

1809810

by David Thomas

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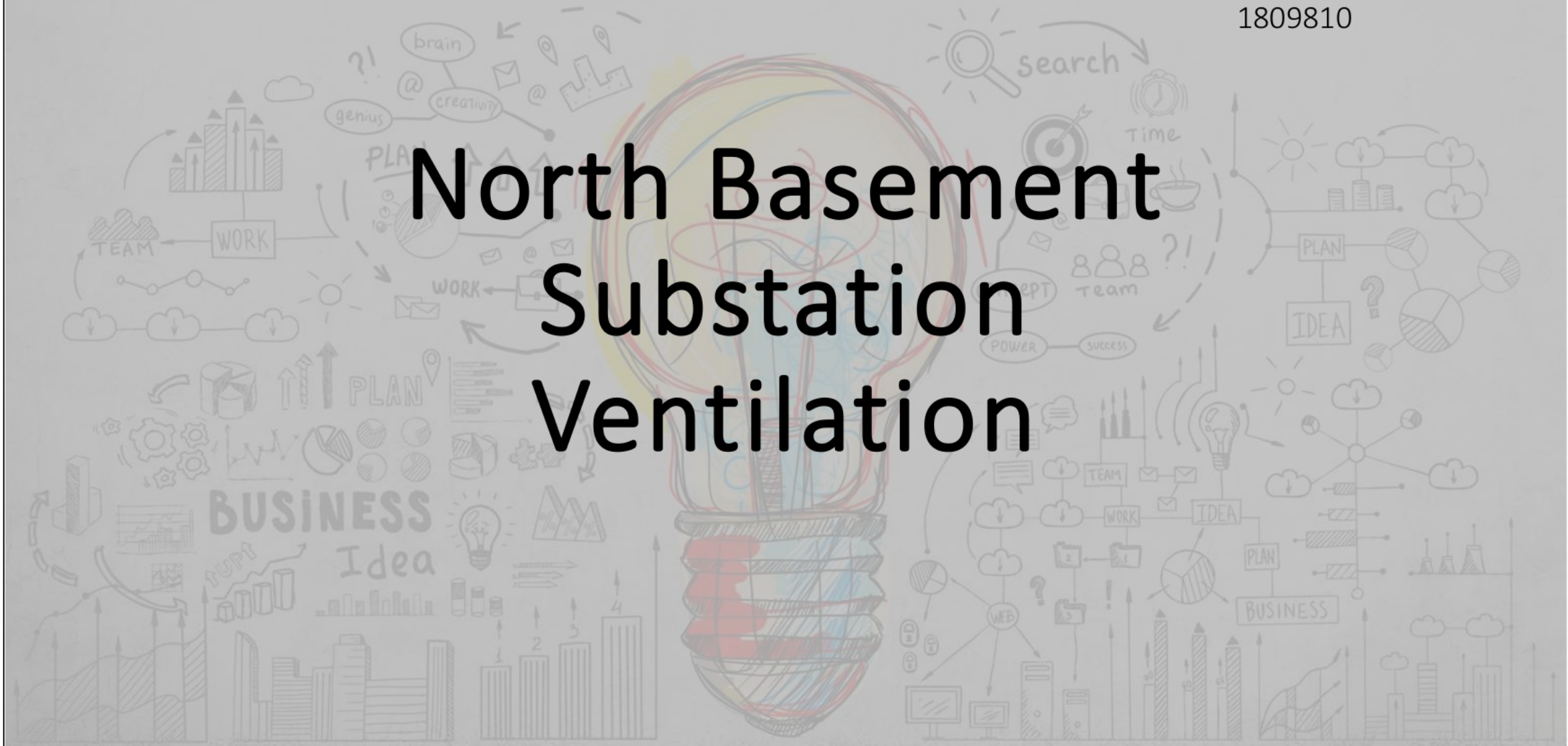
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David Mathew Thomas
1809810

North Basement Substation Ventilation



Introduction



Previous Ventilation System:

- Consists of two belt driven ventilation fans, each powered by 3-phase inductive motors.
- Both motors operate via a DOL starter and are in continuous operation, regardless of substation ambient temperature.

