200 to 200 Pa (Room-to-atmosphere)	+/- 0.25% Full Scale	+5 Pascals with respect to atmosphere for all transmitters.	FAT, SAT (procedures TBC)
Logic Solver	N/A	N/A	N/A	
Final element action	N/A	N/A	N/A (de-energise relay to trip VSD)	

Additional SIF Requirements	
Safe State Definition	Removal of power from the supply and extract fans resulting in these fans being turned off. Supply fans to switch off first, and extract fans to switch off 5 seconds later. Note: This maintains pressure cascade (and therefore containment) better. Systems 01, 02, and 03 are served by two full fresh air, air handling supply units each and two respective extract units each. Each air handling supply-and-extract unit is sized at 100% of the system's total duty, thereby providing plant redundancy if one unit is not available. All fans must be turned off to bring this facility to a safe state.
Sources of Demand	• Operator error; not switching out SMS pressure sensor from the BACS while carrying out maintenance. • Pressure sensor (e.g., F1AR01-PDT01) reading low in error. • Closing gas tight damper in the extraction line from a room in error. • Blockage of HEPA extract filter. • Fault with motorized isolation damper at either end of the AHU. • Manual isolation valve in AHU closed in error. • Air supply AHU put into manual and operating at higher or lower speed than the required safe speed. • Air supply duct pressure control fault including pressure sensors, fan VSD system and the PLC AHU controller.

[1] While the process safety time has been noted as 24 hours, it is unnecessary to configure fans to switch off slowly over 24 hours. This response time is therefore whatever would be the fastest response time available given the available technology at a reasonable cost.
[2] The conditional modifier used in the LOPA scenario assumed the probability of infection of nearby cattle by aerosol transmission of Foot and Mouth Disease Virus (FMDV) calculated over one day. This therefore means process safety time of 24 hours.
[3] Pending validation by SIL Verification.
[4] As a guide, the maximum spurious trip rate should be lower than half of the sum of all the initiating causes' frequencies.

Manual Shutdown	Manual isolation dampers on supply and extract air handling units.
Reset after Shutdown	Reset facility to be made available at the local control panel in the plant room (this makes it consistent with reset operation at the ISO buildings). Overpressure relief dampers (AHU) must also be manually checked to be available before the fans can be started up again.
Bypass Requirements	Yes, Override facility to be operated only via key switch.
SIF Faults and Failures and Required SIS Response	The fans will trip upon: • Any one pressure transmitter detecting over-pressure for longer than 60 seconds (length of time TBC during design stage). • Any one pressure transmitters' fault for longer than 12 hours. • Loss of power to instrument, logic solver, or relays. • Detected open circuit in loop for longer than 12 hours. • Detected short circuit in loop. Discrepancy alarm to be generated if fan motors still running 30 seconds after trip signal has been sent. This indicates that the relay has failed and allows operators to shut manual isolation dampers.
Electrical Supply	The primary source of power shall be via the essential DRUPS power distribution system for the building.

SIF Application Program Requirements	
Logic Solver Tag	TBC
Other SIFs supported by the Application Program	Ventilation system: under-pressure scenario.
SIS Interfaces	To BPCS for secure data logging, archiving of room pressure readings, fault alarms, and trip alarms.
Security Access	Password protection to download and/or modify Application program
Communications Interfaces Requirements	Ethernet, Modbus IP and RTU field network via BACnet or OPC. Logic solver must not be connected to the internet.
Trip Signal Response Time	Quicker than 500 ms
Programming Requirements	Limited Variability Language (LVL) is preferred. Use of Full Variability Language (FVL) must comply with IEC 61508-3.

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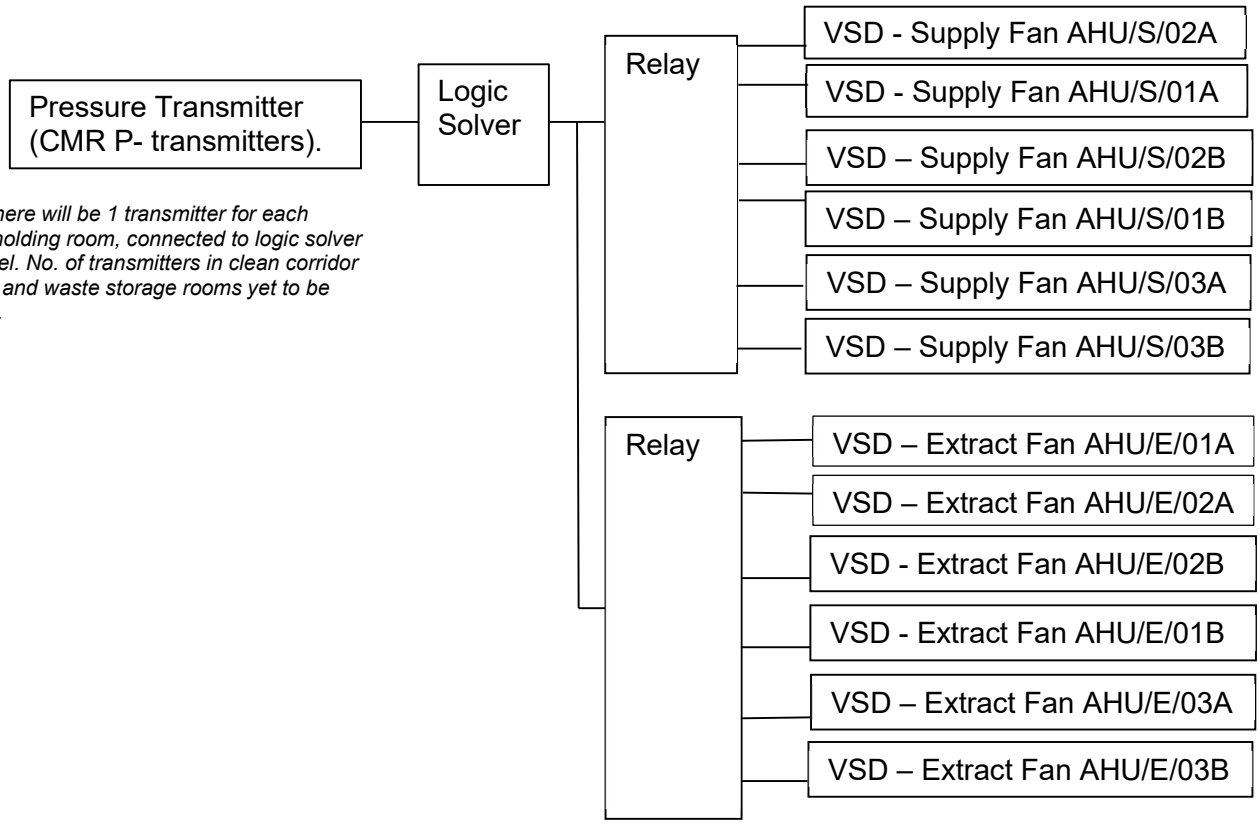
1	23-MAY-2023	5	SRS is ready for FSA Stage 1. This document is a live document and as more information is available (e.g., tag numbers, FAT and SAT procedure numbers), this document will be updated again. The Institute should review the current proposal to shut down all 3 AHU systems when as few as one space i.e. an animal room, could trigger the safety function or whether a more local response would be preferable. In addition, the trip point is driven by the (limited) range of the pressure sensors rather than a pressure than would reasonably result in physical damage.

Safety Instrumented Function (SIF) Information	
Tag	To be confirmed (TBC)
Process Unit	Brooksby Ventilation System
Documents	LOPA Report – L308_ST001Rev. 2 FDS (AHU 1) - P800-SCH-92-ZZ-SP-XX-0011 FDS (AHU 2)- P800-SCH-92-ZZ-SP-XX-0012 FDS (AHU 3)- P800-SCH-92-ZZ-SP-XX-0013 SMS FDS - P800-SCH-92-ZZ-SP-XX-0022 Air System 2 Local Controls FDS - P800-SCH-92-ZZ-TS-XX-0041 Air System 1 Local Controls FDS - P800-SCH-92-ZZ-TS-XX-0049 Air System 3 Local Controls FDS - P800-SCH-92-ZZ-SP-XX-0016
Safety Function Description	Low pressure detection which causes trip of the Air Handling Unit (AHU) supply and extract fans for Systems 1, 2 and 3.
Hazardous Scenario	Under-pressure in Clean Corridor, an animal holding room, or the "-140 Pa" spaces (i.e., waste storage room, PM room and PM euthanasia room) that could result in permanent fabric damage to the building. This increases the likelihood of SAPO4 pathogen release into the atmosphere.

SIF Logic/Architecture (Part 1)



Note: There will be 1 transmitter for each animal holding room, connected to logic solver in parallel. No. of transmitters in clean corridor and PM and waste storage rooms yet to be decided.

SIF Components	Pressure Transmitter Analogue Input (AI) Card Logic Solver Central Processing Unit (CPU) Digital Output (DO) Card Relays Supply and extract Fans Variable Speed Drive (VSD)

SIF Logic/Architecture (Part 2)			
Architecture	**Voting**	**Limitations/Constraints**	**CCF Potential**
Pressure detection	1oo8 (TBC) – No. of transmitters yet to be decided.	N/A	N/A
Logic Solver	1oo1	N/A	N/A
Final element (i.e., Relay) action	2oo2	N/A	N/A

SIF Requirements			
SIL Target	SIL 1	**Demand mode**	Low Demand
Final Element Response Time	~2 minutes[1]	**Process Safety Time**	~24 hours[2]
Proof Test Interval	12 Months[3]	**PFD Required**	0.012
Trip Condition	De-energise to trip	**Max. Spurious Trip Rate**	0.1 / year[4]
Expected MTTR	48 hours	**Mission Time**	15 years[3]

SIF Process Measurement Requirements				
Component	**Range**	**Accuracy**	**Trip Point**	**Validation Criteria**
Differential Pressure detection	-200 to 200 Pa (Room-to-atmosphere)	+/- 0.25% Full Scale	-198 Pa with respect to atmosphere for all transmitters.	FAT, SAT (procedures TBC)
Logic Solver	N/A	N/A	N/A	
Final element action	N/A	N/A	N/A (de-energise relay to trip VSD)	

Additional SIF Requirements	
Safe State Definition	Removal of power from the supply and extract fans resulting in these fans being turned off. Supply fans to switch off first, and extract fans to switch off 5 seconds later. Note: This maintains pressure cascade (and therefore containment) better. Systems 01, 02, and 03 are served by two, full fresh air, air handling supply units and two respective extract units. Each air handling supply-and-extract unit is sized at 100% of the system's total duty, thereby providing plant redundancy if one unit is not available. All fans must be turned off to bring this facility to a safe state.
Sources of Demand	• Manual isolation valve in AHU closed in error. • Blockage of (supply) HEPA filter. • Closing gas tight damper in the air supply line to a room in error whilst the room is still in use. • Failure of air supply AHU fan e.g., AHU S/01A duty supply fan • Air supply duct pressure control fault including pressure sensors AHU-S01-PT-01, AHU-S01-PT-02 and AHU-S01-PT-03, fan VSD system and the PLC AHU controller. • Air supply AHU put into "Manual" and operating at higher or lower speed than required safe speed.

[1] While the process safety time has been noted as 24 hours, it is unnecessary to configure fans to switch off slowly over 24 hours. This response time is therefore chosen to be whatever is the fastest response time available given the available technology at a reasonable cost.

[2] The conditional modifier used in the LOPA scenario assumed the probability of infection of nearby cattle by aerosol transmission of Foot and Mouth Disease Virus (FMDV) calculated over one day. This therefore means process safety time of 24 hours.

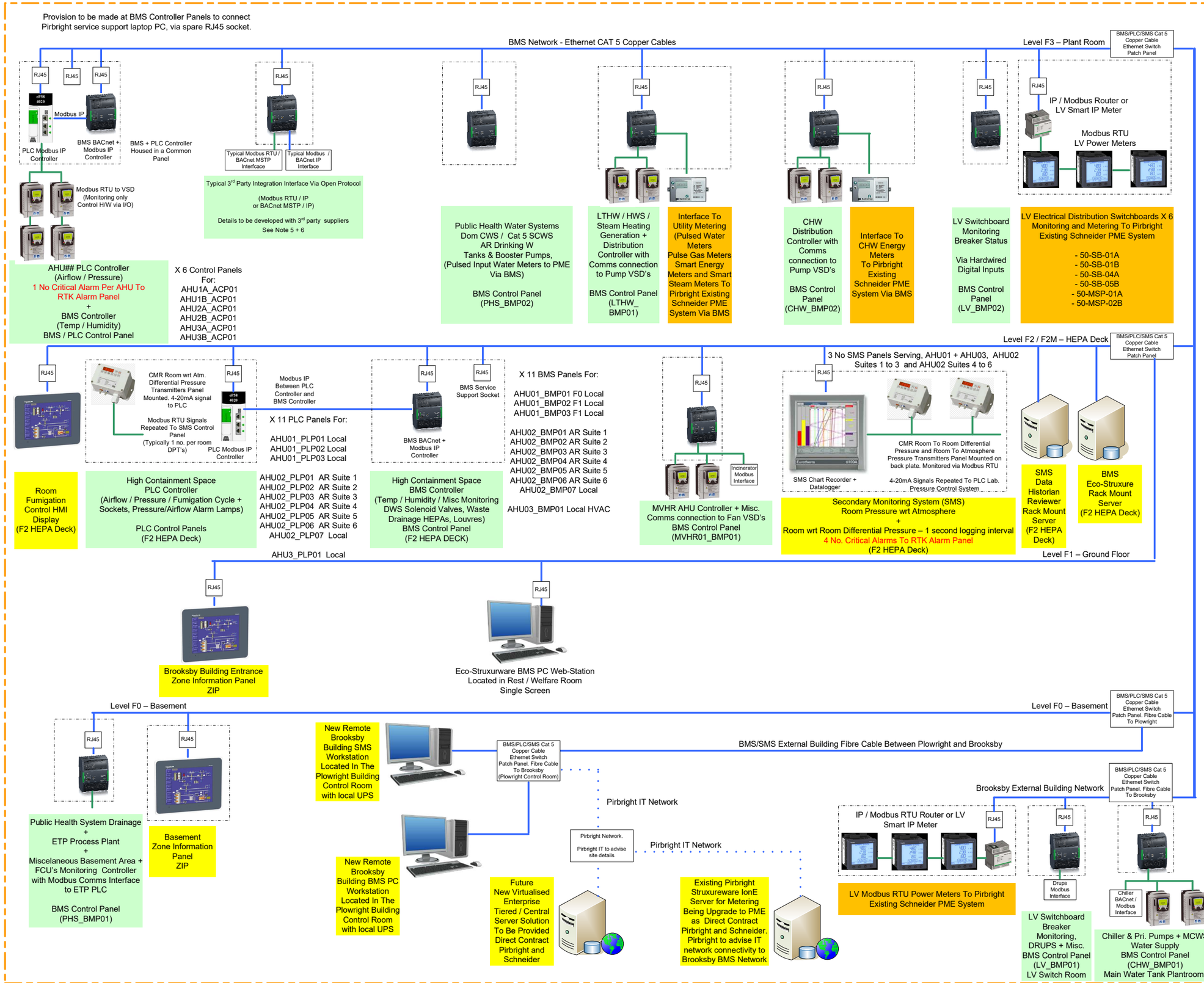
[3] Pending validation by SIL Verification.

[4] As a guide, the maximum spurious trip rate should be lower than half of the sum of all the initiating causes' frequencies.

	• Fault with motorized isolation damper at either end of AHU.
Manual Shutdown	Manual isolation dampers on supply and extract air handling units.
Reset after Shutdown	Reset facility to be made available at the local control panel in the plant room (this makes it consistent with the reset operation at the ISO buildings). Overpressure relief dampers (AHU) must also be manually checked to be available before the fans can be started up again.
Bypass Requirements	Yes, Override facility to be operated only via key switch.
SIF Faults and Failures and Required SIS Response	The fans will trip upon: • Pressure transmitter detecting under-pressure for longer than 60 seconds (length of time TBC during design stage). • Pressure transmitter at fault for longer than 12 hours. • Loss of power to instrument, logic solver, or relays. • Detected open circuit in loop for longer than 12 hours. • Detected short circuit in loop. Discrepancy alarm to be generated if fan motors still running 30 seconds after trip signal has been sent. This indicates that the relay has failed and allows operators to shut manual isolation dampers.
Electrical Supply	The primary source of power shall be via the essential DRUPS power distribution system for the building.

SIF Application Program Requirements	
Logic Solver Tag	TBC
Other SIFs supported by the Application Program	Ventilation system: over-pressure scenario.
SIS Interfaces	To BPCS for secure data logging, archiving of room pressure readings, fault alarms and trip alarms.
Security Access	Password protection to download and/or modify Application program
Communications Interfaces Requirements	Ethernet, Modbus IP and RTU field network Logic solver must not be connected to the internet.
Trip Signal Response Time	Quicker than 500 ms
Programming Requirements	Limited Variability Language (LVL) is preferred. Use of Full Variability Language (FVL) must comply with IEC 61508-3.

BROOKSBY BUILDING
BMS / PLC / SMS NETWORK OVERVIEW PHILOSOPHY



Notes:

1) This drawing is provided to show the High Level basis of design of the network philosophy of the following Building Systems:

- Building Management System (BMS)
  - Based upon existing site BMS system; Schneider Electric Eco-Struxureware
- Critical System Programmable Logic Controller (PLC)
  - Based upon Schneider Electric Modicon M340 series of PLC controllers.
- Secondary Monitoring System (SMS)
  - Based upon Schneider Electric Eurotherm range of high spec. data integrity chart recorders.
- WAGES aM&T Metering Monitoring System
  - Based upon integration to the existing site Schneider Electric Metering System.

2) The network topology design shall be developed in collaboration with Pirbright and Kier Project Team.

3) This drawing does not show the number of network cables required, network switches / patch panels, IP addresses. These details will be developed during detail design. Pirbright to advise IP address requirements and site IT network connectivity.

4) The Brooksby building electrical power supply is supported by a Diesel Rotary Uninterruptible Powers Supply (DRUPS). There is no proposal to provide further UPS to any of the proposed BMS/PLC/SMS panels or the associated network devices. Any new network devices proposed outside of the Brooksby building may require further UPS consideration.

5) 3rd party high level integration to packaged systems are based upon Open Protocol Modbus or BACnet using either IP or serial communication. (Chillers, ETP, DRUPs, Incinerator, Autoclave and Fumigation Chambers etc) Network details to be developed during detail design.

6) The Schneider AS-P BMS Controller provides Ethernet IP connection to the BMS network and each controller supports 2 no. communication ports providing Open Protocol integration via serial comms (Modbus RTU / BACnet MSTP, Lonworks etc). The AS-P controller also provides a secondary Ethernet port providing an IP subnetwork for BACnet / Modbus IP devices.

Rev	Rev Date	Description
P1-S2	15 Apr 2020	Issued for High Level Information

Title: BROOKSBY BUILDING
BMS / PLC / SMS High Level Network Design Concept

Client: Kier

Contract:

Drawn:	Date Drawn	Package No.	Scale:
DJ	15/04/2020	BMS	NTS
Approved:	Date Approved:	Phase: Contract	Job No.

Drawing Ref:	Sheet No.	Rev.
P800-SCH-92-ZZ-DR-XX-5001	1 of 1	P1-S2

AHU 1 A/B Functional Design Specification

FOR

Brooksby Building P800

BMS and PLC
Automatic Control Panels
P800_AHU01A_ACP01
P800_AHU01B_ACP01

The Pirbright Institute - Pirbright

Prepared by: David Jackson 24Jun20

<David Jackson, Life Science Team Leader, Schneider Electric Buildings> Date

Giles

Vendor Checked By	Function	Name	Signed	Date
Schneider Electric Buildings	Project Manager	Eamonn Wildmore	E. Wildmore	24Jun20
Schneider Electric Buildings	BMS Project Engineer	Chris Giles Chris McCleary Daniel Higgins	Chris Giles	24Jun20

Reviewed By	Function	Name	Signed	Date
KIER	Mechanical / Controls Design Manager	Cliff Brand		
KIER	MEP Package Manager	Paul Hodge		
KIER	Commissioni ng Manager	Chris Butler		
AECOM	Design Consultant	Alan Fox		

Reviewed By	Function	Name	Signed	Date
Pirbright Institute	BMS Manager	Maz Al-Zobaidy		
Arups				
Other ?				

DOCUMENT REVISION HISTORY

The Sequence of Operations becomes effective on the date of final approval. If changes are made that affect the document's content or approach, a revised, complete document must be issued for re-approval by the approvers of the original document or their designated representatives. A description of those changes with revision number will be noted in the revision log below.

Document naming and version will adhere to the project BIM execution plan naming convention.

Document Version	Status	Description	Revised by	Date Last Modified
P01	S3	Document issued for Project Team Review and Comment.	David Jackson	24 Jun 20

Documents Note:

1) The equipment tags in this document will be updated in line with the High Level BMS Design Document P800-SCH-92-ZZSP-XX-0001

2) The BMS and PLC alarm schedule will be updated in collaboration with the Pirbright Institute and Team Pirbright and subject to commissioning.

3) The BMS and PLC set point schedule will be updated in collaboration with the Pirbright Institute and Team Pirbright and updated during commissioning

4) The document will be updated during the life cycle of the project and will be an O&M reference document

CONTENTS

SECTION 1 – HVAC AIR HANDLING SYSTEM 01

Overview of This Document

This document defines:

- General description of the system
- Reference to schematics
- Monitoring and control description of how the PLC and BMS HVAC applications will operate.
- Reference to PLC and BMS Alarm schedules
- Reference to PLC and BMS Set points schedules

1.0 SYSTEM DESCRIPTION INTRODUCTION

This document describes the BMS / PLC * automation system functional description of operations for the HVAC air handling units serving the HVAC System 001, which are connected to the following combined BMS and PLC controller control panels:

- AHU01A-ACP01
- AHU01B-ACP01

The 1st Section 1 provides the reader with an overview of the system description, 2nd Section 2 provides a detailed description of the BMS and PLC description of operation and is the basis of the PLC and BMS software program.

*Important Note *:*

- *The AHU supply and extract airflow, volume and pressure monitoring, and control components of the design are connected to the PLC controllers.*

- *The AHU supply and extract temperature and humidity monitoring, and control components of the design are connected to the BMS controllers.*

- *The BMS controller monitors the all of the PLC interface I/O points via Modbus IP integration which is available for the User supervision via the BMS workstation and Schneider Electric Enterprise Building Operator (EBO) BMS Software, which will after project completion be connected to the Pirbright Institute site BMS EBO central tiered server; allowing full sitewide remote monitoring of the Brooksby plant connected to the BMS.*

All BMS I/O points and set points including those monitored on the PLC system will be supervised by the BMS graphics and alarms notified as configured by the BMS alarm system.

The AHU system 01 provides supply and extract air serving the HEPA deck environmental and containment HVAC services for the F0/F0M floor Undercroft, ETP plant area, Basement entrance PPE change and shower area, together with F1 Animal Entry, Clean Corridor and main F1 entrance lobby, shower and change area.

Refer to the separate functional description of operations Ref. P800-SCH-92-ZZ-SP-XX-0014 for the local HEPA deck HVAC systems serving the basement and change room / shower areas.

Refer to Ventilation System schematics:

- P800-ACM-57-XX-DR-ME-0001_Mechanical Services - Ventilation System Schematic – Sheet 1
- ~~P800-ACM-57-XX-DR-ME-0002_Mechanical Services - Ventilation System Schematic - Sheet 2~~
- P800-ACM-57-XX-DR-ME-0003_Mechanical Services - Ventilation System Schematic - Sheet 3
- ~~P800-ACM-57-XX-DR-ME-0004_Mechanical Services - Ventilation System Schematic - Sheet 4~~

Refer to PLC + BMS input / output point schedules:

- P800-SCH-92-ZZ-SH-XX-7011 ACP AHU1A-Points schedules
- P800-SCH-92-ZZ-SH-XX-7012 ACP AHU1B-Points schedules

The HVAC system 01 plant is served by two, full fresh air, air handling supply units and two respective extract units. Each air handling supply and extract unit is sized at 100% of the system total duty, thereby providing plant redundancy if one unit is not available. Under normal operating times the system operates 24/7.

- AHU/S/01A supply and associated AHU/E/01A extract
- AHU/S/01B supply and associated AHU/E/01B extract

System 01 serves the following rooms which require high containment and environmental monitoring and controls:

Basement Floor

Room Ref	Room Description
F0MUC02	Under-croft
F0ET01	Effluent Treatment Plant (ETP) Area
F0FE01	Fumigation Chamber
F0MCS01	Chemical Shower
F0PP01	PPE Change
F0MWC01	Water Closet
F0MIS01	Inner Shower
F0MS01	Shower
F0MOS01	Outer Shower
F0MOL01	Outer Change Lobby
F0MWC02	Water Closet

Ground Floor (West End)

Room Ref	Room Description
F1AEn01	Animal Entry
F1OC01	Clean Corridor
F1WR01	Worksop
F1WC01/1	Water Closet

Ground Floor (East End)

Room Ref	Room Description
F1WC02	Water Closet
F1OL01	Outer Lobby
F1OS01	Outer Change
F1OS02	Outer Change
F1OS03	Outer Change
F1OS04	Outer Change
F1SH01	Showers
F1SH02	Showers
F1SH03	Showers
F1SH04	Showers
F1IS01	Inner Change
F1IS02	Inner Change
F1IS03	Inner Change
F1IS04	Inner Change
F1WC03	Water Closet
F1IS05	Inner Lobby
F1VM01	Vet Med
F1StR01	Staff Room

Each Supply AHU comprises:

AHU Equipment	BMS Controller Interface	PLC Controller Interface
Manual Isolation Damper	N/A	N/A
Fly Screen Filter	Yes	
Fresh air isolation damper (motorised)		Yes
LTHW heating coil (freeze protection)	Yes	
Pre filter	Yes	
Attenuator section	N/A	N/A
Heat recovery coil and single pump (RAC energy recovery)	Yes	
CHW cooling coil	Yes	
LTHW heating coil	Yes	
Steam humidifier	Yes	
Twin Supply fan section each with variable speed drive and non-return dampers		Yes
Secondary filter	Yes	
Attenuator	N/A	N/A
Discharge isolation damper (motorised)		Yes
Manual Isolation Damper	N/A	N/A

Each Extract AHU comprises:

AHU Equipment	BMS Controller Interface	PLC Controller Interface
Extract air isolation damper (motorised)		Yes
Heat recovery coil and single pump (RAC energy recovery)	Yes	
Fresh air make-up * isolation damper (motorised)		Yes
Fresh air make-up inlet filter	Yes	
Single Extract fan section with variable speed drive and non-return dampers		Yes
Attenuator	N/A	N/A
Discharge isolation damper (motorised)		Yes
Non-Return Damper		

*Note * The two extract AHU's share a single fresh air make-up airflow duct, which is required during the fumigation to maintain a minimum exhaust stack efflux velocity.*

The Common Fresh Air Make Up Duct to the Extract AHU's comprises:

Equipment	BMS Controller Interface	PLC Controller Interface
Extract Fresh air make-up isolation damper (motorised)		Yes
Extract Fresh air make-up control damper (motorised)		Yes
Extract Fresh air make-up airflow station		Yes

The two AHU supply twin * fan sections normally operate in parallel (Each AHU at 50% system capacity) to maintain constant static pressure in the common supply duct header.

*Note * Whilst each AHU is capable of delivering 100% of the design volume, the twin fan section fans are each capable of 50%. i.e if one of the AHU twin fans was not available, that AHU can only deliver a maximum of 50% of the design.*

The two AHU extract fans normally operate in parallel (normally at 50% system, capacity) to maintain constant static pressure in the common extract duct header. Under normal * operation a minimum exhaust stack efflux velocity (10.0 m/s) should be achieved.

A common AHU supply, pressure relief duct with a variable flow, motorised control damper, provides the ability to maintain the minimum design speed of the AHU supply fan motors, when the turn down volume load, during the fumigation sequence, is lower than the minimum volume that the AHU supply fans can effectively operate. Excess AHU supply volume/pressure will bypass to outside via an external, roof mounted duct cowl. A second isolation damper is provided in the ductwork to provide tight shutoff. The control damper operates to maintain the maximum duct pressure, when the AHU fans are at minimum speed. Both the control damper and isolation damper are externally mounted and accessed from the roof.

A common AHU fresh air-make up duct with a variable flow, motorised control damper, provides the ability to maintain the

minimum extract efflux velocity, when the turn down volume load, during the fumigation sequence, is lower than the minimum volume necessary to maintain the efflux velocity. The make-up volume will derive from an external, roof mounted duct cowl. In this fumigation mode; the control damper operates to maintain the common extract duct pressure. Both the control damper and isolation damper are externally mounted and accessed from the roof.

Each supply AHU operates independently to maintain:

- Freeze protection control
- Energy recovery control
- Supply air temperature control
- Supply air humidity control / protection

Refer to the AHU system 01 local HVAC function description of operation to the BMS/PLC monitoring and control of the local LTHW reheat coils, terminal supply and extract HEPA filters, motorised CAV / VAV dampers and manual fumigation isolation dampers:

- P800-SCH-92-ZZ-SP-XX-0014 Air system 1 local controls Functional design spec

Refer to the secondary monitoring system (SMS) functional description of operation of the independent room pressure monitoring system:

- P800-SCH-92-ZZ-XX-0010 SMS Functional Design Spec

1.1 AHU Motor Control Panel LV Electrical Power Distribution

Each AHU derives electrical power supply from different mechanical services electrical LV panels (MSP's) which in turn derive power from separate LV switchboards (SB's).

- AHU/S/01A * and AHU/E/1A derive power from 50-MSP-01-A
  - 50-MSP-01-A derives power from 50-SB-04-A

- AHU/S/01B * and AHU/E/1B derive power from 50-MSP-01-B
  - 50-MSP-01-A derives power from 50-SB-05-B

*Note * The AHU twin fan section electrical power supply derives from a common fused breaker at the MSP and then is further distributed via a dedicated AHU sub-main fuse board to feed each supply fan VSD and motor.*

The main LV switchboards and mechanical services panels (MSP) are supported by an essential diesel rotary uninterruptible power supply (DRUPS)

The main LV MSP panels are in the F3 plant room and constructed to Form 4, type 6.

Small power to the AHU's lighting / RAC coil pump / BMS/PLC control panel derive from a mechanical plant distribution boards, fed from the respective mechanical services panel.

The BMS monitors the status (Off, Open and Tripped) of the electrical power moulded case circuit breakers (MCCB) to each power feed.

The site wide, aM&T metering system, Power Monitoring Expert (PME) monitors the power meters Refer to LV monitoring Functional Design Spec:

- P800-SCH-92-ZZ-SP-XX-0019 M&E metering systems including LV monitoring functional design spec

Electrical Motor Ratings

AHU/01A Served From 50-MSP-01-A

Description	Plant Ref	Motor name plate (kW)	VSD
Supply Fan 1	AHU/S/01A SF1	11	Yes (Danfoss by AHU supplier)
Supply Fan 2	AHU/S/01A SF2	11	Yes (Danfoss by AHU supplier)
Extract Fan	AHU/E/01A EF1	18	Yes (Danfoss by AHU supplier)

AHU/01A Small Power Served From 50-DB-MCP1-A-A02

Description	Plant Ref	Motor name plate (kW)	VSD
AHU HRC Pump	AHU/S/01A PU01	0.75	Yes Integral Pump
AHU Lighting	Luminaires	6 amp (MCB)	N/A
AHU BMS / PLC Control Panel	AHU/01A/ACP01	16 amp (MCB)	N/A

AHU/01B Served From 50-MSP-01-B

Description	Plant Ref	Motor name plate (kW)	VSD
Supply Fan 1	AHU/S/01B SF1	11	Yes (Danfoss by AHU supplier)
Supply Fan 2	AHU/S/01B SF2	11	Yes (Danfoss by AHU supplier)
Extract Fan	AHU/E/01B EF1	18	Yes (Danfoss by AHU supplier)

AHU/01B Small Power Served From 50-DB-MCP1-B-A02

Description	Plant Ref	Motor name plate (kW)	VSD
AHU HRC Pump	AHU/S/01B PU01	0.75	Yes Integral Pump
AHU Lighting	Luminaires	6 amp (MCB)	N/A
AHU BMS / PLC Control Panel	AHU/01B/ACP01	16 amp (MCB)	N/A

Each AHU fan VSD is mounted adjacent to the respective AHU motor. A local isolator downstream of the VSD provides the facility to safely isolate the motor. Each VSD is provided with local run/trip/fault/ operating diagnostics and control keypad.

1.2 AHU BMS + PLC Control Panel

Each of the AHU 01 BMS and PLC control panels are manufactured as detailed in the High Level BMS Design Document P800-SCH-92-ZZSP-XX-0001.

- AHU/01A/ACP01
- AHU/01B/ACP01

Each panel is provided with:

- Key lockable door
- Internal mains power disconnect isolator
- MCB protection fuses
- BMS controller and supporting transformer power supplies and I/O modules
- PLC controller and supporting transformer power supplies and I/O modules and PLC network switch
- Interfacing relays and relay timers
- Power healthy and plant status LED indication lamps
- AHU fan and pump Test/Off/Auto key operated switches
- Interfacing terminals with knife disconnect
- SELV fused terminals to 24Vac field equipment

- RCD service laptop socket
- RJ45 socket service laptop connection to BMS network

The BMS Control Panel Fascia will have the following lamps and switches

AHU/01A/ACP01

Equipment Reference	Description	Fascia Key Switch	Fascia LED Lamp
Mains Healthy			230Vac Lamp
BMS 24Vac Power Supply			24Vac Lamp
PLC 24Vac Power Supply			24Vac Lamp
AHU/S/01A/SF1	AHU 01A Supply Fan 1	Test / Off / Auto	Run Trip Frost + Reset
AHU/S/01A/SF2	AHU 01A Supply Fan 2	Test / Off / Auto	Run Trip Frost + Reset
AHU/E/01A/EF	AHU 01A Extract Fan	Test / Off / Auto	Run Trip
AHU/S/01A/PU	AHU 01A Run Around Coil Pump	Test / Off / Auto	Run Trip Low Pressure

AHU/01B/ACP01

Equipment Reference	Description	Fascia Key Switch	Fascia LED Lamp
Mains Healthy			230Vac Lamp
BMS 24Vac Power Supply			24Vac Lamp
PLC 24Vac Power Supply			24Vac Lamp
AHU/S/01B/SF1	AHU 01B Supply Fan 1	Test / Off / Auto	Run Trip Frost + Reset
AHU/S/01B/SF2	AHU 01B Supply Fan 2	Test / Off / Auto	Run Trip Frost + Reset
AHU/E/01B/EF	AHU 01B Extract Fan	Test / Off / Auto	Run Trip
AHU/S/01B/PU	AHU 01A Run	Test / Off /	Run

	Around Coil Pump	Auto	Trip Low Pressure

1.3 PLC Controller AHU Supply Fan and Extract Fan Operational Interlocks

If both twin AHU supply fans are not available to operate, the respective extract fan will shut down. The available operating supply and extract fans will automatically ramp up to maintain respective system pressures.

