green building council australia
green star
environmental rating system for buildings

BUILDING A SUSTAINABLE FUTURE
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Green Star Credit Cover Sheet Round 2

Green Star - Office Interiors v1.1
IEQ-2 Carbon Dioxide Monitoring and Control

Points available: 1 **Points claimed:** 1 **CIR or TC Used:** N

Round 1 Assessment Comments
In order for the point to be awarded, please provide extracts from the Commissioning Report that verifies that the CO2 monitoring system is operational and meets the design criteria.

The Certified Assessors note that the report provided by Honeywell is a functional description of the system, not a commissioning report that confirms that the system is operational and meeting the design criteria (i.e. the report states that the system "will" do this and "shall" do this, where a commissioning report would state that the system “does” do this).

Compliance with Credit Criteria
The CO2 monitoring system installed controls the concentration of CO2 within the meeting rooms and open plan space by providing fresh air to the space when the sensors detect a concentration of CO2 within the space above 800ppm. They continue to supply fresh air until the CO2 concentration drops below 700ppm.

Documents Provided
- [2] CO2 monitor commissioning report confirming that system is functional
- [3] Round 1 Submission is provided in its entirety

Discussion
As the functional description provided in Round 1 was unclear demonstrating that the system had actually been commissioned to function as per specification, Honeywell was brought back in to ensure that the monitors function correctly. The commissioning report provided confirms that through site testing of all CO2 monitors within enclosed spaces of less than 100m2, CO2 concentration is being controlled successfully.

Honeywell

FAX TRANSMISSION – Building Solutions

Honeywell
2 Richardson
Place North Ryde
NSW 2113

Date: 05/06/2009

# of Pages: 1
(including cover)

____ Urgent
____ Please Review
X
____ Reply ASAP

To: Peter Williams
Company: J.L Williams
Fax #: 02 9313 5612
Phone#:

From: Mark Olender
Fax#: [redacted]
Phone#:

(Call if you did not receive all pages, or if document is illegible)

Peter,

Functionality tests were done for Green Building Council at 179 Elizabeth St, level 15, last week on the CO2 controls with regards to the economy cycle on the air conditioning. Joe Karten was present and witnessed the events as they were tested.

The functionality of the CO2 system as outlined in the functional description manual is deemed to have operated correctly.

The test carried out was to witness that the outside air dampers were closed in an automatic state when CO2 levels in the 3 rooms (Meeting Room 1, Meeting Room 2, and Boardroom) were at normal levels. We then increased the CO2 level at each sensor by breathing directly onto it and saw that the CO2 value rose from approximately 400 parts per million to greater than 2000 ppm. This then enabled the outside air dampers to open as the CO2 level went greater than the 800ppm setpoint. When the level of CO2 went below the 800ppm by 100ppm, the outside air cycle was then disabled.

This test was done individually to each of the 3 sensors / meeting rooms.

In summary, the CO2 control of the economy cycle works in accordance with the functional description.

Regards,

Mark Olender.

Indoor Environment Quality
IEQ-2 Carbon Dioxide Monitoring and Control

Points Available	Points Claimed	CIR Submitted
1	1	N

Credit Criteria
One point is awarded where it is demonstrated that the following condition is met in the tenancy fitout:
• A carbon dioxide (CO_2) monitoring system with a minimum of one CO_2 sensor per return duct in the tenancy fitout that facilitates continuous monitoring and adjustment of outside air ventilation rates for all enclosed spaces less than 100m² in area.

Documents Provided

✓	A description of the system and its method of operation (referring to drawings and commissioning report). IEQ-2: 1
✓	As-built drawings that show the location of all HVAC return air ducts and CO_2 sensors and the enclosed areas served by those sensors. IEQ-2: 2
✓	Commissioning report extracts confirming that the CO2 sensors are operating correctly and can adjust fresh air rates as required. IEQ-2: 3
✓	Entire commissioning report confirming that the CO2 sensors are operating correctly and can adjust fresh air rates as required. IEQ-2: 4

Discussion
- CO_2 sensors have been provided in the space to control the concentration of CO_2 within the office. Eight CO_2 sensors have been supplied corresponding to the eight points of air extraction from the office space (five return air ducts and three exhaust grilles). These sensors have been distributed throughout the tenancy to provide optimum monitoring effectiveness.
- The system is described in the Description of CO_2 Monitoring System document and location of sensors and operation are confirmed in the as-built drawings and commissioning report (Functional Description) provided.
- For ease of assessment, the applicable extracts from the Functional Description document have been provided have been in IEQ-2: 3, with the report provided in its entirety immediately following in IEQ-2: 4.