Introduction

Upgraded Ventilation System Objectives:

- Incorporates existing ventilation fans that are each driven by belt driven 3-phase inductive motors.
- Motors operate via VSDs with temperature setpoints to alter operation speed, dependant on substation ambient temperature.
- Air intake to be monitored for two purposes, filter replacement and broken fan drive belts.
- Reduced energy consumption and associated cost savings.



Functional Design Specification

Performance & Functionality

Ambient Temperature Set point	Ventilation Fan Output
> 20°C	High Speed
10°C to 19.9°C	Low Speed
< 10°C	Off/Idle

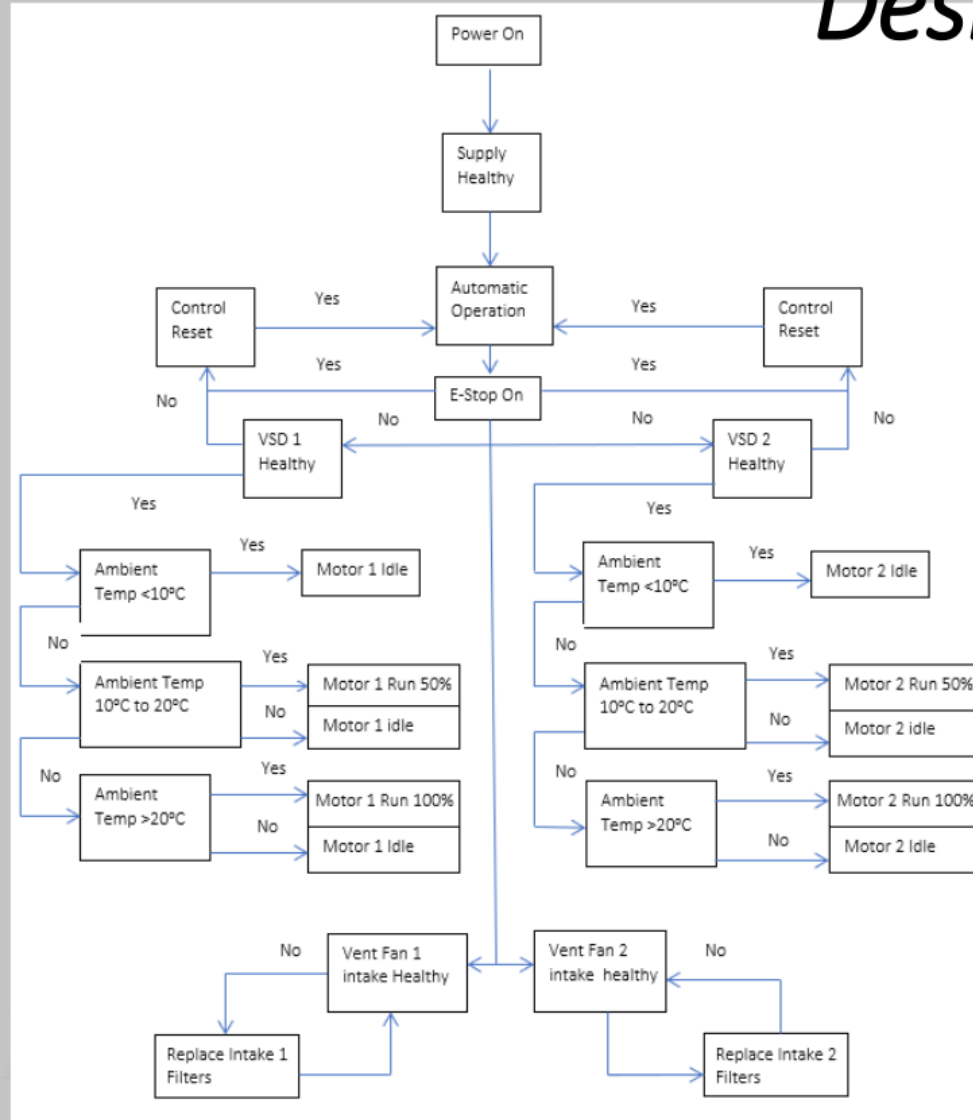
Intake Airflow Set Point	Indication
> 70%	No indication for filter replacement
< 70% intake 1	Indication for intake 1 filters to be replaced
< 70% intake 2	Indication for intake 2 filters to be replaced
0% intake 1	Indication for belt failure for motor 1
0% intake 2	Indication for belt failure for motor 2