If the AHU extract fan is not available, the respective supply AHU will shut down. The available operating supply and extract fans will automatically ramp up to maintain respective system pressures.

PLC Controller Hardwired Plant Interlocks

Hardwired interlocks shall be operable for both Auto (Remote) and Hand (local VSD only) mode control of motor operation.

- AHU Off/Auto Switch
- AHU fresh air damper position end switch closed inhibits the AHU supply fan VSD from operating.
- AHU discharge air damper position end switch closed inhibits the AHU supply fan VSD from operating.
- AHU supply fan interlocked to extract fan.
- AHU extract fan interlocked to supply fan *(timed start relay)*
- AHU Off Frost Coil Low Limit Thermostat Temperature Alarm interlocked to inhibit AHU supply fan and extract fan.
- AHU extract air inlet damper position end switch closed inhibits the AHU extract fan VSD from operating.
- AHU extract air discharge damper position end switch closed inhibits the AHU extract fan VSD from operating.

BMS Controller Hardwired Plant Interlocks

- AHU run around coil high- and low-pressure switch in alarm interlocked to inhibit pump operation.
- AHU supply air high limit humidistat switch in alarm interlocked to close spring return steam control valve.

Note there are:

- No hardwired fire alarm to shut down the plant
- No hardwired fireman's over mode to operate the plant
- No hardwired pressure safety switches to shut down the plant

2.0 Control Sequences

2.0.1 Overview

The plant operates 24/7 subject to BMS operator plant control flags and defined software and hardwired interlocks.

The monitoring and controls are performed by both BMS and PLC controllers. The following controls section title indicates the main controller, BMS or PLC performing the control software.

Note: It is anticipated that the HVAC system may take 20 to 30 minutes to start up and stabilise. All timers required in software will be established during commissioning and final setting recorded in the respective set point schedule.

2.1.1 PLC Controller Normal System Start Up

Non critical plant and environmental BMS alarms are inhibited (disabled) during start up. Room pressure alarms always remain activated, unless manually disabled by the Pirbright Institute via the BMS PC graphics screen.

- Room pressure alarms to always be activated for safety.
- Plant, temperature / humidity alarms de-activated,

Important Note. The Operation and Start-up of the containment HVAC system is subject to manual SOP's.

The following conditions are pre-requisite to start up the HVAC system and assumes that all manual SOP's have been correctly adhered to.

- BMS graphics software operator plant flag is set to 'ENABLE' {PLC Modbus Point}
- At least one of the two AHU plant, AHU 1A or 1B PLC available flags is 'AVAILABLE'

Note. Any AHU 1A or 1B Mode selected 'Off' via the BMS workstation graphics will not start.

Step 1 – Activate BMS frost coil control regime. (Refer Section 2.2.1)

Note: If the ambient conditions {BMS global point} below [5] deg C, then activate AHU cold start regime to preheat the frost coils. Check the

temperature of the LTHW frost coil return line to indicate that heating is available {BMS Modbus before proceeding with AHU start up.

Step 2 – Activate PLC airflow and room pressure controls. Refer to PLC Functional Description of Operation:

- P800-SCH-92-ZZ-SP-XX-0014 Air system 1 local controls Functional design spec

Note: The local PLC airflow / pressure controller ramps the airflow / pressure damper controls to keep the airflow negative into the high containment laboratories throughout the start-up sequence.

Step 3 – PLC to command the AHU supply and extract inlet and discharge air damper isolation dampers to 'OPEN'

Step 4 – PLC to established that each damper has opened as monitored by the damper actuator end switches

If the damper fails to open, (after a suitable proving period) The PLC shall notify a damper failure alarm to the BMS and shall cause the PLC control strategy to make the associated fan/AHU as Not Available.

Step 5 - When all respective isolation dampers are proved open:
The PLC to command to start the available AHU extract fans,
followed by the available AHU twin supply fans.

Note: AHU supply fan and general extract fan shall start and initially operate at pre-fixed minimum speeds set points, set at the VSD.

Step 6 – The PLC is to ramp up the AHU extract fan and supply fan in a controlled sequence to attain the respective supply and extract pressure control set points. (Air regime to maintain negative flow / containment in the high containment laboratories)

Step 7 – The PLC is to enable a Modbus signal to the BMS controller environmental control loops when the VSD run status or airflow differential pressure switch across the AHU supply fans has been established.

- AHU supply air and room temperature control regimes.
- AHU supply air and room humidity control regimes.

Step 9 - After pre-fixed times, allowing for the plant to attain control conditions, the BMS will activate the following BMS alarm monitoring.

- AHU supply and extract temperature, humidity and flow and pressure
- Room temperature alarms

2.1.2 Normal System Shutdown

Any of the following conditions shall cause the AHU HVAC system to shut down:

- BMS plant operator software flag {PLC Modbus Point} is set to 'SHUTDOWN'

In the event of the HVAC system being shut down the following sequence shall follow.

Step1 – The BMS will disable temperature, humidity, flow and duct pressure monitoring BMS alarms.

Step 2 – BMS to close humidifier control valve

Step 3 – PLC AHU controller to send a Modbus signal to the local room PLC controllers to slowly ramp down room pressure CVB and VVB volume set points to minimum control set points whilst aiming to maintain a negative air flow regime within the laboratories.

- P800-SCH-92-ZZ-SP-XX-0014 Air system 1 local controls Functional design spec

Note: AHU supply fan and extract fans will automatically ramp down under PLC control to maintain index pressures.

- At a preset AHU low volume; (beyond which no reliable control is possible) the PLC is to switch off the supply fan followed by extract fans and set fan speed control to zero:

- AHU Supply fan AHU/S/01A
- AHU Supply fan AHU/S/01B

- AHU Extract fan AHU/E/01A
- AHU Extract fan AHU/E/01A

- The PLC AHU controller will send a Modbus signal to the local room PLC controllers to inhibit / freeze the control of the respective room pressure / VAV controls.

When the AHU fans have stopped the PLC will disable the signal to the BMS controllers to close the respective AHU and local coil control valves

Step 4 – BMS to close AHU heating coil control valve
Step 5 – BMS to close AHU cooling coil control valve
Step 6 – BMS to switch off RAC pump
Step 7 – PLC to fully close AHU supply / extract inlet and discharge air dampers
Step 8 – BMS to fully close local heating coil control valves
Step 9 – BMS to close AHU frost coil control valve

2.1.3 Plant Fault Shutdown Scenarios

General Note: Following an 'alarmed/fault' shutdown of the system (except Mains power failure) the User shall be required to manually reset of the appropriate graphic software flag via the BMS operator workstation.

AHU Supply Fan Failure Shutdown:

- If both AHU twin fans have failed.

Step1 – BMS to disable AHU temperature, humidity index pressure and volume monitoring alarms.

Step 2 – BMS to close humidifier control valve output to 0% open

Step 3 – PLC to switch off the following fans and set fan speed control to zero:

Note The remaining operational AHU will automatically ramp up in speed (circa 100% of design duty) to maintain required index pressure set points.

- Switch off both failed AHU supply twin fans
- Switch off respective AHU Extract fan

Note: Extract fan specified as hardwired interlock and it will shutdown immediately as soon as the supply fan VSD run status is in-active.

This will cause a step change in system pressure and the remaining extract fan is to ramp up quickly to retain control of the extract index pressure.

Step 4 – BMS to Close AHU heating coil control valve
Step 5 – BMS to Close AHU cooling coil control valve
Step 6 – PLC to Close AHU fresh air damper

Step 7 – PLC to Close AHU discharge air damper
Step 8 – BMS to Close AHU frost coil control valve
Step 9 – BMS to Switch off AHU RAC coil pump and set pump speed control to zero

Step 10 – PLC to Close AHU extract inlet air damper
Step 11 – PLC to Close AHU extract discharge air damper
Step 12 – PLC to Close AHU extract fresh air make-up isolation damper

AHU Supply Fan Fault Reset

A manual reset of the AHU supply fan fault flag, via the BMS PC graphic head end, shall allow the AHU and general extract fan to restart.

Sequence start the extract fan first followed by supply fan.

- PLC to command open the AHU extract and AHU supply inlet and discharge isolation dampers as per a normal start. The AHU extract and AHU supply non return dampers will remain closed whilst there is back pressure from the operating AHU.

- When the AHU extract inlet and discharge dampers are open the PLC Enables the extract fan. Fan operates at minimum speed and slowly ramps up speed towards the speed of the already operating fan. When the starting AHU speed matches that of the operating fans, release the ramp control and operate both AHU fan speeds in parallel. (Note as the restarting fan contributes to system pressure the PLC pressure fan speed control will automatically reduce the speed of the other AHU fans, such that pressure is maintained).

- Simultaneously to above the PLC operates the AHU supply inlet and discharge dampers and controls the speed of the AHU twin fans in a similar way to the above extract fans.

General Extract Fan Failure

- As per AHU supply fan failure

Note: The AHU supply fans are hardwired to not operate if the respective extract fan is not running.

General Extract Fault Reset

A manual reset of the AHU extract fan fault flag, via the BMS PC graphic head end, shall allow the AHU and general extract fan to restart.

2.2.4 BMS AHU Freeze Protection Control

The BMS monitors the off-frost coil temperature * and modulates, via a PID control loop, the AHU LTHW frost heating coil 2 port (PICV) control valve to maintain minimum off coil air temperature set point of [5] deg C.

*Note * A 6000mm length, averaging, temperature control sensor is laced across the frost coil discharge.*

The BMS monitors the AHU fresh air inlet temperature, via a duct mounted averaging sensor. Under low fresh air inlet, ambient temperature conditions below [0] deg C the BMS shall schedule an increase of the off-frost coil temperature to [10] deg C

Note: To avoid problems with the AHU tripping on low limit frost protecting, on a cold AHU, start-up routine. (ambient temperature below 5 deg C) The off-frost coil temperature set point will be set to [10] deg C and ramped down to normal set point, after a preset time 20 minutes.

The BMS will send an AHU supply and AHU extract shutdown signal (Via Modbus) to the PLC controller if the BMS control sensor monitors a low limit below [3] deg C for a transient period of time (5 minutes).

The BMS will notify a critical alarm to the BMS alarm engine and graphic if the off-frost coil temperature falls below [3] deg C.

The BMS monitors the LTHW frost coil return pipe water temperature, via an immersion temperature sensor. The BMS will send an AHU supply and AHU extract shutdown signal (Via Modbus) to the PLC controller if the BMS control sensor monitors a low limit below [20] * deg C for a transient period of time (5 minutes). The BMS will fully open the frost coil valve.

Note: Review specified 20 deg to shutdown the AHU and fully open the frost coil valve. This may cause nuisance tripping and also overheat the AHU when it is off and isolated.

The BMS will notify a critical alarm to the BMS alarm engine and graphic if the frost coil return water temperature falls below [4] deg C.

The BMS monitors the control valve actuator feedback and notifies an alarm if the valve control signal does not match the feedback signal within 5% allowing for a suitable transient time [10s] for the actuator motor to operate.

The BMS notifies a valve exercise alarm, if the valve has not operated in 100 hours. The BMS operator can override the BMS automatic control and

manually signal the valve 0 to 100 to 0% open and then release back to automatic via the BMS graphic.

AHU/S/1A

Control and Instrument Ref	Point Descriptor
AHU_S_01A_ TEM01	Fresh Air Temperature
AHU_S_01A_ ACV01	Frost Coil Control Valve
AHU_S_01A_ ACV01	Frost Coil Control Valve Position
AHU_S_01A_ TEM02	Off Frost Coil Temperature
AHU_S_01A_ TEM03	Frost Coil Return Temperature

AHU/S/1B

Control and Instrument Ref	Point Descriptor
AHU_S_01B_ TEM01	Fresh Air Temperature
AHU_S_01B_ ACV01	Frost Coil Control Valve
AHU_S_01B_ ACV01	Frost Coil Control Valve Position
AHU_S_01B_ TEM02	Off Frost Coil Temperature
AHU_S_01B_ TEM03	Frost Coil Return Temperature

2.2.5 PLC AHU Freeze Protection Control

A low limit, automatic reset, thermostat * (manually set at [3] deg C) is hardwired via a latched relay adjustable timer in the panel (0-15minutes) to protect the AHU from freezing.

If the off-frost coil low limit temperature exists for more than 5 minutes (adjustable PLC panel relay timer) the AHU supply fan and extract fan will shut down.

*Note * A 6000mm length, capillary, thermostat is laced across the frost coil discharge.*

A frost alarm indication lamp and manual reset button is located on the fascia respective BMS/PLC control panel.

The PLC also monitors a Modbus AHU freeze protection signal from the BMS system. If the freeze protection alarm is active the PLC will shut down the respective AHU supply and AHU extract units.

AHU/S/1A

Control and Instrument Ref	Point Descriptor
AHU_S_01A _ FRO01	Off Frost Coil Low Limit Thermostat

AHU/S/1B

Control and Instrument Ref	Point Descriptor
AHU_S_01B _ FRO01	Off Frost Coil Low Limit Thermostat

2.1.6 BMS AHU Run Around Coil Control and Monitoring

Refer also to supply air temperature control which operates in conjunction with energy recovered from the run around coil.

The AHU heating and cooling coil valves operate in sequence to maintain supply air temperature set point.

The BMS monitors the AHU inlet air temperature and associated AHU extract temperature.

Heating Mode
The RAC pump is switched On and operated at 100% speed for first stage heating when the AHU fresh air inlet temperature is below the AHU supply air set point temperature and below the AHU return air temperature by more than a value defined in the set point. [3] deg C

The RAC pump is switched off when this temperature difference falls to [1.5]K or less for a period of [5]minutes.

Cooling Mode

The RAC pump is switched On and operated at 100% speed for first stage cooling when the AHU fresh air inlet temperature is above the AHU supply air temperature set point and above return air by more than a value defined in the set point [3] deg C.

The RAC pump is switched off when this temperature difference falls to [1.5]K or less for a period of [5]minutes.

The cooling valve modulates to maintain the desired supply air temperature set point.

RAC Pump Monitoring

The RAC pump is fitted with an integral VSD.

The BMS provides a remote enable of the pump VSD and speed control.

The BMS monitors the status of the RAC pump Test-Off-Auto switch on the BMS control panel. The BMS notifies an alarm is the pump is not in Auto mode.

The BMS monitors the pump's VSD run status and notifies a pump failure alarm if there is a mis-match between BMS pump VSD enable signal and the VSD run feedback.

The BMS monitors the pump's VSD fault status and notifies an pump fault alarm if the pump is in fault condition.

The BMS monitors the pump VSD status via Modbus open protocol

The BMS monitors the performance of the RAC by measuring the on-air and off-air coil and pipe-inlet and pipe-outlet coil temperatures.

The BMS shall notify a warning and critical low temperature alarm at the BMS workstation.

The BMS monitors a RAC circuit, high- and low-pressure switch and shall notify an alarm if there is a pressure alarm. In the event of an alarm the BMS switches off the RAC pump. (The alarm is also hardwired interlocked to disable pump)

AHU/S/01A

Plant Ref	Control and Instrument Ref	Point Descriptor
n/a	AHU_S_01A_ TEM01	AHU Inlet Air Temperature
n/a	AHU_E_01A_ TEM01	AHU Extract Air Temperature
AHU/S/01A/ PU01	n/a	RAC Pump VSD Enable
	n/a	RAC Pump VSD Speed Control
	n/a	RAC Pump VSD Run Status
	n/a	RAC Pump VSD Fault Status
	n/a	RAC Pump VSD Local / Remote Status
AHU/S/01A/ HRC	AHU_S_01A_ TEM02	AHU On Air RAC Coil Temperature
	AHU_S_01A_ TEM04	AHU Off Air RAC Coil Temperature
	AHU_S_01A_ _TEM08	AHU RAC Coil Inlet Temperature
	AHU_S_01A_ _TEM09	AHU RAC Coil Outlet Temperature

AHU/S/01B

Plant Ref	Control and Instrument Ref	Point Descriptor
n/a	AHU_S_01B_ TEM01	AHU Inlet Air Temperature
n/a	AHU_E_01B_ TEM01	AHU Extract Air Temperature
AHU/S/01A/ PU01	n/a	RAC Pump VSD Enable
	n/a	RAC Pump VSD Speed Control
	n/a	RAC Pump VSD Run Status
	n/a	RAC Pump VSD Fault Status
	n/a	RAC Pump VSD

		Local / Remote Status
AHU/S/01A/ HRC	AHU_S_01B_ TEM02	AHU On Air RAC Coil Temperature
	AHU_S_01B_ TEM04	AHU Off Air RAC Coil Temperature
	AHU_S_01B_ _TEM08	AHU RAC Coil Inlet Temperature
	AHU_S_01B_ _TEM09	AHU RAC Coil Outlet Temperature

The BMS monitors the RAC Pump VSD Modbus Registers

VSD Monitoring Parameter	VSD Modbus Register	BMS Point Descriptor
		AHU RAC Pump Local Remote Status
		AHU RAC Pump Fault Code
		Power Consumption kW
		Frequency Hz Feedback
		Amperes Current

2.1.7 PLC AHU Supply Fan Pressure Control

The PLC monitors the average AHU common, supply air main header pressure sensors, as measured via 3 duct pressure sensors. * The PLC modulates, via a PID control loop, the operating AHU supply fan VSD, speed control signal in parallel to maintain the pressure set point [###Pa].

Review Impact of Specification which may cause problems with the ability to provide accurate room pressure damper authority and control.

In order to negate the effects of the increasing pressure drop across the terminal HEPA filters as they dirty and the decrease in pressure drop when filters are replaced the supply and extract static pressure setpoints shall be reset.

The PLC shall continuously monitor the position of the large VAV box dampers. The PLC shall then reset the static pressure setpoint up/down to ensure the most open large VAV on the supply or extract remains [90]% open ± [2]%.

The increments at which the supply and extract static pressure setpoints are reset and the time delays between each resetting step shall be developed by the Contractor and proven in the commissioning period.

The two AHU PLC fan speed controllers are arranged master / slave. If the master speed controller CPU is not available, the slave controller shall take over speed control. The CPU available signal is determined by a simple controller 1 task that turns a PLC digital output on and off repetitively; This is then monitored as a digital input by the slave controller. If the input repetitively changes state on and off then the PLC controller no. 1 is deemed functioning okay. If the input stops, the controller no.1 is deemed to be unavailable and the slave controller takes over the control loop for VSD fan speed control.

The PLC Controller speed reference control signal to each AHU VSD is also duplicated as a control signal to the 2nd AHU PLC Controller, so that

*Note * The Duct sensors are CMR manufactured P-Sensors each complete with dual channel 4-20mA / 0-10Vdc outputs. Two of the sensors are powered from PLC Controller 1 (AHU/01A) and the Third sensor powered from PLC Controller 2. The 2nd 0-10Vdc output channel from each sensor is shared to the other controller.*

A low / high static pressure alarm shall be notified at the BMS. (Refer to alarm schedule)

Note the PLC shall monitor the 3 pressure sensors and discard any single value that is [5%] out of range or failed because of open or short circuit signal.

The pressure is controlled by one of the 2 PLC controllers. If the lead PLC controller fails, the 2nd PLC controller will become the lead pressure controller.

AHU/S/01A - PLC Controller No.1

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/01A/ SF01	AHU_01A_ VSD01	AHU Supply Fan 1 Speed Control
AHU/S/01A/ SF02	AHU_01A_ VSD02	AHU Supply Fan 2 Speed Control
	n/a	AHU Supply Fan Controller 1 Speed Output Controller 2
	n/a	AHU Supply Fan Controller 1 Speed Input Controller 2
	AHU/S/01_ PT01	AHU Common Supply Header Pressure No.1
	AHU/S/01_ PT02	AHU Common Supply Header Pressure No.2
	Shared Input (0-10Vdc)	AHU Common Supply Header Pressure No.3
		PLC Controller 1 CPU Sanity Control Output
		PLC Controller 2 CPU Sanity Control Input

AHU/S/01B- PLC Controller No.2

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/01B/ SF01	AHU_01B_ VSD01	AHU Supply Fan 1 Speed Control
AHU/S/01B/	AHU_01B_	AHU Supply Fan 2

SF02	VSD02	Speed Control
	n/a	AHU Supply Fan Controller 2 Speed Output Controller 1
	n/a	AHU Supply Fan Controller 1 Speed Input Controller 2
	Shared Input (0-10Vdc)	AHU Common Supply Header Pressure No.1
	Shared Input (0-10Vdc)	AHU Common Supply Header Pressure No.2
	AHU/S/01_ PT03	AHU Common Supply Header Pressure No.3
		PLC Controller 2 CPU Sanity Control Output
		PLC Controller 1 CPU Sanity Control Input

2.1.8 PLC Common AHU Supply Header Pressure Control

The AHU supply duct is connected to pressure relief duct, connected to an external roof cowl. The duct relief operates in two modes:

- AHU system fumigation high pressure.
- AHU normal operation high duct pressure.

AHU Fumigation Mode Control

The AHU supply volume will reduce when rooms are isolated during the fumigation sequence. If the supply volume reduces below the minimum operating speed of the AHU fans, the PLC will operate the AHU's at the minimum operating speed * and open the common supply pressure relief isolation damper (fast acting) whilst modulating, via a PID control loop, a supply pressure, pressure relief control damper (fast acting) to maintain the constant supply volume pressure set point.

The AHU 1A PLC controller will control the common pressure control damper and isolation damper.

*Note * The AHU fan motor minimum operating speeds will be determined during commissioning and fixed at the VSD inverter.*

The PLC uses the same triplicate monitoring arrangement of duct pressure sensors as used for normal supply fan speed control.

The BMS notifies the damper position mis-match alarm, if the PLC control output signal does not match the damper feedback position.

AHU Normal Operation High Pressure Protection

The PLC will control the supply duct pressure relief dampers to cap the main supply duct pressure at a maximum of [###Pa].*

Note. the maximum pressure set point is to be carefully determined during commissioning not to conflict with the PLC supply fan pressure control set point. (initial high limit cap to be 20% above normal set point. i.e if supply air pressure is 750Pa the high limit set point will be set at 900Pa)

The PLC will open the common supply pressure relief isolation damper (fast acting) whilst modulating, via a control loop, a supply pressure, pressure relief control damper (fast acting) to limit the AHU supply pressure

Common Supply Duct Pressure Relief Control – PLC Controller 1

Control and Instrument Ref	Point Descriptor
AHU_S_01_ ACD01	Supply Pressure Relief Control Damper
AHU_S_01_ ACD01	Supply Pressure Relief Control Damper FB Position
AHU_S_01_ FT02	Supply Pressure Relief Volume
AHU_S_01_ ACD02	Supply Pressure Relief Isolation Damper
AHU_S_01_ ACD02	Supply Pressure Relief Isolation Damper FB Position
Refer to Triplicate Duct Pressure Sensor on Fan Control	

2.1.9 PLC AHU Extract Fan Speed Control – No Room Fumigation

During normal operation the 2no. AHU extract fans operate in parallel at a prefixed VSD speed to attain a constant efflux (at 50% duty each) The PLC monitors the average AHU common, Extract air main header pressure sensors, as measured via 3 duct pressure sensors. * The PLC modulates, via PID loop, the operating AHU Extract fan VSD, speed control signal in parallel to maintain the pressure set point [###Pa].

The PLC extract fan uses the same Master/Slave controller arrangement as the supply fan control.

The PLC Controller speed reference control signal to each AHU VSD is also duplicated as a control signal to the 2nd AHU PLC Controller, so that

*Note * The Duct sensors are CMR manufactured P-Sensors each complete with dual channel 4-20mA / 0-10Vdc outputs. Two of the sensors are powered from PLC Controller 1 (AHU/01A) and the Third sensor powered from PLC Controller 2. The 2nd 0-10Vdc output channel from each sensor is shared to the other controller.*

A low / high static pressure alarm shall be notified at the BMS. (Refer to alarm schedule)

Note the PLC shall monitor the 3 pressure sensors and discard any single value that is [5%] out of range or failed because of open or short circuit signal.

The pressure is controlled by one of the 2 PLC controllers. If the lead PLC controller fails, the 2nd PLC controller will become the lead pressure controller.

AHU/E/01A – PLC Controller No.1

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/E/01A/ EF0 1	AHU_E_01A_ VSD01	AHU Extract Fan 1 Speed Control
	n/a	AHU Extract Fan Controller 1 Speed Output Controller 2
	n/a	AHU Extract Fan Controller 1 Speed Input

		Controller 2
	AHU/E/01_ PT01	AHU Common Extract Header Pressure No.1
	AHU/E/01_ PT02	AHU Common Extract Header Pressure No.2
	Shared Input (0-10Vdc)	AHU Common Extract Header Pressure No.3

AHU/E/01B – PLC Controller No.2

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/E/01B/ SF01	AHU_E_01B_ VSD01	AHU Extract Fan 1 Speed Control
	n/a	AHU Extract Fan Controller 2 Speed Output Controller 1
	n/a	AHU Extract Fan Controller 1 Speed Input Controller 2
	Shared Input (0-10Vdc)	AHU Common Extract Header Pressure No.1
	Shared Input (0-10Vdc)	AHU Common Extract Header Pressure No.2
	AHU/S/01_ PT03	AHU Common Extract Header Pressure No.3

2.1.10 PLC AHU Extract Fan Speed Control and Fresh Air Make Up Pressure Control – During Room Fumigation Sequence.

During the fumigation mode of risk spaces, the stack exhaust volume must maintain a constant volume to achieve a minimum safe efflux velocity. (10 m/s at the exhaust cone)

During the fumigation mode the AHU extract fans will operate at a fixed speed *(speed to be determined during commissioning)* and the PLC will control, via PID loop, the common fresh air inlet make up damper to maintain the duct pressure set point * and hence maintain a constant exhaust volume.

*Note *: The duct pressure set point will need to be checked during design review / commissioning to establish if the set point is the same during normal extract fan speed control and fumigation control ?*

The PLC monitors the common stack extract volume via an externally * mounted CMR airflow station (velo-probes) mounted in the extract stack. The PLC will use the measured volume to calculate the velocity at the cone section where there is a reduced outlet area and signal this value to the BMS. The BMS notifies an alarm if the efflux velocity is below a low threshold alarm limit.

*Note *: The extract volume CMR airflow transducer will be mounted inside the plantroom, at a location to be accessed for calibration. The external PVC tubing shall be protected via conduit from UV sunlight and provided internally with a condensate loop to prevent water entering the transmitter.*

The PLC uses the same triplicate monitoring arrangement of duct pressure sensors as used for normal extract fan speed control.

Prior to being able to control the fresh air make-up damper, the PLC will:

- Open the common fresh air make up damper isolation damper
- Open the respective extract AHU fresh air make up isolation damper, which allow the fresh air to enter the AHU after the AHU extract run around coil.

The PLC monitors that the damper actuator end switch, closed positions.

The BMS notifies the damper position mis-match alarm, if the PLC control output signal does not match the damper end switch position.

The BMS monitors the differential pressure across the fresh air make up filter, on the inlet to the AHU and notifies an alarm if the filter requires maintenance.

Common Fresh Air Make Up Duct – Proposed By PLC Controller 1

Control and Instrument Ref	Point Descriptor
AHU_EM_01_ ACD01	Extract System Fresh Air Make Up Control Damper
AHU_EM_01_ ACD01_ZT	Extract System Fresh Air Make Up Control Damper FB Position
AHU_MA_01_ FT01	Extract System Fresh Air Make Up Volume
AHU_EM_01_ ACD01	Extract System Fresh Air Make Up Isolation Damper
AHU_EMA_01_ ACD01_ZT	Extract System Fresh Air Make Up Isolation Damper FB Position
AHU_E_01_FT01	Total Extract Stack Volume
Refer to Triplicate Duct Pressure Sensor on Fan Control	

AHU/E/01A Extract Fresh Air Make Up

Control and Instrument Ref	Point Descriptor
AHU_EM_01A_ FXD01	AHU Extract Fresh Air Make Up Isolation Damper
AHU_EM_01A_ FXD01_ZSc	AHU Extract System Fresh Air Make Up Isolation Damper FB Closed Position
AHU_EM_01A_ DIF01	AHU Extract System Fresh Air Make Up Filter Differential Pressure

AHU/E/01B Extract Fresh Air Make Up

Control and Instrument Ref	Point Descriptor

AHU_EM_01B_ FXD01	AHU Extract Fresh Air Make Up Isolation Damper
AHU_EM_01B_ FXD01_ZSc	AHU Extract System Fresh Air Make Up Isolation Damper FB Closed Position
AHU_EM_01B_ DIF01	AHU Extract System Fresh Air Make Up Filter Differential Pressure

2.1.11 PLC Fan Monitoring and Fan Failure Monitoring

The PLC determines the running status of the fan using the differential pressure air flow switch and VSD run status.

- When a fan is commanded to start by the PLC, a pre-fixed timer is activated (proving period). If after the timer expires, the VSD run status and air flow switch does not indicate both run and air flow then the fan is deemed to have failed. The PLC will raise a fan failed signal and via a Modbus register, an alarm will be notified by the BMS.

- Having commanded a fan to start, the PLC continues to monitor the status of the air flow alarm, allowing for a transient time, to indicate that the fan is still operating. If after the timer expires, the air flow status does not indicate air flow then the fan is deemed to have failed. The PLC will raise a fan failed signal and via a Modbus register, an alarm will be notified by the BMS.

- The PLC monitors the VSD common fault status (VSD locked out – motor is not available). In the event of an alarm, the respective fan is instantly deemed to have failed; and via the Modbus register the BMS notifies a VSD fault alarm.

- The PLC monitors the VSD Local / Remote status via Modbus and via the Modbus register the BMS notifies an alarm If the VSD is operated in local (hand mode).

- The PLC monitors the control panel Test/Off/Auto switch and via the Modbus register the BMS notifies an alarm if the switch is not in Auto.

- The PLC monitors the common AHU supply airflow volume, using CMR volume sensor and velo-probes mounted in the duct.

- The PLC monitors the common AHU extract airflow volume, from the risk space, using a CMR volume sensor and velo-probes mounted in the duct.

- The PLC monitors the common stack extract airflow volume, using a CMR volume sensor and velo-probes mounted in the duct. Via a Modbus register the BMS notifies an efflux velocity alarm if the velocity is below the low limit threshold.

- The PLC monitors the AHU fan VSD via Modbus RTU (See Modbus register table)

AHU/S/01A

Plant Ref	Control and Instrument Ref	Point Descriptor
SF01	AHU_S_01A_ SF01_VSD01	AHU Supply Fan 1 VSD Enable
SF01	n/a	AHU Supply Fan 1 VSD Fault Status
SF01	n/a	AHU Supply Fan 1 VSD Run Status
SF01	n/a	AHU Supply Fan 1 VSD Local/Remote Status
SF01	AHU_S_01A_ SF01_PDS01	AHU Supply Fan 1 Differential Pressure Switch (Flow) Status
SF02	AHU_S_01A_ SF01_VSD01	AHU Supply Fan 2 VSD Enable
SF02	n/a	AHU Supply Fan 2 VSD Fault Status
SF02	n/a	AHU Supply Fan 2 VSD Run Status
SF02	n/a	AHU Supply Fan 2 VSD Local/Remote Status
SF02	AHU_S_01A_ SF01_PDS01	AHU Supply Fan 2 Differential Pressure Switch (Flow) Status

AHU/S/01B

Plant Ref	Control and Instrument Ref	Point Descriptor
SF01	AHU_S_01B_ SF01_VSD01	AHU Supply Fan 1 VSD Enable
SF01	n/a	AHU Supply Fan 1 VSD Fault Status
SF01	n/a	AHU Supply Fan 1 VSD Run Status
SF01	n/a	AHU Supply Fan 1 VSD Local/Remote Status
SF01	AHU_S_01B_ SF01_PDS01	AHU Supply Fan 1 Differential Pressure Switch (Flow) Status
SF02	AHU_S_01B_ SF01_VSD01	AHU Supply Fan 2 VSD Enable
SF02	n/a	AHU Supply Fan 2 VSD Fault Status
SF02	n/a	AHU Supply Fan 2 VSD Run Status
SF02	n/a	AHU Supply Fan 2 VSD Local/Remote Status
SF02	AHU_S_01B_ SF01_PDS01	AHU Supply Fan 2 Differential Pressure Switch (Flow) Status

AHU/E/01A

Plant Ref	Control and Instrument Ref	Point Descriptor
EF01	AHU_E_01A_ EF01_VSD01	AHU Extract Fan VSD Enable
	n/a	AHU Extract Fan VSD Fault Status
	n/a	AHU Extract Fan VSD Run Status
	n/a	AHU Extract Fan VSD Local/Remote Status
	AHU_E_01A_ EF01_PDS01	AHU Extract Fan Differential Pressure Switch (Flow) Status

The BMS monitors the AHU Fan VSD Modbus Registers

VSD Monitoring Parameter	VSD Modbus Register	BMS Point Descriptor
		AHU Fan Local Remote Status
		AHU Fan Fault Code
		Power Consumption kW
		Frequency Hz Feedback
		Amperes Current

2.1.12 BMS AHU Cooling Coil & Heating Coil Temperature Control

Refer to the BMS 1st stage heating / cooling mode via the operation of the AHU RAC coil pump.

2nd Stage Heating / Cooling Mode

- The BMS monitors the AHU supply air temperature * and modulates***, via a PID control loop, the AHU heating coil control valve ** and cooling coil control valve ** in sequence to maintain the supply air temperature set point.

*Note * The supply air temperature transmitter is combined with a relative humidity transmitter (See BMS AHU humidity control section)*

*** The 2 port control valves and associated actuators are pressure independent control valves (PICV)*

**** The BMS controls the AHU cooling coil control valve signal according to the highest demand from the dehumidify or AHU supply air temperature cooling mode control loop. Refer to BMS AHU Humidity Monitoring and Control Section.*

When operating to dehumidify the air the AHU heating coil shall remain operational under the supply air temperature control loop in order to provide reheat when necessary.

- The BMS automatically schedules the AHU supply air temperature between a minimum [12] deg C and maximum [22] deg C depending on maximum cooling load requirements from any of the rooms.

Note review design and specification which indicates a control maximum of 30 deg c, which is too warm.

- The BMS monitors the performance of the cooling and heating coil by measuring the on and off coil air temperatures.

- The BMS monitors the cooling coil performance by measuring the off coil, air humidity. The humidity transmitter is combined with the temperature transmitter.
- The BMS monitors the control valve actuator feedback and notifies an alarm if the valve control signal does not match the feedback signal within 5% allowing for a suitable transient time for the actuator motor to operate.
- The BMS notifies a valve exercise. The BMS operator can overide the BMS automatic control and manually signal the valve 0 to 100 to 0% open and then release back to automatic via the BMS graphic.
- A low and high AHU supply air temperature alarm shall be notified at the BMS.

