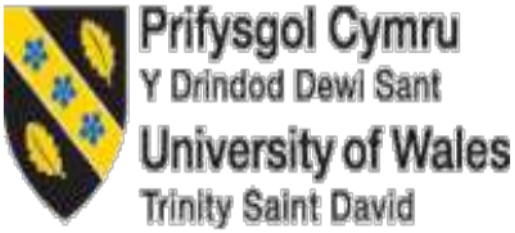
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2. Executive Summary.

Included in this report is the design and implementation of the North Basement substation ventilation fan project employing the chosen solution of the ABB ACS380-040S-17A0-4 variable speed drive, VSD. The aim of the project was to apply control to the substation ventilation system by installing two VSDs, alongside temperature and pressure sensors, enabling automatic operation with fan operation speeds dependant on substation ambient temperature, improving operational costs and efficiency, whilst future proofing a 60+ year old installation.

Although the project only reached a 90% completion rate within the timeframe, the use of meticulous project planning, design and an adaptive management technique ensured that major milestones of the project were achieved despite limitations with component availability and company demands. Although incomplete, this was not deemed to determine project failure, as in order for the project to be determined a success, the installed system must be capable of automated operation as well as a reduction in operation and energy costs. This was proven to be the case, as within the defined 5-day monitoring period, the installation of a single VSD provided savings of up to £90.94.

At various stages during the implementation, testing was conducted as per the project functional design specification and test plan. Further to the test plan, the implemented project was subject to conformity checks, confirming compliance with defined standards and specifications, essential to confirm the project is suitable, safe, and fit for purpose. Testing of the installation was met with several setbacks; however, these challenges were met with improvements and modifications before the system was successfully commissioned and tested, meeting all specified criteria.

Project management and implementation evaluation was conducted to identify planning and project improvements. The project plan was subject to several changes as a result of component and material availability, however given these restrictions and deviations, the overall planning was considered a success, delivering a functional project within the allocated timeframe. Various project improvements however were identified, several which were deemed suitable for future implementation. Whilst some required im ents were determined to be of more urgent nature, and therefore approved for immediate implementation, there were not able to be completed within the defined project timeline.

Spelling

3. Introduction.

The project noted within this report follows employment of the chosen solution, the ABB ACS380-040S-17A0-4 variable speed drive, with the aim of improving efficiency of operation and reducing associated running costs, for a ventilation system based with a substation of an industrial manufacturing plant. Following installation, the operational system will be subjected to a site acceptance test and commissioning in accordance with a test plan, to prove functionality and determine project outcome. Project implementation is to be completed within a defined timeframe and a maximum allocated budget of £18,750.00, inclusive of contingency.

The report will comprise several project stages from early system and logic design to installation, commissioning, and analysis. Post-installation testing following a defined test plan, paying particular attention to the functional design specification will be undertaken, with any deviations or failures noted.

Project and management techniques will be evaluated simultaneously, comparing execution to original design and planning, with any deviations scrutinised. Finally, the entire process will be summarised and areas for improvement highlighted.

4. Design.

Prior to designing the new control logic required for the project, information contained within the block diagram, as shown in appendix 10.1, as well as essential performance parameters contained within the functional design specification (FDS), as shown in appendix 10.2, were required to assist with design of the flow chart. The flow chart diagram for the system's automatic operation, shown in figure 1, details the process steps required for successful design and operation of the logic control. See appendix 10.3 for manual operation flow chart.

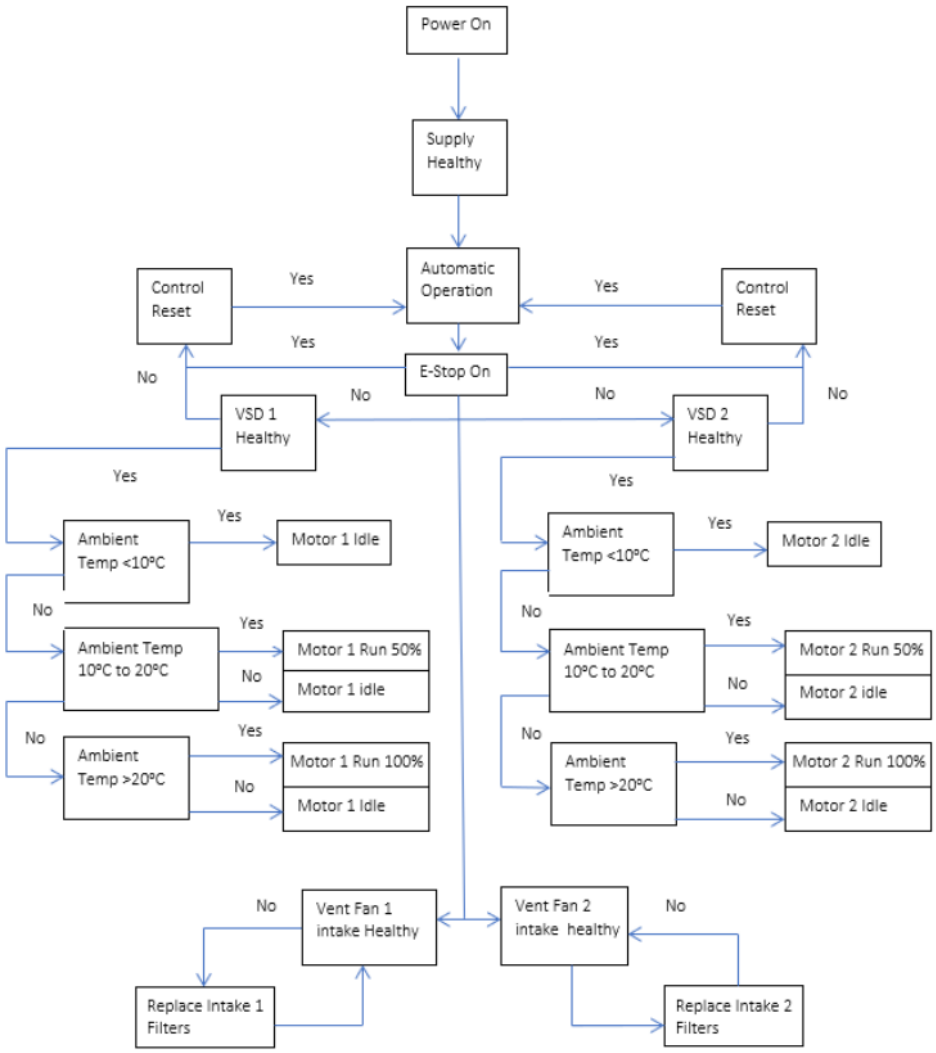


Figure 1 - Automatic Operation Logic Flow Chart

As the project required a bespoke panel to be built, which was outside expertise of company personnel, engagement with a local specialist contractor was required prior to initiating electrical design and logic phase. Upon meeting with the contractor and agreeing project requirements, quotes were received, reviewed, and subsequently approved (see appendix 10.4)

Contractor involvement was limited to the following:

- Panel build.
- Component acquisition.
- Panel and component installation.

Using the information contained within the project flow chart, FDS and block diagram, electrical drawings were designed. As the company lacked the software to convert the design into the required computerised format, the contractor was also employed for this final stage. Development of the final electrical drawings using E-Plan® ensures compliance with industry standards and practice (E-Plan, 2023), which require electrical drawings to be electronically produced. Despite requiring contractor involvement, this stage remained under the close supervision of the project manager.

For ease of design, the electrical drawings (see appendix 10.5), were divided into sections:

- 400/230VAC circuit.
- 24VDC circuit.
- Safety circuit.
- Digital circuit.
- Analogue circuit.

In addition to the Operational and Maintenance (O&M) manual, part of the overall project documentation required as part of conformance with several standards and specifications (Darley PCM Ltd, 2023), the contractor also recommended project panel design be included in the project electrical drawings. The panel schematic was produced with assistance of the contractor (see appendix 10.6).

With drawings produced and approved, programming could commence. Programming was written in Siemens' Totally Integrated Automation (TIA) Portal, as shown in figure 2 below, using a combination of Ladder Diagram (LAD) and Function Block Diagram (FBD) (Siemens , 2023). The programming, although simple in terms of system programming, required several function calls, data blocks, and tags. Function calls are code blocks without memory where each function

cannot be left blank; they must be assigned a parameter of either: In, Out, or In-Out (Zip Automations , 2023). Data blocks are code blocks with saved memory, containing variable data used by the program (Siemens AG, 2018). Tag tables contain the definitions of each addressed function within the PLC and HMI (Reinauld, 2021). Each function block, data block and tags form the foundation of the organisation block, with the organisation block interfacing between the user program and operating system (Siemens AG, 2018).

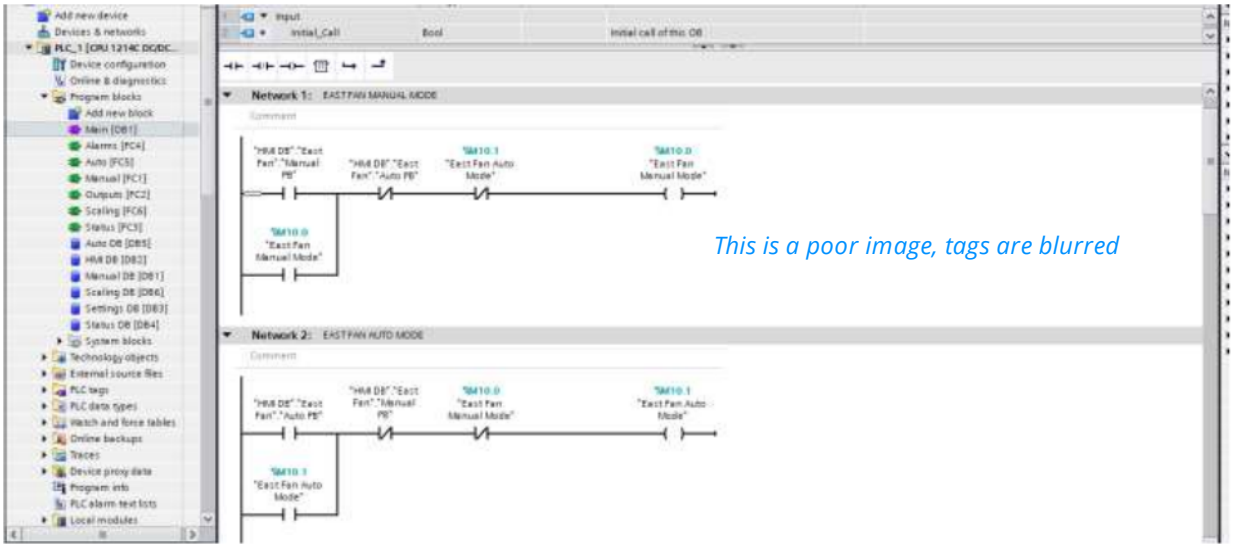


Figure 2 - TIA Portal System Programming

Project programming was created to allow for two separate operation functions: automatic mode and manual mode, preventing each function from being simultaneously in operation. Each of the operation's logic could be created using the block diagram and logic flow charts (see appendix 10.7 for PLC Logic Programming & Design).