- Make use of existing infrastructure (Motors/Fans/Ducting)
- Motors must be variable speed controlled. (1 VSD due to component availability).
- Automatic system operation according to ambient temperature set points
- Filter replacement indication for reduced air speed
- Belt replacement indication for zero air speed (Omitted due to feasibility)

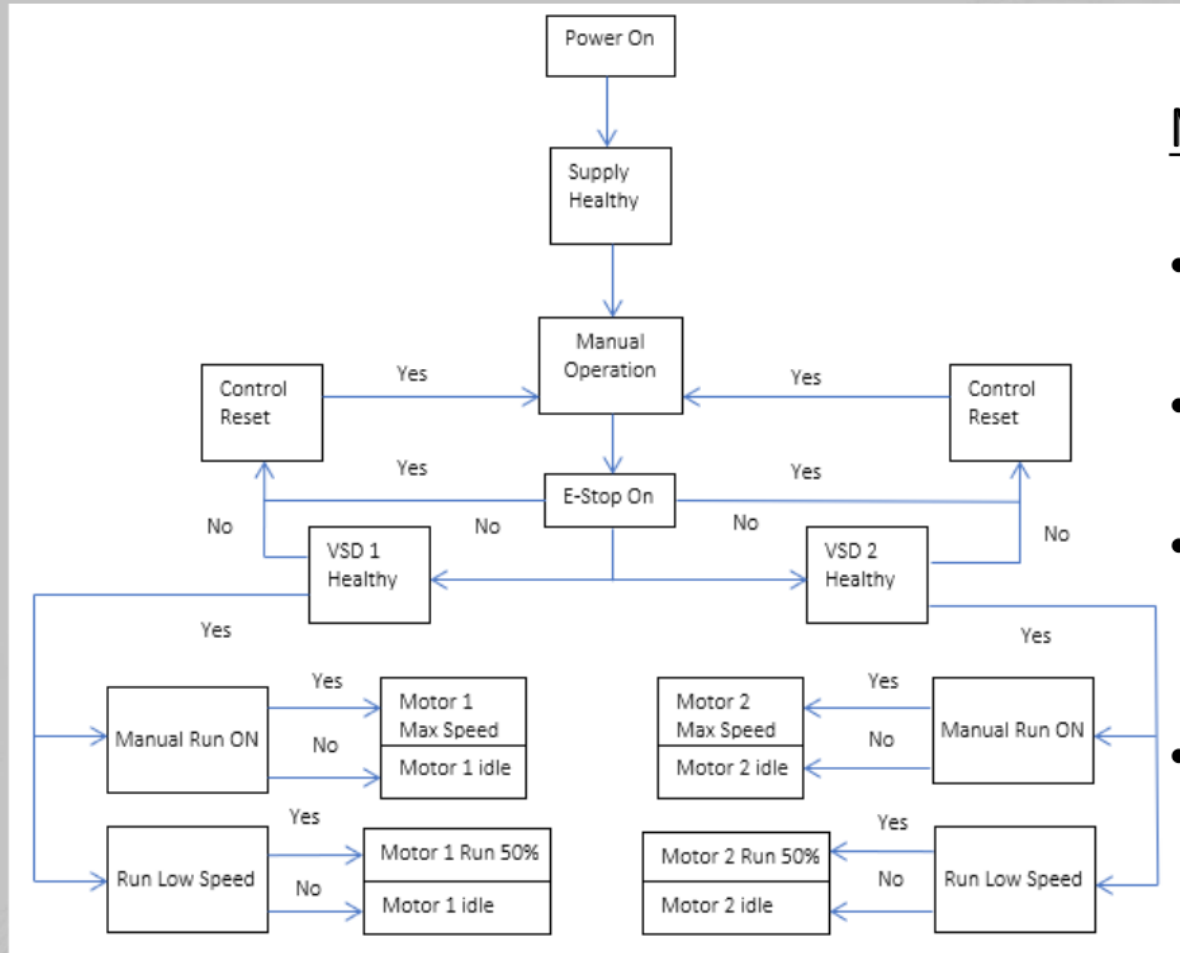
Design

Automatic Operation

- Automatically operate fans in high speed.
- Automatically change between high and low speed dependent on temperature set points.
- Fans idle if temperature setpoint $\leq 10^{\circ}\text{C}$ is reached.
- Operation only possible when VSD is healthy.