AHU/S/01A

Plant Ref	Control and Instrument Ref	Point Descriptor
	AHU_S_01A_ TEM04	*Note * The On-cooling coil air temperature is the Off RAC coil air temperature.* *See RAC coil section*
AHU/S/01A/ CC01	AHU_S_01A_ ACV01	AHU Cooling Coil Valve Control
		AHU Cooling Coil Valve Control Feedback Position
	AHU_S_01A_ TEM05 MOI01	AHU Off Cooling Coil Temperature
		AHU Off Cooling Coil Humidity
AHU01/ HC01	AHU_S_01A_ ACV01	Heating Coil Valve Control
		AHU Heating Coil Valve Control Feedback Position
	AHU_S_01A_ TEM05	AHU Off Heating Coil Temperature
n/a	AHU_S_01A_ TEM07 MOI02	AHU Supply Air Temperature
		AHU Supply Air Humidity

AHU/S/01B

Plant Ref	Control and Instrument Ref	Point Descriptor
	AHU_S_01B_	*Note * The On-cooling coil air*

	TEM04	*temperature is the Off RAC coil air temperature.* *See RAC coil section*
AHU/S/01A/ CC01	AHU_S_01B_ ACV02	AHU Cooling Coil Valve Control
		AHU Cooling Coil Valve Control Feedback Position
	AHU_S_01B_ TEM05 MOI01	AHU Off Cooling Coil Temperature
		AHU Off Cooling Coil Humidity
AHU/S/01A/ HC01	AHU_S_01B_ ACV03	Heating Coil Valve Control
		AHU Heating Coil Valve Control Feedback Position
	AHU_S_01B_ TEM06	AHU Off Heating Coil Temperature
n/a	AHU_S_01B_ TEM07 MOI02	AHU Supply Air Temperature
		AHU Supply Air Humidity

2.1.13 BMS AHU Humidity Control and Monitoring

- The BMS monitors the Clean Corridor extract relative humidity * and resets the individual AHU supply air moisture content set point between a minimum [1g/kg] and [11g/kg] to maintain the Clean Corridor extract relative humidity at set point [55%RH] +/- [15%RH]. The AHU supply air moisture content set point is initially set at [7 g/kg]

*Note * The Clean Corridor relative humidity measurements derive from the local BMS monitoring and control panels associated with the Clean Corridor. Refer to P800-SCH-92-ZZ-SP-XX-014 for further details of local HVAC BMS monitoring and control.*

If the Clean Corridor is in fumigation mode or the room extract RH sensor has failed, (open circuit or short circuit = 0mA) the BMS will set the AHU at the last known supply air set point value. (Extract RH Sensor failure is notified by the respective BMS control panel)

- The BMS modulates, via a PID control loop, the AHU cooling coil control valve and humidifier steam control valve, in sequence to maintain the calculated AHU supply air moisture content set point.

- The BMS controls the AHU cooling coil control valve signal according to the highest demand from the dehumidify or AHU supply air temperature cooling mode control loop. The

BMS graphic shall indicate the control mode of the AHU cooling valve – i.e. temp control or dehum control.

*Note: * When operating to dehumidify the air the AHU heating coil shall remain operational under the supply air temperature control loop in order to provide reheat when necessary.*

Clean Corridor Design Performance:
Room humidity Minimum 40%RH, Maximum 70%RH

- The BMS monitors a dedicated, automatic reset, AHU supply air high limit humidistat which provides hardwired protection to shut the steam humidifier control valve. (hardwired spring close under power failure). (High limit humidistat set manually set at 90%RH)

An AHU high limit supply air humidity alarm shall be notified at the BMS.

BMS Animal Room Relative Humidity Monitoring

BMS Panel Ref	Control and Instrument Ref	Point Descriptor
AHU01_ BMP02	F2_MOI## ~~F1OC01_EMTEM01~~	Suite 1 Animal Room Extract Humidity

AHU/S/01A

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/01A /HUM01	AHU_S_01A_ ACV04	AHU Humidifier Valve Control
		AHU Humidifier Valve Control Feedback Position
AHU/S/01A /CC01	AHU_S_01A_ ACV02	AHU Cooling Coil Valve Control
		AHU Cooling Coil Valve Control Feedback Position
n/a	AHU_S_01A_TEM07 MOI01	AHU Supply Air Humidity
		AHU Supply Air Temperature
	AHU_S_01A_ MSH01	AHU Supply Air Humidity High Limit Humidistat

AHU/S/01B

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/01B /HUM01	AHU_S_0BA_ ACV04	AHU Humidifier Valve Control
		AHU Humidifier Valve Control Feedback Position
AHU/S/01B /CC01	AHU_S_01BA_ ACV02	AHU Cooling Coil Valve Control
		AHU Cooling Coil Valve Control Feedback Position
n/a	AHU_S_01B_TEM07 MOI01	AHU Supply Air Humidity
		AHU Supply Air Temperature
	AHU_S_01B_ MSH01	AHU Supply Air Humidity High Limit Humidistat

2.1.14 BMS AHU Filter Monitoring

AHU Filters

The BMS monitors the filter condition of the AHU insect filter, primary bag and secondary bag filters using differential pressure sensors located across each bank of filters.

The BMS notifies a filter maintenance alarm if the differential pressure exceeds the filter dirty condition.

AHU Mounted Magnahelic gauges provide local indication of the actual filter differential pressure.

Refer to P800-SCH-92-ZZ-SP-XX-014 for further details of local HVAC BMS and PLC monitoring of the Krantz supply and extract HEPA filters.

AHU/S/01A and AHU/E/01A

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/1A/##	AHU/S/01A_ DIF01	AHU Insect Screen Filter
AHU/S/1A/##	AHU/S/01A_ DIF02	AHU Primary Bag Filter F7
AHU/S/1A/##	AHU/S/01A_ DIF03	AHU Secondary Bag Filter F7
AHU/E/1A/##	AHU/E/01A_ DIF01	AHU Extract Fresh Air Inlet Filter G4

AHU/S/01B and AHU/E/01B

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/1B/##	AHU/S/01B_ DIF01	AHU Insect Screen Filter
AHU/S/1B/##	AHU/S/01B_ DIF02	AHU Primary Bag Filter F7
AHU/S/1B/##	AHU/S/01B_ DIF03	AHU Secondary Bag Filter F7
AHU/E/1B/##	AHU/E/01B_ DIF01	AHU Extract Fresh Air Inlet Filter G4

2.1.15 Power Failure and Power Return Control

The HVAC system AHU/01 including BMS and PLC monitoring and control panels are supported by the Brooksby building DRUPs essential power electrical distribution system. Refer to the electrical distribution design schematic. As such there is seamless transition of power from normal mains power failure to mains supplied by the DRUPS power generation.

Should the DRUPs power supply fail to the BMS / PLC AHU control panel the respective AHU supply and extract components will function as follows:

Supply AHU BMS Equipment

- Fresh air isolation damper actuator – Remain last position.
- LTHW frost heating coil valve actuator – Remain last position.
- Heat recovery coil pump – Off
- CHW cooling coil valve actuator - Remain last position.
- LTHW heating coil valve actuator - Remain last position.
- Steam humidifier valve actuator – Closed Spring Return)
- Supply fan 1 with variable speed drive – Off
- Supply fan 1 non return dampers - Close
- Supply fan 2 with variable speed drive – Off
- Supply fan 2 non return dampers - Close
- Discharge isolation damper actuator - Remain last position.

Extract AHU BMS Equipment

- Inlet air isolation damper actuator - Remain last position.
- Fresh air inlet isolation damper actuator – Remain last position
- Extract fan with variable speed drive - Off
- Discharge isolation damper actuator - Closed

Return To Power

There is no load shedding of the high containment HVAC system 01 plant.

Following a return to mains electrical power; the BMS/PLC will, following the time out of the delay timer [10s] * automatically 'start up' the HVAC system, subject to the satisfaction and sequencing of start-up conditions and signals.

Note: The power return delay timers will be adjusted during commissioning to suit the capability of the electrical LV power supply. i.e Staggered start to limit the starting current of the building electrical load.

2.1.15 Fire Alarm Control

The PLC monitors the status of the HVAC fire alarm signal derived from an addressable digital relay, located adjacent the AHU BMS/PLC control panel. The fire alarm relay is connected to the fire alarm network.

In the event that the Fire alarm is in 'alarm' the HVAC plant shall continue to operate. The BMS notifies a fire alarm to the BMS system.

2.1.16 Fireman's Override Control

There is no hardwired fireman's override of the HVAC plant.

Operation of the AHU01 HVAC System 01, is managed as required by the Pirbright Operator, via the BMS PC workstation graphic.

2.1.17 Fire Dampers

There are no drop leaf or motorised smoke dampers on the AHU01 HVAC system and as such there is no BMS / PLC monitoring of fire or smoke dampers.

2.1.18 PLC RTK Remote Alarm System Interface

Each PLC notifies, via a digital output signal, a respective plant failure alarm to the Brooksby building RTK alarm system if AHU/1A or AHU1B supply or extract AHU fails.

Refer to RTK Functional Alarm System Description:
P800-SCH-92-ZZ-SP-XX-0008

2.1.19 BMS Controller Communication Alarms

The BMS provides a controller critical network alarm if the BMS controller fails to communicate to the BMS network. In the event of network failure each controller shall continue to operate in it's last known operating state.

The BMS provides a controller critical network alarm if the respective BMS PLC controller fails to communicate to the BMS network. In the event of network failure each controller shall continue to operate in it's last known operating state.

3.0 Document Hold Register

Outstanding Info / Hold Number	Description	Outstanding Information	Outcome
1	Specification refers to both single and twin extract fan on the AHU. Only a single fan is provided.	Confirm AHU extract is single fan RFI	
2	AHU common supply pressure relief duct external control damper details and isolation damper details	Confirm external damper design details RFI	
3	AHU common extract fresh air make-up duct external control damper details and isolation damper details.	Confirm external damper design details RFI	
4	AHU extract fresh air make up filter	Confirm if this is required RFI	
5	BMS and PLC Asset Tags will be updated on the document as agreed with the Project Team	Confirm BMS Asset Register	

Appendix 1 BMS and PLC Alarm Schedule

BMS and PLC alarm template and lists to be agreed with The Pirbright Institute team and adhere to the BMS alarm management configuration guidelines detailed in the P800-SCH-92-ZZ-SP-XX-0001

*Note * Alarm inhibit timers to be adjusted during commissioning to suit start up sequence attaining normal control.*

- P800-AHU-01A-ACP01
- P800-AHU-01B-ACP01

PLC Initiated * Alarm To The BMS Digital Alarm Schedule

*Note *: PLC alarms required for PLC software functional control requirements will be initiated at the PLC controller and replicated to the BMS.*

AHU/01A Supply and Extract Air Handling Unit
P800-AHU-01A-ACP01

Description	PLC Object Name	Alarm Priority	Alarm Value	Alarm Transient Time *	Initial Alarm Inhibit *	Comment
AHU Fresh Air Damper Failure Alarm	{tag name}	1	Normal / Alarm	180s	0s	Damper Control Mis-Match Position Alarm
AHU Freeze Protection Thermostat	{tag name}	1	Normal / Alarm	5s	0s	Manually Set at 1 Deg C Thermostat already has latched relay timer [0-10minutes]
AHU Supply Fan 1 Not In Auto Alarm	{tag name}	1	Normal / Alarm	0S	0s	Panel Test/Off/Auto Switch Alarm
AHU Supply Fan 1 VSD In Local Alarm	{tag name}	1	Normal / Alarm	0S	0s	Fan VSD Modbus Signal Alarm
AHU Supply Fan 1 Failed Status	{tag name}	1	Normal / Alarm	20S	0s	Fan VSD Run and Flow Mismatch Alarm
AHU Supply Fan 1 VSD Fault / Trip Status	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Trip Alarm
AHU Supply Fan 1 VSD	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Modbus Alarm VSD

Hours Run						
AHU Supply Fan 2 Not In Auto Alarm	{tag name}	1	Normal / Alarm	0S	0s	Panel Test/Off/Auto Switch Alarm
AHU Supply Fan 2 VSD In Local Alarm	{tag name}	1	Normal / Alarm	0S	0s	Fan VSD Modbus Signal Alarm
AHU Supply Fan 2 Failed Status	{tag name}	1	Normal / Alarm	20S	0s	Fan VSD Run and Flow Mismatch Alarm
AHU Supply Fan 2 VSD Fault / Trip Status	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Trip Alarm
AHU Supply Fan 2 VSD Hours Run	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Modbus Alarm VSD
AHU Discharge Air Damper Failure Alarm	{tag name}	1	Normal / Alarm	180s	0s	Damper Control Mis-Match Position Alarm
FEF Extract Fan 1A Failed Status	{tag name}	1	Normal / Alarm	20S	0s	Fan Flow Mismatch Alarm
AHU Extract Inlet Air Damper Failure Alarm	{tag name}	1	Normal / Alarm	180s	0s	Damper Control Mis-Match Position Alarm
AHU Extract Fresh Air Inlet Damper Failure Alarm	{tag name}	1	Normal / Alarm	180s	0s	Damper Control Mis-Match Position Alarm
Extract Discharge Air Damper Failure Alarm	{tag name}	1	Normal / Alarm	180s	0s	
AHU Extract Fan Not In Auto Alarm	{tag name}	1	Normal / Alarm	0S	0s	Panel Test/Off/Auto Switch Alarm
AHU Extract Fan VSD In Local Alarm	{tag name}	1	Normal / Alarm	0S	0s	Fan VSD Modbus Signal Alarm

AHU Extract Fan Failed Status	{tag name}	1	Normal / Alarm	20S	0s	Fan VSD Run and Flow Mismatch Alarm
AHU Extract Fan VSD Fault / Trip Status	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Trip Alarm
AHU Extract Fan VSD Hours Run	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Modbus Alarm VSD

BMS Initiated Alarm To The BMS Digital Alarm Schedule

AHU/01A Supply and Extract Air Handling Unit
P800-AHU-01A-ACP01

Description	BMS Object Name	Alarm Priority	Alarm Value	Alarm Transient Time *	Initial Alarm Inhibit *	Comment
AHU Frost Coil 1 Control Valve Failure Alarm	{tag name}	3	Normal / Alarm	60s	0s	Valve Control Mis-Match Position Alarm
AHU RAC Coil Pump Fail	{tag name}	3	Normal / Alarm	30s	0s	Pump Control Mis-Match Status Alarm
AHU RAC Coil Low Pressure Alarm	{tag name}	3	Normal / Alarm	30s	0s	Low Pressure Switch Status Alarm
AHU CHW Coil Control Valve Failure Alarm	{tag name}	3	Normal / Alarm	60s	0s	Valve Control Mis-Match Position Alarm
AHU LTHW Coil Control Valve Failure Alarm	{tag name}	3	Normal / Alarm	60s	0s	Valve Control Mis-Match Position Alarm
AHU Steam Humidifier Control Valve Failure Alarm	{tag name}	3	Normal / Alarm	60s	0s	Valve Control Mis-Match Position Alarm
AHU Supply Air Humidistat Alarm	{tag name}	1	Normal / Alarm	180s	0s	Humidistat Hardwired To Steam Control Valve

AHU/01B Supply and Extract Air Handling Unit

Repeat as for AHU 01A PLC and BMS alarms

PLC Initiated * Alarm To The BMS Analogue Alarm Schedule

*Note *: PLC alarms required for PLC software functional control requirements will be initiated at the PLC controller and replicated to the BMS.*

AHU/01A Supply and Extract Air Handling Unit
P800-AHU-01A-ACP01

Description	BMS Alias Address	Alarm Priority	Alarm Value	Alarm Transient Time *	Initial Alarm Inhibit *	Comment
AHU Insect Screen Filter Differential Pressure	{tag name}	5	High 300 Pa	300s	0	Maintenance
AHU Frost Coil LTHW Return Temperature	{tag name}	1	Low 1 Deg C	300s	0	Critical Action (Will Shutdown AHU)
AHU Frost Coil LTHW Return Temperature	{tag name}	1	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Off Frost Coil Average Air Temperature	{tag name}	3	Low 3 Deg C	300s	0	Warning Alert
AHU Off Frost Coil Average Air Temperature	{tag name}	1	Low 1 Deg C	300s	0	Critical Action (Will Shutdown AHU)
AHU Off Frost Coil Average Air Temperature	{tag name}	1	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Pre Filter Differential Pressure	{tag name}	3	High ### Pa	300s	0	Maintenance
AHU Pre Filter Differential Pressure	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Sec. Filter Differential	{tag name}	3	High ### Pa	300s	0	Maintenance

Pressure						
AHU Sec. Filter Differential Pressure	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Supply Average Air Temperature	{tag name}	3	Low 12 Deg C	300s	600s	Warning / Alert
AHU Supply Average Air Temperature	{tag name}	3	High 28 Deg C	300s	600s	Warning / Alert
AHU Supply Air Temperature	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Supply Air Humidity	{tag name}	3	Low 12 Deg C	300s	600s	Warning / Alert
AHU Supply Air Humidity	{tag name}	3	High 28 Deg C	300s	600s	Warning / Alert
AHU Supply Air Humidity	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Air Volume	{tag name}	3	Low ####l/s	30s	600s	Warning / Alert
AHU Common Supply Air Volume	{tag name}	3	High #### l/s	30s	600s	Warning / Alert
AHU Common Supply Air Volume	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Average Calculated Air Pressure	{tag name}	3	Low ##Pa	60s	600s	Warning / Alert
AHU Common Supply Average Calculated Air Pressure	{tag name}	3	High ##Pa	60s	600s	Warning / Alert

AHU Common Supply Air Pressure Sensor 1	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Air Pressure Sensor 2	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Air Pressure Sensor 3	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Air Pressure Mismatch	{tag name}	1	5 % Difference	30s	0	Triplicate Sensors Mismatch
AHU Common Supply Average Air Temperature	{tag name}	3	Low 12 Deg C	300s	600s	Warning / Alert
AHU Common Supply Average Air Temperature	{tag name}	3	High 28 Deg C	300s	600s	Warning / Alert
AHU Common Supply Air Temperature	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Air Humidity	{tag name}	3	Low ## g/kg	300s	600s	Warning / Alert
AHU Common Supply Air Humidity	{tag name}	3	High ##g/kg	300s	600s	Warning / Alert
AHU Common Supply Air Humidity	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
Extract Stack Average Air Velocity	{tag name}	3	Low ##m/s	60s	600s	Warning / Alert
Extract Stack Average Air Velocity	{tag name}	3	High ##m/s	60s	600s	Warning / Alert

Extract Stack Air Velocity	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
Common Extract Air Pressure	{tag name}	3	Low ##Pa	60s	600s	Warning / Alert
Common Extract Air Pressure	{tag name}	3	High ##Pa	60s	600s	Warning / Alert
Common Extract Air Pressure Sensor 1	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
Common Extract Air Pressure Sensor 2	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
Common Extract Air Pressure Sensor 3	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
Common Extract Air Pressure Mismatch	{tag name}	1	5 % Difference	30s	0	Triplicate Sensors Mismatch
Fume Extract Fresh Air Make Up Volume	{tag name}	3	Low ### L/S	30s	0	
Fume Extract Fresh Air Make Up Volume	{tag name}	3	High ### L/S	30s	0	
Fume Extract Fresh Air Make Up Volume	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Extract Fresh Air Inlet Filter Differential	{tag name}	3	High ### Pa	300s	0	Maintenance

Pressure						
AHU Extract Fresh Air Inlet Filter Differential Pressure	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)

Appendix 2 BMS and PLC Set Point Schedule

The BMS User Adjustable Control Set Point Schedules will be developed during the detailed software design and added to this section as required.

AHU1A_ACP01 BMS Set Point Schedule
AHU1B_ACP01 BMS Set Point Schedule

Set Point Description	BMS OBJECT NAME	Set Point *	Set Point Control Tolerance	Comment
AHU Off Frost Coil Air Temperature Control Set Point	[tag name]	5 deg C	MIN 2 deg C	
AHU Off Frost Coil Air Cold Start UP Temperature Control Set Point	[tag name]	20 deg C	MIN 2 deg C	
AHU Supply Air Temperature Control Set Point	[tag name]	Calculated ## deg C	+/- 2 deg C	Calculated between min. and max. according to local room load / demand
AHU Supply Air Humidity Control Set Point	[tag name]	Calculated 7 g/kg	+/- # g/kg	Calculated between min. 1g/kg and 11g/kg max. according to local room %RH load / demand. See local room BMS control description
AHU Common Supply Air Fan Pressure	[tag name]	### Pa	(+/- 5%)	
AHU Common Supply Air Relief Pressure	[tag name]	### Pa	(+/- 5%)	
AHU Common Extract Air Pressure	[tag name]	## Pa	(+/- 5%)	
Extract Stack Efflux Velocity	[tag name]	10.0 m/s	(+/- 5%)	Minimum 10 m/s
Others Set Points To Be Added As Required				

AHU 2 A/B Functional Design Specification

FOR

Brooksby Building P800

BMS and PLC
Automatic Control Panels
P800_AHU02A_ACP01
P800_AHU02B_ACP01

The Pirbright Institute - Pirbright

Prepared by: _____ _____

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DOCUMENT REVISION HISTORY

The Sequence of Operations becomes effective on the date of final approval. If changes are made that affect the document's content or approach, a revised, complete document must be issued for re-approval by the approvers of the original document or their designated representatives. A description of those changes with revision number will be noted in the revision log below.

Document naming and version will adhere to the project BIM execution plan naming convention.

Document Version	Status	Description	Revised by	Date Last Modified
P01	S3	Document issued for Project Team Review and Comment.	David Jackson	22 Apr 20
P02	S3	Document Title Update	CM	03/06/20

Documents Note:

1) The equipment tags in this document will be updated in line with the High Level BMS Design Document P800-SCH-92-ZZSP-XX-0001

2) The BMS and PLC alarm schedule will be updated in collaboration with the Pirbright Institute and Team Pirbright and subject to commissioning.

3) The BMS and PLC set point schedule will be updated in collaboration with the Pirbright Institute and Team Pirbright and updated during commissioning

4) The document will be updated during the life cycle of the project and will be an O&M reference document

CONTENTS

SECTION 1 – HVAC AIR HANDLING SYSTEM 02

Overview of This Document

This document defines:

- General description of the system
- Reference to schematics
- Monitoring and control description of how the PLC and BMS HVAC applications will operate.
- Reference to PLC and BMS Alarm schedules
- Reference to PLC and BMS Set points schedules

1.0 SYSTEM DESCRIPTION INTRODUCTION

This document describes the BMS / PLC * automation system functional description of operations for the HVAC air handling units serving the HVAC System 002, which are connected to the following combined BMS and PLC controller control panels:

- AHU02A-ACP01
- AHU02B-ACP01

The 1st Section 1 provides the reader with an overview of the system description, 2nd Section 2 provides a detailed description of the BMS and PLC description of operation and is the basis of the PLC and BMS software program.

*Important Note *:*

- *The AHU supply and extract airflow, volume and pressure monitoring, and control components of the design are connected to the PLC controllers.*

- *The AHU supply and extract temperature and humidity monitoring, and control components of the design are connected to the BMS controllers.*

- *The BMS controller monitors the all of the PLC interface I/O points via Modbus IP integration which is available for the User supervision via the BMS workstation and Schneider Electric Enterprise Building Operator (EBO) BMS Software, which will after project completion be connected to the Pirbright Institute site BMS EBO central tiered server; allowing full sitewide remote monitoring of the Brooksby plant connected to the BMS.*

All BMS I/O points and set points including those monitored on the PLC system will be supervised by the BMS graphics and alarms notified as configured by the BMS alarm system.

The AHU system 02 provides supply and extract air serving the HEPA deck environmental and containment HVAC services for the Animal Holding Suite 1 to 6.

Refer to the separate functional description of operations Ref. P800-SCH-92-ZZ-SP-XX-0012 for the local HEPA deck HVAC systems serving the Animal Holding Suite rooms on the F1, ground floor area.

Refer to Ventilation System schematics:

- ~~P800-ACM-57-XX-DR-ME-0001_Mechanical Services - Ventilation System Schematic – Sheet 1~~
- P800-ACM-57-XX-DR-ME-0002_Mechanical Services - Ventilation System Schematic - Sheet 2
- P800-ACM-57-XX-DR-ME-0003_Mechanical Services - Ventilation System Schematic - Sheet 3
- ~~P800-ACM-57-XX-DR-ME-0004_Mechanical Services - Ventilation System Schematic - Sheet 4~~

Refer to PLC + BMS input / output point schedules:

- P800-SCH-92-ZZ-SH-XX-7013 ACP AHU2A-Points schedules
- P800-SCH-92-ZZ-SH-XX-7014 ACP AHU2B-Points schedules

The HVAC system 02 plant is served by two, full fresh air, air handling supply units and two respective extract units. Each air handling supply and extract unit is sized at 100% of the system total duty, thereby providing plant redundancy if one unit is not available. Under normal operating times the system operates 24/7.

- AHU/S/02A supply and associated AHU/E/02A extract
- AHU/S/02B supply and associated AHU/E/02B extract

System 02 serves the following rooms which require high containment and environmental monitoring and controls:

<u>Ground Floor</u>

Room Reference	Room Description
F1CC01	Dirty Corridor
F1AR01	Suite 1 Animal Holding Room
F1SG01	Suite 1 Storage Room

F1AP01	Suite 1 Procedure Room
F1CS01	Suite 1 Chemical Shower
F1PP01	Suite 1 & 2 PPE Changing Room
F1AR02	Suite 2 Animal Holding Room
F1SG02	Suite 2 Storage Room
F1AP02	Suite 2 Procedure Room
F1CS02	Suite 2 Chemical Shower
F1AR03	Suite 3 Animal Holding Room
F1SG03	Suite 3 Storage Room
F1AP03	Suite 3 Procedure Room
F1CS03	Suite 3 Chemical Shower
F1PP03	Suite 3 PPE Changing Room
F1AR04	Suite 4 Animal Holding Room
F1SG04	Suite 4 Storage Room
F1AP04	Suite 4 Procedure Room
F1CS04	Suite 4 Chemical Shower
F1PP04	Suite 4 & 5 PPE Changing Room
F1AR05	Suite 5 Animal Holding Room
F1SG05	Suite 5 Storage Room
F1AP05	Suite 5 Procedure Room
F1CS05	Suite 5 Chemical Shower
F1AR06	Suite 6 Animal Holding Room
F1SG06	Suite 6 Storage Room
F1AP06	Suite 6 Procedure Room
F1CS06	Suite 6 Chemical Shower
F1PP06	Suite 6 PPE Changing Room

Each Supply AHU comprises:

AHU Equipment	BMS Controller Interface	PLC Controller Interface
Manual Isolation Damper	N/A	N/A
Fly Screen Filter	Yes	
Fresh air isolation damper (motorised)		Yes
LTHW heating coil (freeze protection)	Yes	
Pre filter	Yes	
Attenuator section	N/A	N/A

Heat recovery coil and single pump (RAC energy recovery)	Yes	
CHW cooling coil	Yes	
LTHW heating coil	Yes	
Steam humidifier	Yes	
Twin Supply fan section each with variable speed drive and non-return dampers		Yes
Secondary filter	Yes	
Attenuator	N/A	N/A
Discharge isolation damper (motorised)		Yes
Manual Isolation Damper	N/A	N/A

Each Extract AHU comprises:

AHU Equipment	BMS Controller Interface	PLC Controller Interface
Extract air isolation damper (motorised)		Yes
Heat recovery coil and single pump (RAC energy recovery)	Yes	
Fresh air make-up * isolation damper (motorised)		Yes
Fresh air make-up inlet filter	Yes	
Single Extract fan section with variable speed drive and non-return dampers		Yes
Attenuator	N/A	N/A
Discharge isolation damper (motorised)		Yes
Non-Return Damper		

*Note * The two extract AHU's share a single fresh air make-up airflow duct, which is required during the fumigation to maintain a minimum exhaust stack efflux velocity.*

The Common Fresh Air Make Up Duct to the Extract AHU's comprises:

Equipment	BMS Controller Interface	PLC Controller Interface
Extract Fresh air make-up isolation damper (motorised)		Yes
Extract Fresh air make-up		Yes

control damper (motorised)		
Extract Fresh air make-up airflow station		Yes

The two AHU supply twin * fan sections normally operate in parallel (Each AHU at 50% system capacity) to maintain constant static pressure in the common supply duct header.

*Note * Whilst each AHU is capable of delivering 100% of the design volume, the twin fan section fans are each capable of 50%. i.e if one of the AHU twin fans was not available, that AHU can only deliver a maximum of 50% of the design.*

The two AHU extract fans normally operate in parallel (normally at 50% system, capacity) to maintain constant static pressure in the common extract duct header. Under normal * operation a minimum exhaust stack efflux velocity (10.0 m/s) should be achieved.

A common AHU supply, pressure relief duct with a variable flow, motorised control damper, provides the ability to maintain the minimum design speed of the AHU supply fan motors, when the turn down volume load, during the fumigation sequence, is lower than the minimum volume that the AHU supply fans can effectively operate. Excess AHU supply volume/pressure will bypass to outside via an external, roof mounted duct cowl. A second isolation damper is provided in the ductwork to provide tight shutoff. The control damper operates to maintain the maximum duct pressure, when the AHU fans are at minimum speed. Both the control damper and isolation damper are externally mounted and accessed from the roof.

A common AHU fresh air-make up duct with a variable flow, motorised control damper, provides the ability to maintain the minimum extract efflux velocity, when the turn down volume load, during the fumigation sequence, is lower than the minimum volume necessary to maintain the efflux velocity. The make-up volume will derive from an external, roof mounted duct cowl. In this fumigation mode; the control damper operates to maintain the common extract duct pressure. Both the control damper and isolation damper are externally mounted and accessed from the roof.

Each supply AHU operates independently to maintain:

- Freeze protection control
- Energy recovery control
- Supply air temperature control
- Supply air humidity control / protection

Refer to the AHU system 02 local HVAC function description of operation to the BMS/PLC monitoring and control of the local LTHW reheat coils, terminal supply and extract HEPA filters, motorised CAV / VAV dampers and manual fumigation isolation dampers:

- P800-SCH-92-ZZ-SP-XX-0015 Air system 2 local controls Functional design spec

Refer to the secondary monitoring system (SMS) functional description of operation of the independent room pressure monitoring system:

- P800-SCH-92-ZZ-XX-0010 SMS Functional Design Spec

1.1 AHU Motor Control Panel LV Electrical Power Distribution

Each AHU derives electrical power supply from different mechanical services electrical LV panels (MSP's) which in turn derive power from separate LV switchboards (SB's).

- AHU/S/02A * and AHU/E/2A derive power from 50-MSP-01-A
  - 50-MSP-01-A derives power from 50-SB-04-A

- AHU/S/02B * and AHU/E/2B derive power from 50-MSP-01-B
  - 50-MSP-01-A derives power from 50-SB-05-B

*Note * The AHU twin fan section electrical power supply derives from a common fused breaker at the MSP and then is further distributed via a dedicated AHU sub-main fuse board to feed each supply fan VSD and motor.*

The main LV switchboards and mechanical services panels (MSP) are supported by an essential diesel rotary uninterruptible power supply (DRUPS)

The main LV MSP panels are in the F3 plant room and constructed to Form 4, type 6.

Small power to the AHU's lighting / RAC coil pump / BMS/PLC control panel derive from a mechanical plant distribution boards, fed from the respective mechanical services panel.

The BMS monitors the status (Off, Open and Tripped) of the electrical power moulded case circuit breakers (MCCB) to each power feed.

The site wide, aM&T metering system, Power Monitoring Expert (PME) monitors the power meters Refer to LV monitoring Functional Design Spec:

- P800-SCH-92-ZZ-SP-XX-0019 M&E metering systems including LV monitoring functional design spec

Electrical Motor Ratings

AHU/02A Served From 50-MSP-01-A

Description	Plant Ref	Motor name plate (kW)	VSD
Supply Fan 1	AHU/S/02A SF1	11	Yes (Danfoss by AHU supplier)
Supply Fan 2	AHU/S/02A SF2	11	Yes (Danfoss by AHU supplier)
Extract Fan	AHU/E/02A EF1	30	Yes (Danfoss by AHU supplier)

AHU/02A Small Power Served From 50-DB-MCP1-A-A02

Description	Plant Ref	Motor name plate (kW)	VSD
AHU HRC Pump	AHU/S/02A PU01	0.75	Yes Integral Pump
AHU Lighting	Luminaires	6 amp (MCB)	N/A
AHU BMS / PLC Control Panel	AHU/02A/ACP01	16 amp (MCB)	N/A

AHU/02B Served From 50-MSP-01-B

Description	Plant Ref	Motor name plate (kW)	VSD
Supply Fan 1	AHU/S/02B SF1	11	Yes (Danfoss by AHU supplier)
Supply Fan 2	AHU/S/02B SF2	11	Yes (Danfoss by AHU supplier)
Extract Fan	AHU/E/02B EF1	30	Yes (Danfoss by AHU supplier)

AHU/02B Small Power Served From 50-DB-MCP1-B-A02

Description	Plant Ref	Motor name plate (kW)	VSD
AHU HRC Pump	AHU/S/02B PU01	0.75	Yes Integral Pump
AHU Lighting	Luminaires	6 amp (MCB)	N/A
AHU BMS / PLC Control Panel	AHU/02B/ACP01	16 amp (MCB)	N/A

Each AHU fan VSD is mounted adjacent to the respective AHU motor. A local isolator downstream of the VSD provides the facility to safely isolate the motor. Each VSD is provided with local run/trip/fault/ operating diagnostics and control keypad.

1.2 AHU BMS + PLC Control Panel

Each of the AHU 02 BMS and PLC control panels are manufactured as detailed in the High Level BMS Design Document P800-SCH-92-ZZSP-XX-0001.