Manual mode was designed to enable each ventilation fan to be operated independently, at either full- or reduced speed, regardless of ambient temperature. Manual operation would only be possible when the system is deemed safe to operate, requiring healthy status feedback from the system's safety circuit, comprising of each drives' safe-torque-off feature and the installation's emergency stops (EPO). Furthermore, manual operation at full or reduced speed would only be possible by the operator selecting the required operation speed.

Automatic mode was also designed for each ventilation fan to operate independently at either full or reduced speed with each fan able to operate at different speeds simultaneously. To achieve this each fan has a dedicated temperature sensor (thermostat). Data blocks containing ambient temperature feedback from each of the two installed temperature probes calculates the substations' ambient temperature. Scaling the temperature device's feedback, where the device's raw 4-20mA value is transformed to a real value provides comprehensible ambient temperature values for each temperature probe (Bee, 2022), which subsequently determines the speed of each fan independently (see appendix 10.10 for data sheet).

As with manual operation, the system will only operate automatically when the correct mode is selected by the operator. Automatic operation, regardless of ambient temperature, would only be possible when the system is safe to operate, requiring healthy status feedback from the systems' safety circuit, comprising of each drives' safe-torque-off feature and the installation's EPO.

In both automatic and manual operation modes, airflow monitoring provides indication of differential pressure for each ventilation fan. Data blocks containing differential pressure feedback from each installed differential pressure sensor calculate existing operation airflow. Scaling the feedback, where the raw 4-20mA value is transformed to a real value, provides comprehensive real time intake airflow/air pressure (Bee, 2022) (see appendix 10.10 for data sheet).

The initial FDS specified airflow monitoring was to be utilised for two functions: blocked filter indication and broken fan drive belt indication.

- High pressure: indicate blocked intake filters
- Low pressure: indicate broken fan drive belts.

However, following detailed research into the differential pressure sensors, it was identified both functions could not be achieved. With the system required to automatically operate between idle, low and high speed, fan idling would falsely indicate that fan drive belts were broken due to the subsequent low pressure. Discussions were held between the company's projects department and engineering manager regarding possible alternative solutions for fan drive belt failure indications, however due to the impending project deadline, it was agreed, that although a deviation from the FDS, pressure sensors would be used for blocked filter indication only. Agreement and implementation of an alternative solution would occur at a later date.

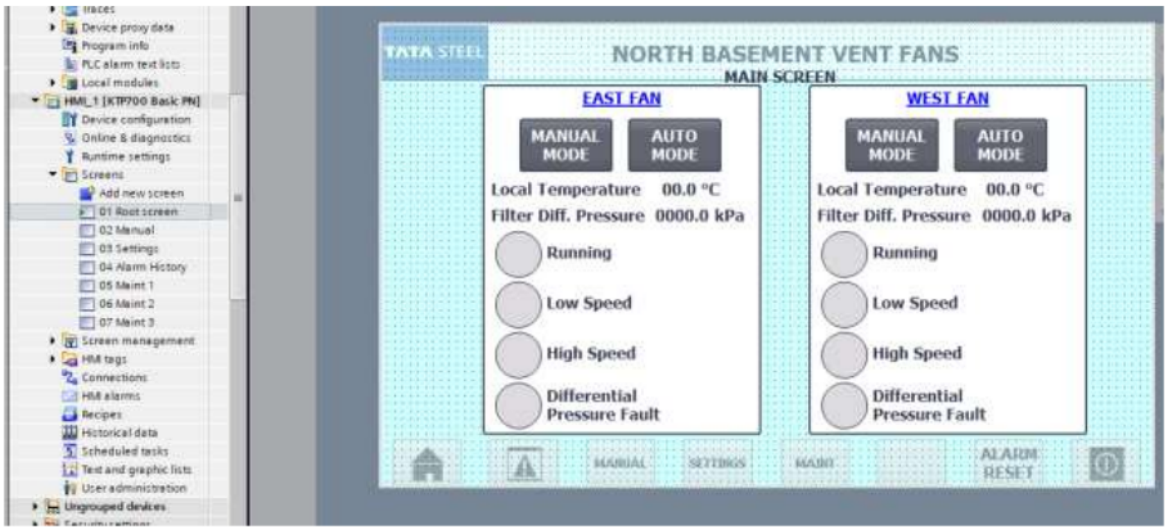


Figure 3 - TIA Portal HMI Programming

HMI screens were also designed using Siemens' TIA Portal, shown in figure 3. The HMI screens are designed to be user-friendly, whilst containing the required relevant information for both user and engineer. The system has two dedicated screens for operation, where automatic or manual mode can be selected. When in automatic mode, the screen will display fan operation speed, ambient temperature, and air intake pressure, with an additional settings screen designed to operate in conjunction with automatic mode, allowing the engineer to alter temperature and air pressure set points.

The manual HMI screen allows both user and engineer to independently operate each ventilation fan. Fans will only begin to operate in manual mode once the start button has been pressed, programmed to begin in low speed requiring the user/engineer to manually select high speed operation. When in manual mode, the screen will display fan operation speed, ambient temperature, and air intake pressure

A further four screens were developed, each designed to assist the engineer with commissioning and fault finding.

- Alarms screen: providing visual representation of past and present alarms, with an alarm reset function for active alarms.
- Three maintenance screens, indicating PLC digital inputs, digital outputs and analogue inputs: providing an indication and visual representation, assisting commissioning and fault finding. See appendix 10.8 for programming and design.

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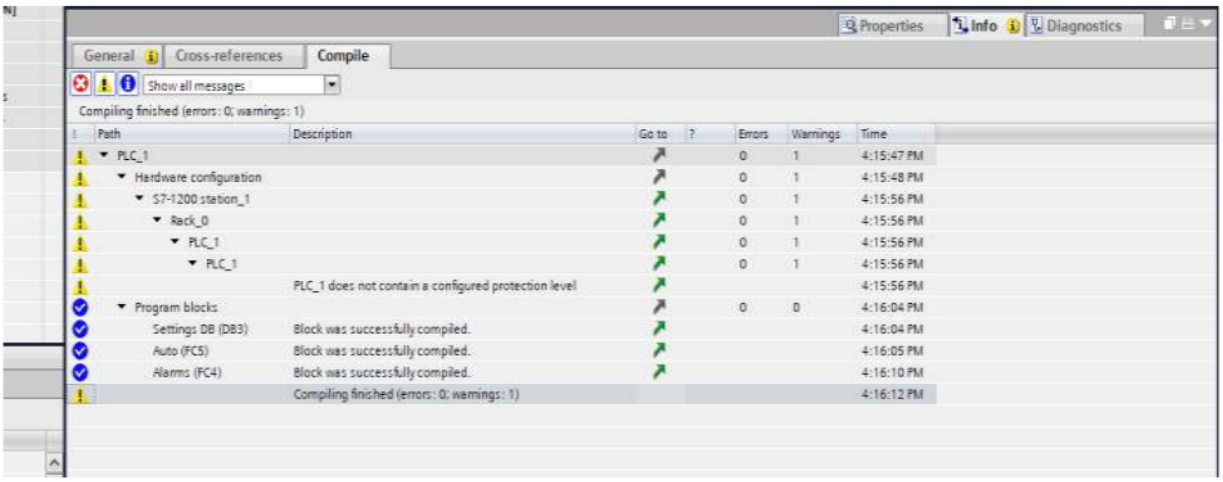


Figure 4 - TIA Portal Project Compile

Following completion of project programming the program was compiled as shown in figure 4, prior to simulation in TIA portal (see appendix 10.9 for simulation). Compiling is essential to display any faults, highlighting any programming errors (Ghareb, 2023). Although considered successful, the simulation capability was limited to demonstrating successful switching between manual and automatic operation only for both VSDs, as the TIA portal was unable to simulate external components. In this case the output was external to the PLC i.e., to simulate a run, feedback is needed from the VSD safe-torque-off and safety circuit (Pilz relay and safe-torque-offs), an external component. Failure of the simulation to send a 'Fan Run' signal for either motor at either set speed, in automatic or manual mode, proves the programming required healthy status inputs prior to function outputs being operational.

Prior to completing programming, discussions between the company and contractor were held regarding availability of the second VSD. Due to the project deadline looming, it was agreed to proceed with installation of a single VSD, installing the second VSD at a later date suitable for both parties. Once conformation of panel build was received, arrangements were made for a suitable date and time for factory acceptance testing (FAT), required to verify equipment meets the intended purpose, validating the operation and specification, and meeting of company (customer) requirements (DXP Enterprise , 2022) (see appendix 10.11 for FAT). Due to involvement of the contracting firm being limited to panel build the FAT was only for the related panel project deliverables, covering component acquisition and panel build only i.e. not programming elements (see appendix 10.12 for test plan). Opportunistic inspections and observations were conducted during the FAT to ensure the panel met standards and specifications set in the FDS. Although unable to meet all required standards and specifications at this stage (as only panel build is assessed), it was critical the following were met:

- BS7671:2022 Requirements for Electrical Installations. (IET, 2022)
- IEC60085 Electrical Insulation, (iTeh,Inc, 2013)
- BSEN 60529 Degree of Protection Provided by Enclosure, (British Standards Institution, 1992)
- BSEN 13602 Copper & Alloys for Conductors, (European Standards, 2022)
- BSEN 61439 Low Voltage Switchgear and Control Gear Assemblies, (Michael Smith Switchgear, 2022)
- BSEN 60947 Low Voltage Switch Gear and Control Gear, (BSI, 2021)

Certifying required standards and specifications are met ensures the panel is built for safety, reliability, and compliance with regulations. (NI Business Info, 2023) (see appendix 10.13 for relation of standards and specifications). With FAT deemed a success, discussions were held regarding availability for commencing implementation.