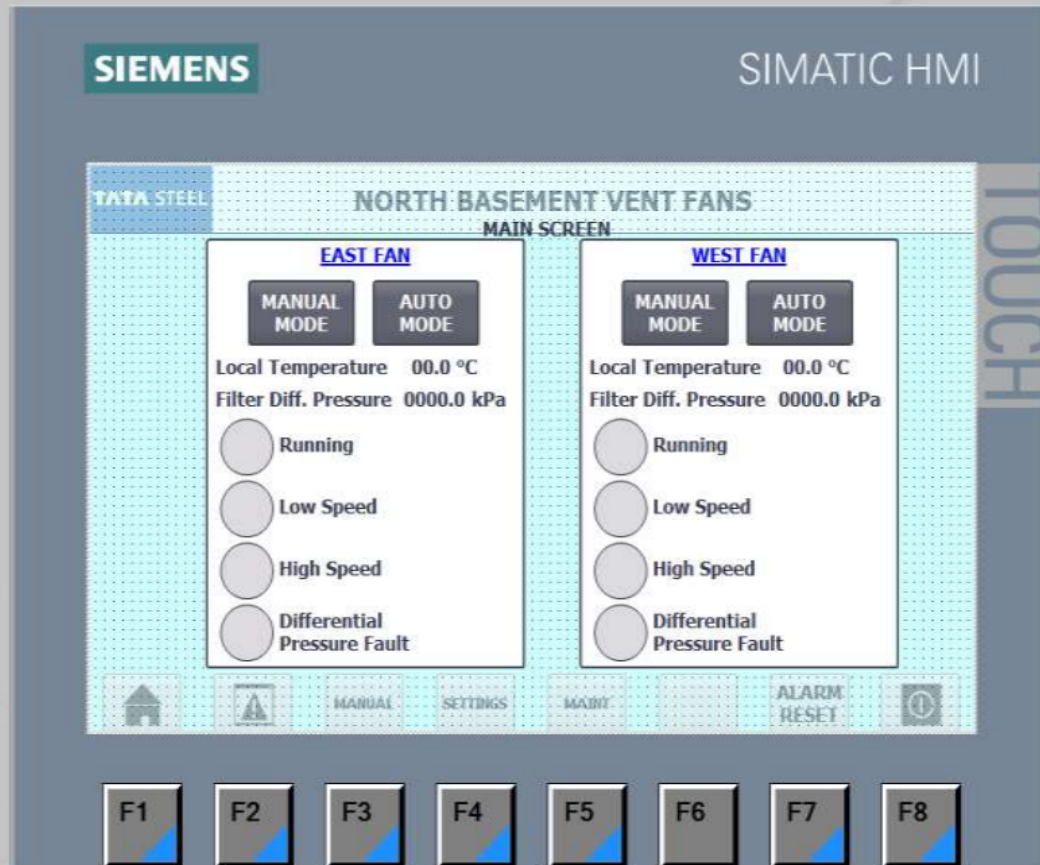
Design



Manual Operation

- Manually operate fans in highspeed
- Manually operate fans in low speed.
- Fans able to individually operate in high and low speed
- Operation only possible when VSD is healthy.

Design



- System programming written in LAD and FBD languages, using Siemens TIA Portal
- Several HMI Screens designed for operational and engineer use.
- System successfully simulated prior to downloading to PLC.

Construction

Test Plan					
Item	Description of Test	Expected Outcome	Actual Outcome	Pass/Fail	Evidence
General					
1.1	Main Isolator - Power ON	Panel Powers Up	Supply energised	Pass	Panel powers Up
1.2	Main Isolator - Power ON	Operates with a nominal supply voltage less than 1000VAC, 1500VDC.	Supply tested	Pass	Supply voltage 400VAC
1.3	Main Isolator - Power ON	Power Supply Healthy	Supply energised	Pass	Power on, indication present
1.4	Main Isolator - Power ON	Power On VSD 1	Supply energised	Pass	HMI indication for VSD Healthy
1.5	Main Isolator - Power ON	Power On VSD 2	VSD 2 is not currently in place. Delay on component delivery	Fail	N/A
1.6	Main Isolator - Power ON	Power on Logic Computer	Supply energised	Pass	Power on PLC. PLC LED indications on.
1.7	Main Isolator - Power ON	Power on Display/Indication	Supply energised	Pass	Power on HMI. Indication present.
1.8	Main Isolator - Power ON	No operation of Fans	Supply energised	Pass	No output on PLC. PLC Not programmed. Drive not programmed
1.9	Simulate Supply Failure. (Remove supply fuse)	System Shutdown. No operation of system	Supply failure. Supply lost/isolated.	Pass	Power was lost, System shutdown
1.10	Simulate Supply Failure (Operate Emergency Stop)	Indication of Emergency Stop activated. No operation of system	E-stop not programmed	Fail	N/A