- AHU/02A/ACP01
- AHU/02B/ACP01

Each panel is provided with:

- Key lockable door
- Internal mains power disconnect isolator
- MCB protection fuses
- BMS controller and supporting transformer power supplies and I/O modules
- PLC controller and supporting transformer power supplies and I/O modules and PLC network switch
- Interfacing relays and relay timers
- Power healthy and plant status LED indication lamps
- AHU fan and pump Test/Off/Auto key operated switches
- Interfacing terminals with knife disconnect
- SELV fused terminals to 24Vac field equipment
- RCD service laptop socket
- RJ45 socket service laptop connection to BMS network

The BMS Control Panel Fascia will have the following lamps and switches

AHU/02A/ACP01

Equipment Reference	Description	Fascia Key Switch	Fascia LED Lamp
Mains Healthy			230Vac Lamp
BMS 24Vac Power Supply			24Vac Lamp
PLC 24Vac Power Supply			24Vac Lamp
AHU/S/02A/SF1	AHU 02A Supply Fan 1	Test / Off / Auto	Run Trip Frost + Reset
AHU/S/02A/SF2	AHU 02A Supply Fan 2	Test / Off / Auto	Run Trip Frost + Reset
AHU/E/02A/EF	AHU 02A Extract Fan	Test / Off / Auto	Run Trip
AHU/S/02A/PU	AHU 02A Run Around Coil Pump	Test / Off / Auto	Run Trip Low Pressure

AHU/02B/ACP01

Equipment Reference	Description	Fascia Key Switch	Fascia LED Lamp
Mains Healthy			230Vac Lamp
BMS 24Vac Power Supply			24Vac Lamp
PLC 24Vac Power Supply			24Vac Lamp
AHU/S/02B/SF1	AHU 02B Supply Fan 1	Test / Off / Auto	Run Trip Frost + Reset
AHU/S/02B/SF2	AHU 02B Supply Fan 2	Test / Off / Auto	Run Trip Frost + Reset
AHU/E/02B/EF	AHU 02B Extract Fan	Test / Off / Auto	Run Trip
AHU/S/02B/PU	AHU 02A Run Around Coil Pump	Test / Off / Auto	Run Trip Low Pressure

1.3 PLC Controller AHU Supply Fan and Extract Fan Operational Interlocks

If both twin AHU supply fans are not available to operate, the respective extract fan will shut down. The available operating supply and extract fans will automatically ramp up to maintain respective system pressures.

If the AHU extract fan is not available, the respective supply AHU will shut down. The available operating supply and extract fans will automatically ramp up to maintain respective system pressures.

PLC Controller Hardwired Plant Interlocks

Hardwired interlocks shall be operable for both Auto (Remote) and Hand (local VSD only) mode control of motor operation.

- AHU Off/Auto Switch
- AHU fresh air damper position end switch closed inhibits the AHU supply fan VSD from operating.
- AHU discharge air damper position end switch closed inhibits the AHU supply fan VSD from operating.
- AHU supply fan interlocked to extract fan.
- AHU extract fan interlocked to supply fan *(timed start relay)*
- AHU Off Frost Coil Low Limit Thermostat Temperature Alarm interlocked to inhibit AHU supply fan and extract fan.
- AHU extract air inlet damper position end switch closed inhibits the AHU extract fan VSD from operating.
- AHU extract air discharge damper position end switch closed inhibits the AHU extract fan VSD from operating.

BMS Controller Hardwired Plant Interlocks

- AHU run around coil high- and low-pressure switch in alarm interlocked to inhibit pump operation.
- AHU supply air high limit humidistat switch in alarm interlocked to close spring return steam control valve.

Note there are:

- No hardwired fire alarm to shut down the plant
- No hardwired fireman's over mode to operate the plant
- No hardwired pressure safety switches to shut down the plant

2.0 Control Sequences

2.0.1 Overview

The plant operates 24/7 subject to BMS operator plant control flags and defined software and hardwired interlocks.

The monitoring and controls are performed by both BMS and PLC controllers. The following controls section title indicates the main controller, BMS or PLC performing the control software.

Note: It is anticipated that the HVAC system may take 20 to 30 minutes to start up and stabilise. All timers required in software will be established during commissioning and final setting recorded in the respective set point schedule.

2.1.1 PLC Controller Normal System Start Up

Non critical plant and environmental BMS alarms are inhibited (disabled) during start up. Room pressure alarms always remain activated, unless manually disabled by the Pirbright Institute via the BMS PC graphics screen.

- Room pressure alarms to always be activated for safety.
- Plant, temperature / humidity alarms de-activated,

Important Note. The Operation and Start-up of the containment HVAC system is subject to manual SOP's.

The following conditions are pre-requisite to start up the HVAC system and assumes that all manual SOP's have been correctly adhered to.

- BMS graphics software operator plant flag is set to 'ENABLE' {PLC Modbus Point}
- At least one of the two AHU plant, AHU 2B or 2B PLC available flags is 'AVAILABLE'

Note. Any AHU 2A or 2B Mode selected 'Off' via the BMS workstation graphics will not start.

Step 1 – Activate BMS frost coil control regime. (Refer Section 2.2.1)

Note: If the ambient conditions {BMS global point} below [5] deg C, then activate AHU cold start regime to preheat the frost coils. Check the

temperature of the LTHW frost coil return line to indicate that heating is available {BMS Modbus before proceeding with AHU start up.

Step 2 – Activate PLC airflow and room pressure controls. Refer to PLC Functional Description of Operation:

- P800-SCH-92-ZZ-SP-XX-0015 Air system 2 local controls Functional design spec

Note: The local PLC airflow / pressure controller ramps the airflow / pressure damper controls to keep the airflow negative into the high containment laboratories throughout the start-up sequence.

Step 3 – PLC to command the AHU supply and extract inlet and discharge air damper isolation dampers to 'OPEN'

Step 4 – PLC to established that each damper has opened as monitored by the damper actuator end switches

If the damper fails to open, (after a suitable proving period) The PLC shall notify a damper failure alarm to the BMS and shall cause the PLC control strategy to make the associated fan/AHU as Not Available.

Step 5 - When all respective isolation dampers are proved open:
The PLC to command to start the available AHU extract fans,
followed by the available AHU twin supply fans.

Note: AHU supply fan and general extract fan shall start and initially operate at pre-fixed minimum speeds set points, set at the VSD.

Step 6 – The PLC is to ramp up the AHU extract fan and supply fan in a controlled sequence to attain the respective supply and extract pressure control set points. (Air regime to maintain negative flow / containment in the high containment laboratories)

Step 7 – The PLC is to enable a Modbus signal to the BMS controller environmental control loops when the VSD run status or airflow differential pressure switch across the AHU supply fans has been established.

- AHU supply air and room temperature control regimes.
- AHU supply air and room humidity control regimes.

Step 9 - After pre-fixed times, allowing for the plant to attain control conditions, the BMS will activate the following BMS alarm monitoring.

- AHU supply and extract temperature, humidity and flow and pressure
- Room temperature alarms

2.1.2 Normal System Shutdown

Any of the following conditions shall cause the AHU HVAC system to shut down:

- BMS plant operator software flag {PLC Modbus Point} is set to 'SHUTDOWN'

In the event of the HVAC system being shut down the following sequence shall follow.

Step1 – The BMS will disable temperature, humidity, flow and duct pressure monitoring BMS alarms.

Step 2 – BMS to close humidifier control valve

Step 3 – PLC AHU controller to send a Modbus signal to the local room PLC controllers to slowly ramp down room pressure CVB and VVB volume set points to minimum control set points whilst aiming to maintain a negative air flow regime within the laboratories.

- P800-SCH-92-ZZ-SP-XX-0015 Air system 2 local controls Functional design spec

Note: AHU supply fan and extract fans will automatically ramp down under PLC control to maintain index pressures.

- At a preset AHU low volume; (beyond which no reliable control is possible) the PLC is to switch off the supply fan followed by extract fans and set fan speed control to zero:

- AHU Supply fan AHU/S/02A
- AHU Supply fan AHU/S/02B

- AHU Extract fan AHU/E/02A
- AHU Extract fan AHU/E/02A

- The PLC AHU controller will send a Modbus signal to the local room PLC controllers to inhibit / freeze the control of the respective room pressure / VAV controls.

When the AHU fans have stopped the PLC will disable the signal to the BMS controllers to close the respective AHU and local coil control valves

Step 4 – BMS to close AHU heating coil control valve
Step 5 – BMS to close AHU cooling coil control valve
Step 6 – BMS to switch off RAC pump
Step 7 – PLC to fully close AHU supply / extract inlet and discharge air dampers
Step 8 – BMS to fully close local heating coil control valves
Step 9 – BMS to close AHU frost coil control valve

2.1.3 Plant Fault Shutdown Scenarios

General Note: Following an 'alarmed/fault' shutdown of the system (except Mains power failure) the User shall be required to manually reset of the appropriate graphic software flag via the BMS operator workstation.

AHU Supply Fan Failure Shutdown:

- If both AHU twin fans have failed.

Step1 – BMS to disable AHU temperature, humidity index pressure and volume monitoring alarms.

Step 2 – BMS to close humidifier control valve output to 0% open

Step 3 – PLC to switch off the following fans and set fan speed control to zero:

Note The remaining operational AHU will automatically ramp up in speed (circa 100% of design duty) to maintain required index pressure set points.

- Switch off both failed AHU supply twin fans
- Switch off respective AHU Extract fan

Note: Extract fan specified as hardwired interlock and it will shutdown immediately as soon as the supply fan VSD run status is in-active.

This will cause a step change in system pressure and the remaining extract fan is to ramp up quickly to retain control of the extract index pressure.

Step 4 – BMS to Close AHU heating coil control valve
Step 5 – BMS to Close AHU cooling coil control valve
Step 6 – PLC to Close AHU fresh air damper

Step 7 – PLC to Close AHU discharge air damper
Step 8 – BMS to Close AHU frost coil control valve
Step 9 – BMS to Switch off AHU RAC coil pump and set pump speed control to zero

Step 10 – PLC to Close AHU extract inlet air damper
Step 11 – PLC to Close AHU extract discharge air damper
Step 12 – PLC to Close AHU extract fresh air make-up isolation damper

AHU Supply Fan Fault Reset

A manual reset of the AHU supply fan fault flag, via the BMS PC graphic head end, shall allow the AHU and general extract fan to restart.

Sequence start the extract fan first followed by supply fan.

- PLC to command open the AHU extract and AHU supply inlet and discharge isolation dampers as per a normal start. The AHU extract and AHU supply non return dampers will remain closed whilst there is back pressure from the operating AHU.

- When the AHU extract inlet and discharge dampers are open the PLC Enables the extract fan. Fan operates at minimum speed and slowly ramps up speed towards the speed of the already operating fan. When the starting AHU speed matches that of the operating fans, release the ramp control and operate both AHU fan speeds in parallel. (Note as the restarting fan contributes to system pressure the PLC pressure fan speed control will automatically reduce the speed of the other AHU fans, such that pressure is maintained).

- Simultaneously to above the PLC operates the AHU supply inlet and discharge dampers and controls the speed of the AHU twin fans in a similar way to the above extract fans.

General Extract Fan Failure

- As per AHU supply fan failure

Note: The AHU supply fans are hardwired to not operate if the respective extract fan is not running.

General Extract Fault Reset

A manual reset of the AHU extract fan fault flag, via the BMS PC graphic head end, shall allow the AHU and general extract fan to restart.

2.2.4 BMS AHU Freeze Protection Control

The BMS monitors the off-frost coil temperature * and modulates, via a PID control loop, the AHU LTHW frost heating coil 2 port (PICV) control valve to maintain minimum off coil air temperature set point of [5] deg C.

*Note * A 6000mm length, averaging, temperature control sensor is laced across the frost coil discharge.*

The BMS monitors the AHU fresh air inlet temperature, via a duct mounted averaging sensor. Under low fresh air inlet, ambient temperature conditions below [0] deg C the BMS shall schedule an increase of the off-frost coil temperature to [10] deg C

Note: To avoid problems with the AHU tripping on low limit frost protecting, on a cold AHU, start-up routine. (ambient temperature below 5 deg C) The off-frost coil temperature set point will be set to [10] deg C and ramped down to normal set point, after a preset time 20 minutes.

The BMS will send an AHU supply and AHU extract shutdown signal (Via Modbus) to the PLC controller if the BMS control sensor monitors a low limit below [3] deg C for a transient period of time (5 minutes).

The BMS will notify a critical alarm to the BMS alarm engine and graphic if the off-frost coil temperature falls below [3] deg C.

The BMS monitors the LTHW frost coil return pipe water temperature, via an immersion temperature sensor. The BMS will send an AHU supply and AHU extract shutdown signal (Via Modbus) to the PLC controller if the BMS control sensor monitors a low limit below [20] * deg C for a transient period of time (5 minutes). The BMS will fully open the frost coil valve.

Note: Review specified 20 deg to shutdown the AHU and fully open the frost coil valve. This may cause nuisance tripping and also overheat the AHU when it is off and isolated.

The BMS will notify a critical alarm to the BMS alarm engine and graphic if the frost coil return water temperature falls below [4] deg C.

The BMS monitors the control valve actuator feedback and notifies an alarm if the valve control signal does not match the feedback signal within 5% allowing for a suitable transient time [10s] for the actuator motor to operate.

The BMS notifies a valve exercise alarm, if the valve has not operated in 100 hours. The BMS operator can override the BMS automatic control and

manually signal the valve 0 to 100 to 0% open and then release back to automatic via the BMS graphic.

AHU/S/2A

Control and Instrument Ref	Point Descriptor
AHU_S_02A_ TT00	Fresh Air Temperature
AHU_S_02A_ HCV01	Frost Coil Control Valve
AHU_S_02A_ HCV01	Frost Coil Control Valve Position
AHU_S_02A_ TT01	Off Frost Coil Temperature
AHU_HC_02A_ TT01	Frost Coil Return Temperature

AHU/S/2B

Control and Instrument Ref	Point Descriptor
AHU_S_02B_ TT00	Fresh Air Temperature
AHU_S_02B_ HCV01	Frost Coil Control Valve
AHU_S_02B_ HCV01	Frost Coil Control Valve Position
AHU_S_02B_ TT01	Off Frost Coil Temperature
AHU_HC_02B_ TT01	Frost Coil Return Temperature

2.2.5 PLC AHU Freeze Protection Control

A low limit, automatic reset, thermostat * (manually set at [3] deg C) is hardwired via a latched relay adjustable timer in the panel (0-15minutes) to protect the AHU from freezing.

If the off-frost coil low limit temperature exists for more than 5 minutes (adjustable PLC panel relay timer) the AHU supply fan and extract fan will shut down.

*Note * A 6000mm length, capillary, thermostat is laced across the frost coil discharge.*

A frost alarm indication lamp and manual reset button is located on the fascia respective BMS/PLC control panel.

The PLC also monitors a Modbus AHU freeze protection signal from the BMS system. If the freeze protection alarm is active the PLC will shut down the respective AHU supply and AHU extract units.

AHU/S/2A

Control and Instrument Ref	Point Descriptor
AHU_S_02A _ TSL01	Off Frost Coil Low Limit Thermostat

AHU/S/2B

Control and Instrument Ref	Point Descriptor
AHU_S_02B _ TSL01	Off Frost Coil Low Limit Thermostat

2.1.6 BMS AHU Run Around Coil Control and Monitoring

Refer also to supply air temperature control which operates in conjunction with energy recovered from the run around coil.

The AHU heating and cooling coil valves operate in sequence to maintain supply air temperature set point.

The BMS monitors the AHU inlet air temperature and associated AHU extract temperature.

Heating Mode
The RAC pump is switched On and operated at 100% speed for first stage heating when the AHU fresh air inlet temperature is below the AHU supply air set point temperature and below the AHU return air temperature by more than a value defined in the set point. [3] deg C

The RAC pump is switched off when this temperature difference falls to [1.5]K or less for a period of [5]minutes.

Cooling Mode
The RAC pump is switched On and operated at 100% speed for first stage cooling when the AHU fresh air inlet temperature is above the AHU supply air temperature set point and above return air by more than a value defined in the set point [3] deg C.

The RAC pump is switched off when this temperature difference falls to [1.5]K or less for a period of [5]minutes.

The cooling valve modulates to maintain the desired supply air temperature set point.

RAC Pump Monitoring
The RAC pump is fitted with an integral VSD.

The BMS provides a remote enable of the pump VSD and speed control.

The BMS monitors the status of the RAC pump Test-Off-Auto switch on the BMS control panel. The BMS notifies an alarm is the pump is not in Auto mode.

The BMS monitors the pump's VSD run status and notifies a pump failure alarm if there is a mis-match between BMS pump VSD enable signal and the VSD run feedback.

The BMS monitors the pump's VSD fault status and notifies an pump fault alarm if the pump is in fault condition.

The BMS monitors the pump VSD status via Modbus open protocol

The BMS monitors the performance of the RAC by measuring the on-air and off-air coil and pipe-inlet and pipe-outlet coil temperatures.

The BMS shall notify a warning and critical low temperature alarm at the BMS workstation.

The BMS monitors a RAC circuit, high- and low-pressure switch and shall notify an alarm if there is a pressure alarm. In the event of an alarm the BMS switches off the RAC pump. (The alarm is also hardwired interlocked to disable pump)

AHU/S/02A

Plant Ref	Control and Instrument Ref	Point Descriptor
n/a	AHU_S_02A_ TT01	AHU Inlet Air Temperature
n/a	AHU_E_02A_ TT01	AHU Extract Air Temperature
AHU/S/02A/ PU01	n/a	RAC Pump VSD Enable
	n/a	RAC Pump VSD Speed Control
	n/a	RAC Pump VSD Run Status
	n/a	RAC Pump VSD Fault Status
	n/a	RAC Pump VSD Local / Remote Status
AHU/S/02A/ HRC	AHU_S_02A_ TT03	AHU On Air RAC Coil Temperature
	AHU_S_02A_ TT04	AHU Off Air RAC Coil Temperature
	AHU_S_02A_ HRC_TT01	AHU RAC Coil Inlet Temperature
	AHU_S_02A_ HRC_TT01	AHU RAC Coil Outlet Temperature

AHU/S/02B

Plant Ref	Control and Instrument Ref	Point Descriptor
n/a	AHU_S_02B_ TT01	AHU Inlet Air Temperature
n/a	AHU_E_02B_ TT01	AHU Extract Air Temperature
AHU/S/02A/ PU01	n/a	RAC Pump VSD Enable
	n/a	RAC Pump VSD Speed Control
	n/a	RAC Pump VSD Run Status
	n/a	RAC Pump VSD Fault Status

	n/a	RAC Pump VSD Local / Remote Status
AHU/S/02A/ HRC	AHU_S_02B_ TT03	AHU On Air RAC Coil Temperature
	AHU_S_02B_ TT04	AHU Off Air RAC Coil Temperature
	AHU_S_02B_ HRC_TT01	AHU RAC Coil Inlet Temperature
	AHU_S_02B_ HRC_TT01	AHU RAC Coil Outlet Temperature

The BMS monitors the RAC Pump VSD Modbus Registers

VSD Monitoring Parameter	VSD Modbus Register	BMS Point Descriptor
		AHU RAC Pump Local Remote Status
		AHU RAC Pump Fault Code
		Power Consumption kW
		Frequency Hz Feedback
		Amperes Current

2.1.7 PLC AHU Supply Fan Pressure Control

The PLC monitors the average AHU common, supply air main header pressure sensors, as measured via 3 duct pressure sensors. * The PLC modulates, via a PID control loop, the operating AHU supply fan VSD, speed control signal in parallel to maintain the pressure set point [###Pa].

Review Impact of Specification which may cause problems with the ability to provide accurate room pressure damper authority and control.

In order to negate the effects of the increasing pressure drop across the terminal HEPA filters as they dirty and the decrease in pressure drop when filters are replaced the supply and extract static pressure setpoints shall be reset.

The PLC shall continuously monitor the position of the large VAV box dampers. The PLC shall then reset the static pressure setpoint up/down to ensure the most open large VAV on the supply or extract remains [90]% open ± [2]%.

The increments at which the supply and extract static pressure setpoints are reset and the time delays between each resetting step shall be developed by the Contractor and proven in the commissioning period.

The two AHU PLC fan speed controllers are arranged master / slave. If the master speed controller CPU is not available, the slave controller shall take over speed control. The CPU available signal is determined by a simple controller 1 task that turns a PLC digital output on and off repetitively; This is then monitored as a digital input by the slave controller. If the input repetitively changes state on and off then the PLC controller no. 1 is deemed functioning okay. If the input stops, the controller no.1 is deemed to be unavailable and the slave controller takes over the control loop for VSD fan speed control.

The PLC Controller speed reference control signal to each AHU VSD is also duplicated as a control signal to the 2nd AHU PLC Controller, so that

*Note * The Duct sensors are CMR manufactured P-Sensors each complete with dual channel 4-20mA / 0-10Vdc outputs. Two of the sensors are powered from PLC Controller 1 (AHU/02A) and the Third sensor powered from PLC Controller 2. The 2nd 0-10Vdc output channel from each sensor is shared to the other controller.*

A low / high static pressure alarm shall be notified at the BMS. (Refer to alarm schedule)

Note the PLC shall monitor the 3 pressure sensors and discard any single value that is [5%] out of range or failed because of open or short circuit signal.

The pressure is controlled by one of the 2 PLC controllers. If the lead PLC controller fails, the 2nd PLC controller will become the lead pressure controller.

AHU/S/02A - PLC Controller No.1

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/02A/ SF01	AHU_02A_ VSD01	AHU Supply Fan 1 Speed Control
AHU/S/02A/ SF02	AHU_02A_ VSD02	AHU Supply Fan 2 Speed Control
	n/a	AHU Supply Fan Controller 1 Speed Output Controller 2
	n/a	AHU Supply Fan Controller 1 Speed Input Controller 2
	AHU/S/02_ PT01	AHU Common Supply Header Pressure No.1
	AHU/S/02_ PT02	AHU Common Supply Header Pressure No.2
	Shared Input (0-10Vdc)	AHU Common Supply Header Pressure No.3
		PLC Controller 1 CPU Sanity Control Output
		PLC Controller 2 CPU Sanity Control Input

AHU/S/02B- PLC Controller No.2

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/02B/ SF01	AHU_02B_ VSD01	AHU Supply Fan 1 Speed Control
AHU/S/02B/	AHU_02B_	AHU Supply Fan 2

SF02	VSD02	Speed Control
	n/a	AHU Supply Fan Controller 2 Speed Output Controller 1
	n/a	AHU Supply Fan Controller 1 Speed Input Controller 2
	Shared Input (0-10Vdc)	AHU Common Supply Header Pressure No.1
	Shared Input (0-10Vdc)	AHU Common Supply Header Pressure No.2
	AHU/S/02_ PT03	AHU Common Supply Header Pressure No.3
		PLC Controller 2 CPU Sanity Control Output
		PLC Controller 1 CPU Sanity Control Input

2.1.8 PLC Common AHU Supply Header Pressure Control

The AHU supply duct is connected to pressure relief duct, connected to an external roof cowl. The duct relief operates in two modes:

- AHU system fumigation high pressure.
- AHU normal operation high duct pressure.

AHU Fumigation Mode Control

The AHU supply volume will reduce when rooms are isolated during the fumigation sequence. If the supply volume reduces below the minimum operating speed of the AHU fans, the PLC will operate the AHU's at the minimum operating speed * and open the common supply pressure relief isolation damper (fast acting) whilst modulating, via a PID control loop, a supply pressure, pressure relief control damper (fast acting) to maintain the constant supply volume pressure set point.

The AHU 2A PLC controller will control the common pressure control damper and isolation damper.

*Note * The AHU fan motor minimum operating speeds will be determined during commissioning and fixed at the VSD inverter.*

The PLC uses the same triplicate monitoring arrangement of duct pressure sensors as used for normal supply fan speed control.

The BMS notifies the damper position mis-match alarm, if the PLC control output signal does not match the damper feedback position.

AHU Normal Operation High Pressure Protection

The PLC will control the supply duct pressure relief dampers to cap the main supply duct pressure at a maximum of [###Pa].*

Note. the maximum pressure set point is to be carefully determined during commissioning not to conflict with the PLC supply fan pressure control set point. (initial high limit cap to be 20% above normal set point. i.e if supply air pressure is 750Pa the high limit set point will be set at 900Pa)

The PLC will open the common supply pressure relief isolation damper (fast acting) whilst modulating, via a control loop, a supply pressure, pressure relief control damper (fast acting) to limit the AHU supply pressure

Common Supply Duct Pressure Relief Control – PLC Controller 1

Control and Instrument Ref	Point Descriptor
AHU_S_02_ PCD01	Supply Pressure Relief Control Damper
AHU_S_02_ PCD01_ZT	Supply Pressure Relief Control Damper FB Position
AHU_S_02_ FT02	Supply Pressure Relief Volume
AHU_S_02_ FXD01	Supply Pressure Relief Isolation Damper
AHU_S_02_ FXD01_ZT	Supply Pressure Relief Isolation Damper FB Position
Refer to Triplicate Duct Pressure Sensor on Fan Control	

2.1.9 PLC AHU Extract Fan Speed Control – No Room Fumigation

During normal operation the 2no. AHU extract fans operate in parallel at a prefixed VSD speed to attain a constant efflux (at 50% duty each) The PLC monitors the average AHU common, Extract air main header pressure sensors, as measured via 3 duct pressure sensors. * The PLC modulates, via PID loop, the operating AHU Extract fan VSD, speed control signal in parallel to maintain the pressure set point [###Pa].

The PLC extract fan uses the same Master/Slave controller arrangement as the supply fan control.

The PLC Controller speed reference control signal to each AHU VSD is also duplicated as a control signal to the 2nd AHU PLC Controller, so that

*Note * The Duct sensors are CMR manufactured P-Sensors each complete with dual channel 4-20mA / 0-10Vdc outputs. Two of the sensors are powered from PLC Controller 1 (AHU/02A) and the Third sensor powered from PLC Controller 2. The 2nd 0-10Vdc output channel from each sensor is shared to the other controller.*

A low / high static pressure alarm shall be notified at the BMS. (Refer to alarm schedule)

Note the PLC shall monitor the 3 pressure sensors and discard any single value that is [5%] out of range or failed because of open or short circuit signal.

The pressure is controlled by one of the 2 PLC controllers. If the lead PLC controller fails, the 2nd PLC controller will become the lead pressure controller.

AHU/E/02A – PLC Controller No.1

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/E/02A/ EF0 1	AHU_E_02A_ VSD01	AHU Extract Fan 1 Speed Control
	n/a	AHU Extract Fan Controller 1 Speed Output Controller 2
	n/a	AHU Extract Fan Controller 1 Speed Input

		Controller 2
	AHU/E/02_ PT01	AHU Common Extract Header Pressure No.1
	AHU/E/02_ PT02	AHU Common Extract Header Pressure No.2
	Shared Input (0-10Vdc)	AHU Common Extract Header Pressure No.3

AHU/E/02B – PLC Controller No.2

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/E/02B/ SF01	AHU_E_02B_ VSD01	AHU Extract Fan 1 Speed Control
	n/a	AHU Extract Fan Controller 2 Speed Output Controller 1
	n/a	AHU Extract Fan Controller 1 Speed Input Controller 2
	Shared Input (0-10Vdc)	AHU Common Extract Header Pressure No.1
	Shared Input (0-10Vdc)	AHU Common Extract Header Pressure No.2
	AHU/S/02_ PT03	AHU Common Extract Header Pressure No.3

2.1.10 PLC AHU Extract Fan Speed Control and Fresh Air Make Up Pressure Control – During Room Fumigation Sequence.

During the fumigation mode of risk spaces, the stack exhaust volume must maintain a constant volume to achieve a minimum safe efflux velocity. (10 m/s at the exhaust cone)

During the fumigation mode the AHU extract fans will operate at a fixed speed *(speed to be determined during commissioning)* and the PLC will control, via PID loop, the common fresh air inlet make up damper to maintain the duct pressure set point * and hence maintain a constant exhaust volume.

*Note *: The duct pressure set point will need to be checked during design review / commissioning to establish if the set point is the same during normal extract fan speed control and fumigation control ?*

The PLC monitors the common stack extract volume via an externally * mounted CMR airflow station (velo-probes) mounted in the extract stack. The PLC will use the measured volume to calculate the velocity at the cone section where there is a reduced outlet area and signal this value to the BMS. The BMS notifies an alarm if the efflux velocity is below a low threshold alarm limit.

*Note *: The extract volume CMR airflow transducer will be mounted inside the plantroom, at a location to be accessed for calibration. The external PVC tubing shall be protected via conduit from UV sunlight and provided internally with a condensate loop to prevent water entering the transmitter.*

The PLC uses the same triplicate monitoring arrangement of duct pressure sensors as used for normal extract fan speed control.

Prior to being able to control the fresh air make-up damper, the PLC will:

- Open the common fresh air make up damper isolation damper
- Open the respective extract AHU fresh air make up isolation damper, which allow the fresh air to enter the AHU after the AHU extract run around coil.

The PLC monitors that the damper actuator end switch, closed positions.

The BMS notifies the damper position mis-match alarm, if the PLC control output signal does not match the damper end switch position.

The BMS monitors the differential pressure across the fresh air make up filter, on the inlet to the AHU and notifies an alarm if the filter requires maintenance.

Common Fresh Air Make Up Duct – Proposed By PLC Controller 1

Control and Instrument Ref	Point Descriptor
AHU_EM_02_ FCD01	Extract System Fresh Air Make Up Control Damper
AHU_EM_02_ FCD01_ZT	Extract System Fresh Air Make Up Control Damper FB Position
AHU_MA_02_ FT01	Extract System Fresh Air Make Up Volume
AHU_EM_02_ FXD01	Extract System Fresh Air Make Up Isolation Damper
AHU_EMA_02_ FXD01_ZT	Extract System Fresh Air Make Up Isolation Damper FB Position
AHU_E_02_FT01	Total Extract Stack Volume
Refer to Triplicate Duct Pressure Sensor on Fan Control	

AHU/E/02A Extract Fresh Air Make Up

Control and Instrument Ref	Point Descriptor
AHU_EM_02A_ FXD01	AHU Extract Fresh Air Make Up Isolation Damper
AHU_EM_02A_ FXD01_ZSc	AHU Extract System Fresh Air Make Up Isolation Damper FB Closed Position
AHU_EM_02A_ PDT01	AHU Extract System Fresh Air Make Up Filter Differential Pressure

AHU/E/02B Extract Fresh Air Make Up

Control and Instrument Ref	Point Descriptor

AHU_EM_02B_ FXD01	AHU Extract Fresh Air Make Up Isolation Damper
AHU_EM_02B_ FXD01_ZSc	AHU Extract System Fresh Air Make Up Isolation Damper FB Closed Position
AHU_EM_02B_ PDT01	AHU Extract System Fresh Air Make Up Filter Differential Pressure

2.1.11 PLC Fan Monitoring and Fan Failure Monitoring

The PLC determines the running status of the fan using the differential pressure air flow switch and VSD run status.

- When a fan is commanded to start by the PLC, a pre-fixed timer is activated (proving period). If after the timer expires, the VSD run status and air flow switch does not indicate both run and air flow then the fan is deemed to have failed. The PLC will raise a fan failed signal and via a Modbus register, an alarm will be notified by the BMS.

- Having commanded a fan to start, the PLC continues to monitor the status of the air flow alarm, allowing for a transient time, to indicate that the fan is still operating. If after the timer expires, the air flow status does not indicate air flow then the fan is deemed to have failed. The PLC will raise a fan failed signal and via a Modbus register, an alarm will be notified by the BMS.

- The PLC monitors the VSD common fault status (VSD locked out – motor is not available). In the event of an alarm, the respective fan is instantly deemed to have failed; and via the Modbus register the BMS notifies a VSD fault alarm.

- The PLC monitors the VSD Local / Remote status via Modbus and via the Modbus register the BMS notifies an alarm If the VSD is operated in local (hand mode).

- The PLC monitors the control panel Test/Off/Auto switch and via the Modbus register the BMS notifies an alarm if the switch is not in Auto.

- The PLC monitors the common AHU supply airflow volume, using CMR volume sensor and velo-probes mounted in the duct.

- The PLC monitors the common AHU extract airflow volume, from the risk space, using a CMR volume sensor and velo-probes mounted in the duct.

- The PLC monitors the common stack extract airflow volume, using a CMR volume sensor and velo-probes mounted in the duct. Via a Modbus register the BMS notifies an efflux velocity alarm if the velocity is below the low limit threshold.

- The PLC monitors the AHU fan VSD via Modbus RTU (See Modbus register table)

AHU/S/02A

Plant Ref	Control and Instrument Ref	Point Descriptor
SF01	AHU_S_02A_ SF01_VSD01	AHU Supply Fan 1 VSD Enable
SF01	n/a	AHU Supply Fan 1 VSD Fault Status
SF01	n/a	AHU Supply Fan 1 VSD Run Status
SF01	n/a	AHU Supply Fan 1 VSD Local/Remote Status
SF01	AHU_S_02A_ SF01_PDS01	AHU Supply Fan 1 Differential Pressure Switch (Flow) Status
SF02	AHU_S_02A_ SF01_VSD01	AHU Supply Fan 2 VSD Enable
SF02	n/a	AHU Supply Fan 2 VSD Fault Status
SF02	n/a	AHU Supply Fan 2 VSD Run Status
SF02	n/a	AHU Supply Fan 2 VSD Local/Remote Status
SF02	AHU_S_02A_ SF01_PDS01	AHU Supply Fan 2 Differential Pressure Switch (Flow) Status

AHU/S/02B

Plant Ref	Control and Instrument Ref	Point Descriptor
SF01	AHU_S_02B_ SF01_VSD01	AHU Supply Fan 1 VSD Enable
SF01	n/a	AHU Supply Fan 1 VSD Fault Status
SF01	n/a	AHU Supply Fan 1 VSD Run Status
SF01	n/a	AHU Supply Fan 1 VSD Local/Remote Status
SF01	AHU_S_02B_ SF01_PDS01	AHU Supply Fan 1 Differential Pressure Switch (Flow) Status
SF02	AHU_S_02B_ SF01_VSD01	AHU Supply Fan 2 VSD Enable
SF02	n/a	AHU Supply Fan 2 VSD Fault Status
SF02	n/a	AHU Supply Fan 2 VSD Run Status
SF02	n/a	AHU Supply Fan 2 VSD Local/Remote Status
SF02	AHU_S_02B_ SF01_PDS01	AHU Supply Fan 2 Differential Pressure Switch (Flow) Status

AHU/E/02A

Plant Ref	Control and Instrument Ref	Point Descriptor
EF01	AHU_E_02A_ EF01_VSD01	AHU Extract Fan VSD Enable
	n/a	AHU Extract Fan VSD Fault Status
	n/a	AHU Extract Fan VSD Run Status
	n/a	AHU Extract Fan VSD Local/Remote Status

	AHU_E_02A_ EF01_PDS01	AHU Extract Fan Differential Pressure Switch (Flow) Status

The BMS monitors the AHU Fan VSD Modbus Registers

VSD Monitoring Parameter	VSD Modbus Register	BMS Point Descriptor
		AHU Fan Local Remote Status
		AHU Fan Fault Code
		Power Consumption kW
		Frequency Hz Feedback
		Amperes Current

2.1.12 BMS AHU Cooling Coil & Heating Coil Temperature Control

Refer to the BMS 1st stage heating / cooling mode via the operation of the AHU RAC coil pump.

2nd Stage Heating / Cooling Mode

- The BMS monitors the AHU supply air temperature * and modulates***, via a PID control loop, the AHU heating coil control valve ** and cooling coil control valve ** in sequence to maintain the supply air temperature set point.