green building council australia

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13 March 2009

Description of CO_2 Monitoring System

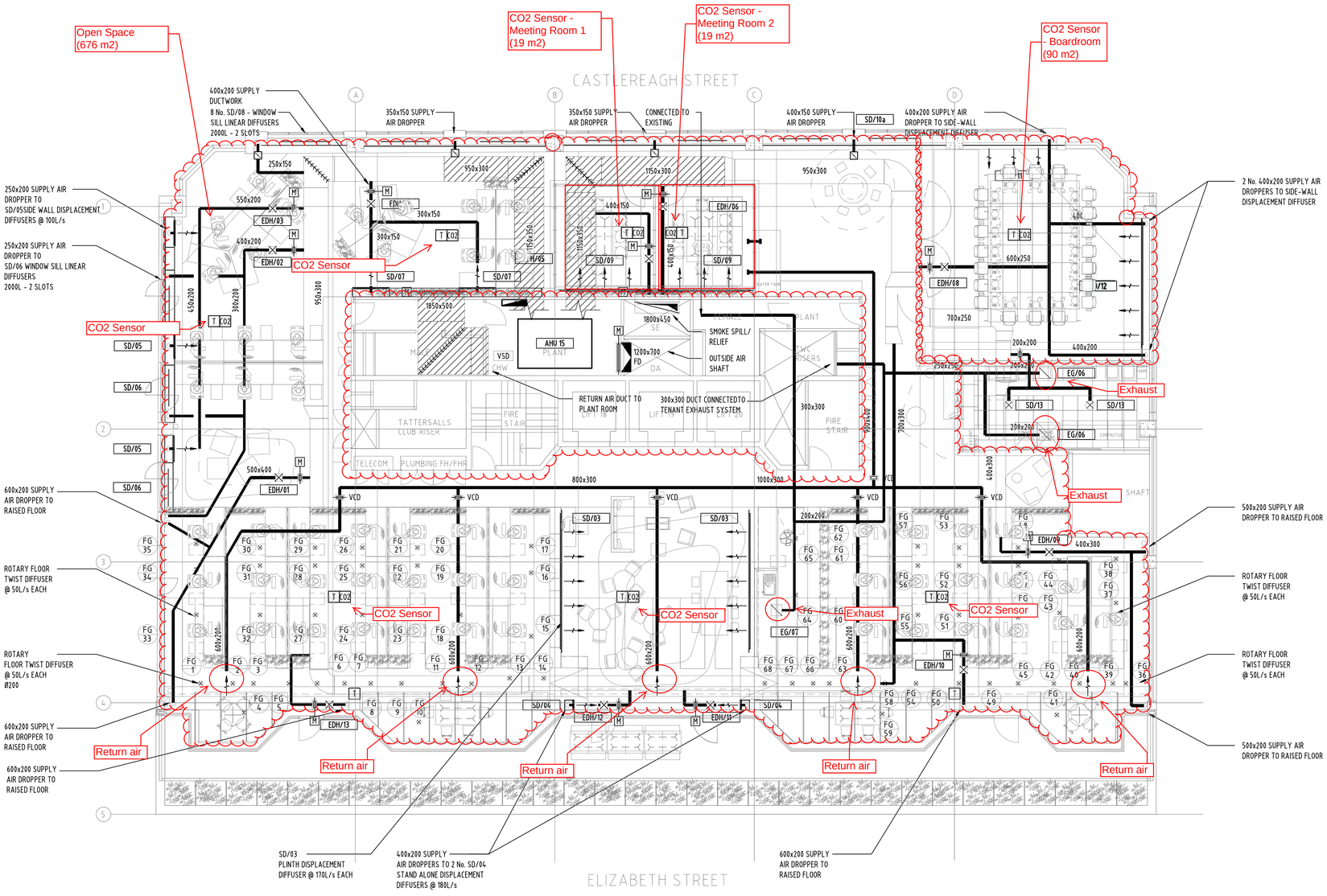
Summary Report written by Joe Karten

The CO_2 monitoring system employed within the GBCA tenancy on Level 15, 179 Elizabeth St, Sydney uses CO_2 sensors that are distributed throughout office with 5 located in the open plan office space and one each in both meeting rooms and in the Board room. A total of 8 CO2 sensors have been installed within the tenancy. The location of these CO_2 sensors is deemed sufficient to modulate outside air rates to decrease CO_2 concentration in all spaces within the tenancy as confirmed by the Functional Description commissioning report written by Honeywell and provided by James L Williams.

There are 5 return air ducts, all located along the eastern façade of the tenancy. In addition, there are 3 exhaust grilles, one located in the kitchen and two located in the server room. All of these are called out on the as-built drawing M01 provided by James L Williams.

The system is designed to control CO_2 levels in the tenancy by adjusting fresh air rates within the tenancy when the CO_2 concentration in the space is measured to be greater than 800ppm. When this occurs, dampers open to increase the fresh air component in the supply air to reduce the amount of CO_2 in the space. When CO_2 levels decrease to below 700ppm, the system returns to standard system procedure. Proper system operation is confirmed in the Honeywell commissioning report.

IEQ-2: 2



AS BUILT

LEGEND

- AxB — RECTANGULAR DUCTWORK
- SUPPLY AIR DUCTWORK
- RETURN AIR DUCTWORK
- EXHAUST AIR DUCTWORK
- DROPPER
- SD/xx — STAND ALONE DISPLACEMENT DIFFUSER
- SD/xx — SIDE WALL DISPLACEMENT DIFFUSER
- SD/xx — SWIRL DIFFUSER
- ROTARY FLOOR DIFFUSER
- EG/xx — RETURN/EXHAUST AIR GRILLE
- FD — FIRE DAMPER
- VCD — VOLUME CONTROL DAMPER
- M — MOTORISED DAMPER
- EDH/xx — ELECTRICAL DUCT HEATER
- T — TEMPERATURE SENSOR
- CO2 — CO2 SENSOR
- DISTRIBUTION BOARD
- FG 48 — FLOOR DIFFUSER NO.

N

Rev	Description	By	Date
A	AS BUILT	ENRAVEL	11.03.2009

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BRISBANE
MOUNT ISA
MELBOURNE
HEAD OFFICE

CLIENT

GBCA

Project

LEVEL 15
179 ELIZABETH STREET
SYDNEY NSW 2000

Drawing Title

DUCTWORK LAYOUT
L15

CAD File	Drawn -
Coordinated	Scale 1:100 @A1
Project Architect	Date 11-03-09
Project Director	
PTW Project No. -	Drawing Number ST 236-M01 A
JLW Project No. ST 236	Rev A

IEQ-2: 3

FUNCTIONAL DESCRIPTION

FOR

Green Building Council of Australia

Level 15
179 Elizabeth St

Sydney

Consulting Engineers :

Mechanical Contractor :

BAS / DDC Services Contractor :

Honeywell Limited Australia
2 Richardson Place
North Ryde NSW 2113

Client :

JL Williams

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TABLE OF CONTENTS

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1 REVISION / ISSUE STATUS

REVISION	ISSUE	DATE	DESCRIPTION
1	1	14-02-2007	Original Issue

NOTES :-

1. **Changes made to a revision of the Functional Description are identified by a line in the right hand margin of the page and will be in "Italics".**

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The sensors are connected as analogue input signals into a Honeywell DDC controller and the instantaneous ambient dry bulb temperature and relative humidity is displayed on a graphic on the operator terminal of the Building Management System.

The instantaneous ambient dry bulb temperature value is also "Globally" transferred from the local DDC controller to the controller serving the air handling unit for use in the economy cycle damper override control system.

Whenever the air handling unit has been commanded "On", the outside air dry bulb temperature is monitored at the local DDC controller.