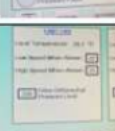
- First stage of project construction subject to Factory Acceptance Test (FAT)
- Project test plan to document FAT.
- FAT subject to Standards & Specifications.
- BSEN 61439 Low Voltage Switchgear and Control Gear Assemblies.
- BSEN 60947 Low Voltage Switch Gear and Control Gear

Construction

- Second stage of project construction subject to Site Acceptance Test (SAT)
- Project test plan to document SAT.
- SAT subject to Standards & Specifications.
- BS7671:2022 Requirements for Electrical Installations.
- BSEN 61439 Low Voltage Switchgear and Control Gear Assemblies.
- BSEN 60947 Low Voltage Switch Gear and Control Gear

Test Plan					
Item	Description of Test	Expected Outcome	Actual Outcome	Pass/Fail	Evidence
General					
1.1	Main Isolator - Power ON	Panel Powers Up	Supply energised	Pass	Panel powers Up
1.2	Main Isolator - Power ON	Operates with a nominal supply voltage less than 1000VAC, 1500VDC.	Supply tested. Supply voltage 434.9VAC	Pass	
1.3	Main Isolator - Power ON	Power Supply Healthy	Supply energised	Pass	Power on, indication present
1.4	Main Isolator - Power ON	Power On VSD 1	Supply energised Power indication for VSD Healthy	Pass	
1.5	Main Isolator - Power ON	Power On VSD 2	VSD 2 is not currently in place. Delay on component	N/A	N/A
1.6	Main Isolator - Power ON	Power on Logic Computer	Supply energised	Pass	Power on PLC. PLC LED indications on.
1.7	Main Isolator - Power ON	Power on Display/Indication	Supply energised Power on HMI. Indication present.	Pass	
1.8	Main Isolator - Power ON	No operation of Fans	Supply energised	Pass	No output on PLC. PLC Not programmed. Drive not programmed
1.9	Simulate Supply Failure. (Remove supply fuse)	System Shutdown. No operation of system	Supply failure. Supply lost/isolated.	Pass	Power was lost, System shutdown
1.10	Simulate Supply Failure (Operate Emergency Stop)	Indication of Emergency Stop activated. No operation of system	E-stop not programmed	N/A	N/A

Construction

System Operation					
2.0	System Run - Fans On	Are electric motors and associated fans operating with the correct rotation (Clockwise)	East fan (VSD 1) operated. Fan operation is correct. Fan operation is clockwise. VSD 2 not in situ.	Pass	
2.1	System Run - Fans On	Display for current operation of motors and ambient temperature	East fan (VSD 1) in operation. HMI indication shows current fan operation	Pass	
2.2	System Run - Simulate temp > 20°C	Fans operate at 100% capacity	Ambient temperature simulated to >20°C. High speed operation of vent fan	Pass	
2.3	System Run - Simulate temp > 20°C	Display for current operation of motors and ambient temperature	System operated at 100%. Indication on HMI and VSD indicate high speed operation	Pass	
2.4	System Run - Simulate temp between < 20°C	Fans operate at 50% capacity	Ambient temperature simulated to <20°C. Low speed operation of vent fan	Pass	
2.5	System Run - Simulate temp between <20°C	Display for current operation of motors and ambient temperature	System operated at 50%. Indication on HMI and VSD indicate low speed operation	Pass	
2.6	System Run - Simulate temp < 10°C	Fans stop	Ambient temperature simulated to <10°C. Zero operation of vent fan. Automatic system idle.	Pass	
2.7	System Run - Simulate temp < 10°C	Display for current operation of motors and ambient temperature	System idle. No operation of vent fan	Pass	