*Note * The supply air temperature transmitter is combined with a relative humidity transmitter (See BMS AHU humidity control section)*

*** The 2 port control valves and associated actuators are pressure independent control valves (PICV)*

**** The BMS controls the AHU cooling coil control valve signal according to the highest demand from the dehumidify or AHU supply air temperature cooling mode control loop. Refer to BMS AHU Humidity Monitoring and Control Section.*

When operating to dehumidify the air the AHU heating coil shall remain operational under the supply air temperature control loop in order to provide reheat when necessary.

- The BMS automatically schedules the AHU supply air temperature between a minimum [12] deg C and maximum [22] deg C depending on maximum cooling load requirements from any of the rooms.

Note review design and specification which indicates a control maximum of 30 deg c, which is too warm.

- The BMS monitors the performance of the cooling and heating coil by measuring the on and off coil air temperatures.
- The BMS monitors the cooling coil performance by measuring the off coil, air humidity. The humidity transmitter is combined with the temperature transmitter.
- The BMS monitors the control valve actuator feedback and notifies an alarm if the valve control signal does not match the feedback signal within 5% allowing for a suitable transient time for the actuator motor to operate.
- The BMS notifies a valve exercise. The BMS operator can overide the BMS automatic control and manually signal the valve 0 to 100 to 0% open and then release back to automatic via the BMS graphic.
- A low and high AHU supply air temperature alarm shall be notified at the BMS.

AHU/S/02A

Plant Ref	Control and Instrument Ref	Point Descriptor
	AHU_S_02A_ TT03	*Note * The On-cooling coil air temperature is the Off RAC coil air temperature.* *See RAC coil section*
AHU/S/02A/ CC01	AHU_S_02A_ CCV01	AHU Cooling Coil Valve Control
		AHU Cooling Coil Valve Control Feedback Position
	AHU_S_02A_ MTT01	AHU Off Cooling Coil Temperature
		AHU Off Cooling Coil Humidity
04/AHU01/ HC01	AHU_S_02A_ CCV01	Heating Coil Valve Control
		AHU Heating Coil Valve Control Feedback Position
	AHU_S_02A_ TT05	AHU Off Heating Coil Temperature
n/a	AHU_S_02A_ MTT02	AHU Supply Air Temperature
		AHU Supply Air Humidity

AHU/S/02B

Plant Ref	Control and	Point Descriptor

	Instrument Ref	
	AHU_S_02B_TT03	*Note * The On-cooling coil air temperature is the Off RAC coil air temperature.* *See RAC coil section*
AHU/S/02A/CC01	AHU_S_02B_CCV01	AHU Cooling Coil Valve Control
		AHU Cooling Coil Valve Control Feedback Position
	AHU_S_02B_MTT01	AHU Off Cooling Coil Temperature
		AHU Off Cooling Coil Humidity
AHU/S/02A/HC01	AHU_S_02B_CCV01	Heating Coil Valve Control
		AHU Heating Coil Valve Control Feedback Position
	AHU_S_02B_TT05	AHU Off Heating Coil Temperature
n/a	AHU_S_02B_MTT02	AHU Supply Air Temperature
		AHU Supply Air Humidity

2.1.13 BMS AHU Humidity Control and Monitoring

- The BMS monitors the average calculated animal room extract relative humidity * and resets the individual AHU supply air moisture content set point between a minimum [1g/kg] and [11g/kg] to maintain the animal room extract relative humidity at set point [55%RH] +/- [10%RH]. The AHU supply air moisture content set point is initially set at [7 g/kg]

*Note * The animal room relative humidity measurements derive from the local BMS monitoring and control panels associated with each of the 1 to 6 Animal Room suites. Refer to P800-SCH-92-ZZ-SP-XX-013 for further details of local HVAC BMS monitoring and control.*

If the Animal Room is in fumigation mode or the room extract RH sensor has failed, (open circuit or short circuit = 0mA) the BMS will remove the measured value from the calculation.

- The BMS modulates, via a PID control loop, the AHU cooling coil control valve and humidifier steam control valve, in sequence to maintain the calculated AHU supply air moisture content set point.

- The BMS controls the AHU cooling coil control valve signal according to the highest demand from the dehumidify or

AHU supply air temperature cooling mode control loop. The BMS graphic shall indicate the control mode of the AHU cooling valve – i.e. temp control or dehum control.

*Note: * When operating to dehumidify the air the AHU heating coil shall remain operational under the supply air temperature control loop in order to provide reheat when necessary.*

Animal Room Design Performance:
Room humidity Minimum 45%RH, Maximum 65%RH

- The BMS monitors a dedicated, automatic reset, AHU supply air high limit humidistat which provides hardwired protection to shut the steam humidifier control valve. (hardwired spring close under power failure). (High limit humidistat set manually set at 90%RH)

An AHU high limit supply air humidity alarm shall be notified at the BMS.

BMS Animal Room Relative Humidity Monitoring

BMS Panel Ref	Control and Instrument Ref	Point Descriptor
AHU02_ BMP01	F1AR01_EMTT01	Suite 1 Animal Room Extract Humidity
AHU02_ BMP02	F1AR02_EMTT01	Suite 2 Animal Room Extract Humidity
AHU02_ BMP03	F1AR03_EMTT01	Suite 3 Animal Room Extract Humidity
AHU02_ BMP04	F1AR03_EMTT01	Suite 4 Animal Room Extract Humidity
AHU02_ BMP05	F1AR04_EMTT01	Suite 5 Animal Room Extract Humidity
AHU02_ BMP06	F1AR06_EMTT01	Suite 6 Animal Room Extract Humidity

AHU/S/02A

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/02A /HUM01	AHU_S_02A_ MCV01	AHU Humidifier Valve Control
		AHU Humidifier Valve Control Feedback Position

AHU/S/02A /CC01	AHU_S_02A_ CCV01	AHU Cooling Coil Valve Control
		AHU Cooling Coil Valve Control Feedback Position
n/a	AHU_S_02A_ TMT01	AHU Supply Air Humidity
		AHU Supply Air Temperature
	AHU_S_02A_ MSH01	AHU Supply Air Humidity High Limit Humidistat

AHU/S/02B

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/02B /HUM01	AHU_S_0BA_ MCV01	AHU Humidifier Valve Control
		AHU Humidifier Valve Control Feedback Position
AHU/S/02B /CC01	AHU_S_02BA_ CCV01	AHU Cooling Coil Valve Control
		AHU Cooling Coil Valve Control Feedback Position
n/a	AHU_S_02B_ TMT01	AHU Supply Air Humidity
		AHU Supply Air Temperature
	AHU_S_02B_ MSH01	AHU Supply Air Humidity High Limit Humidistat

2.1.14 BMS AHU Filter Monitoring

AHU Filters

The BMS monitors the filter condition of the AHU insect filter, primary bag and secondary bag filters using differential pressure sensors located across each bank of filters.

The BMS notifies a filter maintenance alarm if the differential pressure exceeds the filter dirty condition.

AHU Mounted Magnahelic gauges provide local indication of the actual filter differential pressure.

Refer to P800-SCH-92-ZZ-SP-XX-013 for further details of local HVAC BMS and PLC monitoring of the Krantz supply and extract HEPA filters.

AHU/S/02A and AHU/E/02A

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/2A/##	AHU/S/02A_ PDT01	AHU Insect Screen Filter
AHU/S/2A/##	AHU/S/02A_ PDT02	AHU Primary Bag Filter F7
AHU/S/2A/##	AHU/S/02A_ PDT03	AHU Secondary Bag Filter F7
AHU/E/2A/##	AHU/E/02A_ PDT01	AHU Extract Fresh Air Inlet Filter G4

AHU/S/02B and AHU/E/02B

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/2B/##	AHU/S/02B_ PDT01	AHU Insect Screen Filter
AHU/S/2B/##	AHU/S/02B_ PDT02	AHU Primary Bag Filter F7
AHU/S/2B/##	AHU/S/02B_ PDT03	AHU Secondary Bag Filter F7
AHU/E/2B/##	AHU/E/02B_ PDT01	AHU Extract Fresh Air Inlet Filter G4

2.1.15 Power Failure and Power Return Control

The HVAC system AHU/02 including BMS and PLC monitoring and control panels are supported by the Brooksby building DRUPs essential power electrical distribution system. Refer to the electrical distribution design schematic. As such there is seamless transition of power from normal mains power failure to mains supplied by the DRUPS power generation.

Should the DRUPs power supply fail to the BMS / PLC AHU control panel the respective AHU supply and extract components will function as follows:

Supply AHU BMS Equipment

- Fresh air isolation damper actuator – Remain last position.
- LTHW frost heating coil valve actuator – Remain last position.
- Heat recovery coil pump – Off
- CHW cooling coil valve actuator - Remain last position.
- LTHW heating coil valve actuator - Remain last position.
- Steam humidifier valve actuator – Closed Spring Return)
- Supply fan 1 with variable speed drive – Off

- Supply fan 1 non return dampers - Close
- Supply fan 2 with variable speed drive – Off
- Supply fan 2 non return dampers - Close
- Discharge isolation damper actuator - Remain last position.

Extract AHU BMS Equipment

- Inlet air isolation damper actuator - Remain last position.
- Fresh air inlet isolation damper actuator – Remain last position
- Extract fan with variable speed drive - Off
- Discharge isolation damper actuator - Closed

Return To Power

There is no load shedding of the high containment HVAC system 02 plant.

Following a return to mains electrical power; the BMS/PLC will, following the time out of the delay timer [10s] * automatically 'start up' the HVAC system, subject to the satisfaction and sequencing of start-up conditions and signals.

Note: The power return delay timers will be adjusted during commissioning to suit the capability of the electrical LV power supply. i.e Staggered start to limit the starting current of the building electrical load.

2.1.15 Fire Alarm Control

The PLC monitors the status of the HVAC fire alarm signal derived from an addressable digital relay, located adjacent the AHU BMS/PLC control panel. The fire alarm relay is connected to the fire alarm network.

In the event that the Fire alarm is in 'alarm' the HVAC plant shall continue to operate. The BMS notifies a fire alarm to the BMS system.

2.1.16 Fireman's Override Control

There is no hardwired fireman's override of the HVAC plant.

Operation of the AHU02 HVAC System 04, is managed as required by the Pirbright Operator, via the BMS PC workstation graphic.

2.1.17 Fire Dampers

There are no drop leaf or motorised smoke dampers on the AHU02 HVAC system and as such there is no BMS / PLC monitoring of fire or smoke dampers.

2.1.18 PLC RTK Remote Alarm System Interface

Each PLC notifies, via a digital output signal, a respective plant failure alarm to the Brooksby building RTK alarm system if AHU/2A or AHU2B supply or extract AHU fails.

Refer to RTK Functional Alarm System Description:
P800-SCH-92-ZZ-SP-XX-0008

2.1.19 BMS Controller Communication Alarms

The BMS provides a controller critical network alarm if the BMS controller fails to communicate to the BMS network. In the event of network failure each controller shall continue to operate in it's last known operating state.

The BMS provides a controller critical network alarm if the respective BMS PLC controller fails to communicate to the BMS network. In the event of network failure each controller shall continue to operate in it's last known operating state.

3.0 Document Hold Register

Outstanding Info / Hold Number	Description	Outstanding Information	Outcome
1	Specification refers to both single and twin extract fan on the AHU. Only a single fan is provided.	Confirm AHU extract is single fan RFI	
2	AHU common supply pressure relief duct external control damper details and isolation damper details	Confirm external damper design details RFI	
3	AHU common extract fresh air make-up duct external control damper details and isolation	Confirm external damper design	

	damper details.	details RFI	
4	AHU extract fresh air make up filter	Confirm if this is required RFI	
5	BMS and PLC Asset Tags will be updated on the document as agreed with the Project Team	Confirm BMS Asset Register	

Appendix 1 BMS and PLC Alarm Schedule

BMS and PLC alarm template and lists to be agreed with The Pirbright Institute team and adhere to the BMS alarm management configuration guidelines detailed in the P800-SCH-92-ZZ-SP-XX-0001

*Note * Alarm inhibit timers to be adjusted during commissioning to suit start up sequence attaining normal control.*

- P800-AHU-02A-ACP01
- P800-AHU-02B-ACP01

PLC Initiated * Alarm To The BMS Digital Alarm Schedule

*Note *: PLC alarms required for PLC software functional control requirements will be initiated at the PLC controller and replicated to the BMS.*

AHU/02A Supply and Extract Air Handling Unit
P800-AHU-02A-ACP01

Description	PLC Object Name	Alarm Priority	Alarm Value	Alarm Transient Time *	Initial Alarm Inhibit *	Comment
AHU Fresh Air Damper Failure Alarm	{tag name}	1	Normal / Alarm	180s	0s	Damper Control Mis-Match Position Alarm
AHU Freeze Protection Thermostat	{tag name}	1	Normal / Alarm	5s	0s	Manually Set at 1 Deg C Thermostat already has latched relay timer [0-10minutes]
AHU Supply Fan 1 Not In Auto Alarm	{tag name}	1	Normal / Alarm	0S	0s	Panel Test/Off/Auto Switch Alarm
AHU Supply Fan 1 VSD In Local Alarm	{tag name}	1	Normal / Alarm	0S	0s	Fan VSD Modbus Signal Alarm
AHU Supply Fan 1 Failed Status	{tag name}	1	Normal / Alarm	20S	0s	Fan VSD Run and Flow Mismatch Alarm
AHU Supply Fan 1 VSD Fault / Trip Status	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Trip Alarm
AHU Supply Fan 1 VSD	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Modbus Alarm VSD

Hours Run						
AHU Supply Fan 2 Not In Auto Alarm	{tag name}	1	Normal / Alarm	0S	0s	Panel Test/Off/Auto Switch Alarm
AHU Supply Fan 2 VSD In Local Alarm	{tag name}	1	Normal / Alarm	0S	0s	Fan VSD Modbus Signal Alarm
AHU Supply Fan 2 Failed Status	{tag name}	1	Normal / Alarm	20S	0s	Fan VSD Run and Flow Mismatch Alarm
AHU Supply Fan 2 VSD Fault / Trip Status	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Trip Alarm
AHU Supply Fan 2 VSD Hours Run	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Modbus Alarm VSD
AHU Discharge Air Damper Failure Alarm	{tag name}	1	Normal / Alarm	180s	0s	Damper Control Mis-Match Position Alarm
FEF Extract Fan 1A Failed Status	{tag name}	1	Normal / Alarm	20S	0s	Fan Flow Mismatch Alarm
AHU Extract Inlet Air Damper Failure Alarm	{tag name}	1	Normal / Alarm	180s	0s	Damper Control Mis-Match Position Alarm
AHU Extract Fresh Air Inlet Damper Failure Alarm	{tag name}	1	Normal / Alarm	180s	0s	Damper Control Mis-Match Position Alarm
Extract Discharge Air Damper Failure Alarm	{tag name}	1	Normal / Alarm	180s	0s	
AHU Extract Fan Not In Auto Alarm	{tag name}	1	Normal / Alarm	0S	0s	Panel Test/Off/Auto Switch Alarm
AHU Extract Fan VSD In Local Alarm	{tag name}	1	Normal / Alarm	0S	0s	Fan VSD Modbus Signal Alarm

AHU Extract Fan Failed Status	{tag name}	1	Normal / Alarm	20S	0s	Fan VSD Run and Flow Mismatch Alarm
AHU Extract Fan VSD Fault / Trip Status	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Trip Alarm
AHU Extract Fan VSD Hours Run	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Modbus Alarm VSD

BMS Initiated Alarm To The BMS Digital Alarm Schedule

AHU/02A Supply and Extract Air Handling Unit
P800-AHU-02A-ACP01

Description	BMS Object Name	Alarm Priority	Alarm Value	Alarm Transient Time *	Initial Alarm Inhibit *	Comment
AHU Frost Coil 1 Control Valve Failure Alarm	{tag name}	3	Normal / Alarm	60s	0s	Valve Control Mis-Match Position Alarm
AHU RAC Coil Pump Fail	{tag name}	3	Normal / Alarm	30s	0s	Pump Control Mis-Match Status Alarm
AHU RAC Coil Low Pressure Alarm	{tag name}	3	Normal / Alarm	30s	0s	Low Pressure Switch Status Alarm
AHU CHW Coil Control Valve Failure Alarm	{tag name}	3	Normal / Alarm	60s	0s	Valve Control Mis-Match Position Alarm
AHU LTHW Coil Control Valve Failure Alarm	{tag name}	3	Normal / Alarm	60s	0s	Valve Control Mis-Match Position Alarm
AHU Steam Humidifier Control Valve Failure Alarm	{tag name}	3	Normal / Alarm	60s	0s	Valve Control Mis-Match Position Alarm
AHU Supply Air Humidistat Alarm	{tag name}	1	Normal / Alarm	180s	0s	Humidistat Hardwired To Steam Control Valve

AHU/02B Supply and Extract Air Handling Unit

Repeat as for AHU 02A PLC and BMS alarms

PLC Initiated * Alarm To The BMS Analogue Alarm Schedule

*Note *: PLC alarms required for PLC software functional control requirements will be initiated at the PLC controller and replicated to the BMS.*

AHU/02A Supply and Extract Air Handling Unit
P800-AHU-02A-ACP01

Description	BMS Alias Address	Alarm Priority	Alarm Value	Alarm Transient Time *	Initial Alarm Inhibit *	Comment
AHU Insect Screen Filter Differential Pressure	{tag name}	5	High 300 Pa	300s	0	Maintenance
AHU Frost Coil LTHW Return Temperature	{tag name}	1	Low 1 Deg C	300s	0	Critical Action (Will Shutdown AHU)
AHU Frost Coil LTHW Return Temperature	{tag name}	1	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Off Frost Coil Average Air Temperature	{tag name}	3	Low 3 Deg C	300s	0	Warning Alert
AHU Off Frost Coil Average Air Temperature	{tag name}	1	Low 1 Deg C	300s	0	Critical Action (Will Shutdown AHU)
AHU Off Frost Coil Average Air Temperature	{tag name}	1	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Pre Filter Differential Pressure	{tag name}	3	High ### Pa	300s	0	Maintenance
AHU Pre Filter Differential Pressure	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Sec. Filter Differential	{tag name}	3	High ### Pa	300s	0	Maintenance

Pressure						
AHU Sec. Filter Differential Pressure	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Supply Average Air Temperature	{tag name}	3	Low 12 Deg C	300s	600s	Warning / Alert
AHU Supply Average Air Temperature	{tag name}	3	High 28 Deg C	300s	600s	Warning / Alert
AHU Supply Air Temperature	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Supply Air Humidity	{tag name}	3	Low 12 Deg C	300s	600s	Warning / Alert
AHU Supply Air Humidity	{tag name}	3	High 28 Deg C	300s	600s	Warning / Alert
AHU Supply Air Humidity	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Air Volume	{tag name}	3	Low ####l/s	30s	600s	Warning / Alert
AHU Common Supply Air Volume	{tag name}	3	High #### l/s	30s	600s	Warning / Alert
AHU Common Supply Air Volume	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Average Calculated Air Pressure	{tag name}	3	Low ##Pa	60s	600s	Warning / Alert
AHU Common Supply Average Calculated Air Pressure	{tag name}	3	High ##Pa	60s	600s	Warning / Alert

AHU Common Supply Air Pressure Sensor 1	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Air Pressure Sensor 2	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Air Pressure Sensor 3	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Air Pressure Mismatch	{tag name}	1	5 % Difference	30s	0	Triplicate Sensors Mismatch
AHU Common Supply Average Air Temperature	{tag name}	3	Low 12 Deg C	300s	600s	Warning / Alert
AHU Common Supply Average Air Temperature	{tag name}	3	High 28 Deg C	300s	600s	Warning / Alert
AHU Common Supply Air Temperature	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Air Humidity	{tag name}	3	Low ## g/kg	300s	600s	Warning / Alert
AHU Common Supply Air Humidity	{tag name}	3	High ##g/kg	300s	600s	Warning / Alert
AHU Common Supply Air Humidity	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
Extract Stack Average Air Velocity	{tag name}	3	Low ##m/s	60s	600s	Warning / Alert
Extract Stack Average Air Velocity	{tag name}	3	High ##m/s	60s	600s	Warning / Alert

Extract Stack Air Velocity	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
Common Extract Air Pressure	{tag name}	3	Low ##Pa	60s	600s	Warning / Alert
Common Extract Air Pressure	{tag name}	3	High ##Pa	60s	600s	Warning / Alert
Common Extract Air Pressure Sensor 1	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
Common Extract Air Pressure Sensor 2	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
Common Extract Air Pressure Sensor 3	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
Common Extract Air Pressure Mismatch	{tag name}	1	5 % Difference	30s	0	Triplicate Sensors Mismatch
Fume Extract Fresh Air Make Up Volume	{tag name}	3	Low ### L/S	30s	0	
Fume Extract Fresh Air Make Up Volume	{tag name}	3	High ### L/S	30s	0	
Fume Extract Fresh Air Make Up Volume	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Extract Fresh Air Inlet Filter Differential	{tag name}	3	High ### Pa	300s	0	Maintenance

Pressure						
AHU Extract Fresh Air Inlet Filter Differential Pressure	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)

Appendix 2 BMS and PLC Set Point Schedule

The BMS User Adjustable Control Set Point Schedules will be developed during the detailed software design and added to this section as required.

AHU2A_ACP01 BMS Set Point Schedule
AHU2B_ACP01 BMS Set Point Schedule

Set Point Description	BMS OBJECT NAME	Set Point *	Set Point Control Tolerance	Comment
AHU Off Frost Coil Air Temperature Control Set Point	[tag name]	5 deg C	MIN 2 deg C	
AHU Off Frost Coil Air Cold Start UP Temperature Control Set Point	[tag name]	20 deg C	MIN 2 deg C	
AHU Supply Air Temperature Control Set Point	[tag name]	Calculated ## deg C	+/- 2 deg C	Calculated between min. and max. according to local room load / demand
AHU Supply Air Humidity Control Set Point	[tag name]	Calculated 7 g/kg	+/- # g/kg	Calculated between min. 1g/kg and 11g/kg max. according to local room %RH load / demand. See local room BMS control description
AHU Common Supply Air Fan Pressure	[tag name]	### Pa	(+/- 5%)	
AHU Common Supply Air Relief Pressure	[tag name]	### Pa	(+/- 5%)	
AHU Common Extract Air Pressure	[tag name]	## Pa	(+/- 5%)	
Extract Stack Efflux Velocity	[tag name]	10.0 m/s	(+/- 5%)	Minimum 10 m/s
Others Set Points To Be Added As Required				

AHU 3 A/B Functional Design Specification

FOR

Brooksby Building P800

BMS and PLC
Automatic Control Panels
P800_AHU03A_ACP01
P800_AHU03B_ACP01

The Pirbright Institute - Pirbright

Prepared by: David Jackson 24Jun20

<David Jackson, Life Science Team Leader, Schneider Electric Buildings> Date

Review

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DOCUMENT REVISION HISTORY

The Sequence of Operations becomes effective on the date of final approval. If changes are made that affect the document's content or approach, a revised, complete document must be issued for re-approval by the approvers of the original document or their designated representatives. A description of those changes with revision number will be noted in the revision log below.

Document naming and version will adhere to the project BIM execution plan naming convention.

Document Version	Status	Description	Revised by	Date Last Modified
P01	S3	Document issued for Project Team Review and Comment.	David Jackson	24 Jun 20

Documents Note:

1) The equipment tags in this document will be updated in line with the High Level BMS Design Document P800-SCH-92-ZZSP-XX-0001

2) The BMS and PLC alarm schedule will be updated in collaboration with the Pirbright Institute and Team Pirbright and subject to commissioning.

3) The BMS and PLC set point schedule will be updated in collaboration with the Pirbright Institute and Team Pirbright and updated during commissioning

4) The document will be updated during the life cycle of the project and will be an O&M reference document

CONTENTS

SECTION 1 – HVAC AIR HANDLING SYSTEM 03

Overview of This Document

This document defines:

- General description of the system
- Reference to schematics
- Monitoring and control description of how the PLC and BMS HVAC applications will operate.
- Reference to PLC and BMS Alarm schedules
- Reference to PLC and BMS Set points schedules

1.0 SYSTEM DESCRIPTION INTRODUCTION

This document describes the BMS / PLC * automation system functional description of operations for the HVAC air handling units serving the HVAC System 003, which are connected to the following combined BMS and PLC controller control panels:

- AHU03A-ACP01
- AHU03B-ACP01

The 1st Section 1 provides the reader with an overview of the system description, 2nd Section 2 provides a detailed description of the BMS and PLC description of operation and is the basis of the PLC and BMS software program.

*Important Note *:*

- *The AHU supply and extract airflow, volume and pressure monitoring, and control components of the design are connected to the PLC controllers.*

- *The AHU supply and extract temperature and humidity monitoring, and control components of the design are connected to the BMS controllers.*

- *The BMS controller monitors the all of the PLC interface I/O points via Modbus IP integration which is available for the User supervision via the BMS workstation and Schneider Electric Enterprise Building Operator (EBO) BMS Software, which will after project completion be connected to the Pirbright Institute site BMS EBO central tiered server; allowing full sitewide remote monitoring of the Brooksby plant connected to the BMS.*

All BMS I/O points and set points including those monitored on the PLC system will be supervised by the BMS graphics and alarms notified as configured by the BMS alarm system.

The AHU system 03 provides supply and extract air serving the HEPA deck environmental and containment HVAC services for the F1 Post Mortem / Waste Storage area.

Refer to the separate functional description of operations Ref. P800-SCH-92-ZZ-SP-XX-0016 for the local HEPA deck HVAC systems serving the basement and change room / shower areas.

Refer to Ventilation System schematics:

- ~~P800-ACM-57-XX-DR-ME-0001_Mechanical Services - Ventilation System Schematic - Sheet 1~~
- ~~P800-ACM-57-XX-DR-ME-0002_Mechanical Services - Ventilation System Schematic - Sheet 2~~
- P800-ACM-57-XX-DR-ME-0003_Mechanical Services - Ventilation System Schematic - Sheet 3
- P800-ACM-57-XX-DR-ME-0004_Mechanical Services - Ventilation System Schematic - Sheet 4

Refer to PLC + BMS input / output point schedules:

- P800-SCH-92-ZZ-SH-XX-7015 ACP AHU3A-Points schedules
- P800-SCH-92-ZZ-SH-XX-7016 ACP AHU3B-Points schedules

The HVAC system 03 plant is served by two, full fresh air, air handling supply units and two respective extract units. Each air handling supply and extract unit is sized at 100% of the system total duty, thereby providing plant redundancy if one unit is not available. Under normal operating times the system operates 24/7.

- AHU/S/03A supply and associated AHU/E/03A extract
- AHU/S/03B supply and associated AHU/E/03B extract

System 03 serves the following rooms which require high containment and environmental monitoring and controls:
Ground Floor

Room Ref	Room Description
F1PL01	Post Mortem
F1PE01	Post Mortem Euthanasia
F1WS01	Waste Storage
F1FE01	Fumigation Chamber

Each Supply AHU comprises:

AHU Equipment	BMS Controller Interface	PLC Controller Interface
Manual Isolation Damper	N/A	N/A
Fly Screen Filter	Yes	
Fresh air isolation damper (motorised)		Yes
LTHW heating coil (freeze protection)	Yes	
Pre filter	Yes	
Attenuator section	N/A	N/A
Heat recovery coil and single pump (RAC energy recovery)	Yes	
CHW cooling coil	Yes	
LTHW heating coil	Yes	
Steam humidifier	Yes	
Twin Supply fan section each with variable speed drive and non-return dampers		Yes
Secondary filter	Yes	
Attenuator	N/A	N/A
Discharge isolation damper (motorised)		Yes
Manual Isolation Damper	N/A	N/A

Each Extract AHU comprises:

AHU Equipment	BMS Controller Interface	PLC Controller Interface
Extract air isolation damper (motorised)		Yes
Heat recovery coil and single pump (RAC energy recovery)	Yes	
Fresh air make-up * isolation damper (motorised)		Yes
Fresh air make-up inlet filter	Yes	
Single Extract fan section with variable speed drive and non-return dampers		Yes
Attenuator	N/A	N/A
Discharge isolation damper (motorised)		Yes
Non-Return Damper		

*Note * The two extract AHU's share a single fresh air make-up airflow duct, which is required during the fumigation to maintain a minimum exhaust stack efflux velocity.*

The Common Fresh Air Make Up Duct to the Extract AHU's comprises:

Equipment	BMS Controller Interface	PLC Controller Interface
Extract Fresh air make-up isolation damper (motorised)		Yes
Extract Fresh air make-up control damper (motorised)		Yes
Extract Fresh air make-up airflow station		Yes

The two AHU supply twin * fan sections normally operate in parallel (Each AHU at 50% system capacity) to maintain constant static pressure in the common supply duct header.

*Note * Whilst each AHU is capable of delivering 100% of the design volume, the twin fan section fans are each capable of 50%. i.e if one of the AHU twin fans was not available, that AHU can only deliver a maximum of 50% of the design.*

The two AHU extract fans normally operate in parallel (normally at 50% system, capacity) to maintain constant static pressure in the common extract duct header. Under normal * operation a minimum exhaust stack efflux velocity (10.0 m/s) should be achieved.

A common AHU supply, pressure relief duct with a variable flow, motorised control damper, provides the ability to maintain the minimum design speed of the AHU supply fan motors, when the turn down volume load, during the fumigation sequence, is lower than the minimum volume that the AHU supply fans can effectively operate. Excess AHU supply volume/pressure will bypass to outside via an external, roof mounted duct cowl. A second isolation damper is provided in the ductwork to provide tight shutoff. The control damper operates to maintain the maximum duct pressure, when the AHU fans are at minimum speed. Both the control damper and isolation damper are externally mounted and accessed from the roof.

A common AHU fresh air-make up duct with a variable flow, motorised control damper, provides the ability to maintain the

minimum extract efflux velocity, when the turn down volume load, during the fumigation sequence, is lower than the minimum volume necessary to maintain the efflux velocity. The make-up volume will derive from an external, roof mounted duct cowl. In this fumigation mode; the control damper operates to maintain the common extract duct pressure. Both the control damper and isolation damper are externally mounted and accessed from the roof.

Each supply AHU operates independently to maintain:

- Freeze protection control
- Energy recovery control
- Supply air temperature control
- Supply air humidity control / protection

Refer to the AHU system 03 local HVAC function description of operation to the BMS/PLC monitoring and control of the local LTHW reheat coils, terminal supply and extract HEPA filters, motorised CAV / VAV dampers and manual fumigation isolation dampers:

- P800-SCH-92-ZZ-SP-XX-0016 Air system 3 local controls Functional design spec

Refer to the secondary monitoring system (SMS) functional description of operation of the independent room pressure monitoring system:

- P800-SCH-92-ZZ-XX-0010 SMS Functional Design Spec

1.1 AHU Motor Control Panel LV Electrical Power Distribution

Each AHU derives electrical power supply from different mechanical services electrical LV panels (MSP's) which in turn derive power from separate LV switchboards (SB's).

- AHU/S/03A * and AHU/E/3A derive power from 50-MSP-01-A
    - 50-MSP-01-A derives power from 50-SB-04-A

- AHU/S/03B * and AHU/E/3B derive power from 50-MSP-01-B
    - 50-MSP-01-A derives power from 50-SB-05-B

*Note * The AHU twin fan section electrical power supply derives from a common fused breaker at the MSP and then is further distributed via a dedicated AHU sub-main fuse board to feed each supply fan VSD and motor.*

The main LV switchboards and mechanical services panels (MSP) are supported by an essential diesel rotary uninterruptible power supply (DRUPS)

The main LV MSP panels are in the F3 plant room and constructed to Form 4, type 6.

Small power to the AHU's lighting / RAC coil pump / BMS/PLC control panel derive from a mechanical plant distribution boards, fed from the respective mechanical services panel.

The BMS monitors the status (Off, Open and Tripped) of the electrical power moulded case circuit breakers (MCCB) to each power feed.

The site wide, aM&T metering system, Power Monitoring Expert (PME) monitors the power meters Refer to LV monitoring Functional Design Spec:

- P800-SCH-92-ZZ-SP-XX-0019 M&E metering systems including LV monitoring functional design spec

Electrical Motor Ratings

AHU/03A Served From 50-MSP-01-A

Description	Plant Ref	Motor name plate (kW)	VSD
Supply Fan 1	AHU/S/03A SF1	11	Yes (Danfoss by AHU supplier)
Supply Fan 2	AHU/S/03A SF2	11	Yes (Danfoss by AHU supplier)
Extract Fan	AHU/E/03A EF1	37	Yes (Danfoss by AHU supplier)

AHU/03A Small Power Served From 50-DB-MCP1-A-A02

Description	Plant Ref	Motor name plate (kW)	VSD
AHU HRC Pump	AHU/S/03A PU01	0.75	Yes Integral Pump
AHU Lighting	Luminaires	6 amp (MCB)	N/A
AHU BMS / PLC Control Panel	AHU/03A/ACP01	16 amp (MCB)	N/A

AHU/03B Served From 50-MSP-01-B

Description	Plant Ref	Motor name plate (kW)	VSD
Supply Fan 1	AHU/S/03B SF1	11	Yes (Danfoss by AHU supplier)
Supply Fan 2	AHU/S/03B SF2	11	Yes (Danfoss by AHU supplier)
Extract Fan	AHU/E/03B EF1	37	Yes (Danfoss by AHU supplier)

AHU/03B Small Power Served From 50-DB-MCP1-B-A02

Description	Plant Ref	Motor name plate (kW)	VSD
AHU HRC Pump	AHU/S/03B PU01	0.75	Yes Integral Pump
AHU Lighting	Luminaires	6 amp (MCB)	N/A
AHU BMS / PLC Control Panel	AHU/03B/ACP01	16 amp (MCB)	N/A

Each AHU fan VSD is mounted adjacent to the respective AHU motor. A local isolator downstream of the VSD provides the facility to safely isolate the motor. Each VSD is provided with local run/trip/fault/ operating diagnostics and control keypad.

1.2 AHU BMS + PLC Control Panel

Each of the AHU 03 BMS and PLC control panels are manufactured as detailed in the High Level BMS Design Document P800-SCH-92-ZZSP-XX-0001.