Whenever the outside air dry bulb temperature rises above 22° C then the outside and spill air economy cycle dampers will both be driven to the minimum closed position and the return air damper to the maximum open position.

Whenever the outside air dry bulb temperature falls below 21° C then the economy cycle dampers are included in the unit discharge air temperature control strategy as the first stage of cooling.

Sensors are installed on level 15 in various locations.

~~c)~~a) Meeting Room 1 CO2 (1 Sensor).

~~d)~~b) Meeting Room 2 CO2 (1 Sensor).

~~e)~~c) Board Room CO2 (1 Sensor).

~~f)~~d) Return Air temperature CO2 (5 Sensors).

Whenever the air handling unit has been commanded "On", the CO2 sensors are monitored at the local DDC controller.

Whenever any of the CO2 sensors rises above 800 parts per million (ppm), then the unit outside air economy cycle dampers are included in the discharge air temperature control strategy as the first stage of cooling, opening dampers to pull in fresh air.

Whenever any of the CO2 sensors values then falls below 700ppm, then the economy cycle will continue to operate with reference to outside air temperature.

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5.9 Economy Cycle Damper Arrangement

Details and the control arrangements for the economy cycle dampers associated with the air handling unit are as follows.

a) The economy cycle dampers will be driven by separate 24 volt A.C. modulating spring return motors with an input signal of 2-10 Volts D.C.

b) The economy cycle damper motors will be arranged to fail to the following position on a loss of mains power or with an input signal of 2 volts D.C.

Outside Air Damper Motor	Fully Open.
Relief Air Damper Motor	Fully Open.
Return Air Damper Motor	Fully Closed.

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FUNCTIONAL DESCRIPTION

FOR

Green Building Council of Australia

Level 15
179 Elizabeth St

Sydney

Consulting Engineers :

Mechanical Contractor :

BAS / DDC Services Contractor :

Honeywell Limited Australia
2 Richardson Place
North Ryde NSW 2113

Client :

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NOTES :-

1. **Changes made to a revision of the Functional Description are identified by a line in the right hand margin of the page and will be in "Italics".**

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2 PURPOSE OF THE FUNCTIONAL DESCRIPTION

This Functional Description defines the functions to be provided by Honeywell Limited for the Building Automation and Direct Digital Control System for the **Green Building Council of Australia at 179 Elizabeth St.**

This Functional Description describes in detail the manner in which the Honeywell Building Automation and Direct Digital Control System will perform the functions offered for the above project.

This Functional Description, when approved defines the scope of Honeywell Ltd responsibility with respect to the **Green Building Council of Australia at 179 Elizabeth St.**

Any subsequent change in scope may be subject to a proposal for the change. On receipt of an order, the change in scope shall be incorporated as a revision to the Functional Description and approved prior to implementation.

APPROVED BY: PROJECT ENGINEER HONEYWELL

.....DATE.....

APPROVED BY: DESIGN VERIFIER HONEYWELL

.....DATE.....

APPROVED BY: CUSTOMER

.....DATE.....

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3 GENERAL DESCRIPTION AND OVERVIEW

3.1 DDC Input / Output Schedule

The Input / Output schedules for all DDC controllers detail all points physically connected to the Direct Digital controllers together with details on ancillary field equipment and devices associated with the overall control system.
Input / Output schedules for the project are contained in section 4.0 of this manual.

3.2 DDC Contact Convention

The following contact convention has been used on this project.

Status Inputs

Closed Contact	=	On
Open Contact	=	Off

Alarm Inputs

Closed Contact	=	Normal
Open Contact	=	Alarm

Controlled Outputs
(Volt Free Contact)

Closed Contact	=	Start Unit
Open Contact	=	Stop unit

Analogue Inputs

All temperature sensors are 20 k Ω NTC devices unless otherwise advised.
Auxiliary equipment or devices have inputs of 4-20 mA or 2-10 volts D.C.

Analogue Outputs

Analogue output signals are either 0-10 volt D.C. or 2-10 volt D.C. depending on the particular field device being controlled.

Digital Inputs

All digital input signals are provided by voltage free normally open contacts.

Digital Outputs

All digital output signals are derived from normally open contacts rated for a maximum of 2 Amps. The preferred control voltage is 24 volts A.C. which is supplied from the local mechanical electrical switchboard.

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3.3 Design Inputs

This Functional Description document details the control strategies to be used on the various items of equipment installed on the project. The following documents, manuals and drawings have been used as the design inputs in the generation of the Functional Description.

1. Project Specification.

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4 COMMON CONTROL STRATEGIES

The following control strategies apply to all plant controlled by the system. Specific control strategies applicable to each item of plant are fully detailed in the Functional Description section of this document.

4.1 Alarms / Alarm Suppression

Throughout the Honeywell Building Management and Direct Digital Control system, a variety of alarms are generated. In order to prevent the operator of the system from being distracted by nuisance alarms they will be suppressed within the system as detailed below.

4.1.1 Fans and Pump Alarms

Should a fan or pump be commanded "On" or "Off" by the DDC controller and the correct status input signal not be received within 30 seconds then an alarm condition for that plant will be generated by the system.
Fan alarms are inhibited whenever a fire alarm condition occurs.

4.1.2 Temperature Alarms

All temperature sensors located in air conditioned areas of the complex have "High" and "Low" alarm limits associated with them.
The temperature sensor alarms will be inhibited whenever the associated air handling or fan coil unit is "Off" and until it has been operating for a continuous period of 30 minutes (Adjustable).
The following table details the temperature alarm limits as well as the initial time delay period for the various areas of the complex.

Application	Time Delay	High Limit	Low Limit
Zone Temperature	30 Minutes	24° C	20° C

All of the above time delay periods and temperature limits can be changed and adjusted by the plant engineer by means of simple changes at the operators terminal of the Building management System.

4.1.3 General Alarm Inputs

All digital input monitoring points, listed with an alarm condition in the input / output schedule, shall raise an alarm whenever the associated field contacts are set to the alarm state.
Except where stated otherwise in the Functional Description section of this document, the alarm condition will be raised immediately the field contact is set to the alarm condition.