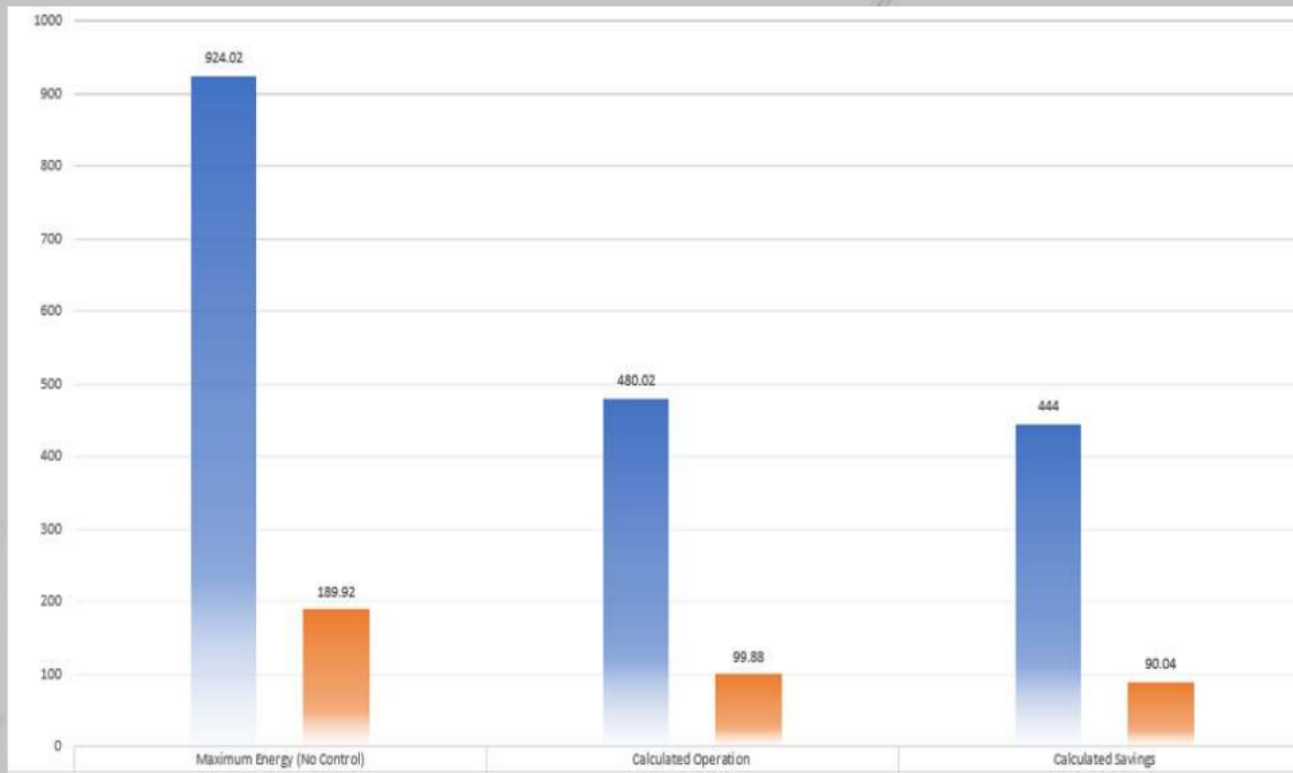
- Third stage of project construction, Programming.
- Test plan used to document. Project subject to Standards & Specifications.
- Programming issues discovered on first download to PLC (VSD reset)
- Programming issues discovered on second download to PLC (Operational & functional)
- Several standards and specifications to be adhered to.

Testing & Analysis



- System operation.
- 10 Day observation period.
- 6 days at high speed
- 4 days at low speed
- Automatically alters speed in relation to substation ambient temperature.

Testing & Analysis



- Calculated energy reduction further monitoring 94-hour period, **444.0KW**
- Calculated financial savings during further monitoring 94-hour period. **£99.88**
- Budget - **£18,750**, including contingency budget.
- Budget spent - **£16,910.00**. 90.2% of budget spent.
- Proposed project payback - 2 years.