- AHU/03A/ACP01
- AHU/03B/ACP01

Each panel is provided with:

- Key lockable door
- Internal mains power disconnect isolator
- MCB protection fuses
- BMS controller and supporting transformer power supplies and I/O modules
- PLC controller and supporting transformer power supplies and I/O modules and PLC network switch
- Interfacing relays and relay timers
- Power healthy and plant status LED indication lamps
- AHU fan and pump Test/Off/Auto key operated switches
- Interfacing terminals with knife disconnect
- SELV fused terminals to 24Vac field equipment

- RCD service laptop socket
- RJ45 socket service laptop connection to BMS network

The BMS Control Panel Fascia will have the following lamps and switches

AHU/03A/ACP01

Equipment Reference	Description	Fascia Key Switch	Fascia LED Lamp
Mains Healthy			230Vac Lamp
BMS 24Vac Power Supply			24Vac Lamp
PLC 24Vac Power Supply			24Vac Lamp
AHU/S/03A/SF1	AHU 03A Supply Fan 1	Test / Off / Auto	Run Trip Frost + Reset
AHU/S/03A/SF2	AHU 03A Supply Fan 2	Test / Off / Auto	Run Trip Frost + Reset
AHU/E/03A/EF	AHU 03A Extract Fan	Test / Off / Auto	Run Trip
AHU/S/03A/PU	AHU 03A Run Around Coil Pump	Test / Off / Auto	Run Trip Low Pressure

AHU/03B/ACP01

Equipment Reference	Description	Fascia Key Switch	Fascia LED Lamp
Mains Healthy			230Vac Lamp
BMS 24Vac Power Supply			24Vac Lamp
PLC 24Vac Power Supply			24Vac Lamp
AHU/S/03B/SF1	AHU 03B Supply Fan 1	Test / Off / Auto	Run Trip Frost + Reset
AHU/S/03B/SF2	AHU 03B Supply Fan 2	Test / Off / Auto	Run Trip Frost + Reset
AHU/E/03B/EF	AHU 03B Extract Fan	Test / Off / Auto	Run Trip
AHU/S/03B/PU	AHU 03A Run	Test / Off /	Run

	Around Coil Pump	Auto	Trip Low Pressure

1.3 PLC Controller AHU Supply Fan and Extract Fan Operational Interlocks

If both twin AHU supply fans are not available to operate, the respective extract fan will shut down. The available operating supply and extract fans will automatically ramp up to maintain respective system pressures.

If the AHU extract fan is not available, the respective supply AHU will shut down. The available operating supply and extract fans will automatically ramp up to maintain respective system pressures.

PLC Controller Hardwired Plant Interlocks

Hardwired interlocks shall be operable for both Auto (Remote) and Hand (local VSD only) mode control of motor operation.

- AHU Off/Auto Switch
- AHU fresh air damper position end switch closed inhibits the AHU supply fan VSD from operating.
- AHU discharge air damper position end switch closed inhibits the AHU supply fan VSD from operating.
- AHU supply fan interlocked to extract fan.
- AHU extract fan interlocked to supply fan *(timed start relay)*
- AHU Off Frost Coil Low Limit Thermostat Temperature Alarm interlocked to inhibit AHU supply fan and extract fan.
- AHU extract air inlet damper position end switch closed inhibits the AHU extract fan VSD from operating.
- AHU extract air discharge damper position end switch closed inhibits the AHU extract fan VSD from operating.

BMS Controller Hardwired Plant Interlocks

- AHU run around coil high- and low-pressure switch in alarm interlocked to inhibit pump operation.
- AHU supply air high limit humidistat switch in alarm interlocked to close spring return steam control valve.

Note there are:

- No hardwired fire alarm to shut down the plant
- No hardwired fireman's over mode to operate the plant
- No hardwired pressure safety switches to shut down the plant

2.0 Control Sequences

2.0.1 Overview

The plant operates 24/7 subject to BMS operator plant control flags and defined software and hardwired interlocks.

The monitoring and controls are performed by both BMS and PLC controllers. The following controls section title indicates the main controller, BMS or PLC performing the control software.

Note: It is anticipated that the HVAC system may take 20 to 30 minutes to start up and stabilise. All timers required in software will be established during commissioning and final setting recorded in the respective set point schedule.

2.1.1 PLC Controller Normal System Start Up

Non critical plant and environmental BMS alarms are inhibited (disabled) during start up. Room pressure alarms always remain activated, unless manually disabled by the Pirbright Institute via the BMS PC graphics screen.

- Room pressure alarms to always be activated for safety.
- Plant, temperature / humidity alarms de-activated,

Important Note. The Operation and Start-up of the containment HVAC system is subject to manual SOP's.

The following conditions are pre-requisite to start up the HVAC system and assumes that all manual SOP's have been correctly adhered to.

- BMS graphics software operator plant flag is set to 'ENABLE' {PLC Modbus Point}
- At least one of the two AHU plant, AHU 3A or 3B PLC available flags is 'AVAILABLE'

Note. Any AHU 3A or 3B Mode selected 'Off' via the BMS workstation graphics will not start.

Step 1 – Activate BMS frost coil control regime. (Refer Section 2.2.1)

Note: If the ambient conditions {BMS global point} below [5] deg C, then activate AHU cold start regime to preheat the frost coils. Check the

temperature of the LTHW frost coil return line to indicate that heating is available {BMS Modbus before proceeding with AHU start up.

Step 2 – Activate PLC airflow and room pressure controls. Refer to PLC Functional Description of Operation:

- P800-SCH-92-ZZ-SP-XX-0016 Air system 3 local controls Functional design spec

Note: The local PLC airflow / pressure controller ramps the airflow / pressure damper controls to keep the airflow negative into the high containment laboratories throughout the start-up sequence.

Step 3 – PLC to command the AHU supply and extract inlet and discharge air damper isolation dampers to 'OPEN'

Step 4 – PLC to established that each damper has opened as monitored by the damper actuator end switches

If the damper fails to open, (after a suitable proving period) The PLC shall notify a damper failure alarm to the BMS and shall cause the PLC control strategy to make the associated fan/AHU as Not Available.

Step 5 - When all respective isolation dampers are proved open:
The PLC to command to start the available AHU extract fans,
followed by the available AHU twin supply fans.

Note: AHU supply fan and general extract fan shall start and initially operate at pre-fixed minimum speeds set points, set at the VSD.

Step 6 – The PLC is to ramp up the AHU extract fan and supply fan in a controlled sequence to attain the respective supply and extract pressure control set points. (Air regime to maintain negative flow / containment in the high containment laboratories)

Step 7 – The PLC is to enable a Modbus signal to the BMS controller environmental control loops when the VSD run status or airflow differential pressure switch across the AHU supply fans has been established.

- AHU supply air and room temperature control regimes.
- AHU supply air and room humidity control regimes.

Step 9 - After pre-fixed times, allowing for the plant to attain control conditions, the BMS will activate the following BMS alarm monitoring.

- AHU supply and extract temperature, humidity and flow and pressure
- Room temperature alarms

2.1.2 Normal System Shutdown

Any of the following conditions shall cause the AHU HVAC system to shut down:

- BMS plant operator software flag {PLC Modbus Point} is set to 'SHUTDOWN'

In the event of the HVAC system being shut down the following sequence shall follow.

Step1 – The BMS will disable temperature, humidity, flow and duct pressure monitoring BMS alarms.

Step 2 – BMS to close humidifier control valve

Step 3 – PLC AHU controller to send a Modbus signal to the local room PLC controllers to slowly ramp down room pressure CVB and VVB volume set points to minimum control set points whilst aiming to maintain a negative air flow regime within the laboratories.

- P800-SCH-92-ZZ-SP-XX-0016 Air system 3 local controls Functional design spec

Note: AHU supply fan and extract fans will automatically ramp down under PLC control to maintain index pressures.

- At a preset AHU low volume; (beyond which no reliable control is possible) the PLC is to switch off the supply fan followed by extract fans and set fan speed control to zero:

- AHU Supply fan AHU/S/03A
- AHU Supply fan AHU/S/03B

- AHU Extract fan AHU/E/03A
- AHU Extract fan AHU/E/03A

- The PLC AHU controller will send a Modbus signal to the local room PLC controllers to inhibit / freeze the control of the respective room pressure / VAV controls.

When the AHU fans have stopped the PLC will disable the signal to the BMS controllers to close the respective AHU and local coil control valves

Step 4 – BMS to close AHU heating coil control valve
Step 5 – BMS to close AHU cooling coil control valve
Step 6 – BMS to switch off RAC pump
Step 7 – PLC to fully close AHU supply / extract inlet and discharge air dampers
Step 8 – BMS to fully close local heating coil control valves
Step 9 – BMS to close AHU frost coil control valve

2.1.3 Plant Fault Shutdown Scenarios

General Note: Following an 'alarmed/fault' shutdown of the system (except Mains power failure) the User shall be required to manually reset of the appropriate graphic software flag via the BMS operator workstation.

AHU Supply Fan Failure Shutdown:

- If both AHU twin fans have failed.

Step1 – BMS to disable AHU temperature, humidity index pressure and volume monitoring alarms.

Step 2 – BMS to close humidifier control valve output to 0% open

Step 3 – PLC to switch off the following fans and set fan speed control to zero:

Note The remaining operational AHU will automatically ramp up in speed (circa 100% of design duty) to maintain required index pressure set points.

- Switch off both failed AHU supply twin fans
- Switch off respective AHU Extract fan

Note: Extract fan specified as hardwired interlock and it will shutdown immediately as soon as the supply fan VSD run status is in-active.

This will cause a step change in system pressure and the remaining extract fan is to ramp up quickly to retain control of the extract index pressure.

Step 4 – BMS to Close AHU heating coil control valve
Step 5 – BMS to Close AHU cooling coil control valve
Step 6 – PLC to Close AHU fresh air damper

Step 7 – PLC to Close AHU discharge air damper
Step 8 – BMS to Close AHU frost coil control valve
Step 9 – BMS to Switch off AHU RAC coil pump and set pump speed control to zero

Step 10 – PLC to Close AHU extract inlet air damper
Step 11 – PLC to Close AHU extract discharge air damper
Step 12 – PLC to Close AHU extract fresh air make-up isolation damper

AHU Supply Fan Fault Reset

A manual reset of the AHU supply fan fault flag, via the BMS PC graphic head end, shall allow the AHU and general extract fan to restart.

Sequence start the extract fan first followed by supply fan.

- PLC to command open the AHU extract and AHU supply inlet and discharge isolation dampers as per a normal start. The AHU extract and AHU supply non return dampers will remain closed whilst there is back pressure from the operating AHU.

- When the AHU extract inlet and discharge dampers are open the PLC Enables the extract fan. Fan operates at minimum speed and slowly ramps up speed towards the speed of the already operating fan. When the starting AHU speed matches that of the operating fans, release the ramp control and operate both AHU fan speeds in parallel. (Note as the restarting fan contributes to system pressure the PLC pressure fan speed control will automatically reduce the speed of the other AHU fans, such that pressure is maintained).

- Simultaneously to above the PLC operates the AHU supply inlet and discharge dampers and controls the speed of the AHU twin fans in a similar way to the above extract fans.

General Extract Fan Failure

- As per AHU supply fan failure

Note: The AHU supply fans are hardwired to not operate if the respective extract fan is not running.

General Extract Fault Reset

A manual reset of the AHU extract fan fault flag, via the BMS PC graphic head end, shall allow the AHU and general extract fan to restart.

2.2.4 BMS AHU Freeze Protection Control

The BMS monitors the off-frost coil temperature * and modulates, via a PID control loop, the AHU LTHW frost heating coil 2 port (PICV) control valve to maintain minimum off coil air temperature set point of [5] deg C.

*Note * A 6000mm length, averaging, temperature control sensor is laced across the frost coil discharge.*

The BMS monitors the AHU fresh air inlet temperature, via a duct mounted averaging sensor. Under low fresh air inlet, ambient temperature conditions below [0] deg C the BMS shall schedule an increase of the off-frost coil temperature to [10] deg C

Note: To avoid problems with the AHU tripping on low limit frost protecting, on a cold AHU, start-up routine. (ambient temperature below 5 deg C) The off-frost coil temperature set point will be set to [10] deg C and ramped down to normal set point, after a preset time 20 minutes.

The BMS will send an AHU supply and AHU extract shutdown signal (Via Modbus) to the PLC controller if the BMS control sensor monitors a low limit below [3] deg C for a transient period of time (5 minutes).

The BMS will notify a critical alarm to the BMS alarm engine and graphic if the off-frost coil temperature falls below [3] deg C.

The BMS monitors the LTHW frost coil return pipe water temperature, via an immersion temperature sensor. The BMS will send an AHU supply and AHU extract shutdown signal (Via Modbus) to the PLC controller if the BMS control sensor monitors a low limit below [20] * deg C for a transient period of time (5 minutes). The BMS will fully open the frost coil valve.

Note: Review specified 20 deg to shutdown the AHU and fully open the frost coil valve. This may cause nuisance tripping and also overheat the AHU when it is off and isolated.

The BMS will notify a critical alarm to the BMS alarm engine and graphic if the frost coil return water temperature falls below [4] deg C.

The BMS monitors the control valve actuator feedback and notifies an alarm if the valve control signal does not match the feedback signal within 5% allowing for a suitable transient time [10s] for the actuator motor to operate.

The BMS notifies a valve exercise alarm, if the valve has not operated in 100 hours. The BMS operator can override the BMS automatic control and

manually signal the valve 0 to 100 to 0% open and then release back to automatic via the BMS graphic.

AHU/S/3A

Control and Instrument Ref	Point Descriptor
AHU_S_03A_ TEM01	Fresh Air Temperature
AHU_S_03A_ ACV01	Frost Coil Control Valve
AHU_S_03A_ ACV01	Frost Coil Control Valve Position
AHU_S_03A_ TEM02	Off Frost Coil Temperature
AHU_S_03A_ TEM03	Frost Coil Return Temperature

AHU/S/3B

Control and Instrument Ref	Point Descriptor
AHU_S_03B_ TEM01	Fresh Air Temperature
AHU_S_03B_ ACV01	Frost Coil Control Valve
AHU_S_03B_ ACV01	Frost Coil Control Valve Position
AHU_S_03B_ TEM02	Off Frost Coil Temperature
AHU_S_03B_ TEM03	Frost Coil Return Temperature

2.2.5 PLC AHU Freeze Protection Control

A low limit, automatic reset, thermostat * (manually set at [3] deg C) is hardwired via a latched relay adjustable timer in the panel (0-15minutes) to protect the AHU from freezing.

If the off-frost coil low limit temperature exists for more than 5 minutes (adjustable PLC panel relay timer) the AHU supply fan and extract fan will shut down.

*Note * A 6000mm length, capillary, thermostat is laced across the frost coil discharge.*

A frost alarm indication lamp and manual reset button is located on the fascia respective BMS/PLC control panel.

The PLC also monitors a Modbus AHU freeze protection signal from the BMS system. If the freeze protection alarm is active the PLC will shut down the respective AHU supply and AHU extract units.

AHU/S/3A

Control and Instrument Ref	Point Descriptor
AHU_S_03A _ FRO01	Off Frost Coil Low Limit Thermostat

AHU/S/3B

Control and Instrument Ref	Point Descriptor
AHU_S_03B _ FRO01	Off Frost Coil Low Limit Thermostat

2.1.6 BMS AHU Run Around Coil Control and Monitoring

Refer also to supply air temperature control which operates in conjunction with energy recovered from the run around coil.

The AHU heating and cooling coil valves operate in sequence to maintain supply air temperature set point.

The BMS monitors the AHU inlet air temperature and associated AHU extract temperature.

Heating Mode
The RAC pump is switched On and operated at 100% speed for first stage heating when the AHU fresh air inlet temperature is below the AHU supply air set point temperature and below the AHU return air temperature by more than a value defined in the set point. [3] deg C

The RAC pump is switched off when this temperature difference falls to [1.5]K or less for a period of [5]minutes.

Cooling Mode

The RAC pump is switched On and operated at 100% speed for first stage cooling when the AHU fresh air inlet temperature is above the AHU supply air temperature set point and above return air by more than a value defined in the set point [3] deg C.

The RAC pump is switched off when this temperature difference falls to [1.5]K or less for a period of [5]minutes.

The cooling valve modulates to maintain the desired supply air temperature set point.

RAC Pump Monitoring

The RAC pump is fitted with an integral VSD.

The BMS provides a remote enable of the pump VSD and speed control.

The BMS monitors the status of the RAC pump Test-Off-Auto switch on the BMS control panel. The BMS notifies an alarm is the pump is not in Auto mode.

The BMS monitors the pump's VSD run status and notifies a pump failure alarm if there is a mis-match between BMS pump VSD enable signal and the VSD run feedback.

The BMS monitors the pump's VSD fault status and notifies an pump fault alarm if the pump is in fault condition.

The BMS monitors the pump VSD status via Modbus open protocol

The BMS monitors the performance of the RAC by measuring the on-air and off-air coil and pipe-inlet and pipe-outlet coil temperatures.

The BMS shall notify a warning and critical low temperature alarm at the BMS workstation.

The BMS monitors a RAC circuit, high- and low-pressure switch and shall notify an alarm if there is a pressure alarm. In the event of an alarm the BMS switches off the RAC pump. (The alarm is also hardwired interlocked to disable pump)

AHU/S/03A

Plant Ref	Control and Instrument Ref	Point Descriptor
n/a	AHU_S_03A_ TEM01	AHU Inlet Air Temperature
n/a	AHU_E_03A_ TEM01	AHU Extract Air Temperature
AHU/S/03A/ PU01	n/a	RAC Pump VSD Enable
	n/a	RAC Pump VSD Speed Control
	n/a	RAC Pump VSD Run Status
	n/a	RAC Pump VSD Fault Status
	n/a	RAC Pump VSD Local / Remote Status
AHU/S/03A/ HRC	AHU_S_03A_ TEM02	AHU On Air RAC Coil Temperature
	AHU_S_03A_ TEM04	AHU Off Air RAC Coil Temperature
	AHU_S_03A_ _TEM08	AHU RAC Coil Inlet Temperature
	AHU_S_03A_ _TEM09	AHU RAC Coil Outlet Temperature

AHU/S/03B

Plant Ref	Control and Instrument Ref	Point Descriptor
n/a	AHU_S_03B_ TEM01	AHU Inlet Air Temperature
n/a	AHU_E_03B_ TEM01	AHU Extract Air Temperature
AHU/S/03A/ PU01	n/a	RAC Pump VSD Enable
	n/a	RAC Pump VSD Speed Control
	n/a	RAC Pump VSD Run Status
	n/a	RAC Pump VSD Fault Status
	n/a	RAC Pump VSD

		Local / Remote Status
AHU/S/03A/ HRC	AHU_S_03B_ TEM02	AHU On Air RAC Coil Temperature
	AHU_S_03B_ TEM04	AHU Off Air RAC Coil Temperature
	AHU_S_03B_ _TEM08	AHU RAC Coil Inlet Temperature
	AHU_S_03B_ _TEM09	AHU RAC Coil Outlet Temperature

The BMS monitors the RAC Pump VSD Modbus Registers

VSD Monitoring Parameter	VSD Modbus Register	BMS Point Descriptor
		AHU RAC Pump Local Remote Status
		AHU RAC Pump Fault Code
		Power Consumption kW
		Frequency Hz Feedback
		Amperes Current

2.1.7 PLC AHU Supply Fan Pressure Control

The PLC monitors the average AHU common, supply air main header pressure sensors, as measured via 3 duct pressure sensors. * The PLC modulates, via a PID control loop, the operating AHU supply fan VSD, speed control signal in parallel to maintain the pressure set point [###Pa].

Review Impact of Specification which may cause problems with the ability to provide accurate room pressure damper authority and control.

In order to negate the effects of the increasing pressure drop across the terminal HEPA filters as they dirty and the decrease in pressure drop when filters are replaced the supply and extract static pressure setpoints shall be reset.

The PLC shall continuously monitor the position of the large VAV box dampers. The PLC shall then reset the static pressure setpoint up/down to ensure the most open large VAV on the supply or extract remains [90]% open ± [2]%.

The increments at which the supply and extract static pressure setpoints are reset and the time delays between each resetting step shall be developed by the Contractor and proven in the commissioning period.

The two AHU PLC fan speed controllers are arranged master / slave. If the master speed controller CPU is not available, the slave controller shall take over speed control. The CPU available signal is determined by a simple controller 1 task that turns a PLC digital output on and off repetitively; This is then monitored as a digital input by the slave controller. If the input repetitively changes state on and off then the PLC controller no. 1 is deemed functioning okay. If the input stops, the controller no.1 is deemed to be unavailable and the slave controller takes over the control loop for VSD fan speed control.

The PLC Controller speed reference control signal to each AHU VSD is also duplicated as a control signal to the 2nd AHU PLC Controller, so that

*Note * The Duct sensors are CMR manufactured P-Sensors each complete with dual channel 4-20mA / 0-10Vdc outputs. Two of the sensors are powered from PLC Controller 1 (AHU/03A) and the Third sensor powered from PLC Controller 2. The 2nd 0-10Vdc output channel from each sensor is shared to the other controller.*

A low / high static pressure alarm shall be notified at the BMS. (Refer to alarm schedule)

Note the PLC shall monitor the 3 pressure sensors and discard any single value that is [5%] out of range or failed because of open or short circuit signal.

The pressure is controlled by one of the 2 PLC controllers. If the lead PLC controller fails, the 2nd PLC controller will become the lead pressure controller.

AHU/S/03A - PLC Controller No.1

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/03A/ SF01	AHU_03A_ VSD01	AHU Supply Fan 1 Speed Control
AHU/S/03A/ SF02	AHU_03A_ VSD02	AHU Supply Fan 2 Speed Control
	n/a	AHU Supply Fan Controller 1 Speed Output Controller 2
	n/a	AHU Supply Fan Controller 1 Speed Input Controller 2
	AHU/S/01_ PT01	AHU Common Supply Header Pressure No.1
	AHU/S/01_ PT02	AHU Common Supply Header Pressure No.2
	Shared Input (0-10Vdc)	AHU Common Supply Header Pressure No.3
		PLC Controller 1 CPU Sanity Control Output
		PLC Controller 2 CPU Sanity Control Input

AHU/S/03B- PLC Controller No.2

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/03B/ SF01	AHU_03B_ VSD01	AHU Supply Fan 1 Speed Control
AHU/S/03B/	AHU_03B_	AHU Supply Fan 2

SF02	VSD02	Speed Control
	n/a	AHU Supply Fan Controller 2 Speed Output Controller 1
	n/a	AHU Supply Fan Controller 1 Speed Input Controller 2
	Shared Input (0-10Vdc)	AHU Common Supply Header Pressure No.1
	Shared Input (0-10Vdc)	AHU Common Supply Header Pressure No.2
	AHU/S/01_ PT03	AHU Common Supply Header Pressure No.3
		PLC Controller 2 CPU Sanity Control Output
		PLC Controller 1 CPU Sanity Control Input

2.1.8 PLC Common AHU Supply Header Pressure Control

The AHU supply duct is connected to pressure relief duct, connected to an external roof cowl. The duct relief operates in two modes:

- AHU system fumigation high pressure.
- AHU normal operation high duct pressure.

AHU Fumigation Mode Control

The AHU supply volume will reduce when rooms are isolated during the fumigation sequence. If the supply volume reduces below the minimum operating speed of the AHU fans, the PLC will operate the AHU's at the minimum operating speed * and open the common supply pressure relief isolation damper (fast acting) whilst modulating, via a PID control loop, a supply pressure, pressure relief control damper (fast acting) to maintain the constant supply volume pressure set point.

The AHU 3A PLC controller will control the common pressure control damper and isolation damper.

*Note * The AHU fan motor minimum operating speeds will be determined during commissioning and fixed at the VSD inverter.*

The PLC uses the same triplicate monitoring arrangement of duct pressure sensors as used for normal supply fan speed control.

The BMS notifies the damper position mis-match alarm, if the PLC control output signal does not match the damper feedback position.

AHU Normal Operation High Pressure Protection

The PLC will control the supply duct pressure relief dampers to cap the main supply duct pressure at a maximum of [###Pa].*

Note. the maximum pressure set point is to be carefully determined during commissioning not to conflict with the PLC supply fan pressure control set point. (initial high limit cap to be 20% above normal set point. i.e if supply air pressure is 750Pa the high limit set point will be set at 900Pa)

The PLC will open the common supply pressure relief isolation damper (fast acting) whilst modulating, via a control loop, a supply pressure, pressure relief control damper (fast acting) to limit the AHU supply pressure

Common Supply Duct Pressure Relief Control – PLC Controller 1

Control and Instrument Ref	Point Descriptor
AHU_S_03_ ACD01	Supply Pressure Relief Control Damper
AHU_S_03_ ACD01	Supply Pressure Relief Control Damper FB Position
AHU_S_03_ FT02	Supply Pressure Relief Volume
AHU_S_03_ ACD02	Supply Pressure Relief Isolation Damper
AHU_S_03_ ACD02	Supply Pressure Relief Isolation Damper FB Position
Refer to Triplicate Duct Pressure Sensor on Fan Control	

2.1.9 PLC AHU Extract Fan Speed Control – No Room Fumigation

During normal operation the 2no. AHU extract fans operate in parallel at a prefixed VSD speed to attain a constant efflux (at 50% duty each) The PLC monitors the average AHU common, Extract air main header pressure sensors, as measured via 3 duct pressure sensors. * The PLC modulates, via PID loop, the operating AHU Extract fan VSD, speed control signal in parallel to maintain the pressure set point [###Pa].

The PLC extract fan uses the same Master/Slave controller arrangement as the supply fan control.

The PLC Controller speed reference control signal to each AHU VSD is also duplicated as a control signal to the 2nd AHU PLC Controller, so that

*Note * The Duct sensors are CMR manufactured P-Sensors each complete with dual channel 4-20mA / 0-10Vdc outputs. Two of the sensors are powered from PLC Controller 1 (AHU/03A) and the Third sensor powered from PLC Controller 2. The 2nd 0-10Vdc output channel from each sensor is shared to the other controller.*

A low / high static pressure alarm shall be notified at the BMS. (Refer to alarm schedule)

Note the PLC shall monitor the 3 pressure sensors and discard any single value that is [5%] out of range or failed because of open or short circuit signal.

The pressure is controlled by one of the 2 PLC controllers. If the lead PLC controller fails, the 2nd PLC controller will become the lead pressure controller.

AHU/E/03A – PLC Controller No.1

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/E/03A/ EF0 1	AHU_E_03A_ VSD01	AHU Extract Fan 1 Speed Control
	n/a	AHU Extract Fan Controller 1 Speed Output Controller 2
	n/a	AHU Extract Fan Controller 1 Speed Input

		Controller 2
	AHU/E/03_ PT01	AHU Common Extract Header Pressure No.1
	AHU/E/03_ PT02	AHU Common Extract Header Pressure No.2
	Shared Input (0-10Vdc)	AHU Common Extract Header Pressure No.3

AHU/E/03B – PLC Controller No.2

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/E/03B/ SF01	AHU_E_03B_ VSD01	AHU Extract Fan 1 Speed Control
	n/a	AHU Extract Fan Controller 2 Speed Output Controller 1
	n/a	AHU Extract Fan Controller 1 Speed Input Controller 2
	Shared Input (0-10Vdc)	AHU Common Extract Header Pressure No.1
	Shared Input (0-10Vdc)	AHU Common Extract Header Pressure No.2
	AHU/S/03_ PT03	AHU Common Extract Header Pressure No.3

2.1.10 PLC AHU Extract Fan Speed Control and Fresh Air Make Up Pressure Control – During Room Fumigation Sequence.

During the fumigation mode of risk spaces, the stack exhaust volume must maintain a constant volume to achieve a minimum safe efflux velocity. (10 m/s at the exhaust cone)

During the fumigation mode the AHU extract fans will operate at a fixed speed *(speed to be determined during commissioning)* and the PLC will control, via PID loop, the common fresh air inlet make up damper to maintain the duct pressure set point * and hence maintain a constant exhaust volume.

*Note *: The duct pressure set point will need to be checked during design review / commissioning to establish if the set point is the same during normal extract fan speed control and fumigation control ?*

The PLC monitors the common stack extract volume via an externally * mounted CMR airflow station (velo-probes) mounted in the extract stack. The PLC will use the measured volume to calculate the velocity at the cone section where there is a reduced outlet area and signal this value to the BMS. The BMS notifies an alarm if the efflux velocity is below a low threshold alarm limit.

*Note *: The extract volume CMR airflow transducer will be mounted inside the plantroom, at a location to be accessed for calibration. The external PVC tubing shall be protected via conduit from UV sunlight and provided internally with a condensate loop to prevent water entering the transmitter.*

The PLC uses the same triplicate monitoring arrangement of duct pressure sensors as used for normal extract fan speed control.

Prior to being able to control the fresh air make-up damper, the PLC will:

- Open the common fresh air make up damper isolation damper
- Open the respective extract AHU fresh air make up isolation damper, which allow the fresh air to enter the AHU after the AHU extract run around coil.

The PLC monitors that the damper actuator end switch, closed positions.

The BMS notifies the damper position mis-match alarm, if the PLC control output signal does not match the damper end switch position.

The BMS monitors the differential pressure across the fresh air make up filter, on the inlet to the AHU and notifies an alarm if the filter requires maintenance.

Common Fresh Air Make Up Duct – Proposed By PLC Controller 1

Control and Instrument Ref	Point Descriptor
AHU_EM_03_ ACD01	Extract System Fresh Air Make Up Control Damper
AHU_EM_03_ ACD01	Extract System Fresh Air Make Up Control Damper FB Position
AHU_MA_03_ FT01	Extract System Fresh Air Make Up Volume
AHU_EM_03_ ACD01	Extract System Fresh Air Make Up Isolation Damper
AHU_EMA_03_ ACD01	Extract System Fresh Air Make Up Isolation Damper FB Position
AHU_E_03_FT01	Total Extract Stack Volume
Refer to Triplicate Duct Pressure Sensor on Fan Control	

AHU/E/03A Extract Fresh Air Make Up

Control and Instrument Ref	Point Descriptor
AHU_EM_03A_ FXD01	AHU Extract Fresh Air Make Up Isolation Damper
AHU_EM_03A_ FXD01_ZSc	AHU Extract System Fresh Air Make Up Isolation Damper FB Closed Position
AHU_EM_03A_ DIF01	AHU Extract System Fresh Air Make Up Filter Differential Pressure

AHU/E/03B Extract Fresh Air Make Up

Control and Instrument Ref	Point Descriptor

AHU_EM_03B_ ACD02	AHU Extract Fresh Air Make Up Isolation Damper
AHU_EM_03B_ ACD02	AHU Extract System Fresh Air Make Up Isolation Damper FB Closed Position
AHU_EM_03B_ DIF01	AHU Extract System Fresh Air Make Up Filter Differential Pressure

2.1.11 PLC Fan Monitoring and Fan Failure Monitoring

The PLC determines the running status of the fan using the differential pressure air flow switch and VSD run status.

- When a fan is commanded to start by the PLC, a pre-fixed timer is activated (proving period). If after the timer expires, the VSD run status and air flow switch does not indicate both run and air flow then the fan is deemed to have failed. The PLC will raise a fan failed signal and via a Modbus register, an alarm will be notified by the BMS.

- Having commanded a fan to start, the PLC continues to monitor the status of the air flow alarm, allowing for a transient time, to indicate that the fan is still operating. If after the timer expires, the air flow status does not indicate air flow then the fan is deemed to have failed. The PLC will raise a fan failed signal and via a Modbus register, an alarm will be notified by the BMS.

- The PLC monitors the VSD common fault status (VSD locked out – motor is not available). In the event of an alarm, the respective fan is instantly deemed to have failed; and via the Modbus register the BMS notifies a VSD fault alarm.

- The PLC monitors the VSD Local / Remote status via Modbus and via the Modbus register the BMS notifies an alarm If the VSD is operated in local (hand mode).

- The PLC monitors the control panel Test/Off/Auto switch and via the Modbus register the BMS notifies an alarm if the switch is not in Auto.

- The PLC monitors the common AHU supply airflow volume, using CMR volume sensor and velo-probes mounted in the duct.

- The PLC monitors the common AHU extract airflow volume, from the risk space, using a CMR volume sensor and velo-probes mounted in the duct.

- The PLC monitors the common stack extract airflow volume, using a CMR volume sensor and velo-probes mounted in the duct. Via a Modbus register the BMS notifies an efflux velocity alarm if the velocity is below the low limit threshold.

- The PLC monitors the AHU fan VSD via Modbus RTU (See Modbus register table)

AHU/S/03A

Plant Ref	Control and Instrument Ref	Point Descriptor
SF01	AHU_S_03A_ SF01_VSD01	AHU Supply Fan 1 VSD Enable
SF01	n/a	AHU Supply Fan 1 VSD Fault Status
SF01	n/a	AHU Supply Fan 1 VSD Run Status
SF01	n/a	AHU Supply Fan 1 VSD Local/Remote Status
SF01	AHU_S_03A_ SF01_PDS01	AHU Supply Fan 1 Differential Pressure Switch (Flow) Status
SF02	AHU_S_03A_ SF01_VSD01	AHU Supply Fan 2 VSD Enable
SF02	n/a	AHU Supply Fan 2 VSD Fault Status
SF02	n/a	AHU Supply Fan 2 VSD Run Status
SF02	n/a	AHU Supply Fan 2 VSD Local/Remote Status
SF02	AHU_S_03A_ SF01_PDS01	AHU Supply Fan 2 Differential Pressure Switch (Flow) Status

AHU/S/03B

Plant Ref	Control and Instrument Ref	Point Descriptor
SF01	AHU_S_03B_ SF01_VSD01	AHU Supply Fan 1 VSD Enable
SF01	n/a	AHU Supply Fan 1 VSD Fault Status
SF01	n/a	AHU Supply Fan 1 VSD Run Status
SF01	n/a	AHU Supply Fan 1 VSD Local/Remote Status
SF01	AHU_S_03B_ SF01_PDS01	AHU Supply Fan 1 Differential Pressure Switch (Flow) Status
SF02	AHU_S_03B_ SF01_VSD01	AHU Supply Fan 2 VSD Enable
SF02	n/a	AHU Supply Fan 2 VSD Fault Status
SF02	n/a	AHU Supply Fan 2 VSD Run Status
SF02	n/a	AHU Supply Fan 2 VSD Local/Remote Status
SF02	AHU_S_03B_ SF01_PDS01	AHU Supply Fan 2 Differential Pressure Switch (Flow) Status

AHU/E/03A

Plant Ref	Control and Instrument Ref	Point Descriptor
EF01	AHU_E_03A_ EF01_VSD01	AHU Extract Fan VSD Enable
	n/a	AHU Extract Fan VSD Fault Status
	n/a	AHU Extract Fan VSD Run Status
	n/a	AHU Extract Fan VSD Local/Remote Status
	AHU_E_03A_ EF01_PDS01	AHU Extract Fan Differential Pressure Switch (Flow) Status

The BMS monitors the AHU Fan VSD Modbus Registers

VSD Monitoring Parameter	VSD Modbus Register	BMS Point Descriptor
		AHU Fan Local Remote Status
		AHU Fan Fault Code
		Power Consumption kW
		Frequency Hz Feedback
		Amperes Current

2.1.12 BMS AHU Cooling Coil & Heating Coil Temperature Control

Refer to the BMS 1st stage heating / cooling mode via the operation of the AHU RAC coil pump.

2nd Stage Heating / Cooling Mode

- The BMS monitors the AHU supply air temperature * and modulates***, via a PID control loop, the AHU heating coil control valve ** and cooling coil control valve ** in sequence to maintain the supply air temperature set point.