4.1.4 Fire Override Control

During fire alarm conditions mechanical items of plant will be directly controlled to the required state by means of hard wired electrical interlock and control signals derived from the associated mechanical electrical switchboard.

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Details on exactly how each item of plant is controlled in fire mode is fully detailed in the various sections of the Functional Description section of this document.

4.2 Hour Run Times

The run time for operating equipment is accumulated within the associated DDC controller by using standard software data base functions.
The accumulated run time is then displayed on the relevant graphic page for that particular item of plant.
The items of plant that have their actual run times accumulated are as follows.

1. All fan status inputs.
2. All pump status inputs.
3. All chiller status inputs.

4.3 Control Loop Parameters

All DDC control modules will be installed with Proportional plus Integral (P + I) control action.

Where Proportional only control action is required, the Integral function within the control module is disabled by setting the Integral time parameter to zero.

Final tuning of the individual control modules and setting of throttling range and integral times will be carried out at commissioning in order to establish stable control conditions for the overall control loop.

4.4 Design Assumptions

The following design assumptions have been used in the programming of the DDC controllers.

4.4.1 Field Contact Arrangements

a) All control voltages for the operation of fan motor contactors will be 24 volts A.C. and the supply will be derived from the mechanical electrical switchboard serving the particular unit.

4.4.2 Temperature and Humidity Sensors

a) Zone temperature sensors will all be (20 K Ω N.T.C) devices.

b) The outside and return air temperature sensors will all be (20 K Ω N.T.C) devices.

c) The zone humidity sensors will all have an output of 0-10 volts D.C. for an input of 5% to 95% RH.

d) The outside and return air humidity sensors will all have an output of 0-10 volts D.C. for an input of 5% to 95% RH.

4.4.3 Valves and Valve Actuators

a) The air handling and fan coil unit cooling and heating coil control valve actuators will all be 24 volt A.C. devices driven from a 2-10 volt D.C. analogue output signal from the DDC controller.

b) The air handling and fan coil unit cooling and heating coil control valves will be normally closed devices which will close to the coil when the actuator is driven to 2 volts D.C.

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4.4.4 Economy Cycle Dampers

a) The air handling unit economy cycle dampers will be driven by separate 24 volt A.C. modulating spring return motors with an input of 2-10 Volts D.C.

b) The economy cycle damper motors will be arranged to fail to the following position on a loss of mains power or whenever the controlled input to the motor is set to 2 volts D.C.

Outside Air Damper Motor	Fully Open.
Spill Air Damper Motor	Fully Open.
Return Air Damper Motor	Fully Closed.

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5 TYPICAL VARIABLE VOLUME AIR HANDLING UNIT

5.1 System Synopsis

The variable air volume boxes located throughout levels 15 is served by a dedicated variable volume air handling units located within the plant room.

The air handling unit is fitted with a modulating chilled water cooling coil and outside, return and spill air economy cycle dampers.

The discharge air temperature set point of the air handling unit is reset from the floor variable air volume box with the greatest demand for cooling.

The required static pressure is maintained in the air handling unit supply air duct under all load conditions by modulating a bypass damper connected between the discharge and suction side of the unit supply air fan.

The control strategy also includes override of the air handling unit economy cycle dampers from an outside air high limit dry bulb temperature.

Optimum start operation and separate fire override facilities for a "General" building and specific zone fire alarm conditions of the air handling unit is also included within the overall control strategy.

Fresh outside air is supplied to the air handling units located on levels 13 to 16 inclusive by means of a fresh air fan located on level 17 of the building. The fan is interlocked to operate whenever any of these floor air handling unit systems are commanded "On".

Levels 13 to 16 inclusive are served by a separate relief / smoke spill fan located on level 17 of the building. These relief / smoke spill fans can also operate under the control of the fire officer whenever the building is in a "General" fire alarm condition.

Details of the variable volume air handling units and the areas they serve, as well as the number of associated variable air volume boxes are provided in the following table.

Air Handling Unit	Area Served	Assoc. VAV Boxes
AHU-15	Fifteenth Level VAV Boxes	12

Details of the fresh air fan and the two relief / smoke spill fans as well as the floor levels they serve are provided in the following table.

Unit	Levels Served	Location of Unit
SF-17-10	Fresh Air To Levels 13 to 16 Air Handling Units	Level 17
RSEF-17-1	Relief / Smoke Spill From Levels 13 to 16 (Inc)	Level 17

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5.2 Theory of Operation

This application uses proportional plus integral control to modulate the economy cycle dampers and the cooling coil control valve actuator in sequence from the discharge air temperature sensor.

Proportional plus integral control modules are also used to maintain system static pressure by modulating the supply air fan speed by means of a variable frequency drive unit.

5.3 Air Handling Unit System Sequence of Operation

5.3.1 Supply Air Fan "START / STOP" Control

The air handling unit is activated from either a time schedule within the Honeywell DDC controller, the energy management control system, an after hours manual call button or the Fire Mode Control System.

The signals for the Fire Mode Control System are derived from the main fire indicator panel and are wired to the mechanical electrical switchboard by the fire contractor.

The control of the air handling unit in fire mode is achieved by hard wired control and interlock functions provided by the mechanical electrical sub contractor and mimicked in the DDC controller.

The status of the unit supply air fan is monitored by means of a differential pressure switch. The "High" and "Low" pressure tapings of the switch are connected across the discharge and suction of the fan and the contacts of the internal electrical switch unit are connected as a digital input into the Honeywell DDC controller.

An alarm is enunciated on the relevant air handling unit system graphic display on the operator terminal of the Building Management System whenever the supply air fan fails to respond to start-stop commands.

5.3.2 From a Time Schedule within the DDC Controller

The following table details the initial occupancy schedule that is programmed into the Honeywell DDC controller for the operation of the air handling unit. The schedule can be changed and customised to suit the particular application and requirements of the unit.