5. Implementation and Management.

5.1. Installation and Management

During the course of project design, a visual survey was undertaken on the existing ventilation installation. It was determined the installation was in a state of disrepair and overdue mechanical, electrical, and cosmetic maintenance.

Mechanical tasks:

- Clean ventilation motor intakes.
- Replace damaged drive belt for East fan.
- Inspect drive belt for West fan.
- Inspect ventilation ducting isolation shutters.

Electrical tasks:

- Replace failed lighting.
- Install additional lighting in location of new panel.
- Remove and dispose of used ventilation intake filters.
- Instal new ventilation filters.

With required maintenance tasks identified, work orders were created in the company's system analysis program development (SAP), (SAP, 2023). SAP is a database used by the company to create work orders against a specific item of plant i.e., North Basement Ventilation Fans, which can be retrieved by electrical and mechanical maintenance personnel. Following creation of the work orders (see appendix 10.14), the mechanical and electrical maintenance tasks were arranged to be completed by relevant craft personnel.

Prior to arranging a suitable date for installation works to begin, a pre-work briefing sheet (PBS), was created, and sent to the contractor in line with company contractor management and contractor safety rules. The PBS is a document created by the engineer responsible for the work which highlights and specifies hazards associated with the proposed work and location. Using the PBS, the contractor is required to create a relevant job method statement (JMS), a document created by the contractor to be reviewed by the company engineer responsible for the work prior to work commencing. In this way the JMS provides information to the working party about how work is expected to be conducted as well as any relevant precautions to be taken (Health & Safety Executive , 2023). Upon satisfactory review, an Authorisation to Work (ATW) is created, highlighting additional safety documentation/permits required to be generated

prior to any work commencing. The working party must have the ATW signed daily by the engineer responsible for the duration of the works (see appendix 10.15 for documents and communications.)

With the required documentation in place, contact was made with the contractor to confirm a start date for installation. Prior to initiating any works, the following installation requirements were discussed at the work location.

- Cable route locations.
- Component locations
- Overall installation expectations/requirements.

With both engineer and contractor in agreement, installation was ready to commence. The existing installation was isolated, and low voltage permit to work (LV-PTW), a formal written safe system of work controlling potentially hazardous activities (HSE, 2023), and limitation of access (LOA) document issued. LOA is required as the works location involved a high-voltage substation, and therefore verbal instruction is deemed insufficient for the hazards (MoD, 2007) (see appendix 10.16 for LV-PTW and LOA)

With installation underway, an early issue with the existing supply was uncovered. The existing 3-phase supply, to be reused for the new installation, did not contain a neutral supply. Although the installation does not require a neutral to operate, the programming socket in the panel does. With installation work continuing, discussions were held with the contractor and company's project department regarding the feasibility of adding a 400/230v transformer, for the purpose of supplying the programming socket (see appendix 10.16 for installation).

Agreements were made for the contractor to supply and install:

- Transformer for programming socket
- MCB and required cabling
- Alteration of computerised drawings to represent Transformer & MCB
- Alteration of panel schematic

Prior to receiving a quote for the additional work, discussions were held with the contractor regarding component availability, to which assurance was given that components would immediately be available on receipt of purchase order. Following receipt, the quote was reviewed and approved, and to avoid delays to ongoing installation, the purchase order was immediately processed. See appendix 10.17 for additional quote.

On completion of the installation, inclusive of required modifications (see appendix 10.17), arrangements were made for the site acceptance test, SAT, required to verify equipment meets project functionality and requirements, (Highland Equipment Inc, 2021). As with the FAT, the SAT will only be for contractor's project deliverables (see appendix 10.18 for test plan), however includes simultaneous conducting of standard and compliance inspections and observations to ensure the panel continues to meet the following standards and specifications:

- BS7671:2022 Requirements for Electrical Installations. (IET, 2022)
- IEC60085 Electrical Insulation, (iTeh,Inc, 2013)
- BSEN 60529 Degree of Protection Provided by Enclosure, (British Standards Institution, 1992)
- BSEN 13602 Copper & Alloys for Conductors, (European Standards, 2022)
- BSEN 61439 Low Voltage Switchgear and Control Gear Assemblies, (Michael Smith Switchgear, 2022)
- BSEN 60947 Low Voltage Switch Gear and Control Gear, (BSI, 2021)

With the SAT deemed a success, programming and commissioning could commence (see appendix 10.19 for SAT).

5.2. Commissioning and Management

With installation and SAT deemed successful, the programming was downloaded to the PLC, an essential part of the project to enable interaction of all the component parts with the panel. At this point the offline project is sent to the central processing unit, CPU. (Bee, 2022). As part of the download process the program was compiled to ensure it was fault free (Bee, 2022) (see appendix 10.20 for PLC commissioning).

Following successful download, the VSD was programmed. To ensure the VSD functions efficiently, information was taken from the motor data plate, as per table 1 below. With information obtained from the VSD firmware manual, (ABB, 2021) motor information was inputted to the VSD's motor data - motor parameter feature. Within the motor data feature of the VSD parameters, motor type and control methods are selected. Selecting the AsynM function informs the VSD whether the connected motor is induction or asynchronous, with electromagnetic induction generated in the rotor to produce the required torque. (Electrical4U, 2021). Additionally, the motor control method 'Scalar' is also selected, scalar control ensuring constant ratio of voltage to frequency of the stator across all speeds. (Levkin, 2023)

Motor Details	
Power	7.5KW
Voltage	400V
Frequency	50Hz
Current	14.6A
Efficiency	0.82Φ
RPM	1450
Phase Rotation	U,V,W
Motor Type	AsynM
Control Mode	Scalar

Table 1 - Motor Details

Motor control - motor settings was then programmed. The motor control function allows for the motor to have a set ramp time, application of which controls the time taken for the motor to reach the required speed (Variable Frequency Drives, 2023). Applying a ramp time of 3 seconds reduces mechanical stress applied to the motor, fan drive belts and associated components, prolonging life expectancy and reducing maintenance requirements.

Control Macros programming were set with assistance of the ABB firmware manual and company's project department. With information obtained from the firmware manual, parameter 28.23 DI1 is set to high speed, parameter 28.22 DI3

set to low speed, parameter 28.27 set to 50Hz (high speed frequency) and parameter 28.28 set to 30Hz (low speed frequency) (See appendix 10.21 for VSD commissioning).

Drive Parameter settings	
Drive Setting	Setting Description
P28.23 – Set to 2 DI1	High Speed
P28.22 – Set to 4 DI3	Low Speed
P28.27 – 5Hz to 50 Hz	50Hz (High Speed)
P28.28 – 15Hz to 30Hz	30 Hz (Low Speed)

Table 2 - Drive Parameter Settings

(ABB, 2021)

Finally, the VSD's energy efficiency-energy savings settings were defined. By inputting the required information previously gathered from company data, (see appendix 10.22), the VSD energy savings feature will monitor and record power consumption and operation cost savings.

With both PLC and VSD programming complete, commissioning, a vital part of the project, could commence, ensuring the system operates as designed and is fit for purpose (Better Buildings Partnership, 2023).
For the commissioning sequence, the created test plan was followed. During the general stage of commissioning, it was discovered that following activation of the EPO, upon resetting of the system the safety relay would reset but the VSD would not. This test was repeated several times to demonstrate repeatability, each time the VSD failing to reset. Following investigation using experience of both the company and contractor project engineers, it was established the Pilz safety relay was resetting fractionally quicker than the VSD. In effect, the safety relays rising edge transition from low state to high state (Dassault Systèmes, 2023) was happening marginally quicker than the VSD, resulting in the VSD failing to indicate the circuit was healthy and therefore able to reset.

With commissioning halted, discussions took place regarding overcoming the issue. It was determined modifications to the PLC programming were required. With assistance of the company's project and contractor's programming departments, alterations were made to the PLC programming with the addition of two timers, one per VSD, each set at 500ms. Each timer was added to slightly delay the Pilz safety relay healthy pulse to each VSD. It was also determined further alterations to the VSD parameter settings were required, as shown in table 3. The addition of two digital output signals from the PLC to each VSD would allow an external reset signal to reset each VSD following resolution of the fault (ABB Drives , 2021). See appendix 10.23 for modifications.

Drive Parameter settings	
Drive Setting	Setting Description
P28.23 – Set to 2 DI1	High Speed
P28.22 – Set to 4 DI3	Low Speed
P31.11 – Set to 3 DI2	Reset
P28.27 – 5Hz to 50 Hz	50Hz (High Speed)
P28.28 – 15Hz to 30Hz	30 Hz (Low Speed)

Table 3 - Updated Drive Parameter Settings

(ABB, 2021)

Following modifications, the new software was compiled and downloaded to the PLC for commissioning to continue. It was decided commissioning would re-commence from the start, as both the PLC and VSD had experienced modifications. As with the first commissioning attempt, the created test plan was followed.

During the system operation stage of commissioning, it was discovered when in automatic mode the system would fail to operate as expected. In addition, although method and location of EPOs were installed using guidance from BSEN ISO 13850 Emergency Stops, (CIC, 2010), and intended to be dedicated to East and West ventilation fans, in practice, operation of each EPO shut down the entire system.

The following faults were observed in automatic operation:

- System would operate in high speed when temperature setpoint required low speed.
- Low speed operation would only occur when both high and low temperature setpoints were above ambient temperature.
- When in automatic low speed operation, both VSD low speed PLC outputs were active.

Further discussions were held regarding the cause(s) of, and resolutions required for the additional malfunctions identified. It was determined the cause was an error within the automatic sequence of the programming resulting in incorrect system operation. On investigation to the programming, it was discovered when in low-speed automatic operation, both “Auto DB” for East and West fan high-speed operation contact was a ‘normally open’ contact. This appeared to have conflicted with the high-speed automatic operation. Both East and West low-speed automatic operation “Auto DB” contacts were changed to ‘normally closed’ contacts. It was also determined the EPOs were functioning as required, but the corresponding tags would have to be changed in the programming to represent their true operation. Further alterations were made to the PLC and HMI Tag lists. East and West E-stops were replaced for ‘Remote E-Stop 1’ and ‘Remote E-Stop 2’. Adjustments were made to HMI maintenance screen 1, where text for ‘East’

and ‘West’ E-stop were replaced with ‘Remote E-Stop’. Modifications were made to both network one and two ‘status’ function call, where each of the remote E-Stops were placed in series, ensuring that “Fan OK to Run” would only be active when all E-stops and safety circuits are healthy.