*Note * The supply air temperature transmitter is combined with a relative humidity transmitter (See BMS AHU humidity control section)*

*** The 2 port control valves and associated actuators are pressure independent control valves (PICV)*

**** The BMS controls the AHU cooling coil control valve signal according to the highest demand from the dehumidify or AHU supply air temperature cooling mode control loop. Refer to BMS AHU Humidity Monitoring and Control Section.*

When operating to dehumidify the air the AHU heating coil shall remain operational under the supply air temperature control loop in order to provide reheat when necessary.

- The BMS automatically schedules the AHU supply air temperature between a minimum [12] deg C and maximum [22] deg C depending on maximum cooling load requirements from any of the rooms.

Note review design and specification which indicates a control maximum of 30 deg c, which is too warm.

- The BMS monitors the performance of the cooling and heating coil by measuring the on and off coil air temperatures.

- The BMS monitors the cooling coil performance by measuring the off coil, air humidity. The humidity transmitter is combined with the temperature transmitter.
- The BMS monitors the control valve actuator feedback and notifies an alarm if the valve control signal does not match the feedback signal within 5% allowing for a suitable transient time for the actuator motor to operate.
- The BMS notifies a valve exercise. The BMS operator can overide the BMS automatic control and manually signal the valve 0 to 100 to 0% open and then release back to automatic via the BMS graphic.
- A low and high AHU supply air temperature alarm shall be notified at the BMS.

AHU/S/03A

Plant Ref	Control and Instrument Ref	Point Descriptor
	AHU_S_03A_ TEM04	*Note * The On-cooling coil air temperature is the Off RAC coil air temperature.* *See RAC coil section*
AHU/S/03A/ CC01	AHU_S_03A_ ACV01	AHU Cooling Coil Valve Control
		AHU Cooling Coil Valve Control Feedback Position
	AHU_S_03A_ TEM05 MOI01	AHU Off Cooling Coil Temperature
		AHU Off Cooling Coil Humidity
AHU01/ HC01	AHU_S_03A_ ACV01	Heating Coil Valve Control
		AHU Heating Coil Valve Control Feedback Position
	AHU_S_03A_ TEM05	AHU Off Heating Coil Temperature
n/a	AHU_S_03A_ TEM07 MOI02	AHU Supply Air Temperature
		AHU Supply Air Humidity

AHU/S/03B

Plant Ref	Control and Instrument Ref	Point Descriptor
	AHU_S_03B_	*Note * The On-cooling coil air*

	TEM04	*temperature is the Off RAC coil air temperature.* *See RAC coil section*
AHU/S/03A/ CC01	AHU_S_03B_ ACV02	AHU Cooling Coil Valve Control
		AHU Cooling Coil Valve Control Feedback Position
	AHU_S_03B_ TEM05 MOI01	AHU Off Cooling Coil Temperature
		AHU Off Cooling Coil Humidity
AHU/S/03A/ HC01	AHU_S_03B_ ACV03	Heating Coil Valve Control
		AHU Heating Coil Valve Control Feedback Position
	AHU_S_03B_ TEM06	AHU Off Heating Coil Temperature
n/a	AHU_S_03B_ TEM07 MOI02	AHU Supply Air Temperature
		AHU Supply Air Humidity

2.1.13 BMS AHU Humidity Control and Monitoring

- The BMS monitors the average extract relative humidity measured from the following rooms:

  - Post Mortem F1PL01
  - Post Mortem Euthanasia F1PE01
  - Waste Storage Area F1WS01

  and resets the individual AHU supply air moisture content set point between a minimum [1g/kg] and [11g/kg] to maintain the Clean Corridor extract relative humidity at set point [55%RH] +/- [15%RH]. The AHU supply air moisture content set point is initially set at [7 g/kg]

*Note * The average extract relative humidity measurements derive from the local BMS monitoring and control panels associated with the Clean Corridor. Refer to P800-SCH-92-ZZ-SP-XX-016 for further details of local HVAC BMS monitoring and control.*

If the one rooms is in fumigation mode or the room extract RH sensor has failed, (open circuit or short circuit = 0mA) the BMS will remove this sensor from the calculated average value.

- The BMS modulates, via a PID control loop, the AHU cooling coil control valve and humidifier steam control valve, in

sequence to maintain the calculated AHU supply air moisture content set point.

- The BMS controls the AHU cooling coil control valve signal according to the highest demand from the dehumidify or AHU supply air temperature cooling mode control loop. The BMS graphic shall indicate the control mode of the AHU cooling valve – i.e. temp control or dehum control.

*Note: * When operating to dehumidify the air the AHU heating coil shall remain operational under the supply air temperature control loop in order to provide reheat when necessary.*

Clean Corridor Design Performance:
Room humidity Minimum 40%RH, Maximum 70%RH

- The BMS monitors a dedicated, automatic reset, AHU supply air high limit humidistat which provides hardwired protection to shut the steam humidifier control valve. (hardwired spring close under power failure). (High limit humidistat set manually set at 90%RH)

An AHU high limit supply air humidity alarm shall be notified at the BMS.

BMS Animal Room Relative Humidity Monitoring

BMS Panel Ref	Control and Instrument Ref	Point Descriptor
AHU03_ BMP01	F2_MOI## ~~F1PL01_EMTEM01~~	Post Mortem Room Extract Humidity
	F2_MOI## ~~F1PE01_EMTEM01~~	Post Mortem Euthanasia Room Extract Humidity
	F2_MOI## ~~F1WS01_EMTEM01~~	Waste Storage Room Extract Humidity

AHU/S/03A

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/03A /HUM01	AHU_S_03A_ ACV04	AHU Humidifier Valve Control
		AHU Humidifier Valve Control Feedback Position
AHU/S/03A /CC01	AHU_S_03A_ ACV02	AHU Cooling Coil Valve Control
		AHU Cooling Coil Valve Control Feedback Position

n/a	AHU_S_03A_TEM07 MOI01	AHU Supply Air Humidity
		AHU Supply Air Temperature
	AHU_S_03A_ MSH01	AHU Supply Air Humidity High Limit Humidistat

AHU/S/03B

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/03B /HUM01	AHU_S_03BA_ ACV04	AHU Humidifier Valve Control
		AHU Humidifier Valve Control Feedback Position
AHU/S/03B /CC01	AHU_S_03BA_ ACV02	AHU Cooling Coil Valve Control
		AHU Cooling Coil Valve Control Feedback Position
n/a	AHU_S_03B_TEM07 MOI01	AHU Supply Air Humidity
		AHU Supply Air Temperature
	AHU_S_03B_ MSH01	AHU Supply Air Humidity High Limit Humidistat

2.1.14 BMS AHU Filter Monitoring

AHU Filters

The BMS monitors the filter condition of the AHU insect filter, primary bag and secondary bag filters using differential pressure sensors located across each bank of filters.

The BMS notifies a filter maintenance alarm if the differential pressure exceeds the filter dirty condition.

AHU Mounted Magnahelic gauges provide local indication of the actual filter differential pressure.

Refer to P800-SCH-92-ZZ-SP-XX-016 for further details of local HVAC BMS and PLC monitoring of the Krantz supply and extract HEPA filters.

AHU/S/03A and AHU/E/03A

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/3A/##	AHU/S/03A_ DIF01	AHU Insect Screen Filter

AHU/S/3A/##	AHU/S/03A_ DIF02	AHU Primary Bag Filter F7
AHU/S/3A/##	AHU/S/03A_ DIF03	AHU Secondary Bag Filter F7
AHU/E/3A/##	AHU/E/03A_ DIF01	AHU Extract Fresh Air Inlet Filter G4

AHU/S/03B and AHU/E/03B

Plant Ref	Control and Instrument Ref	Point Descriptor
AHU/S/3B/##	AHU/S/03B_ DIF01	AHU Insect Screen Filter
AHU/S/3B/##	AHU/S/03B_ DIF02	AHU Primary Bag Filter F7
AHU/S/3B/##	AHU/S/03B_ DIF03	AHU Secondary Bag Filter F7
AHU/E/3B/##	AHU/E/03B_ DIF01	AHU Extract Fresh Air Inlet Filter G4

2.1.15 Power Failure and Power Return Control

The HVAC system AHU/03 including BMS and PLC monitoring and control panels are supported by the Brooksby building DRUPs essential power electrical distribution system. Refer to the electrical distribution design schematic. As such there is seamless transition of power from normal mains power failure to mains supplied by the DRUPS power generation.

Should the DRUPs power supply fail to the BMS / PLC AHU control panel the respective AHU supply and extract components will function as follows:

Supply AHU BMS Equipment

- Fresh air isolation damper actuator – Remain last position.
- LTHW frost heating coil valve actuator – Remain last position.
- Heat recovery coil pump – Off
- CHW cooling coil valve actuator - Remain last position.
- LTHW heating coil valve actuator - Remain last position.
- Steam humidifier valve actuator – Closed Spring Return)
- Supply fan 1 with variable speed drive – Off
- Supply fan 1 non return dampers - Close
- Supply fan 2 with variable speed drive – Off
- Supply fan 2 non return dampers - Close
- Discharge isolation damper actuator - Remain last position.

Extract AHU BMS Equipment

- Inlet air isolation damper actuator - Remain last position.
- Fresh air inlet isolation damper actuator – Remain last position
- Extract fan with variable speed drive - Off
- Discharge isolation damper actuator - Closed

Return To Power

There is no load shedding of the high containment HVAC system 03 plant.

Following a return to mains electrical power; the BMS/PLC will, following the time out of the delay timer [10s] * automatically 'start up' the HVAC system, subject to the satisfaction and sequencing of start-up conditions and signals.

Note: The power return delay timers will be adjusted during commissioning to suit the capability of the electrical LV power supply. i.e Staggered start to limit the starting current of the building electrical load.

2.1.15 Fire Alarm Control

The PLC monitors the status of the HVAC fire alarm signal derived from an addressable digital relay, located adjacent the AHU BMS/PLC control panel. The fire alarm relay is connected to the fire alarm network.

In the event that the Fire alarm is in 'alarm' the HVAC plant shall continue to operate. The BMS notifies a fire alarm to the BMS system.

2.1.16 Fireman's Override Control

There is no hardwired fireman's override of the HVAC plant.

Operation of the AHU03 HVAC System 03, is managed as required by the Pirbright Operator, via the BMS PC workstation graphic.

2.1.17 Fire Dampers

There are no drop leaf or motorised smoke dampers on the AHU0 HVAC system and as such there is no BMS / PLC monitoring of fire or smoke dampers.

2.1.18 PLC RTK Remote Alarm System Interface

Each PLC notifies, via a digital output signal, a respective plant failure alarm to the Brooksby building RTK alarm system if AHU/3A or AHU3B supply or extract AHU fails.

Refer to RTK Functional Alarm System Description:
P800-SCH-92-ZZ-SP-XX-0008

2.1.19 BMS Controller Communication Alarms

The BMS provides a controller critical network alarm if the BMS controller fails to communicate to the BMS network. In the event of network failure each controller shall continue to operate in it's last known operating state.

The BMS provides a controller critical network alarm if the respective BMS PLC controller fails to communicate to the BMS network. In the event of network failure each controller shall continue to operate in it's last known operating state.

3.0 Document Hold Register

Outstanding Info / Hold Number	Description	Outstanding Information	Outcome
1	Specification refers to both single and twin extract fan on the AHU. Only a single fan is provided.	Confirm AHU extract is single fan RFI	
2	AHU common supply pressure relief duct external control damper details and isolation damper details	Confirm external damper design details RFI	
3	AHU common extract fresh air make-up duct external control damper details and isolation damper details.	Confirm external damper design details RFI	
4	AHU extract fresh air make up filter	Confirm if this is required RFI	
5	BMS and PLC Asset Tags will be updated on the	Confirm BMS Asset	

	document as agreed with the Project Team	Register	

Appendix 1 BMS and PLC Alarm Schedule

BMS and PLC alarm template and lists to be agreed with The Pirbright Institute team and adhere to the BMS alarm management configuration guidelines detailed in the P800-SCH-92-ZZ-SP-XX-0001

*Note * Alarm inhibit timers to be adjusted during commissioning to suit start up sequence attaining normal control.*

- P800-AHU-03A-ACP01
- P800-AHU-03B-ACP01

PLC Initiated * Alarm To The BMS Digital Alarm Schedule

*Note *: PLC alarms required for PLC software functional control requirements will be initiated at the PLC controller and replicated to the BMS.*

AHU/03A Supply and Extract Air Handling Unit
P800-AHU-03A-ACP01

Description	PLC Object Name	Alarm Priority	Alarm Value	Alarm Transient Time *	Initial Alarm Inhibit *	Comment
AHU Fresh Air Damper Failure Alarm	{tag name}	1	Normal / Alarm	180s	0s	Damper Control Mis-Match Position Alarm
AHU Freeze Protection Thermostat	{tag name}	1	Normal / Alarm	5s	0s	Manually Set at 1 Deg C Thermostat already has latched relay timer [0-10minutes]
AHU Supply Fan 1 Not In Auto Alarm	{tag name}	1	Normal / Alarm	0S	0s	Panel Test/Off/Auto Switch Alarm
AHU Supply Fan 1 VSD In Local Alarm	{tag name}	1	Normal / Alarm	0S	0s	Fan VSD Modbus Signal Alarm
AHU Supply Fan 1 Failed Status	{tag name}	1	Normal / Alarm	20S	0s	Fan VSD Run and Flow Mismatch Alarm
AHU Supply Fan 1 VSD Fault / Trip Status	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Trip Alarm
AHU Supply Fan 1 VSD	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Modbus Alarm VSD

Hours Run						
AHU Supply Fan 2 Not In Auto Alarm	{tag name}	1	Normal / Alarm	0S	0s	Panel Test/Off/Auto Switch Alarm
AHU Supply Fan 2 VSD In Local Alarm	{tag name}	1	Normal / Alarm	0S	0s	Fan VSD Modbus Signal Alarm
AHU Supply Fan 2 Failed Status	{tag name}	1	Normal / Alarm	20S	0s	Fan VSD Run and Flow Mismatch Alarm
AHU Supply Fan 2 VSD Fault / Trip Status	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Trip Alarm
AHU Supply Fan 2 VSD Hours Run	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Modbus Alarm VSD
AHU Discharge Air Damper Failure Alarm	{tag name}	1	Normal / Alarm	180s	0s	Damper Control Mis-Match Position Alarm
FEF Extract Fan 3A Failed Status	{tag name}	1	Normal / Alarm	20S	0s	Fan Flow Mismatch Alarm
AHU Extract Inlet Air Damper Failure Alarm	{tag name}	1	Normal / Alarm	180s	0s	Damper Control Mis-Match Position Alarm
AHU Extract Fresh Air Inlet Damper Failure Alarm	{tag name}	1	Normal / Alarm	180s	0s	Damper Control Mis-Match Position Alarm
Extract Discharge Air Damper Failure Alarm	{tag name}	1	Normal / Alarm	180s	0s	
AHU Extract Fan Not In Auto Alarm	{tag name}	1	Normal / Alarm	0S	0s	Panel Test/Off/Auto Switch Alarm
AHU Extract Fan VSD In Local Alarm	{tag name}	1	Normal / Alarm	0S	0s	Fan VSD Modbus Signal Alarm

AHU Extract Fan Failed Status	{tag name}	1	Normal / Alarm	20S	0s	Fan VSD Run and Flow Mismatch Alarm
AHU Extract Fan VSD Fault / Trip Status	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Trip Alarm
AHU Extract Fan VSD Hours Run	{tag name}	1	Normal / Alarm	0s	0s	Fan VSD Modbus Alarm VSD

BMS Initiated Alarm To The BMS Digital Alarm Schedule

AHU/03A Supply and Extract Air Handling Unit
P800-AHU-03A-ACP01

Description	BMS Object Name	Alarm Priority	Alarm Value	Alarm Transient Time *	Initial Alarm Inhibit *	Comment
AHU Frost Coil 1 Control Valve Failure Alarm	{tag name}	3	Normal / Alarm	60s	0s	Valve Control Mis-Match Position Alarm
AHU RAC Coil Pump Fail	{tag name}	3	Normal / Alarm	30s	0s	Pump Control Mis-Match Status Alarm
AHU RAC Coil Low Pressure Alarm	{tag name}	3	Normal / Alarm	30s	0s	Low Pressure Switch Status Alarm
AHU CHW Coil Control Valve Failure Alarm	{tag name}	3	Normal / Alarm	60s	0s	Valve Control Mis-Match Position Alarm
AHU LTHW Coil Control Valve Failure Alarm	{tag name}	3	Normal / Alarm	60s	0s	Valve Control Mis-Match Position Alarm
AHU Steam Humidifier Control Valve Failure Alarm	{tag name}	3	Normal / Alarm	60s	0s	Valve Control Mis-Match Position Alarm
AHU Supply Air Humidistat Alarm	{tag name}	1	Normal / Alarm	180s	0s	Humidistat Hardwired To Steam Control Valve

AHU/03B Supply and Extract Air Handling Unit

Repeat as for AHU 03A PLC and BMS alarms

PLC Initiated * Alarm To The BMS Analogue Alarm Schedule

*Note *: PLC alarms required for PLC software functional control requirements will be initiated at the PLC controller and replicated to the BMS.*

AHU/03A Supply and Extract Air Handling Unit
P800-AHU-03A-ACP01

Description	BMS Alias Address	Alarm Priority	Alarm Value	Alarm Transient Time *	Initial Alarm Inhibit *	Comment
AHU Insect Screen Filter Differential Pressure	{tag name}	5	High 300 Pa	300s	0	Maintenance
AHU Frost Coil LTHW Return Temperature	{tag name}	1	Low 1 Deg C	300s	0	Critical Action (Will Shutdown AHU)
AHU Frost Coil LTHW Return Temperature	{tag name}	1	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Off Frost Coil Average Air Temperature	{tag name}	3	Low 3 Deg C	300s	0	Warning Alert
AHU Off Frost Coil Average Air Temperature	{tag name}	1	Low 1 Deg C	300s	0	Critical Action (Will Shutdown AHU)
AHU Off Frost Coil Average Air Temperature	{tag name}	1	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Pre Filter Differential Pressure	{tag name}	3	High ### Pa	300s	0	Maintenance
AHU Pre Filter Differential Pressure	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Sec. Filter Differential	{tag name}	3	High ### Pa	300s	0	Maintenance

Pressure						
AHU Sec. Filter Differential Pressure	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Supply Average Air Temperature	{tag name}	3	Low 12 Deg C	300s	600s	Warning / Alert
AHU Supply Average Air Temperature	{tag name}	3	High 28 Deg C	300s	600s	Warning / Alert
AHU Supply Air Temperature	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Supply Air Humidity	{tag name}	3	Low 12 Deg C	300s	600s	Warning / Alert
AHU Supply Air Humidity	{tag name}	3	High 28 Deg C	300s	600s	Warning / Alert
AHU Supply Air Humidity	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Air Volume	{tag name}	3	Low ####l/s	30s	600s	Warning / Alert
AHU Common Supply Air Volume	{tag name}	3	High #### l/s	30s	600s	Warning / Alert
AHU Common Supply Air Volume	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Average Calculated Air Pressure	{tag name}	3	Low ##Pa	60s	600s	Warning / Alert
AHU Common Supply Average Calculated Air Pressure	{tag name}	3	High ##Pa	60s	600s	Warning / Alert

AHU Common Supply Air Pressure Sensor 1	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Air Pressure Sensor 2	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Air Pressure Sensor 3	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Air Pressure Mismatch	{tag name}	1	5 % Difference	30s	0	Triplicate Sensors Mismatch
AHU Common Supply Average Air Temperature	{tag name}	3	Low 12 Deg C	300s	600s	Warning / Alert
AHU Common Supply Average Air Temperature	{tag name}	3	High 28 Deg C	300s	600s	Warning / Alert
AHU Common Supply Air Temperature	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Common Supply Air Humidity	{tag name}	3	Low ## g/kg	300s	600s	Warning / Alert
AHU Common Supply Air Humidity	{tag name}	3	High ##g/kg	300s	600s	Warning / Alert
AHU Common Supply Air Humidity	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
Extract Stack Average Air Velocity	{tag name}	3	Low ##m/s	60s	600s	Warning / Alert
Extract Stack Average Air Velocity	{tag name}	3	High ##m/s	60s	600s	Warning / Alert

Extract Stack Air Velocity	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
Common Extract Air Pressure	{tag name}	3	Low ##Pa	60s	600s	Warning / Alert
Common Extract Air Pressure	{tag name}	3	High ##Pa	60s	600s	Warning / Alert
Common Extract Air Pressure Sensor 1	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
Common Extract Air Pressure Sensor 2	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
Common Extract Air Pressure Sensor 3	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
Common Extract Air Pressure Mismatch	{tag name}	1	5 % Difference	30s	0	Triplicate Sensors Mismatch
Fume Extract Fresh Air Make Up Volume	{tag name}	3	Low ### L/S	30s	0	
Fume Extract Fresh Air Make Up Volume	{tag name}	3	High ### L/S	30s	0	
Fume Extract Fresh Air Make Up Volume	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)
AHU Extract Fresh Air Inlet Filter Differential	{tag name}	3	High ### Pa	300s	0	Maintenance

Pressure						
AHU Extract Fresh Air Inlet Filter Differential Pressure	{tag name}	3	Sensors Out Off Limits	30s	0	Sensor Failure (Open & Short Circuit)

Appendix 2 BMS and PLC Set Point Schedule

The BMS User Adjustable Control Set Point Schedules will be developed during the detailed software design and added to this section as required.

AHU3A_ACP01 BMS Set Point Schedule
AHU3B_ACP01 BMS Set Point Schedule

Set Point Description	BMS OBJECT NAME	Set Point *	Set Point Control Tolerance	Comment
AHU Off Frost Coil Air Temperature Control Set Point	[tag name]	5 deg C	MIN 2 deg C	
AHU Off Frost Coil Air Cold Start UP Temperature Control Set Point	[tag name]	20 deg C	MIN 2 deg C	
AHU Supply Air Temperature Control Set Point	[tag name]	Calculated ## deg C	+/- 2 deg C	Calculated between min. and max. according to local room load / demand
AHU Supply Air Humidity Control Set Point	[tag name]	Calculated 7 g/kg	+/- # g/kg	Calculated between min. 1g/kg and 11g/kg max. according to local room %RH load / demand. See local room BMS control description
AHU Common Supply Air Fan Pressure	[tag name]	### Pa	(+/- 5%)	
AHU Common Supply Air Relief Pressure	[tag name]	### Pa	(+/- 5%)	
AHU Common Extract Air Pressure	[tag name]	## Pa	(+/- 5%)	
Extract Stack Efflux Velocity	[tag name]	10.0 m/s	(+/- 5%)	Minimum 10 m/s
Others Set Points To Be Added As Required				

SMS
Functional Design Specification

FOR

Brooksby Building P800

The Pirbright Institute - Pirbright

Prepared by: David Jackson 14Jul2020

<David Jackson, Life Science Team Leader,
Schneider Electric Buildings> Date

Review and Approvals –

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DOCUMENT REVISION HISTORY

The document becomes effective on the date of final approval. If changes are made that affect the document's content or approach, a revised, complete document must be issued for re-approval by the approvers of the original document or their designated representatives. A description of those changes with revision number will be noted in the revision log below.

Document naming and version will adhere to the project BIM execution plan naming convention.

Document Version	Status	Description	Revised by	Date Last Modified
P01	S3	Document issued for Project Team Review and Comment.	David Jackson	10 Jul 20
P02	S3	Updated in line with Kier comments relating to revised design drawing references.	David Jackson	14 Jul 20

Documents Note:

1) The equipment tags in this document will be updated in line with the High Level BMS Design Document P800-SCH-92-ZZSP-XX-0001

2) The SMS alarm schedule will be updated in collaboration with the Pirbright Institute and Team Pirbright and subject to commissioning.

3) The document will be updated during the life cycle of the project and will be an O&M reference document

TABLE OF CONTENTS

INTRODUCTION

1.1. Purpose

The Pirbright Institute intends to construct a new high containment, laboratory facility, as part of a major development program at their Pirbright, GU24 0NF site. The new facility is required to handle dangerous pathogens and is expected to be approved and licensed for operation in the 2022. The new facility must be constructed in accordance with current regulatory guidance.

The new laboratory high containment areas will require an independent monitoring and control system, here after referred to as the Secondary Monitoring System (SMS).

The SMS system is needed to provide secure data logging and archiving of room pressures and provide remote alarms to the SMS Operator Workstation in the Plowright Control Room.

1.2. Scope

This document is intended to define the specific SMS functional requirements for the new facility. This functional specification will address the SMS Requirements detailed in project BMS specification and associated drawings.

The SMS system design and commissioning will adopt Good Engineering Design Practices and be commissioned in line GAMP site acceptance testing protocols to verify the system operation.

1.3. Related Documents and Information

1.3.1. Basis of Design Documents

- HCLAF-ARP-00-XX-SP-M-003
  BMS Controls Specification Stage 4
- P800-ACM-57_XX-DR-ME-0001 Rev C02 Mechanical Services Ventilation System Schematic Sheet 1
- P800-ACM-57_XX-DR-ME-0002 Rev C01 Mechanical Services Ventilation System Schematic Sheet 2
- P800-ACM-57_XX-DR-ME-0003 Rev C02 Mechanical Services Ventilation System Schematic Sheet 3

OVERVIEW

This section provides an overview of the desired system and traceability therefore is not required.

1.4. Key Objectives and Benefits

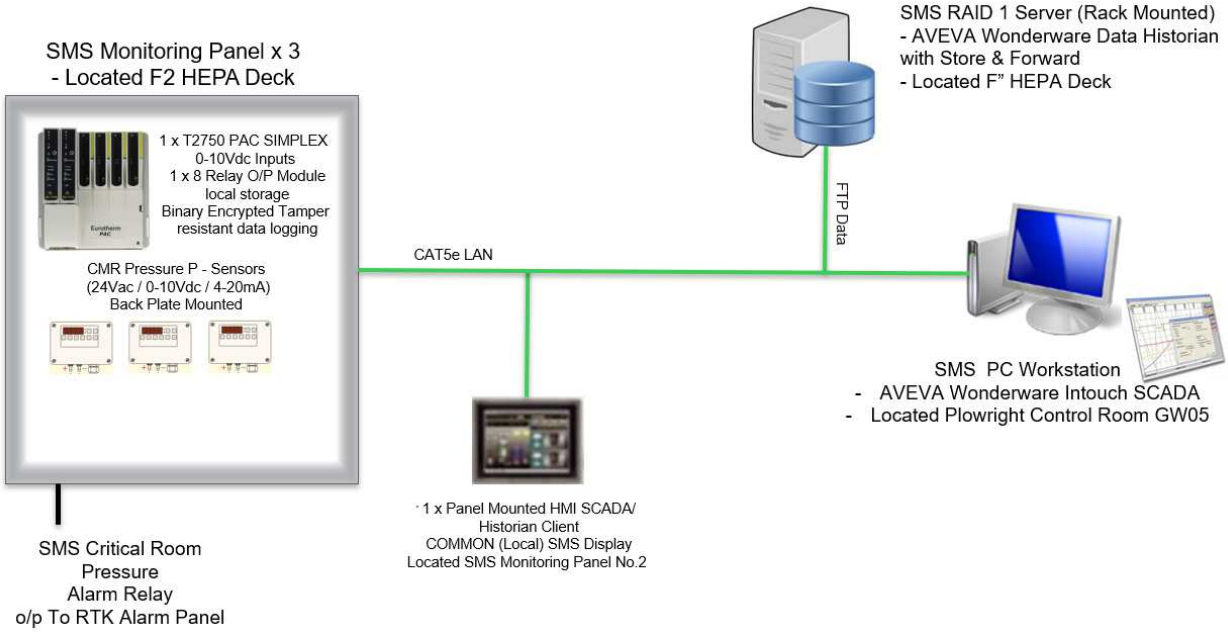
1.4.1. SMS to automatically monitor containment area room pressure with respect to atmosphere in the HEPA deck and room to room differential pressure and provide building remote alarm indication when the measured parameters are out of limits.

1.4.2. Automatically record at the SMS file server data historian, the room pressures with respect to atmosphere (HEPA plant room) and room to room differential pressures. The SMS data historian data will be used to substantiate regulatory requirements have been met.

1.4.3. The SMS monitored room pressure transmitters will be shared via active signals to the Brooksby building HVAC PLC controllers, which in turn will use the signals for control and alarms as per the HVAC PLC functional requirements.

1.5. High Level System Description

The following drawing shows the high-level overview of the SMS network topology. A detailed network drawing shall be provided as part of the SMS detail design information.



1.5.1. Networks

The system will use the dedicated BMS/SMS Ethernet Cat 5E IP network to communicate between the SMS programmable logic controllers (PLC's), SMS file server, SMS control panel PC HMI display and the remote SMS PC operator workstation.

1.5.2. SMS File Server

The SMS file server will housed in a floor mounted, server rack located in the F2 HEPA deck.

The SMS server will host the database and serve as the storage location for system configuration and programs, security and user rights information, archived data, and 21 CFR Part 11 audit trails. The server will be configured for RAID 1.

The SMS rack will also house the server keyboard and monitor.

1.5.3. SMS PC Operators Workstations

A single SMS PC PC operator station will be remotely mounted in Plowright building, ground floor, Control Room (GW05).

The SMS operator workstation is the primary operator 'viewing' interface to the SMS system and will display information relating to the containment risk space conditions.

1.5.4. SMS HMI Panel Operator Workstation

A single SMS PC HMI workstation will be provided on the SMS control panel no. 2 , located in the F2 HEPA deck. The SMS HMI will be fascia mounted and touch screen on the panel front door.

The HMI operator workstation will provide a graphical display of the floor layout , indicating the SMS measured room pressures and the HMI will display the SMS notified alarms.

1.5.5. SMS Panel Controller

The SMS monitoring and control will be accomplished using distributed PLC controllers. The PLC controllers will be provided with input and output capabilities for reading space measurement devices and SMS equipment devices.

The PLC controller hardware will be manufactured and supplied by Schneider Electric – Eurotherm.

1.5.6. Input Devices

The SMS controller will monitor input devices from:

- Room pressure differential pressure measurement transmitters

1.5.7. Output Devices

The SMS controller will provide a critical alarm, volt free contact alarm that will be relayed to the remote building RTK alarm panels located in the Plowright building and Security / Gatehouse.

The SMS will provide a common critical alarm for each of the following HVAC zones; if any of the respective zone SMS monitored rooms indicate a critical alarm:

- AHU System 01
- AHU System 02
- AHU System 03

FUNCTIONAL REQUIREMENTS

The following requirements define the system hardware, software, and functionality. Traceability must be maintained for each of the requirements specified in this section, unless specifically noted otherwise.

1.6. Hardware

1.6.1. Networks and Network Devices

The SMS File server, Operator Workstations, and Network Controller shall communicate on the BMS /SMS Network' through a 100 Mbps 10/100BaseT network utilizing TCP.

The BMS/SMS network switches will connect the SMS File Server, Plowright building GW05 Building Control Room, SMS PLC Field Controllers and SMS panel no.2 PC HMI operator workstation to the SMS network.

The BMS / SMS Server rack power supply is supported by the building DRUPs power supply.

1.6.2. SMS File Server Panel

The file server panel will be housed in a BMS/SMS dedicated rack located in the F2 HEPA deck.

The SMS server capacities will meet or exceed the minimum Schneider Electric Eurotherm manufacturer application requirements:

a) Rack Mountable platform
b) CPU: Equal or Greater than 2.0 GHz
c) Memory: Equal or Greater than 16 GB RAM
d) Hard Drive: Equal or Greater than 2000 GB with RAID 1

The SMS file server shall include the following software:

a) Microsoft Windows Server 2016 or greater
b) Schneider AVEVA Historian Server / Suite

The SMS file server shall house Schneider AVEVA database which includes the following:

a) System configuration files
b) Graphic files
c) Measurement data history files for a minimum of fourteen months

d) Event and alarm history files for a minimum of fourteen months

Random Access Memory (RAM) shall meet or exceed the sum of the software manufacturer's recommended requirements.

RAID 1 Hard-Disk Array size shall be provided and shall be of sufficient size to hold the programs

Interface Hardware should be as follows:

a) One Network Card; 100 Mbps LAN, 10/100BaseT

Tagging

The SMS Server 1 shall be tagged as …Pirbright to advise

1.6.3. Operators Workstation Located in BMS Building Control Room

This SMS operator's workstation to be located in the Building Control Room (GW05) shall be provided by Schneider Electric. The workstation shall meet or exceed application requirements specified:

Workstation Platform Manufacturer shall meet Institute for Animal Health standards and shall be as follows. Supplier shall verify capacities meet or exceed application requirements specified:

a) CPU: Equal or Greater than 3.6 GHz
b) Memory: Equal or Greater than 16 GB
c) Hard Drive: Equal or Greater than 512 GB

The workstation shall include the following software:

a) Microsoft Windows 10 Professional
b) Schneider AVEVA Historian

Random Access Memory (RAM) shall meet or exceed of the sum of the software manufacturer's recommended requirements.

Hard-Disk size shall meet or exceed the sum of the required program and storage memory requirements. History file storage shall be based on the intervals specified in the functional requirements

Interface Hardware should be as follows:

a) Media; R/W CD-ROM
b) One Network Card; 100 Mbps LAN, 10/100BaseT

Monitor, Keyboard and Mouse shall be as follows

a) Minimum 19 inch LCD Monitor Display
b) Standard Keyboard and Mouse

Uninterruptible Power Supply

The workstation shall receive power from an uninterruptible power supply to be provided by the Schneider Electric. This shall supply a minimum of sixty minutes standby power.

Tagging

The Workstation shall be tagged as …… Pirbright To Advise

1.6.4. HEPA Deck Plant Room Master HMI

The SMS HMI touch screen workstation to be located in the SMS PLC control panel no.2. The HMI shall meet or exceed the following requirements.

Workstation Platform Manufacturer will be Siemens and shall be as follows:

Supplier shall verify capacities meet or exceed application requirements specified:

a) CPU: Equal or Greater than 2.0 GHz
b) Memory: Equal or Greater than 8 GB
c) Hard Drive: Equal or Greater than 1TB

The workstation shall include the following software:

a) Microsoft Windows10 Professional
b) AVEVA Historian

Random Access Memory (RAM) shall meet or exceed of the sum of the software manufacturer's recommended requirements.

Hard-Disk size shall meet or exceed the sum of the required program and storage memory requirements. History file storage shall be based on the intervals specified in the functional requirements

Interface Hardware should be as follows:

a) One Network Card; 100 Mbps LAN, 10/100BaseT

Monitor, Keyboard and Mouse shall be as follows

a) Integral 14 inch Touch Screen
b) Integral Mouse and Virtual Keyboard

Tagging

The SMS HMI Workstation shall be tagged as ……. Pirbright to advise

1.6.5. Field Controller

Field Controller

The SMS Field Controller will be manufactured by Schneider Electric – Eurotherm T2750 range of PLC controllers. The controller shall include sufficient capacity to support the required communications and controller tasks. There shall be spare space within the control panel to accommodate 20% spare input and output points.