Air Handling Unit Occupancy Schedule

Day	Start Time	Stop Time
Monday	07 : 00	18 : 00
Tuesday	07 : 00	18 : 00
Wednesday	07 : 00	18 : 00
Thursday	07 : 00	18 : 00
Friday	07 : 00	18 : 00
Saturday	00 : 00	00 : 00
Sunday	00 : 00	00 : 00
Holiday	00 : 00	00 : 00

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5.3.3 Outside Air Fan "START / STOP" Control

The outside air fan SF-17-10 is software interlocked to operate when any associated air handling unit supply air fan is commanded "On". The fan supplies fresh outside air to the variable volume air handling units located on levels 13 to 16 inclusive of the building.

Whenever an associated air handling unit supply air fan is commanded "On" and the correct status input signal has been received at the Honeywell DDC controller then the outside air fan is also commanded "On". Whenever all associated air handling unit supply air fans have been commanded "Off" then the outside air fan is also commanded "Off".

The status of the outside air fan is monitored by means of an electrical current switch. The current switch is located in the mechanical electrical switch board and monitors one of the phase currents supplied to the fan. The output switch of the unit is connected as a digital input signal into the DDC controller and the unit is adjusted so that the output switch contacts are made when the fan is running at 20% of full load amps.

An alarm is enunciated on the outside air fan system graphic display on the operator terminal of the Building Management System whenever the fan fails to respond to start stop commands.

5.3.4 Control of Relief / Smoke Exhaust Fans

Levels 13 to 16 inclusive of the building are served by two relief / smoke exhaust fans as detailed in the following table.

Fan	Levels Served
RSEF-17-1	Relief / Smoke Spill From Levels 13 to 16 (Inc)

In normal operation the fans are software interlocked to operate with the associated floor air handling unit system while in a general building fire alarm condition they are controlled directly from the Fire Mode Control System and their operation is mimicked in the Honeywell DDC controller.

The signals for the Fire Mode Control System are derived from the main fire indicator panel and are wired to the mechanical electrical switchboard by the fire contractor.

The control of the two relief / smoke exhaust fans in fire mode is achieved by hard wired control and interlock functions provided by the mechanical electrical sub contractor and mimicked in the DDC controller.

Whenever an associated air handling unit supply air fan is commanded "On" in normal operation and the correct status input signal has been received at the Honeywell DDC controller then the relief / smoke exhaust fan is also commanded "On". Whenever all associated air handling unit supply air fans have been commanded "Off" then the relief / smoke exhaust fan is also commanded "Off".

The status of the relief / smoke exhaust fan is monitored by means of an electrical current switch. The current switch is located in the mechanical electrical switch board and monitors one of the phase currents supplied to the fan. The output switch of the unit is connected as a digital input signal into the DDC controller and the unit is adjusted so that the output switch contacts are made when the fan is running at 20% of full load amps.

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An alarm is enunciated on the relevant relief / smoke exhaust fan system graphic display on the operator terminal of the Building Management System whenever the fan fails to respond to start stop commands.

5.3.5 From After Hours Manual Call Button

Two separate standard wall modules complete with a key switch are installed within the tenancy areas on the floor of the building at locations to be determined on site.

The key switch is a spring loaded device which when activated provides a momentary closure of the switch contacts before returning to the off position. The contacts of the switch are connected as a digital input signal into the DDC controller.

Whenever the switch is activated during the normal occupancy time period of the air handling unit the input signal will be ignored. When activated outside of the normal occupancy time period the unit will start up under full automatic control and will run for a time period of two hours (Adjustable).

On expiration of the initial two hour period the unit will shut down under automatic control. Should the switch be activated again any time during the two hour run on period then the unit will be commanded "Off".

Should further after hour use be required it will be necessary to again activate the switch when a further two hour operation of the air handling unit will occur.

Whenever the air handling unit is running in "After Hours Mode" the actual total run time will be logged and displayed on the relevant air handling unit system graphic display on the operator terminal of the Building Management System.

5.3.6 From Optimum Start Energy Management System.

The optimum start energy management function can be selected to operate by means of a "Software" switch within the Honeywell DDC controller software module. The module will normally be arranged so that the optimum start feature is activated.

When activated and with the air handling unit not in the "Occupied Mode", the optimum start energy management function will start the unit for a period of up to 60 minutes (Adjustable) prior to the standard occupancy start time.

The air handling unit will be started by means of the energy management system if the "Average" selected zone temperature of all variable air volume boxes served by the air handling unit is more than 2° K outside of the temperature range of 20.5° C to 24° C.

Once activated and operational the self adaptive optimum start feature of the program will start the air handling unit at a time period before the scheduled occupancy time that enables the "Average" zone temperature on the floor to be within the above temperature limits at occupancy.

Whenever the optimum start energy management program is activated the following control action will occur.

a) The air handling unit system will operate in full automatic mode.
b) The floor mounted variable air volume boxes associated with the air handling unit will operate in full automatic mode.

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5.3.7 From Fire Mode Override Control

5.3.7.1 Activation of A "General" Building Wide Fire Alarm Condition

Should a "General" building wide fire alarm condition be detected then the following control action will occur.

a) The unit supply air fan will be commanded "Off".

b) The unit cooling coil control valve actuator will be driven to the closed position.

c) The outside and spill air economy cycle dampers will both be driven to the open position.

d) The return air damper will be driven to the open position.

e) The unit bypass damper is driven to the fully closed position.

f) A "Global" software signal will be sent from the Honeywell DDC controller serving the air handling unit to the local controllers serving the associated variable air volume boxes to drive all the box primary air dampers to the open position.

g) The outside air fan SF-17-10 will be commanded "On" or will continue to run.

h) The two relief / smoke exhaust fans RSEF-16-1 and RSEF-17-1 will both be commanded "On" or will continue to operate.

5.4 Air Handling Unit System "OFF" Mode

Whenever the air handling unit system is to be commanded "Off" the following control action will occur.

a) A "Global" software signal will be sent from the Honeywell DDC controller serving the air handling unit to the local controllers serving the associated variable air volume boxes to de-energise all stages of electric reheat and to drive all the box primary dampers to the "Closed" position.

b) The unit cooling coil control valve actuator is driven to the fully closed position.

c) The unit return air economy cycle damper is driven to the open position.

d) The unit outside air economy cycle damper is driven to the closed position.

e) The unit spill air damper is driven to the closed position.

f) The unit bypass damper is driven to the fully closed position.

g) The unit supply air fan will continue to run on for a time period of 3 minutes (Adjustable) to dissipate the heat from the variable air volume box electric reheat units after which it will be commanded "Off".