Following discussions and with assistance from the company’s projects department, further modifications were made to both fans’ organisation blocks, where a ‘First Scan’ bit was added; a useful feature to trigger logic that only needs to operate once when powered up (Liffe, 2008). The first scan feature will have the system default to start in automatic mode when the safety circuit/control reset indicates it is safe to do so (see appendix 10.24 for modifications). Following modifications, both PLC and HMI were compiled, as shown below, and the software downloaded to the PLC for commissioning and testing.



Figure 5 - PLC Complied Following Modifications



Figure 6 - HMI Complied Following Modifications

6. Testing and Results.

With all programming faults considered to have been resolved, software was downloaded to the PLC. As with previous testing/commissioning attempts, the process would start from the beginning following the created test plan, as the programming had undergone significant alterations and modifications.

Testing was conducted in stages; general for panel, infrastructure and components, and system operation for the overall performance of the installed equipment (See appendix 10.25 for test plan and test results). Whilst testing was being undertaken, conformity checks were performed simultaneously in line with FDS requirements, ensuring compliance with the with the following standards and specifications (see appendix 10.26 for system standards and specifications):

- BSEN-ISO 13850 Emergency Stops. (GT Engineering, 2015)
- BS5801:2017 Industrial Fans - Performance Testing. (BSI, 2017)
- BSEN 61800 Adjustable Speed Electrical Power Drive Systems. (IEC, 2021)
- BSEN 50598 Eco-Design for Power Drive Systems, Motor Starters, Power Electronics and their Driven Applications. (iTeh, Inc, 2015)
- BSEN 60204-1:2018 Safety of Machinery - Electrical Equipment of Machines. (Procter Brothers, 2018)
- BSEN 60034-1:2022 Rotating Electrical Machines Rating and Performance. (European Standards, 2022)
- BSEN 13849 Safety of Machinery. Safety-related parts of control systems. (BSI., 2022)

Testing of the project was considered a success. The system functioned as expected when in automatic operation:

- Ambient temperature setpoint $\geq$20°C; fan operates at full speed
- Ambient temperature setpoint <20°C; fan operates at reduced speed
- Ambient temperature setpoint ≤10°C; fan operation stops, system in idle mode.

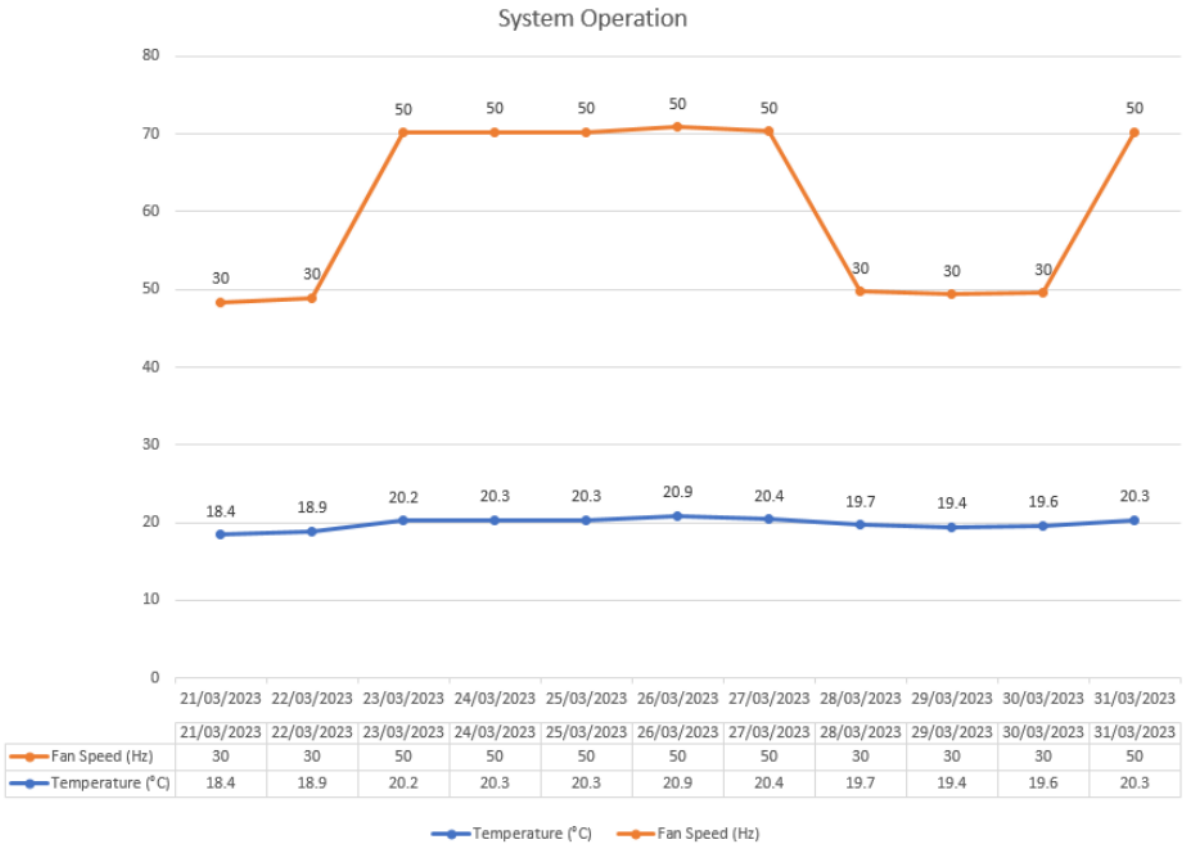
The system functioned as expected in manual operation:

- System in manual; no fan operation
- Low speed selected; fan operates at reduced speed.
- High speed selected; fan operates at full speed.

System air flow indication functioned as expected:

- Intake air pressure at nominal pressure; no filter fault indicated.
- Intake air pressure increased; blocked filter fault indicated.

All safety checks functioned as expected, each operation of the EPOs resulting in the immediate halting of operation, requiring each EPO and control to be manually reset prior to the system being able to be restarted in both automatic and manual mode. All available components functioned as expected and conformed to the project FDS. At this point, conformity checks were also conducted to ensure compliance with required standards and specifications, see appendix 10.27 for project conformities.



	21/03/2023	22/03/2023	23/03/2023	24/03/2023	25/03/2023	26/03/2023	27/03/2023	28/03/2023	29/03/2023	30/03/2023	31/03/2023
Fan Speed (Hz)	30	30	50	50	50	50	50	30	30	30	50
Temperature (°C)	18.4	18.9	20.2	20.3	20.3	20.9	20.4	19.7	19.4	19.6	20.3

Figure 7 - System Operation

After successful implementation and testing of the system alongside conformity checks, the system's operation and performance was monitored. Due to the various issues identified resulting in continuous adjustment to the schedule, post-test operation was altered to ensure sufficient data could be gathered for meaningful analysis.

Daily system checks were conducted, where ambient temperature and fan operation were documented. As shown in figure 7 above, the system operates as intended; when ambient temperature is ≥20°C, the system operates at full speed, with the supply frequency at 50Hz, when ambient temperature is reduced to <20°C, the system automatically reduces supply frequency to 30Hz, in turn reducing fan speed and energy consumption. The system automatically stopping during routine operation was not observed during system monitoring as ambient temperature did not drop to ≤10°C (see appendix 10.28 for system monitoring).

Following the monitoring period, the VSD's energy savings feature was documented, shown in appendix 10.28. During the monitoring period additional power monitoring was conducted to calculate and further verify the ability of the system to provide the savings during operation (see in appendix 10.28). A power quality analyser was installed over a 5-day period, totalling 94 hours of recorded data.

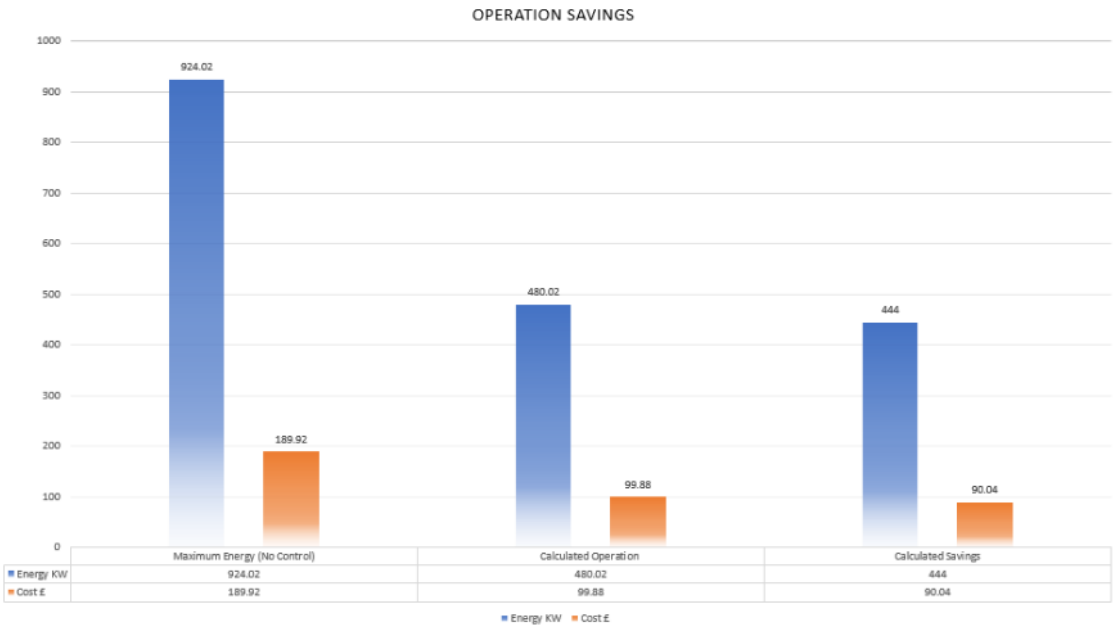


Figure 8 - Operational Savings

With system operating automatically adjusting between high and low speed as determined by the set points, up to 462kW in energy consumption has been proven to be saved (as demonstrated in figure 8), providing an energy reduction of up to 48.1%. This converts to a financial saving of up to £90.94, providing an operational cost reduction of up to 47.4% over the 5-day analytical period (see appendix 10.28 for calculations). The gathered data and calculations further verify the system successfully accomplishes the requirements of the FDS; the system providing sufficient energy reduction, an in turn monetary energy savings, achieved through automatic ventilation operation with automatic fan speed changes at the programmed set points.