Evaluation



Project Deviations from FDS

- Addition of transformer for programming socket. (Required as supply to panel had no neutral)
- No second VSD due to component availability.
- Unable to complete project documentation.
- Unable to fully meet company constraints with Management of Change (MoC)

Evaluation

Project Outcomes

- ≈90% complete.
- Fully functional automatic ventilation system.
- Air flow monitoring for filter indication.
- Provides energy savings
- Provides financial savings



Project Planning

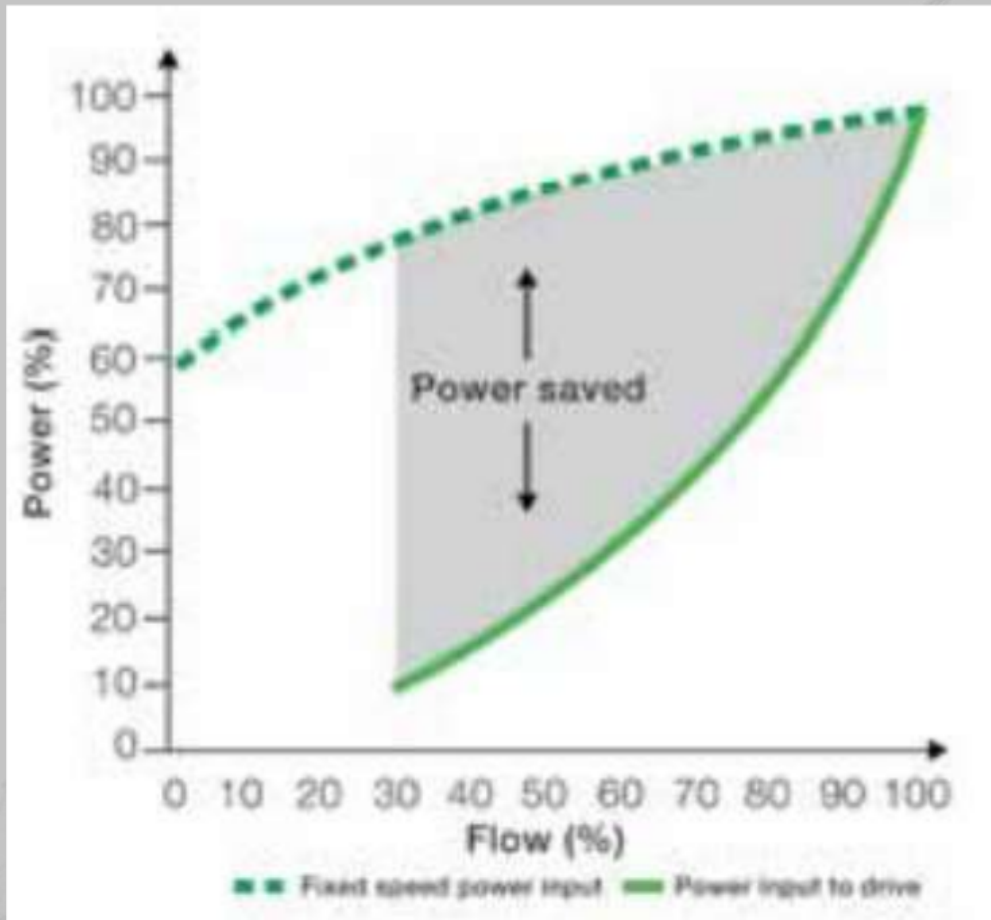
- Adaptive management technique
- Current economic climate and component availability.