5.5 Air Handling Unit System "On" Mode

Whenever the unit is called to run the supply air fan will start and the air handling unit, together with the associated variable air volume boxes, will operate under full automatic control.

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5.6 Discharge Air Temperature Control

Whenever the air handling unit supply air fan has been commanded "On", and the correct status input signals have been received at the Honeywell DDC controller, the unit thermal control system is "Enabled" to operate.

The unit economy cycle dampers and cooling coil control valve actuator are controlled in sequence to maintain the required discharge air temperature set point.

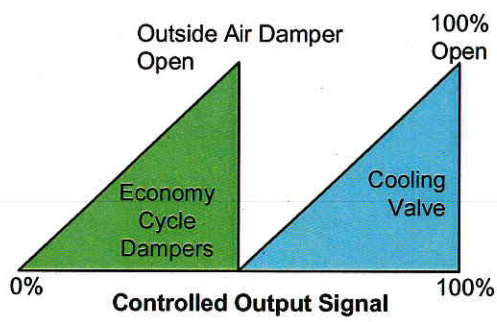
On initial start up of the unit controls are set for no outside air economy cycle or cooling and then depending on the discharge air temperature and its set point the controls act to gradually open the outside air economy cycle dampers and then bring on the mechanical cooling.

When the discharge air temperature falls below set point the cooling coil control valve actuator will be driven to the closed position and the economy cycle dampers will be driven to the full return air position.

When the discharge air temperature rises above set point the economy cycle dampers will be driven to the full outside air position and then the cooling coil control valve actuator will be driven towards the open position.

The following sequence diagram details the control of the economy cycle dampers and the cooling coil control valve actuator from the discharge air temperature sensor.

Control Sequence with Economy Cycle Dampers Operational



The operation of the economy cycle dampers in the above sequences will be subject to the override controller which is detailed in the "Override Control of Economy Cycle Dampers" section of this document.

Whenever the operation of the economy cycle dampers is overridden, the operation of the cooling coil control valve actuator is extended so that it is controlled through the full 0-100% output of the control module.

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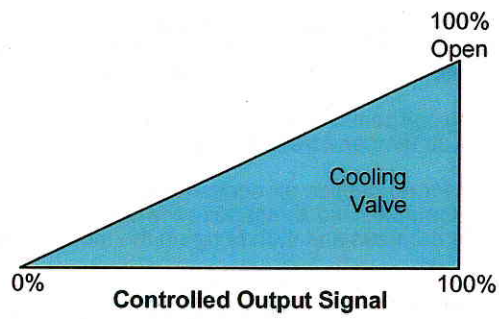
Control Sequence with Economy Cycle Dampers Overridden



The discharge air temperature control module will initially be set up with the following default values.

a) Set Point	24° C.
b) Throttling Range	20° C.
c) Integral Time	100 Seconds.

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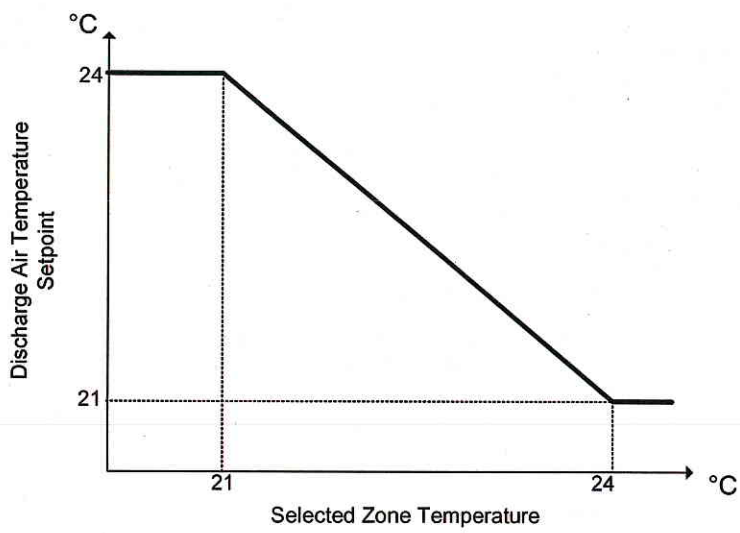
5.7 Discharge Air Temperature Reset Control

A reset schedule is incorporated in the Honeywell DDC controller program to reset the discharge air temperature set point of the air handling unit depending on the maximum deviation from set point temperature of all the floor variable air volume boxes served by the unit.

The temperature of all of the floor mounted variable air volume boxes is monitored by the DDC controller and the "Highest" temperature is selected to reset the leaving air temperature set point of the air handling unit.

As the selected temperature rises from 21° C to 24° C the discharge air temperature set point will be proportionally reset from 24° C down to 16° C.

The air handling unit discharge air temperature reset schedule is depicted in the following diagram.



The above zone temperature values and discharge air temperature set point settings can be easily adjusted to suit the particular site conditions by means of simple parameter changes in the Honeywell DDC controller software.

5.8 Override Control of Economy Cycle Dampers

Sensors are installed in the roof area of the building to monitor the following ambient conditions.

a) Ambient dry bulb temperature.
b) Ambient relative humidity.

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The sensors are connected as analogue input signals into a Honeywell DDC controller and the instantaneous ambient dry bulb temperature and relative humidity is displayed on a graphic on the operator terminal of the Building Management System.

The instantaneous ambient dry bulb temperature value is also "Globally" transferred from the local DDC controller to the controller serving the air handling unit for use in the economy cycle damper override control system.

Whenever the air handling unit has been commanded "On", the outside air dry bulb temperature is monitored at the local DDC controller.

Whenever the outside air dry bulb temperature rises above 22° C then the outside and spill air economy cycle dampers will both be driven to the minimum closed position and the return air damper to the maximum open position.

Whenever the outside air dry bulb temperature falls below 21° C then the economy cycle dampers are included in the unit discharge air temperature control strategy as the first stage of cooling.

Sensors are installed on level 15 in various locations.