Ensuing successful implementation, final alterations and updates were made to the project drawings, as shown in appendix 10.29. The production of updated drawings is essential to the project O&M manual, essential for providing a single reliable document for all matters relating to the management, maintenance, and operation of the system (Morris, 2022).

7. Evaluation of Project Outcomes.

7.1. Project Conformity

you mean partial success

On reflection of the project as a whole and review of the FDS, the project can be considered both a success and failure. The project has successfully delivered a fully functioning, fully automated (with manual option) ventilation system to the North Basement substation, however it has failed to fully meet all requirements of the FDS.

The final design deviated from the original FDS on three occasions.

- VSD number 2

Due to the current global economic climate causing component shortage and component demand, a recognised project constraint, the second VSD is still to be delivered, installed and commissioned. Once identified the VSD would not be delivered before the proposed deadline, discussions regarding the feasibility of delivering a project within the timescale able to meet the majority, and essential, FDS requirements were held between company and contractor personnel. It was agreed between all parties that this was an acceptable and achievable solution, with the second VSD installed and commissioned at a later date. Although overall operation and performance with a single motor and VSD will not provide true representation of project deliverables in terms of energy and efficiency savings, the project still delivers an installation operating as specified, and able to provide some energy savings. The majority of the FDS is therefore able to be met.

- Air pressure monitoring for zero air flow, indicating broken fan belts.

The air pressure monitoring for broken fan drive belts failed to materialise and therefore meet the requirements set in the FDS. When the project design was being conceived, it was understood the airflow sensors would be capable of detecting broken fan drive belts through low pres[illegible] indication. However, there was a failure to identify conflict with the overall system operation in relation to automatically adjustment of fan speeds in relation to ambient temperature. As designed, when <10°C the fan automatically switches off as no cooling is required, however this would result in a false indication that the fan drive belt was broken. Furthermore, as both fans distribute to the same ducting, if one fan had a failed drive belt, resulting in motor operation but no ventilation fan drive, air pressure would fail to drop and therefore fail to indicate a fault, as circulating air from the second ventilation fan would be sufficient to cause the fan to freewheel and maintain a steady air pressure. As these issues were not identified at project design phase and therefore included in the FDS, it was agreed between company personnel to intentionally deviate from the original FDS and use air pressure monitoring only to indicate high pressure fault i.e. blocked filters at this stage. Future viable options for

Spelling

broken drive belt indication however were discussed (see recommendations). Although failing to meet the original FDS, this deviation is not considered critical as it is does not affect the overall project aim to improve efficiency and provide energy savings.

- 400/230v transformer for programming socket.

Addition of a transformer for the programming socket was not envisioned during the initial design, as it was expected that the existing supply for the programming socket could be utilised. During the implementation of the project, it was realised that the installation supply was three-phase, not the required 3 phase and neutral, resulting in the programming socket not being viable. Discussions were held between company and contractor personnel to discuss solutions. Due to the location of the installation and cost implications of installing a dedicated supply for a 3pin socket, it was determined that addition of a 400/230v transformer in the panel would be the most practical solution for supplying the programming socket. This addition illustrates an oversight and failure in the project design phase, affecting the subsequent FDS and materials list, however as identified early and rectified with a simple and cost-effective solution, it has not affected the overall outcome of the project.

Materials for the project as reasonably practicable have been ethically sourced. Where possible, required project materials have been obtained from company stores and stocks, and the existing infrastructure remained untouched. Bespoke materials and non-company stock items have been a[illegible]source, nullifying the requirement for multiple orders for different components from different companies. in turn reducing transport emissions, costs and waste (Int J Environ Res Public Health, 2021). The c[illegible]ments as detailed in the FDS, with regards to product life span and life in service further attribute to the projects requirements to reduce its environmental impact.

7.2. Project Execution

Due to current economic issues and worldwide component shortage and demand, as recognised during project planning, an 'adaptive management' technique was evident throughout the project. This allowed for several adjustments to be made to project tasks' projected timescales, whilst the project budget and end date remained constant. (Indeed Editorial, 2021).

Although a Gantt chart envisioned as part of project planning, as shown in appendix 10.30, considered current global economic climate and issues with component supply chains, it failed to correctly predict when these issues would be experienced, and as expected unforeseen project issues and setbacks. The adaptive management technique however allowed for the work to be rescheduled accordingly when issues and setbacks arose without affecting the overall deadline. Project planning and the Gantt chart was constantly under review to ensure identified tasks remained feasible and project deadline met.

As a result of availability issues and various setbacks none the identified tasks required to complete the project in line with the original Gantt chart, see appendix 10.31 for actual project Gantt chart. The project suffered an early setback due to a busy company annual maintenance period and plant start-up issues, this along with subsequent other setbacks resulting in the project becoming 'back end heavy'. That said, the ability to complete several co-dependant tasks within a short timeframe ensured the project deadline was maintained.

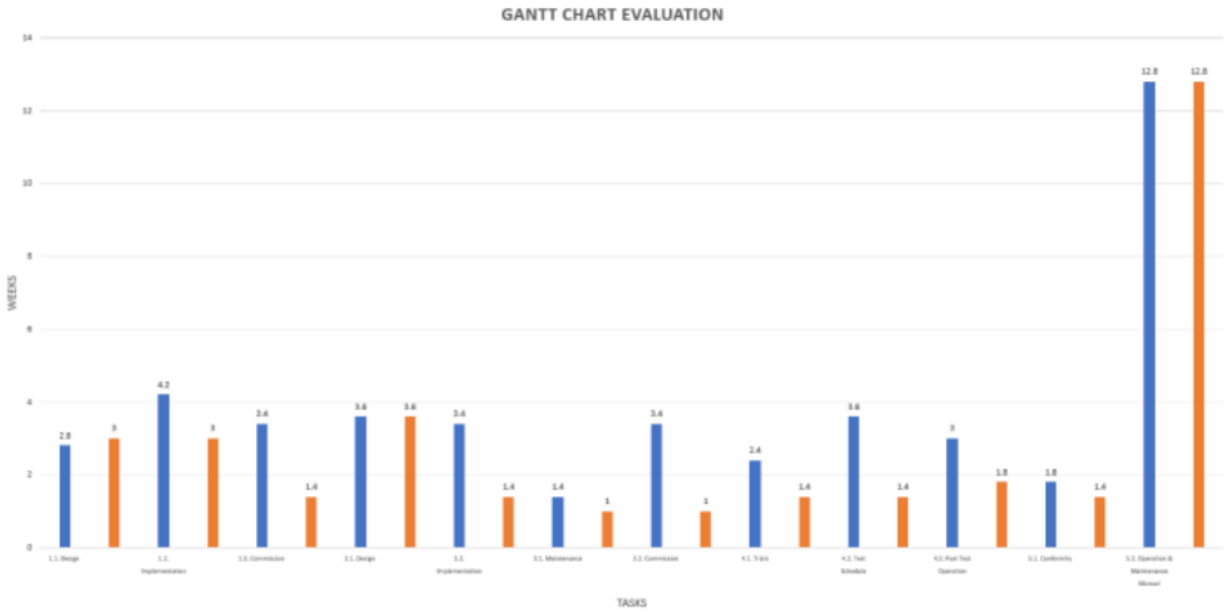


Figure 9 - Project Gant Chart Evaluation

Figure 9 shows the comparison of planned and actual time allocated to each identified task. Despite delays, as the project progressed, in most cases the actual time to carry out each task was reduced meaning time was recovered.

- Electrical.

The design stage of the electrical phase remained relatively on track. The implementation stage suffered setback due to component availability which had a subsequent impact on the commissioning.

- Software.

Software design initially suffered a setback due to plant issues and workload priority. Further setbacks were experienced following the failed first and second commissioning attempts. Initial software design, although a delay in the starting, was completed ahead of schedule.

- Mechanical.

Mechanical maintenance and commissioning were both completed ahead of project schedule, although due to craft and engineer availability, the maintenance was implemented a week later than the allotted date.

- Testing.

Testing suffered setbacks due to component availability and software issues, and as a result, the post-test operation had to be significantly reduced, limiting the amount of testing analysis data obtained.

- Standards.

Conformity checks were delayed due to earlier setbacks with commissioning, software issues and testing. Whilst the O&M manual began at the planned stage, it is yet to be completed due to component availability meaning the full project not being completed.

7.3. Project Management

When initial project budgets were conceived, considerations were given to the current economic climate and ever-increasing rise in inflation, resulting in the current cost of living crisis (Hourston, 2022). Due to these considerations a 25% contingency was included to allow a maximum budget of £18,750.00.

As illustrated in figure 10, initial costings projected project completion for less than £15,000.00, 21% under budget, however in actuality, the spend came in at a total cost of £16,910.00, 11.22% above projections. The increase in spend can be attributed to two factors. Firstly, initial costings were conducted in late 2022, whereas purchase orders and component acquisition were carried out in early 2023. Accurate predication of price rises was not possible when projected spend was calculated. Secondly, the planning oversight that required additional components to be installed resulted in unforeseen further costs (see appendix 10.32 for project costings).

Despite total spend being greater than anticipated, the project remained 9.81% under budget. As result of comprehensive financial planning, and allowance for contingencies in volatile financial uncertainties, project management can be deemed a success.