Project Schedule & Comparison

North Basement Ventilation Project Gantt Chart																																																																				
Task		Duration (Weeks)	Start (Week)	End (Week)	Project Duration																																																															
					Week 1					Week 2				Week 3				Week 4				Week 5				Week 6				Week 7				Week 8				Week 9				Week 10				Week 11				Week 12				Week 13														
					M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F														
					2-Jan-2023	3-Jan-2023	4-Jan-2023	5-Jan-2023	6-Jan-2023	9-Jan-2023	10-Jan-2023	11-Jan-2023	12-Jan-2023	13-Jan-2023	16-Jan-2023	17-Jan-2023	18-Jan-2023	19-Jan-2023	20-Jan-2023	23-Jan-2023	24-Jan-2023	25-Jan-2023	26-Jan-2023	27-Jan-2023	30-Jan-2023	31-Jan-2023	1-Feb-2023	2-Feb-2023	3-Feb-2023	6-Feb-2023	7-Feb-2023	8-Feb-2023	9-Feb-2023	10-Feb-2023	13-Feb-2023	14-Feb-2023	15-Feb-2023	16-Feb-2023	17-Feb-2023	20-Feb-2023	21-Feb-2023	22-Feb-2023	23-Feb-2023	24-Feb-2023	27-Feb-2023	28-Feb-2023	1-Mar-2023	2-Mar-2023	3-Mar-2023	6-Mar-2023	7-Mar-2023	8-Mar-2023	9-Mar-2023	10-Mar-2023	13-Mar-2023	14-Mar-2023	15-Mar-2023	16-Mar-2023	17-Mar-2023	20-Mar-2023	21-Mar-2023	22-Mar-2023	23-Mar-2023	24-Mar-2023	27-Mar-2023	28-Mar-2023	29-Mar-2023	30-Mar-2023
1. Electrical		9.2																																																																		
Planned	1.1. Design	2.8	1	3																																																																
Actual		3	1	4																																																																
Planned	1.2. Implementation	4.2	3	7																																																																
Actual		3	8	10																																																																
Planned	1.3. Commission	3.4	7	9																																																																
Actual		1.4	10	12																																																																
2. Software		7.4																																																																		
Planned	2.1. Design	3.6	4	7																																																																
Actual		3.6	4	12																																																																
Planned	2.2. Implementation	3.4	7	9																																																																
Actual		1.4	10	12																																																																
3. Mechanical		4.4																																																																		
Planned	3.1. Maintenance	1.4	6	9																																																																
Actual																																																																				
Planned	3.2. Commission	3.4	7	9																																																																
Actual																																																																				
4. Testing		6																																																																		
Planned	4.1. Trials	2.4	8	10																																																																
Actual																																																																				
Planned	4.2. Test Schedule	3.6	10	13																																																																
Actual																																																																				
Planned	4.3. Post Test Operation	3	11	13																																																																
Actual																																																																				
5. Standards		12.8																																																																		
Planned	5.1. Conformity	1.8	9	10																																																																
Actual																																																																				
Planned	5.2. Operation & Maintenance Manual	12.8	1	13																																																																
Actual																																																																				

Recommendations



- Alter system operation frequency and temperature setpoints to further increase savings.
- High speed frequency reduced to 47Hz.
- High speed temperature setpoint increased to $\geq 22^{\circ}\text{C}$
- Low speed temperature setpoint increased to $\geq 15.1^{\circ}\text{C}$ to $\leq 21.9^{\circ}\text{C}$
- System idle temperature setpoint increased to $\leq 15^{\circ}\text{C}$

Recommendations



- Installation of panel vent fan to reduce heat buildup in panel.
- Installation of limit switch on fan belt guard to stop system from being operated without guard in place.
- Current monitoring to indicate broken fan belt.

Current Status



FINAL GRADE

GENERAL COMMENTS

Instructor

68/100

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GRADING FORM: NEW CSG-RUBRIC

DAVID THOMAS

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1. ENGAGEMENT WITH LITERATURE

 N/A

2. KNOWLEDGE AND UNDERSTANDING

	Project design Some evidence of design shown limited to drawings and programming but the panel was built by a subcontractor (6/10) Project implementation Good evidence given the with support of sub-contractors (7/10) Response to questions Good but there were gaps in knowledge (5/10)	18
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3. COGNITIVE AND INTELLECTUAL

	Testing and analysis of results Good testing and analysis explained (8/10) Critical evaluation of the project outcomes relating to FDS and constraints Excellent explanation given (8/10) Conclusions and recommendations Good conclusions and recommendations (7/10)	23
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4. PRACTICAL APPLICATION

	Deployment method, use of material, tools, equipment and techniques in the construction of the project.	21
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Excellent methods adopted. (7/10)

Quality of the final product or system

Excellent quality build of the panel but nothing seen of the program (7/10)

Management of the design process including use of plans, costing spreadsheet

Excellent methods employed (7/10)

5. TRANSFERABLE SKILLS



Quality of the presentation slides

Excellent quality (3/5)

Quality of the delivery style

Good style though rather nervous (3/5)

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