~~c)~~a) Meeting Room 1 CO2 (1 Sensor).
~~d)~~b) Meeting Room 2 CO2 (1 Sensor).
~~e)~~c) Board Room CO2 (1 Sensor).
~~f)~~d) Return Air temperature CO2 (5 Sensors).

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Whenever the air handling unit has been commanded "On", the CO2 sensors are monitored at the local DDC controller.

Whenever any of the CO2 sensors rises above 800 parts per million (ppm), then the unit outside air economy cycle dampers are included in the discharge air temperature control strategy as the first stage of cooling, opening dampers to pull in fresh air.

Whenever any of the CO2 sensors values then falls below 700ppm, then the economy cycle will continue to operate with reference to outside air temperature.

5.9 Economy Cycle Damper Arrangement

Details and the control arrangements for the economy cycle dampers associated with the air handling unit are as follows.

a) The economy cycle dampers will be driven by separate 24 volt A.C. modulating spring return motors with an input signal of 2-10 Volts D.C.

b) The economy cycle damper motors will be arranged to fail to the following position on a loss of mains power or with an input signal of 2 volts D.C.

Outside Air Damper Motor	Fully Open.
Relief Air Damper Motor	Fully Open.
Return Air Damper Motor	Fully Closed.

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5.10 Supply Air Duct Variable Speed Drive Control

Whenever the air handling unit supply air fan is commanded "On" the unit supply air duct relief air damper control system is "Enabled" to operate.

A variable speed drive is installed to control the speed of the supply air. The variable speed drive accepts a 2 – 10 volt D.C. signal from the Honeywell DDC controller. With an input signal of 2 volts D.C. the motor is driven to the minimum speed and with an input of 10 volts D.C. the motor is driven to the maximum speed.

A differential pressure transmitter is located in the plant room area adjacent to the air handling unit. The "High" pressure tapping of the transmitter is located in the unit supply air duct at a location to be determined on site while the "Low" pressure tapping is referenced to the adjacent plant room area.

It is imperative that the "Low" pressure tapping of the transmitter is not unduly affected by draughts or wind.

Should the supply air duct static pressure deviate from set point, then the differential pressure transmitter and the Honeywell DDC controller will modulate the variable speed drive to maintain the required set point value.

On an increase in static pressure above set point the variable speed drive will be driven towards the minimum position while on a decrease in static pressure below set point the variable speed drive will be driven towards the maximum position.

The supply air duct variable speed drive control module will initially be set up with the following default values for normal operation of the air handling unit system.

a) Set Point 130 Pa.
b) Throttling Range 200 Pa.
c) Integral Time 100 Seconds.

5.11 Hardware Point Summary

5.11.1 Air Handling Unit System

The following table details the hardware points associated with each air handling unit system.

Tag Name	Description	Point Type	Eng Unit
-DaTemp	Discharge Air Temperature	AI	Deg
-SaStatic	Supply Air Duct Static Pressure	AI	Pa
-ClgVlv	Air Handling Unit Cooling Valve	AO	Pct
-OaDmpr	Outside Air Economy Cycle Damper	AO	Pct
-RaDmpr	Return Air Economy Cycle Damper	AO	Pct
-SaDmpr	Spill Air Economy Cycle Damper	AO	Pct
-SaVSD	Supply Air Duct Variable Speed Drive	AO	Pct
-SaFSt	Supply Air Fan Status	DI	Off / On
-AftHrsSw	After Hours Control Switch	DI	Off / On
-SaFS/S	Supply Air Fan Start / Stop	DO	Off / On

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5.11.2 Outside Air Fan

The following table details the hardware points associated with the outside air fan SF-17-10.

Tag Name	Description	Point Type	Eng Unit
-OaFSt	Outside Air Fan Status	DI	Off / On
-OaFS/S	Outside Air Fan Start / Stop	DO	Off / On

5.11.3 Relief / Smoke Exhaust Fans

The following table details the hardware points associated with the relief / smoke exhaust fans outside air fan and RSEF-17-1.

Tag Name	Description	Point Type	Eng Unit
-RSEFSt	Relief Smoke Exhaust Fan Status	DI	Off / On
-RSEFS/S	Relief Smoke Exhaust Fan Start / Stop	DO	Off / On

5.11.4 Ambient Temperature and Humidity Monitoring

The following table details the hardware points associated with the monitoring of the ambient temperature and humidity readings.

Tag Name	Description	Point Type	Eng Unit
-AmbTemp	Ambient Dry Bulb Temperature	AI	Deg
-AmbHum	Ambient Humidity	AI	RH

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6 VARIABLE AIR VOLUME BOX SCHEDULE

6.1 General Overview

The following schedule identifies and details the variable air volume boxes installed throughout levels 15.

Each variable air volume box has stages of electric heating are also incorporated in the box and are sequenced on if additional heating is required in the zone or area served by the box.

The table below also details the maximum and minimum design air flow rates for each variable air volume box as well as the stages of electric reheat fitted to each box.

6.2 Air Handling Unit AHU-15

Air handling unit AHU-15 serves the variable air volume boxes installed throughout level 15 of the building.

The variable air volume boxes served by the unit are detailed in the table below.

Box No.	Box Model No.	Max Design l/s	Minimum l/s	Reheat Stages	Reheat Capacity
VAV – 15 – 1	9P1UHWT	1200	360	3	9.0 kW
VAV – 15 – 2	1P1UBWT	300	90	1	1.0 kW
VAV – 15 – 3	1S2UCWT	270	81	1	2.0 kW
VAV – 15 – 4	1S2UCWT	200	60	1	1.25 kW
VAV – 15 – 5	1P1UBWT	150	45	1	1.0 kW
VAV – 15 – 6	1P1UBWT	150	45	1	1.0 kW
VAV – 15 – 8	6P07UDWT	630	189	2	4.5 kW
VAV – 15 – 9	6P1UEWT	800	240	2	6.0 kW
VAV – 15 – 10	6P1UEWT	800	240	2	6.0 kW
VAV – 15 – 11	1S2UCWT	180	54	1	1.25 kW
VAV – 15 – 12	1S2UCWT	180	54	1	1.25 kW
VAV – 15 – 13	6P1UEWT	800	240	2	6.0 kW

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7 TYPICAL VAV BOX WITH REHAETS

7.1 System Synopsis

This is a standard pressure independent variable air volume box with an additional three stages of electric re-heat.