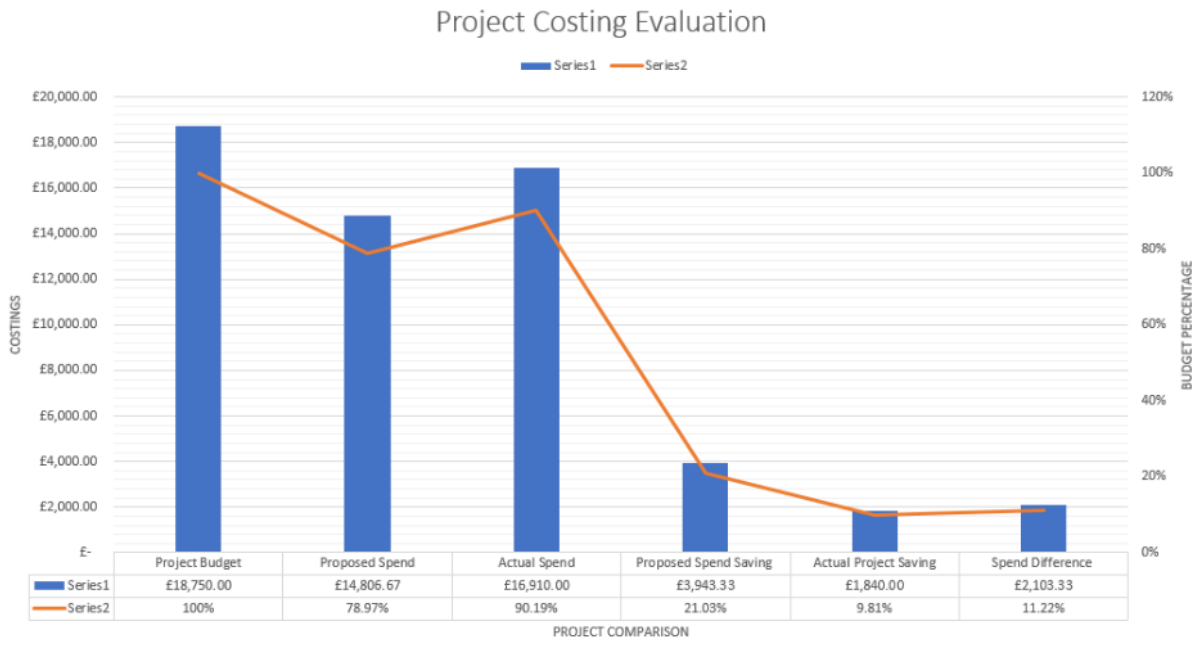


Figure 10 - Project Costing Evaluation

8. Conclusions and Recommendations.

The delivered project, although failing to fully meet the full criteria set by the FDS was considered a success. Whilst currently incomplete due to the delay with the second VSD, the project has delivered a fully functioning automated ventilation system implemented to company and industry standards. Furthermore, success of the project ultimately relied on addressing the operational needs of reducing energy consumption and providing cost savings, a key factor in the company's drive to be carbon neutral by 2048. The new system, although currently incomplete, has proven to have met both requirements, with significant energy reduction and associated cost savings evident.

Delivery of the project was met with several issues that greatly affected the project plan, a number of which have identified planning improvements. With the project timeline set for the academic year, there was no scope for slippage beyond the set deadline. Although the planning technique applied allowed for tasks to deviate from the planned schedule, as discussed the project became very back-end heavy requiring completion of several tasks in a limited time to remain on track. For future projects, more comprehensive research into likely component availability and delivery timelines will be applied to planning and scheduling, ensuring future project timelines are adequately applied.

Compulsory and priority recommendations for the project are to install the second VSD, timeframe for this dependent on availability. Once delivered and installed, although no impact on the already commissioned VSD is anticipated, the system will be fully re-commissioned to ensure it complies with the original test plan and conformity checks when operating as a complete system. Upon completion of the final commissioning and conformity checks, the O&M manual can be finalised, and the company's management of change process completed.

During the course of the project, several design improvements have been identified. Due to allocated slippage time being consumed by implementation delay issues, identified improvements were not able to be designed and implemented within the project timeframe.

- Fan drive belt limit switches.

Although fan drive belt guarding complies with ISO 14120:2015 (general requirements for the design, construction, and selection of guards provided to protect persons from mechanical hazards) (ISO, 2015), being mechanically protected and requiring tools to undo for removal, the system is still able to operate without the guarding in place. During mechanical maintenance activities, it was identified that applying limit switches, as shown in appendix 10.33, to both

fan drive belt guards would prevent operation without the guarding in place, providing improved safety features and improved compliance with company safety procedures.

- Current monitoring for broken drive belts.

With air pressure sensors not being suitable to detect broken fan drive belts, an alternative solution is utilising motor current motoring to detect fan belt failure. When the system is in operation, as shown in appendix 10.33, the three speed settings have recorded current values of 15.09A at high speed, 8.13A at low speed and 0.00A when idle. Although continuing to operate with broken fan drive belts, the motors would not experience torque at any speed setting, resulting in decreased current values. Applying current monitoring for setpoint values of ≥1.00A and ≤5.00A, can therefore be used to indicate broken fan drive belts. A delay timer of ≥10s would also be required to prevent false indication of failure, as with the system automatically idling when <10˚C, the motor current will gradually pass through the recommended current value threshold indicating a failed fan drive belt. Setting a timer to delay the signal will therefore prevent false indication. Furthermore, current monitoring can also be implemented to the system's safety circuit, ensuring operation ceases if broken fan drive belts are detected.

- Panel vent fan.

An oversight during component acquisition and electrical design was to not account for a panel vent fan. With the panels IP rating, heat generated by the VSD does not dissipate from the panel, an issue that will only worsen when the second VSD is installed and commissioned. By installing a ventilation fan and air intake to either side of the panel, cool air can be drawn in whilst hot air is expelled (see appendix 10.33). The heat build-up in the panel was not identified until post-test operation was underway, at which point there was insufficient time in the schedule to correct.

- Alter system setpoints and frequencies.

Further study into Cube Law has identified possible further energy and cost savings; applying a modest reduction in motor speed can result in significant energy savings (Quantum Controls, 2023). As expressed in the image below, although an over-exaggeration of potential savings using Cube law as installation losses, performance and efficiency are not accounted for, further savings can be made by reducing the system's high speed setting operation frequency from 50Hz to 47Hz. As shown in table 4, savings could be achieved with minimal effect on ventilation performance.

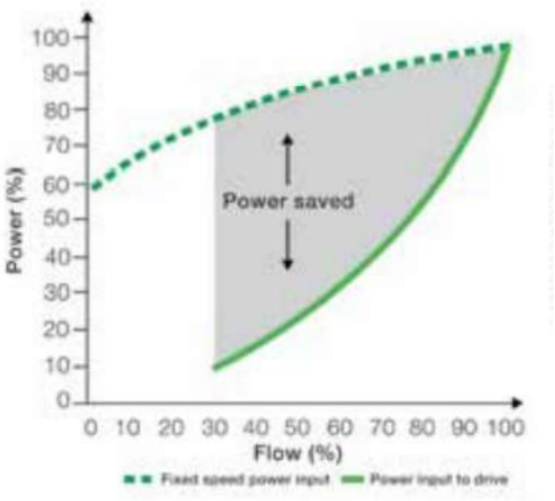


Figure 11 - Potential Savings from VSD

(Efficient Power Solutions, 2017)

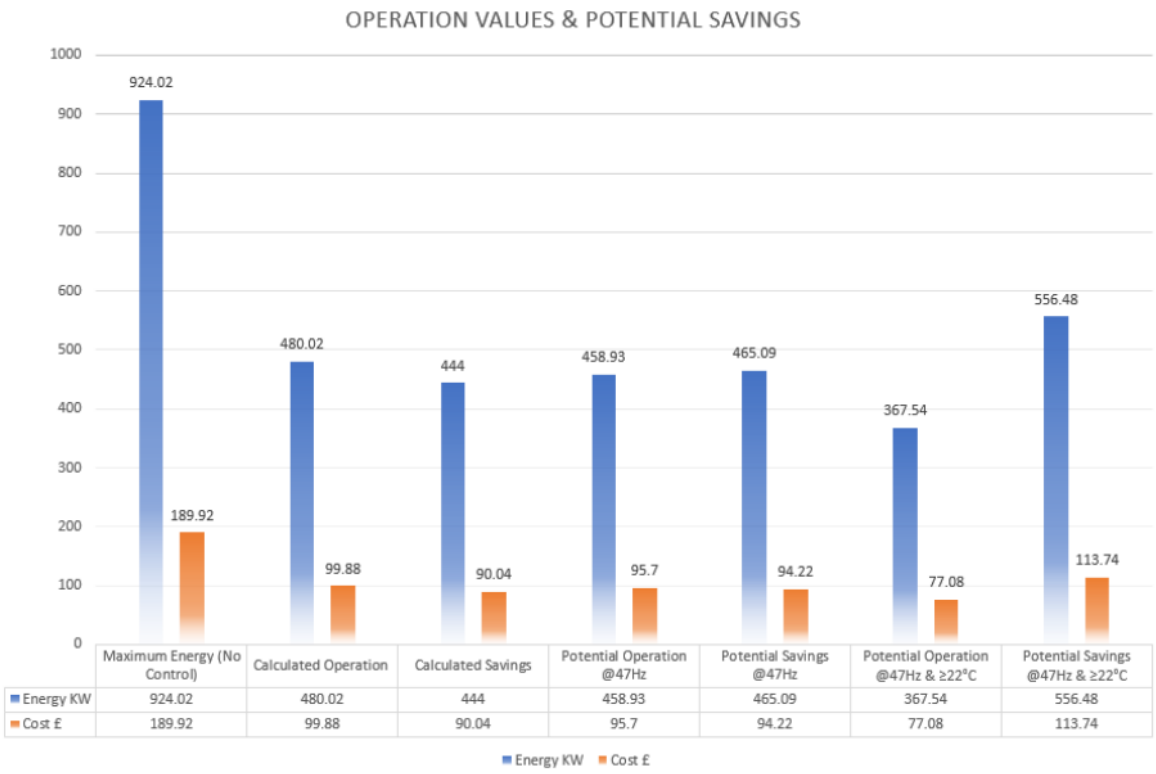
Further savings could be realised by altering operation ambient temperature setpoints from the current settings to those proposed in the table below. Increasing setpoints in relation to ventilation fan speed and proposed frequency, will further reduce energy consumption, providing additional financial savings, whilst having little to no impact on overall performance.

Ventilation Fan Output	Current Ambient Temperature Set point	Current System Frequency	Proposed Ambient Temperature Set point	Proposed System Frequency
High Speed	≥ 20°C	50Hz	≥ 22°C	47Hz
Low Speed	10.1°C to 19.9°C	30Hz	15.1°C to 21.9°C	30Hz
Idle	≤ 10°C	0Hz	≤ 15°C	0Hz

Table 4 - Recommendations New System Setpoints

Illustrated in figure 12 and using operation calculations shown in appendix 10.33, adjustment of high speed motor frequency to 47Hz for the duration of system monitoring would have generated energy savings of up to 465.09KW, providing an energy consumption reduction of up to 50.3%, a further 2.3% than seen during the 5 days of independent monitoring. The equates to financial savings of up to £94.22, and operational cost reduction of up to 49.6%, a further financial saving of 3% on top of that already realised. Had the high speed setpoint been increased to ≥22°C during the monitoring period, energy savings of up to 556.48KW equating to an overall energy consumption reduction of up to 60.2% would have been seen, improving energy consumption reduction by an overall total of 25.3%. In combination

with frequency changes, this relates to overall financial savings of up to £113.74, and a total operational cost reduction of up to 59.2%, a potential financial saving of 25.3%.