Communication

Controller Communications shall support communications over Ethernet and Modbus IP and RTU field network.

Analog Inputs

a) 0-10Vd to CMR P- pressure transmitters.
b) Modbus RTU optional connection to CMR pressure transmitters.

Analog Outputs

Not used.

Digital Inputs

Digital input modules shall support volt free contact inputs.

Digital Outputs

Digital output modules shall be rated 0.5A at 24Vdc. (Switching on VFC on RTK alarm display

Tagging

Schneider coordinate tag numbers with the Pirbright.

Power

a) The primary source of power shall be via the essential DRUPS power distribution system for the building. The 3 no. SMS control panels are served from a single distribution board in the HEPA deck plantroom.(DB ref = 50-DB-06-A)

Location and Mounting

a) The 3 no. SMS Controllers shall be located in the F2 HEPA deck plant room.
b) Controllers and interfacing input/output modules shall be back plate mounted in a Form 1 IP54 wardrobe control panel.
c) Control cabinets shall include a key lock for security. All cabinets shall be keyed the same.

Field Hardware, Input Devices

Space Pressure

Space differential pressure transmitters shall be CMR P-Sensors and meet the following requirements:

a) Room to atmosphere pressure transmitters shall be ranged -200 to 200 Pa
b) Room to room pressure transmitters shall be ranged -100 to 100 Pa
c) +/- 0.25% FS accuracy
b) 24Vdc with 0-10Vdc and 4-20mA outputs
   a. 4-20mA shall be wired via interfacing terminals to the HVAC PLC system
   b. 0-10Vdc shall be via interfacing terminals wired to the SMS
   c. 24Va shall be wired via fused terminals for each pressure sensor.
c) Modbus RTU network. (Option for SMS – Not specified)
d) LED display.
e) The SMS CMR sensors shall be mounted and pre-wired on the back plate of the SMS control panel and be accessible for maintenance and calibration. The pressure sensors positive and negative pressure ports shall be tubed in silicon at the factory to an interfacing array of manifold nipples to provide connection to the field PCV tubing.
f) P-Sensors Instruments shall be provided with Factory UKAS Traceable Calibration Certificate
g) Schneider shall re-calibrate instruments as per site standards and certify calibration prior to final acceptance.
h) Stainless steel room pressure probes (6mm OD) shall be for used with the pressure transmitter. These shall pass through ceiling slab via the bio-seal. Where necessary the pressure probe shall be deflected away from other service to allow provision and access to Helapet filter. (All SAPO4 pressure lines)
i) Use PVC green * tubing provided by CMR to connect the pressure sensor to the pressure probes.

Tagging

All SMS field devices shall be tagged in accordance with the Pirbright BIM asset tagging protocol. All SMS sensors are to be referenced as SEN.

Building Ref_ Equipment Location _Parent Tag _Child Tag

- P800-F2HD-SMS-SEN01*
- P800-F2HD-SMS-SEN02

Through to

- P800-F2HD-SMS-SEN125 (On the basis there are 125 SMS sensors)

Note * the BIM asset register does not refer to the room that the SMS pressure sensors are monitoring, only requirement is the location where the SMS sensors are located i.e F2 HEPA Deck.

1.7. Software

1.7.1. SMS File Server

The following file server software shall be provided by supplier

- Schneider AVEVA Historian Server
- Microsoft Windows Server

The SMS Server backup utilities to be provided by The Pirbright Institute as per their standard operating procedures.

1.7.2. SMS Workstations

The following workstation software shall be provided by Schneider Electric:

- Windows 10 Professional
- Schneider AVEVA Intouch Historian

1.8. Functionality

All system components shall be designed to operate continuously and reliably.

1.8.1. SMS File Server

SMS Database

The SMS database which is used by the workstations and controllers is kept on the SMS Server in a SQL file. The database includes the following components and shall be automatically updated anytime this information changes. The database disks shall be RAID 1.

a) Windows Operating System
b) Schneider AVEVA Historian
b) Operator activity histories
e) Alarm and event histories
f) Measurement trend history data

Data Archives

Shall provide a secure archive of measurement and event data in accordance with the following requirements.

a) Critical measurements including space pressure wrt to atmosphere and space differential pressure.
b) Pressure values shall be recorded once every second. A minimum of 14 * months worth of data shall be available for reports and trending.
b) History files shall be capable of being split so that old history files can be saved on an archive and shall be capable of being remerged as required to restore archives of more than one year.
d) Provide means to export data.

Event Logs

Events such as system notifications, alarms, and status changes shall be recorded as follows:

a) Alarm events shall be recorded including tag name, time, and date related to the alarm event, acknowledgement, and return to normal.
b) Alarms associated with critical events such as space pressure shall be stored for a period of not less than 14 * months.
c) Non-critical alarms shall be stored for a period of not less than 3 months.
d) Event files shall be capable of being stored as an event archive.

21 CFR Part 11 Compliance

a) All operator events associated with both the operating system and the Win CC system shall be logged in 21CFR Part 11 compliant audit trail files.
b) Electronic records (files) shall be stored and protected in compliance with 21 CFR Part 11 requirements.
c) The SMS File server shall maintain access security files and user rights, which shall include electronic signatures which are Part 11 compliant
d) 21 CFR Part 11 audit trail information shall be stored for a period of not less than 14 * months.
e) Security files including user names, security groups, and authorization rights and permissions.

Backup Functionality

a) Once each project is completed a back -up of the system will be created and issued to the client.

1.8.2. Operators Workstations

Operator workstations shall include the following functionality

Display subsystem include but is not limited to-

a) *Main Menu including system overview*

b) Area overview with floor plan indicating space pressures, and alarm conditions
c) Trend Log Archive Reporter
d) Alarm Event Log Archive Reporter
e) User Activity Log Archive Reporter
f) Alarm Summary display
g) Trend display for each measurement
h) Navigations to be by display hotspots and by functional buttons on display screen

Operator Displays shall indicate the values of measurements follows:

a) Display of parameters- Through the operator workstation HMI, display current room condition
b) Alarming- through audible and visual alarm cues, alert the operator to the occurrence of any alarms. Record the alarm event, acknowledgement, and return to normal in a time and date stamped event file. Provide means to print alarm histories to hard copy.
c) Recording- through the use of extended logging, data archives and trend displays, record the values of room conditions for substantiation of performance within user requirement envelope. Records shall be stored for period defined in Data Archives.

Operator workstations shall include features to enforce 21CFR Part 11 Compliance including:

a) Two part access control using unique username and password.
b) Password shall be tested for a minimum length of eight characters.
c) System shall require password be changed every 115 days.
d) User session shall automatically time out after thirty minutes of inactivity.
e) System must require users to insert a comment for inclusion in the audit trail whenever a parameter is changed.
f) Audit trail shall be stored on the SMS File server. Records include user, time, date, change made, previous state or value, and comment field. Storage period shall be as defined for Data Archives.

Operator Workstation(s) with Archive Viewer shall include the features to retrieve and display long term archives for the data listed in the previous item which is stored on the SMS File Server. It will be necessary to retrieve and link in the archive data using the SMS Server Panel.

1.8.3. Field Controller

Control system shall reliably monitor and control the equipment it serves on a 24 hour a day, seven day a week basis.

Space Pressure

The following functionality shall be provided as defined by schedule of room pressure sensors indicated in Appendix 1

a) The SMS shall monitor the room pressure measured with respect to the F2 HEPA deck pressure (atmosphere). Each room shall be monitored by duplicated arrangement of pressure sensors housed in different panels:
   - Sensor no.1 shall be mounted in the HVAC PLC control panel
   - Sensor no.2 shall be mounted in the SMS PLC control panel

b) The SMS shall monitor the room to room differential pressure.
   - Room to room differential pressure sensors shall be mounted in the SMS PLC control panel

c) SMS pressure sensors shall be monitored at 1 second intervals by the SMS PLC field controller and alarms notified when measured values are outside of the alarm threshold limits.

d) The SMS field PLC controller shall provide the room pressure SMS maintenance and critical alarm notifications as follows: (SMS alarms shall be provided with a SMS graphic that allows the The Pirbright Institute to manually enable or disable each SMS space alarm during the fumigation process or particular maintenance requirements) The SMS graphics shall also provide the facility to manually enable and disable all the SMS alarms associated to a particular AHU Zone (1 to 3) in one action.

   - Maintenance alarms shall be notified to:
     - Plowright GW05 Building Control Room
     - SMS panel No.2 HMI
   - Maintenance alarm shall be logged at the SMS server

   - Critical SMS alarms shall be notified to:
     - Plowright GW05 Building Control Room
     - SMS panel No.2 HMI

   - Critical SMS ‘common’ alarms shall be signaled to the

- Plowright GW05 Building Control Room
- Plowright RTK alarm panel and relayed from there to the Security Gatehouse

Refer also to the following HVAC local zone function descriptions which also describe the HVAC alarms associated to the duplicated monitoring of all SMS monitored inputs.

- P800-SCH-92-ZZ-SP-XX-0014 – Air system 1 local controls FDS
- P800-SCH-92-ZZ-SP-XX-0015 – Air system 2 local controls FDS
- P800-SCH-92-ZZ-SP-XX-0016 – Air system 3 local controls FDS

There are no local SMS alarm beacons.

The SMS alarm parameters (alarm set point and transient alarm timer) shall be adjustable via the SMS HMI's touch screen PC's and the networked Plowright Building Control Room SMS PC Workstations.

The following values shall be used to configure the SMS alarm thresholds, however it is acknowledged that the final threshold values may be adjusted during commissioning / occupation to suit operational dynamics.

Room to Room Differential Pressure Alarms

- In the event that the SMS measures a room to room differential pressure that is more than +/- 10Pa away from the room to room differential pressure set point for more than 60 seconds; the SMS shall raise an action critical alarm.
- In the event that the SMS measures a room to room differential pressure that is more than +/- 20Pa away from the room to room differential pressure set point for more than 60 seconds; the SMS shall raise an action critical alarm.

Action Critical Low Level Alarm	Alert Maintenance Low Level Alarm	Room To Room Differential Pressure Design Set Point	Alert Maintenance High Level Alarm	Action Critical High Level Alarm
-40Pa	-30Pa	-20Pa	-10Pa	-0Pa

Room to Atmosphere Differential Pressure Alarms

- In the event that the SMS measures a room to room differential pressure that is more than +/- 10Pa away from the room to atmosphere set point for more than 60 seconds; the SMS shall raise an action critical alarm.
- In the event that the SMS measures a room to atmosphere room differential pressure that is more than +/- 20Pa away from the room to room differential pressure set point for more than 60 seconds; the SMS shall raise an action critical alarm.

Action Critical Low Level Alarm	Alert Maintenance Low Level Alarm	Room To Atmosphere Differential Pressure Design Set Point	Alert Maintenance High Level Alarm	Action Critical High Level Alarm
-120Pa	-110Pa	-100Pa	-90Pa	-80Pa

c) The duplicated room pressure differential WRT atmosphere and room pressure WRT adjacent room pressure shall be available for display on a SMS display graphic screen as a measurement and available as trend log.

d) Room pressure differential WRT atmosphere and room to room differential pressures shall be recorded to an historical archive file.

The control programs and controller configuration developed for this application shall be stored in the PLC controller memory.

Control Loops operating in the Controller program shall process input information, perform control and alarm calculations, and update outputs at least once per second.

Data exchange between the SMS PLC controller and the SMS workstation, via the SMS server shall be continuous.

1.8.4. SMS Interface to Other Systems

Refer to the duplicated HVAC PLC room pressure sensors previously detailed. The CMR pressure sensor located in the HVAC PLC control panels provide a 0-10Vdc shared signal to the SMS control panels.

The following functionality shall be achieved through the hardwired interface of the SMS to the control systems provided with packaged equipment.

SMS Inputs from BMS System Interface :

1.8.5. SMS Output To RTK Alarm Panel

Gatehouse / Building Control Room RTK U625 alarm interface.

- HVAC System 01 SMS common room pressure critical alarm
- HVAC System 02 SMS common room pressure critical alarm
- HVAC System 03 SMS common room pressure critical alarm

1.8.6. SMS Interface to the Internet

Interface of the SMS through the internet is not required.

1.9. Security

1.9.1. Security Groups – Develop Requirements with The Pirbright Institute & Schneider (Eurotherm)

Security groups shall include four configured user groups to be given rights as follows and as explained in detail in Appendix 3.

- System Administrator – Will have administrative rights and read / write access to all objects and screens on the system.
  - Users will include The Pirbright Institute administrator(s)
  - Users will include Schneider administrator(s)

- E&M Engineering - Will have access read and write access to all objects except security settings and user account.
- The Pirbright Institute Supervisors- Will have access to view all objects and write to set points and override outputs.
- Guest- (No password required) able to navigate the system and view any graphic display.

1.9.2. User Security

User security shall include the following rights and requirements.

- Users shall be assigned to one or more security groups depending on their authorization level.
- Users shall have a unique ID username.
- Users shall be required to have a unique password with a minimum of 8 alpha numeric characters, which will expire after 115 days.

- User inactivity shall be limited to 30 min.
- Users shall be required to enter operator text when any changes are made.
- Users shall be required to enter operator text upon alarm acknowledgment.
- Each user file shall included key employee information including first and last name, title, department, and supervisor.

1.10 TESTING

1.10. Acceptance Testing

Schneider (Eurotherm) shall prepare testing protocols and conduct acceptance testing to prove to the owner and his representatives that the system performs as specified in the functional specification and detailed design documents. Testing shall include both factory and site acceptance tests. Testing protocols shall be submitted for review and approval prior to execution of the testing.

1.10.1. Factory Acceptance Test (FAT)

Schneider (Eurotherm) shall perform factory acceptance testing including the following.

All fabricated control panels shall be tested for proper wiring, tagging, and neatness prior to shipment to jobsite.

Supplier shall demonstrate the operation of the server and workstations under simulation. Screen navigation, security, display content, and point linking shall be demonstrated.

Supplier shall demonstrate controller functionality including the proper execution of control sequences, alarms, inputs, and outputs. Demonstration shall include integration with server and workstations.

1.10.2. Site Acceptance Testing (SAT)

Schneider (Eurotherm) shall perform site acceptance testing of installed equipment including server, workstations, controllers, sensors and measurement devices.

Supplier shall demonstrate proper installation and operation of all field devices.

Supplier shall demonstrate proper operation of all alarms including the facility for authorised User to enable / disable SMS alarms.

Supplier shall demonstrate proper operation of all SMS logging and requirements.

1.11. Qualification

Any requirement for formal validation qualification i.e Installation Qualification, (IQ) Operational Qualification (OQ) and Performance Qualification (PQ) shall be managed and executed by others.

DOCUMENTATION

1.12. Design Documents

1.12.1. Control System design documents suitable to quantify the design so that it can be properly installed, commissioned, acceptance tested, and maintained. Documents to include:

Detailed Design Specification (DDS) including the following hardware and software design details: This is to be provided in PDF format

- Instrument Lists
- Panel layout and fabrication drawings in PDF format
- System architecture drawings in PDF format
- Equipment datasheets

Control Program backups on CD

Equipment and system operating and maintenance manuals in paper and PDF format

Supplier testing protocols including FAT and SAT

Manufacturer's calibration certificates

1.13. Standard Operating Procedures

The following standard operating procedures are to be in place at the time the system is qualified. Existing procedures may be modified to reflect this new equipment as needed. Where existing procedures do not exist, new procedures shall be written by site Engineering. Multiple procedures may be combined together in one procedure if appropriate.

1.13.1. Operation and Maintenance of SMS

1.13.2. Assignment of User Rights

1.13.3. Server Backup

1.13.4. Workstation Backup

1.13.5. Disaster Recovery Plan

1.13.6. Calibration of Critical Instruments

TRAINING

Training must take place prior to qualification of the system.
User training programs to be developed

1.14. Control System Operation and Maintenance

1.14.1. System administration

1.14.2. Use by Engineering and Supervisors operators

1.14.3. Backups and Disaster recovery

1.15. Use of Standard Operating Procedures

Where dictated by access level assignments, personnel shall be trained in the methods specified in the Standard Operating Procedures as specified in the previous section.

End of Functional Requirement Specification

Appendix 1
SMS Room Pressure Monitoring Points List

Key To Table Colours

HVAC PLC System Room Differential Pressure Measured WRT Atmosphere and repeated to the SMS PLC
SMS PLC System Room Differential Pressure Measured WRT Atmosphere and repeated to the HVAC PLC
SMS PLC System Room Differential Pressure Measured WRT Room and repeated to the HVAC PLC

SMS Control Panel No.1 – Located F2 HEPA Deck Plantroom

Design Note	AHU Ref	Control Point Ref	Room Ref	Room Name	Point Description
Repeat 0-10Vdc Signal From HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F1OL01	Outer Lobby	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F1OL01	Outer Lobby	Room Differential Pressure WRT Atm
Repeat 0-10Vdc Signal From HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F1IS05	Inner Lobby	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F1IS05	Inner Lobby	Room Differential Pressure WRT Atm
Repeat 0-10Vdc Signal From HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F1VM01	Vet Med	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F1FVM01	Vet Med	Room Differential Pressure WRT Atm
Repeat 0-10Vdc Signal From HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F1StR01	Staff Room	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F1StR01	Staff Room	Room Differential Pressure WRT Atm
Repeat 0-10Vdc Signal From HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F1OC01	Clean Corridor	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel AHU01 F1 Z1	01	P800-F2PD-SMS-SEN##	F1OC01	Clean Corridor	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F1OC01	Clean Corridor	Room Differential Pressure WRT Inner Lobby F1IS05
Repeat Signal From HVAC PLC Panel AHU02 Local	01	P800-F2PD-SMS-SEN##	F1AEn01	Animal Entry	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel AHU02 Local	01	P800-F2PD-SMS-SEN##	F1AEn01	Animal Entry	Room Differential Pressure WRT Atm

Repeat 4-20mA Signal To HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F1AEn01	Animal Entry	Room Differential Pressure WRT Clean Corridor
Repeat 0-10Vdc Signal From HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F1WR01	Workshop	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel AHU01 F1 Z1	01	P800-F2PD-SMS-SEN##	F1WR01	Workshop	Room Differential Pressure WRT Atm
Repeat 0-10Vdc Signal From HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F0MOL01	Outer Lobby	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F0MOL01	Outer Lobby	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F0MOL01	Outer Lobby	Room Differential Pressure WRT PPE Change Inner Lobby
Repeat 0-10Vdc Signal From HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F0MPP01	PPE Change / Inner Lobby	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F0MPP01	PPE Change / Inner Lobby	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F0MPP01	PPE Change / Inner Lobby	Room Differential Pressure WRT Chemical Shower
Repeat 0-10Vdc Signal From HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F0MCS01	Chemical Shower	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F0MCS01	Chemical Shower	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F0MCS01	Chemical Shower	Room Differential Pressure WRT ETP / Undercroft
Repeat 0-10Vdc Signal From HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F0FE01	Fumigation Chamber 2	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F0FE01	Fumigation Chamber 2	Room Differential Pressure WRT Atm
Repeat 0-10Vdc Signal From HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F0MUC02	Undercroft & ETP	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	01	P800-F2PD-SMS-SEN##	F0MUC02	Undercroft & ETP	Room Differential Pressure WRT Atm
Repeat 0-10Vdc Signal From HVAC PLC Panel	03	P800-F2PD-SMS-SEN##	F1PE01	PM Euthanasia	Room Differential Pressure WRT Atm

Repeat 4-20mA Signal To HVAC PLC Panel	03	P800-F2PD-SMS-SEN##	F1PE01	PM Euthanasia	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	03	P800-F2PD-SMS-SEN##	F1PE01	PM Euthanasia	Room Differential Pressure WRT Dirty Corridor
Repeat 4-20mA Signal To HVAC PLC Panel	03	P800-F2PD-SMS-SEN##	F1PE01	PM Euthanasia	Room Differential Pressure WRT Waste Storage
Repeat 0-10Vdc Signal From HVAC PLC Panel	03	P800-F2PD-SMS-SEN##	F1PL01	Post Mortem	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	03	P800-F2PD-SMS-SEN##	F1PL01	Post Mortem	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	03	P800-F2PD-SMS-SEN##	F1PL01	Post Mortem	Room Differential Pressure WRT PM Euthanasia
Repeat 4-20mA Signal To HVAC PLC Panel	03	P800-F2PD-SMS-SEN##	F1PL01	Post Mortem	Room Differential Pressure WRT Dirty Corridor
Repeat 0-10Vdc Signal From HVAC PLC Panel	03	P800-F2PD-SMS-SEN##	F1WS01	Waste Str	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	03	P800-F2PD-SMS-SEN##	F1WS01	Waste Str	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	03	P800-F2PD-SMS-SEN##	F1WS01	Waste Str	Room Differential Pressure WRT Post Mortem
Repeat 4-20mA Signal To HVAC PLC Panel	03	P800-F2PD-SMS-SEN##	F1CR01	Cold Room	Room Differential Pressure WRT Waste Storage
Repeat 0-10Vdc Signal From HVAC PLC Panel	03	P800-F2PD-SMS-SEN##	F1FE01	Fumigation Chamber 1	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	03	P800-F2PD-SMS-SEN##	F1FE01	Fumigation Chamber 1	Room Differential Pressure WRT Atm
VFC Alarm Status To RTK Alarm System				AHU 01 ZONE	SMS Panel Critical Alarm To RTK Alarm Panel
VFC Alarm Status To RTK Alarm System				AHU 03 ZONE	SMS Panel Critical Alarm To RTK Alarm Panel
				Total No Of SMS Points	**45**

SMS Room Pressure Monitoring Points List

SMS Control Panel No.2 – Located F2 HEPA Deck Plantroom

Design Note	AHU Ref	Control Point Ref	Room Ref	Room Ref	Point Description
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 1	02	P800-F2PD-SMS-SEN##	F1AR01	Suite 1 Holding Room	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 1	02	P800-F2PD-SMS-SEN##	F1AR01	Suite 1 Holding Room	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 1	02	P800-F2PD-SMS-SEN##	F1AR01	Suite 1 Holding Room	Room Differential Pressure WRT Dirty Corridor
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 1	02	P800-F2PD-SMS-SEN##	F1SG01	Suite 1 Storage	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 1	02	P800-F2PD-SMS-SEN##	F1SG01	Suite 1 Storage	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 1	02	P800-F2PD-SMS-SEN##	F1SG01	Suite 1 Storage	Room Differential Pressure WRT Clean Corridor
Repeat 4-20mA Signal To HVAC PLC Panel Suite 1	02	P800-F2PD-SMS-SEN##	F1AP01	Suite 1 Procedure	Room Differential Pressure WRT Chemical Shower
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 1	02	P800-F2PD-SMS-SEN##	F1AC01	Suite 1 Chemical Shower	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 1	02	P800-F2PD-SMS-SEN##	F1AC01	Suite 1 Chemical Shower	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 1	02	P800-F2PD-SMS-SEN##	F1AC01	Suite 1 Chemical Shower	Room Differential Pressure WRT PPE 1 & 2
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 1	02	P800-F2PD-SMS-SEN##	F1PP01	Suite 1 & 2 PPE Change	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 1	02	P800-F2PD-SMS-SEN##	F1PP01	Suite 1 & 2 PPE Change	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 1	02	P800-F2PD-SMS-SEN##	F1PP01	Suite 1 & 2 PPE Change	Room Differential Pressure WRT Clean Corridor
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 2	02	P800-F2PD-SMS-SEN##	F1AR02	Suite 2 Holding Room	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 2	02	P800-F2PD-SMS-SEN##	F1AR02	Suite 2 Holding Room	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 2	02	P800-F2PD-SMS-SEN##	F1AR02	Suite 2 Holding Room	Room Differential Pressure WRT Dirty Corridor

Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 2	02	P800-F2PD-SMS-SEN##	F1SG02	Suite 2 Storage	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 2	02	P800-F2PD-SMS-SEN##	F1SG02	Suite 2 Storage	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 2	02	P800-F2PD-SMS-SEN##	F1SG02	Suite 2 Storage	Room Differential Pressure WRT Clean Corridor
Repeat 4-20mA Signal To HVAC PLC Panel Suite 2	02	P800-F2PD-SMS-SEN##	F1AP02	Suite 2 Procedure	Room Differential Pressure WRT Chemical Shower
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 2	02	P800-F2PD-SMS-SEN##	F1AC02	Suite 2 Chemical Shower	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 2	02	P800-F2PD-SMS-SEN##	F1AC02	Suite 2 Chemical Shower	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 2	02	P800-F2PD-SMS-SEN##	F1AC02	Suite 2 Chemical Shower	Room Differential Pressure WRT PPE 1 & 2
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 3	02	P800-F2PD-SMS-SEN##	F1AR03	Suite 3 Holding Room	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 3	02	P800-F2PD-SMS-SEN##	F1AR03	Suite 3 Holding Room	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 3	02	P800-F2PD-SMS-SEN##	F1AR03	Suite 3 Holding Room	Room Differential Pressure WRT Dirty Corridor
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 3	02	P800-F2PD-SMS-SEN##	F1SG03	Suite 3 Storage	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 3	02	P800-F2PD-SMS-SEN##	F1SG03	Suite 3 Storage	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 3	02	P800-F2PD-SMS-SEN##	F1SG03	Suite 3 Storage	Room Differential Pressure WRT Clean Corridor
Repeat 4-20mA Signal To HVAC PLC Panel Suite 3	02	P800-F2PD-SMS-SEN##	F1AP03	Suite 3 Procedure	Room Differential Pressure WRT Chemical Shower
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 3	02	P800-F2PD-SMS-SEN##	F1AC03	Suite 3 Chemical Shower	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 3	02	P800-F2PD-SMS-SEN##	F1AC03	Suite 3 Chemical Shower	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 3	02	P800-F2PD-SMS-SEN##	F1AC03	Suite 3 Chemical Shower	Room Differential Pressure WRT PPE
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 3	02	P800-F2PD-SMS-SEN##	F1PP03	Suite 3 PPE Change	Room Differential Pressure WRT Atm

Repeat 4-20mA Signal To HVAC PLC Panel Suite 3	02	P800-F2PD-SMS-SEN##	F1PP02	Suite 3 PPE Change	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 3	02	P800-F2PD-SMS-SEN##	F1PP02	Suite 3 PPE Change	Room Differential Pressure WRT Clean Corridor
Repeat 0-10Vdc Signal From HVAC PLC Panel AHU02 Local	02	P800-F2PD-SMS-SEN##	F1 Dirty Cor002 Local	Dirty Corridor	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel AHU02 Local	02	P800-F2PD-SMS-SEN##	F1Dirty Corr02	Dirty Corridor	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel AHU02 Local	02	P800-F2PD-SMS-SEN##	F1Dirty Corr02	Dirty Corridor	Room Differential Pressure WRT Clean Corridor
VFC Alarm Status To RTK Alarm System				AHU 02 ZONE	SMS Panel Critical Alarm To RTK Alarm Panel
				Total No Of SMS Points	**40**

SMS Room Pressure Monitoring Points List

SMS Control Panel No.3 – Located F2 HEPA Deck Plantroom

Design Note	AHU Ref	Control Point Ref	Room Ref	Room Ref	Point Description
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 4	02	P800-F2PD-SMS-SEN##	F1AR04	Suite 4 Holding Room	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 4	02	P800-F2PD-SMS-SEN##	F1AR04	Suite 4 Holding Room	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 4	02	P800-F2PD-SMS-SEN##	F1AR04	Suite 4 Holding Room	Room Differential Pressure WRT Dirty Corridor
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 4	02	P800-F2PD-SMS-SEN##	F1SG04	Suite 4 Storage	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 4	02	P800-F2PD-SMS-SEN##	F1SG04	Suite 4 Storage	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 4	02	P800-F2PD-SMS-SEN##	F1SG04	Suite 4 Storage	Room Differential Pressure WRT Clean Corridor
Repeat 4-20mA Signal To HVAC PLC Panel Suite 4	02	P800-F2PD-SMS-SEN##	F1AP04	Suite 4 Procedure	Room Differential Pressure WRT Chemical Shower
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 4	02	P800-F2PD-SMS-SEN##	F1AC04	Suite 4 Chemical Shower	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 4	02	P800-F2PD-SMS-SEN##	F1AC04	Suite 4 Chemical Shower	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 4	02	P800-F2PD-SMS-SEN##	F1AC04	Suite 4 Chemical Shower	Room Differential Pressure WRT PPE 4 & 5
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 4	02	P800-F2PD-SMS-SEN##	F1PP03	Suite 4 & 5 PPE Change	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 4	02	P800-F2PD-SMS-SEN##	F1PP03	Suite 4 & 5 PPE Change	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 4	02	P800-F2PD-SMS-SEN##	F1PP03	Suite 4 & 5 PPE Change	Room Differential Pressure WRT Clean Corridor
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 5	02	P800-F2PD-SMS-SEN##	F1AR05	Suite 5 Holding Room	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 5	02	P800-F2PD-SMS-SEN##	F1AR05	Suite 5 Holding Room	Room Differential Pressure WRT Atm

Repeat 4-20mA Signal To HVAC PLC Panel Suite 5	02	P800-F2PD-SMS-SEN##	F1AR05	Suite 5 Holding Room	Room Differential Pressure WRT Dirty Corridor
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 5	02	P800-F2PD-SMS-SEN##	F1SG05	Suite 5 Storage	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 5	02	P800-F2PD-SMS-SEN##	F1SG05	Suite 5 Storage	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 5	02	P800-F2PD-SMS-SEN##	F1SG05	Suite 5 Storage	Room Differential Pressure WRT Clean Corridor
Repeat 4-20mA Signal To HVAC PLC Panel Suite 5	02	P800-F2PD-SMS-SEN##	F1AP05	Suite 5 Procedure	Room Differential Pressure WRT Chemical Shower
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 5	02	P800-F2PD-SMS-SEN##	F1AC05	Suite 5 Chemical Shower	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 5	02	P800-F2PD-SMS-SEN##	F1AC05	Suite 5 Chemical Shower	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 5	02	P800-F2PD-SMS-SEN##	F1AC05	Suite 5 Chemical Shower	Room Differential Pressure WRT PPE 4 & 5
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 6	02	P800-F2PD-SMS-SEN##	F1AR06	Suite 6 Holding Room	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 6	02	P800-F2PD-SMS-SEN##	F1AR06	Suite 6 Holding Room	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 6	02	P800-F2PD-SMS-SEN##	F1AR06	Suite 6 Holding Room	Room Differential Pressure WRT Dirty Corridor
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 6	02	P800-F2PD-SMS-SEN##	F1SG06	Suite 6 Storage	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 6	02	P800-F2PD-SMS-SEN##	F1SG06	Suite 6 Storage	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 6	02	P800-F2PD-SMS-SEN##	F1SG06	Suite 6 Storage	Room Differential Pressure WRT Clean Corridor
Repeat 4-20mA Signal To HVAC PLC Panel Suite 6	02	P800-F2PD-SMS-SEN##	F1AP06	Suite 6 Procedure	Room Differential Pressure WRT Chemical Shower
Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 6	02	P800-F2PD-SMS-SEN##	F1AC06	Suite 6 Chemical Shower	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 6	02	P800-F2PD-SMS-SEN##	F1AC06	Suite 6 Chemical Shower	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 6	02	P800-F2PD-SMS-SEN##	F1AC06	Suite 6 Chemical Shower	Room Differential Pressure WRT PPE 6

Repeat 0-10Vdc Signal From HVAC PLC Panel Suite 6	02	P800-F2PD-SMS-SEN##	F1APP04	Suite 6 PPE Change	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 6	02	P800-F2PD-SMS-SEN##	F1APP04	Suite 6 PPE Change	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel Suite 6	02	P800-F2PD-SMS-SEN##	F1APP04	Suite 6 PPE Change	Room Differential Pressure WRT Clean Corridor
Repeat 0-10Vdc Signal From HVAC PLC Panel	02	P800-F2PD-SMS-SEN##	F1PP05	PM PPE Change	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	02	P800-F2PD-SMS-SEN##	F1PP05	PM PPE Change	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	02	P800-F2PD-SMS-SEN##	F1PP05	PM PPE Change	Room Differential Pressure WRT Inner Change Lobby F1IS05
Repeat 0-10Vdc Signal From HVAC PLC Panel	02	P800-F2PD-SMS-SEN##	F1CS01	Chemical Shower	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	02	P800-F2PD-SMS-SEN##	F1CS01	Chemical Shower	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	02	P800-F2PD-SMS-SEN##	F1CS01	Chemical Shower	Room Differential Pressure WRT PPE Change F1PP05
Repeat 0-10Vdc Signal From HVAC PLC Panel	02	P800-F2PD-SMS-SEN##	F1LO01	Lobby	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	02	P800-F2PD-SMS-SEN##	F1LO01	Lobby	Room Differential Pressure WRT Atm
Repeat 4-20mA Signal To HVAC PLC Panel	02	P800-F2PD-SMS-SEN##	F1LO01	Lobby	Room Differential Pressure WRT Chemical Shower F1CS01
VFC Alarm Status To RTK Alarm System Junction Box				AHU 02 ZONE	SMS Panel Critical Alarm To RTK Alarm Panel
				Total No Of SMS Points	**46**

Appendix 2

SMS Software Group Rights and Permissions

The Pirbright Institute to advise User group and software read / write requirements.

The software security requirements table will be developed and detailed in the SMS detail design specification.

The User shall be able to manually disable SMS alarms during fumigation or for calibration via the SMS PC workstation / SMS panel no. 2 HMI. The user will need to also manually repeat the respective alarm disable at the BMS PC workstation.

Vvv Parameter Groups >>>>	System Administrator	Engineering Supervisor	System Engineer	Guest		
Operational Permissions						
Browse Displays	Y	Y	Y	Y		
Silence Alarm Horn	Y	Y	Y	N		
Acknowledge Action Alarms	Y	Y	Y	N		
Acknowledge Alert Alarms	Y	Y	Y	N		
Acknowledge Advisory Alarms	Y	Y	Y	N		
Adjust Critical Setpoints	Y	Y	Y	N		
Adjust non-Critical Setpoints	Y	Y	Y	N		
Access Archived Data	Y	Y	Y	N		
Print Reports	Y	Y	Y	N		
Engineering Permissions						
Add/Delete/Modify Objects	Y	N	Y	N		
Add/Delete/Modify Alarms	Y	N	Y	N		
Add/Delete/Modify Programs or Functions	Y	N	Y	N		
Add/Delete/Modify Graphic Pages	Y	N	Y	N		
Add/Delete/Modify Workstations	Y	N	Y	N		
Tune Control Loops	Y	N	Y	N		
Adjust Input/Output Scaling	Y	N	Y	N		
Administrative						
Add/Delete/Modify Users	Y	N	N	N		
Add/Delete/Modify Groups	Y	N	N	N		
Add/Delete/Modify User Rights	Y	N	N	N		
Add/Delete/Modify Group Rights	Y	N	N	N		