The field mounted variable air volume boxes are served from a main air handling unit whose discharge air temperature is reset from a schedule based on the highest zone temperature of all of the variable air volume boxes.

The control strategy also includes separate fire override facilities for the variable air volume boxes.

The variable air volume box controller is the Honeywell Direct Digital control module device which is specifically designed to be mounted on the individual variable air volume box and to perform all local box functions.

7.2 Theory of Operation

This application uses a proportional plus integral control module to modulate the variable air volume box primary damper and a separate proportional plus integral control module to bring on up to three stages of electric re-heat from the room or zone temperature sensor.

7.3 Sequence of Operation

7.3.1 Activation of Controls for Variable Air Volume Boxes

The variable air volume box controls are interlocked with the operation of the main air handling unit as detailed below.

7.3.2 Air Handling Unit "OFF" Mode

Whenever the air handling unit serving the variable air volume boxes is in the "Off" mode the following control action will occur.

a) The variable air volume box primary damper is driven to a position that will control the air flow rate through the box to zero litres / second.

b) All stages of electric re-heat are de-energised.

7.3.3 Air Handling Unit "ON" Mode:

Whenever the air handling unit serving the variable air volume boxes is "On", and the correct status input has been received, the box controls are "Enabled" and the control system is able to operate in a fully automatic mode.

7.3.4 Variable Air Volume Box Flow Control

The primary air flow rate entering the variable air volume box is monitored by the box controller and is reset from the minimum flow rate set point to the maximum flow rate set point as the temperature in the room or zone increases above the "Cooling" temperature set point value.

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The actual air flow rate entering the variable air volume box is controlled between the minimum and maximum design set points and is displayed on the relevant air handling unit system graphic on the operator terminal of the Building Management System.

7.4 Variable Air Volume Box Zone Temperature Control

When the air handling unit serving the variable air volume boxes is commanded "On", and the correct input status has been received at the Honeywell DDC controller, the controls for the variable air volume boxes are "Enabled" to operate in full automatic mode.

The design of the temperature control loop for the Honeywell variable air volume box controller is based on the ASHRAE standard 90.1 - 1989 "Energy Efficient Design of New Buildings".

To comply with this standard the temperature control loop is arranged with separate "Heating" and "Cooling" set points and the minimum "Zero Energy Band" that can be set between the two set points is 1° K.

The "Cooling" throttling range for the operation of the variable air volume box primary damper can be set to a minimum of 1° K while the "Heating" throttling range for the operation of the secondary fan and stages of electric re-heat can be set to a minimum of 1.1° K.

If required the "Zero Energy Band" and both throttling ranges can be increased to suit the particular application and in addition Integral action can be added to the control module to eliminate any "Offset" from the desired set point temperature that may occur with Proportional only control.

In addition to the above strategies should the pick up sensor associated with the variable air volume box detect a low air flow rate then all stages of electric re-heat will be inhibited from operating.

7.4.1 Control of Variable Air Volume Box in Cooling Mode

As the zone or room temperature rises above the "Cooling" set point value the variable air volume box primary damper will be driven from the minimum air flow rate set point towards the maximum air flow rate set point by means of a proportional plus integral control module within the box controller to maintain the required temperature set point.

Should the temperature fall below the "Cooling" set point value the primary damper will be at the minimum air flow rate set point and no further control action will occur until the temperature falls to the "Heating" set point value.

7.4.2 Control of Variable Air Volume Box in Heating Mode

As the room or zone temperature falls below the "Heating" set point value the variable air volume box primary damper is at its minimum air flow rate set point position. Should the room or zone temperature continue to fall the electric re-heaters are energised in stages, in a time proportioning mode, to maintain the required set point temperature.

Should the room or zone temperature increase towards the "Heating" set point value the stages of electric re-heat are all de-energised in steps until the temperature reaches the "Heating" set point value when all stages are de-energised.

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Should the temperature continue to rise above the "Heating" set point then no further control action will occur until the temperature rises above the "Cooling" set point value.

For this particular application the following set point and control settings are programmed into the local variable air volume box controller.

Cooling Set Point.	22° C
Cooling Throttling Range	2° K
Cooling Integral Action	4000 Seconds
Heating Set Point.	21° C
Heating Throttling Range	3° K
Heating Integral Action	2400 Seconds

7.5 Variable Air Volume Box Operation in Fire Mode.

7.5.1 Fire Alarm Detected On Floor or Zone Served By the Air Handling Unit.

Should a fire alarm condition be detected on the floor(s) or zone(s) served by the air handling unit then the following control action will occur.

a) The variable air volume box controller will drive the primary air damper to a position that will control the air flow rate through the box to zero litres / second.

b) The variable air volume box stages of electric re-heat will all be de-energised.

7.5.2 "General" Fire Alarm Condition Detected.

Should a "General" building fire alarm condition be detected then the following control action will occur.

a) The variable air volume box controller will drive the primary air damper to a position that maintains the maximum design air flow rate through the box.

b) The variable air volume box stages of electric re-heat will all be de-energised.

As soon as the fire alarm input returns to normal the associated variable air volume boxes will revert to their normal operating control function for that period of the day.

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7.6 Variable Air Volume Box Operation with Air Handling Unit Mode.

The following table details the action of the variable air volume box for the various operating modes of the associated air handling unit.

A.H.U. Mode	Variable Air Volume Box Operation
Off	Primary Damper Set To Zero Air Flow Rate Position
Normal	VAV Box Controlled In Full Automatic Mode.

7.7 Hardware Point Summary

Tag Name	Description	Point Type	Eng Unit
ZnTemp	Zone Temperature	AI	Deg
PrDamp	VAV Box Primary Damper	AO	Pct
ElRht1	Stage 1 Electric Re-heat	DO	Off / On
ElRht2	Stage 2 Electric Re-heat	DO	Off / On
ElRht3	Stage 3 Electric Re-heat	DO	Off / On

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