	Maximum Energy (No Control)	Calculated Operation	Calculated Savings	Potential Operation @47Hz	Potential Savings @47Hz	Potential Operation @47Hz & ≥22°C	Potential Savings @47Hz & ≥22°C
Energy KW	924.02	480.02	444	458.93	465.09	367.54	556.48
Cost £	189.92	99.88	90.04	95.7	94.22	77.08	113.74

Figure 12 - Operation Values and Potential Savings

With successful planning and project management, the project was able to overcome the challenges and delays encountered. The project remained within the allocated budget and delivered a functioning energy efficient automated ventilation system, which was proven to be a company and environmental success.

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10. Appendix.

10.1. Project Block Diagram

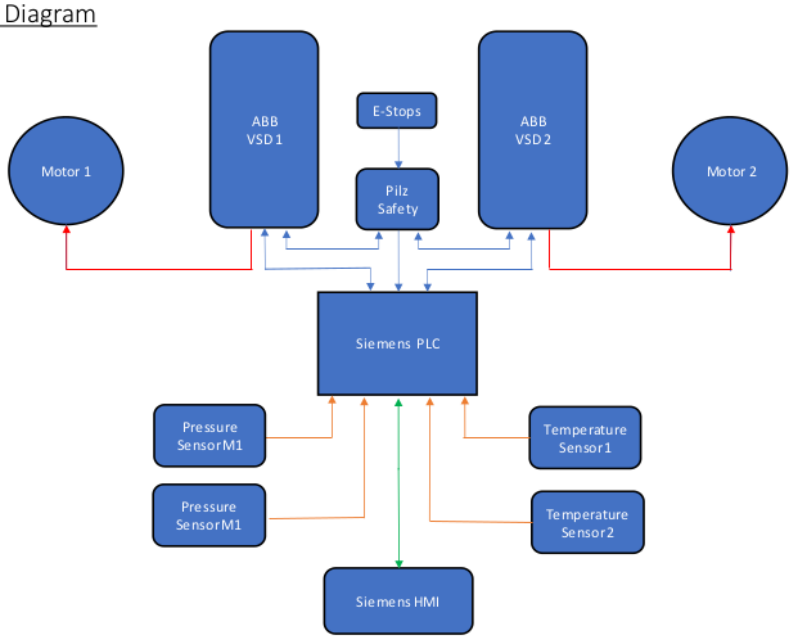


Figure 13 - Project Block Diagram

(Thomas, 2023)

Signal	To	From	Description
400VAC	Motor 1	VSD 1	Power from VSD to operate motor 1
400VAC	Motor 2	VSD 2	Power from VSD to operate motor 2
Profinet	HMI	PLC	Communications between HMI and PLC
Profinet	PLC	HMI	Communications between PLC and HMI
RTD	PLC	Temperature Sensor 1	Substation ambient temperature for Motor 1 operation
RTD	PLC	Temperature Sensor 2	Substation ambient temperature for Motor 2 operation
Analogue	PLC	Pressure Sensor 1	Airflow pressure for Motor 1 air intake
Analogue	PLC	Pressure Sensor 2	Airflow pressure for Motor 2 air intake
Digital	PLC	VSD 1	Signal from PLC to indicate required operation speed for motor 1
Digital	PLC	VSD 2	Signal from PLC to indicate required operation speed for motor 2
Digital	VSD 1	PLC	VSD 1 Healthy Indication from VSD to PLC
Digital	VSD 2	PLC	VSD 2 Healthy Indication from VSD to PLC
Digital	E-Stop	Pilz Relay	Indication of Healthy E-Stop Circuit or E-Stop Operation to Pilz Relay
Digital	Pilz Relay	PLC	Indication of Healthy E-Stop Circuit or E-Stop Operation to PLC
Digital	Pilz Relay	VSD 1	Indication of Healthy E-Stop Circuit or E-Stop Operation to VSD
Digital	Pilz Relay	VSD 2	Indication of Healthy E-Stop Circuit or E-Stop Operation to VSD
Digital	VSD 1	Pilz Relay	STO healthy indication to Pilz Relay
Digital	VSD 2	Pilz Relay	STO healthy indication to Pilz Relay

Table 5 - Block Diagram Signal Designation

(Thomas, 2023)

10.2. Functional Design Specification

1. Ambient temperature of substation to be monitored. Fan speeds to automatically change in response to ambient temperature set point, as per table below

Ambient Temperature Set point	Ventilation Fan Output
≥ 20°C	100%
10.1°C to 19.9°C	50%
≤ 10°C	0%

Table 6 - Ventilation Control Temperature Set Points

(Thomas, 2023)

2. Intake airflow to be monitored for reduction in intake air velocity and zero air intake velocity. Indication to be present when intake speed has been reduced, as per table below.

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

Table 7 - Ventilation Intake Airflow Set Point

(Thomas, 2023)

3. System must start, stop, and reset through use of local control via HMI, or push buttons.
4. System must stop via use of local physical emergency stop button.
5. Ventilation system must be automatically operated and loaded according to ambient temperature.
6. System to have indication for intake filter replacement when intake air speed is reduced.
7. System is to have a physical local isolator, lockable by use of padlock or multi-lock hasp.
8. Indication must be present through use of HMI. Indication must include:
    - Power supply health and failure.
    - Motor running.
    - Fan/Motor operating speed set points.
    - Current fan operation/loading (2 fan system).
    - Low suction pressure, indicating ventilation filters are blocked.
    - Zero suction pressure, indicating motor belt failure.
    - Current ambient temperature.

10.3. Manual Operation Flow Chart

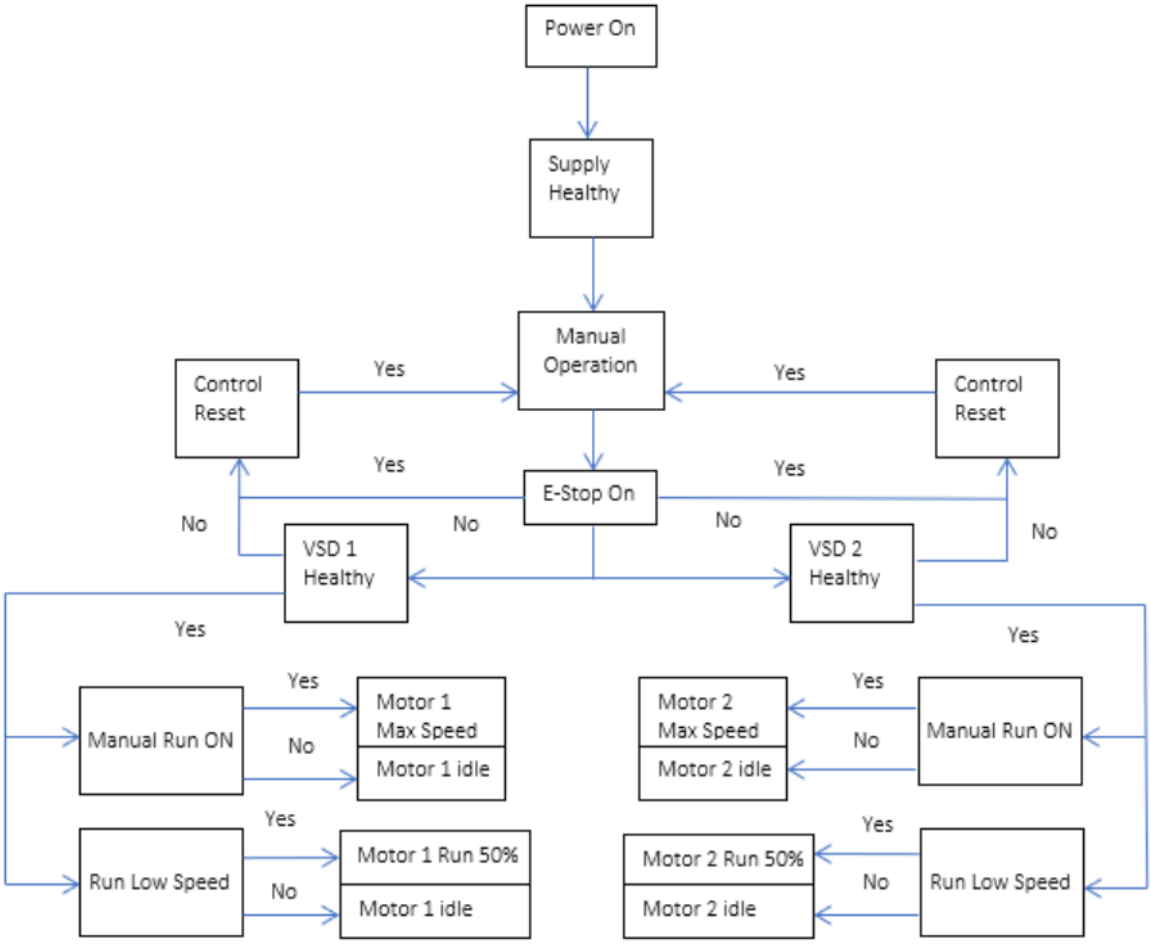


Figure 14 - Manual Operation Flow Chart

10.4. Contractor Communications & Quotes

Hello Mathew

Not a problem.
We'll be on site for 11:00.
See you then.

Regards



RW Evans

Electechs Ltd
Tel: 01792775055
Fax: 01792 700035

Mobile: 07870619909
wayne@electechs.co.uk

From: Thomas, Mathew <Mathew.Thomas@tatasteeleurope.com>
Sent: 05 January 2023 07:24
To: Wayne Evans <Wayne@electechs.co.uk>
Subject: North Basement Vent Fans

Morning Wayne.

Regarding our recent conversation for the North Basement ventilation project.

Graham has a meeting first thing Monday morning.

Would you be able to make it to site for 11:00?

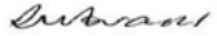
Mathew Thomas
HV Engineering Services

Figure 15 - Initial Contractor Correspondence

Hello Mathew

Thank you for that.
Not an issue, we welcome the challenge.
Will have the quotes to you by the end of the week

Regards



RW Evans

Electechs Ltd
Tel: 01792775055
Fax: 01792 700035
Mobile: 07870619909
wayne@electechs.co.uk

From: Thomas, Mathew <Mathew.Thomas@tatasteeleurope.com>
Sent: 05 January 2023 16:02
To: Wayne Evans <Wayne@electechs.co.uk>
Subject: North Basement Vent Fans

Hi Wayne.

Thanks for taking the time to see us today.
We appreciate that the timetable on this project is tighter than usual.

As discussed, we'd like a couple of quotes.

1. Material acquisition and panel build.
2. Panel, component, and cable install

1	VSD	2
2	Siemens S7 PLC - 1214C	1
3	Siemens KTP700 HMI	1
4	Siemens Ethernet Switch	1
5	Siemens 4x Analogue Input RTD	1
6	24VDC Power Supply	1
7	Pilz Safety Relay	1
8	Temperature Sensor	2
9	Pressure Sensors	2
10	Cabinet - 1200x1200x400	1
11	63A Switch Fuse with Shaft	1
12	32A 15KW Manual Starter	2
13	E Stop	3
14	Cables, Containment & Miscellaneous	1

Above is the list of materials we believe that is required for the project, based on the FDS.
Any problems or confusion, please let me know.
Any recommendations or things you'd change or add, please let me know.

Mathew Thomas

Figure 16 - Contractor Correspondence

To: Tata Steel Trostre

For the Attention of: Mr Mathew Thomas

From: Wayne Evans

Pages including this: 1

electechs Limited

Electrical, Control and Automation Engineers
Panel Manufacturers
Installation Contractors

Date: 12th January 2023

Quote ref. Q4067/WE

Subject: North Basement Vent Materials & Panel

Dear Mathew,

Thank you, for the enquiry regarding the above. I have pleasure in submitting the following quotation based on our site meeting dated Monday 9th January 2023.

Scope:

Supply 2 x 7.5kW ABB Vsd's / Keypad c/w Schneider circuit breakers
Supply a mild steel enclosure measuring approx. 1200H x 1200W x 400D fitted with:
Door interlocked fused isolator c/w shaft & handle.
24VDC Power Supply.
Siemens S7 Plc CPU1214C.
Siemens I/O Link card.
Siemens KTP700 HMI.
Siemens Ethernet switch.
Pilz safety relay.
Panel vent fans.
E Stop & Illuminated reset button.
Supply & install 2 off Pressure Sensors
Cable, trunking, terminals etc.

Total Cost ex VAT £ 9365.00

We trust we have interpreted your requirements correctly and hope to be favoured with your valued order, should you have any questions relating to this quotation, please feel free to contact the undersigned.

All prices subject to VAT

This quotation is valid for 30 days.

Yours faithfully

Figure 17 - Contractor Quote Vent Materials & Panel

To: Tata Steel Trostre

For the Attention of: Mr Mathew Thomas

From: Wayne Evans

Pages including this: 1

electechs Limited

Electrical, Control and Automation Engineers
Panel Manufacturers
Installation Contractors

Date: 12th January 2023

Quote ref. Q4068/WE

Subject: North Basement Vent Panel Install

Dear Mathew,

Thank you, for the enquiry regarding the above. I have pleasure in submitting the following quotation based on our site meeting dated Monday 9th January 2023.

Scope:

Supply & install control panel onto wall as discussed.
Disconnect existing 3 phase supply to the two fan DOL starters.
Pull back slack and gland off into new panel (parallel feed).
Supply & install 100mm tray from the new panel location to the motor area.
Supply & install two local isolators near the motors.
Install pressure and temperature sensors, associated cables and containment

Total Cost ex VAT £ 7150.00

We trust we have interpreted your requirements correctly and hope to be favoured with your valued order, should you have any questions relating to this quotation, please feel free to contact the undersigned.

All prices subject to VAT

This quotation is valid for 30 days.

Yours faithfully

Figure 18 - Contractor Quote Vent Panel Install

10.5. Electrical Drawings

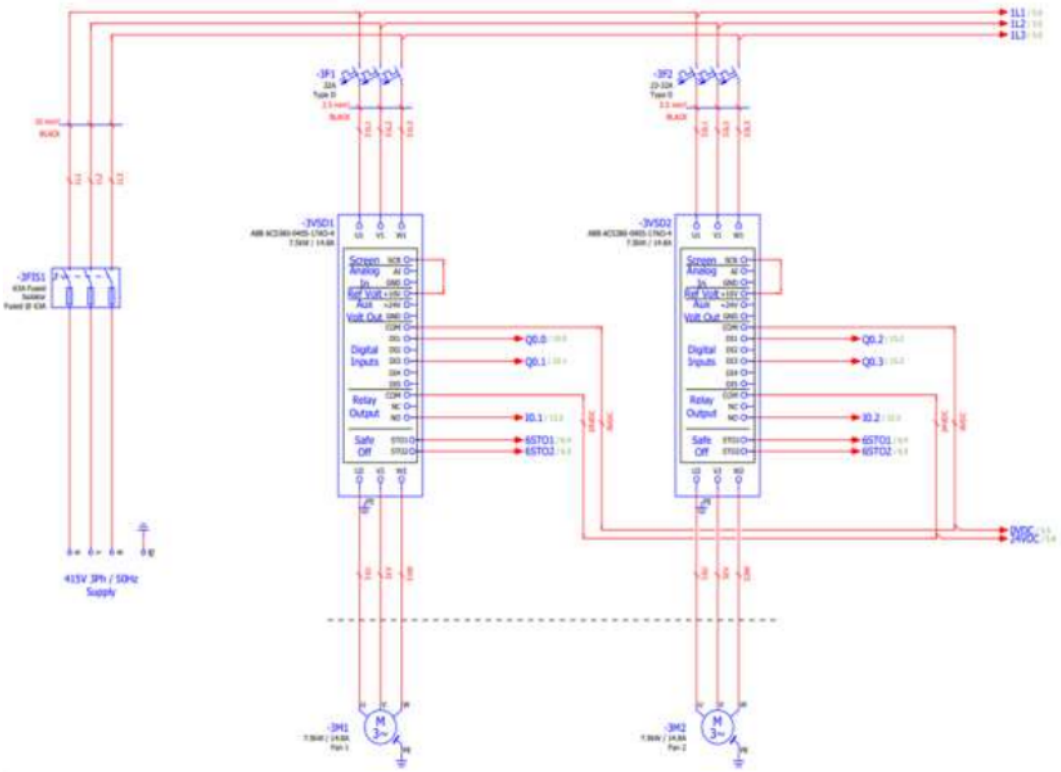


Figure 19 - 400/230VAC Electrical Drawing

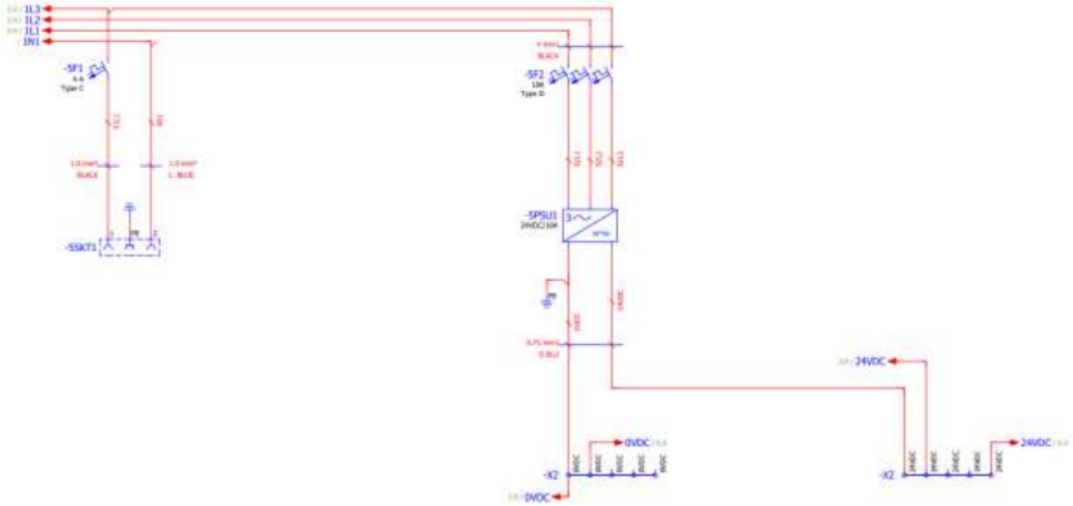


Figure 20 - 400/230VAC & 24VDC Circuit Drawing

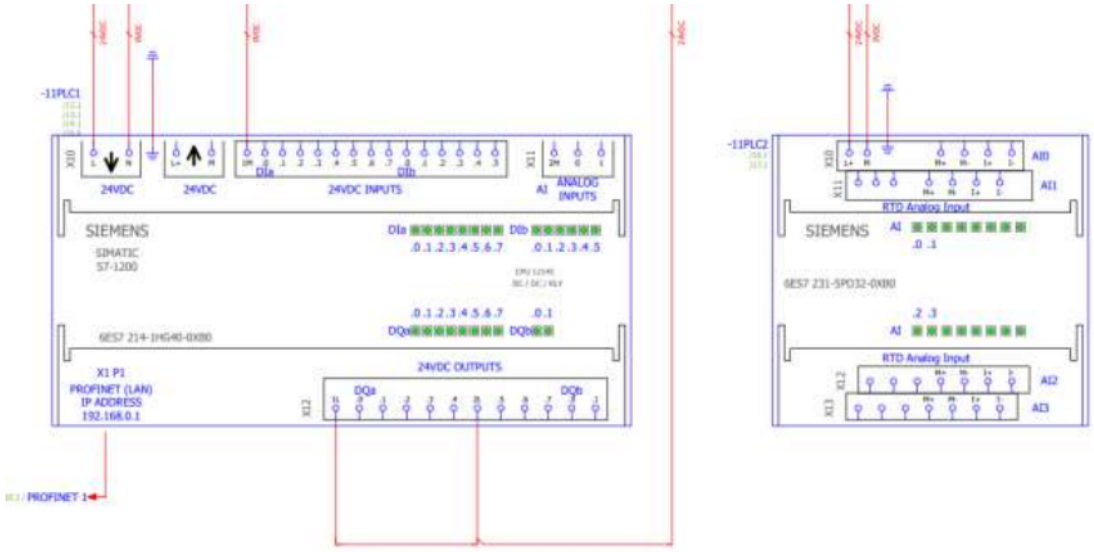


Figure 21 - 24VDC Circuit Drawing

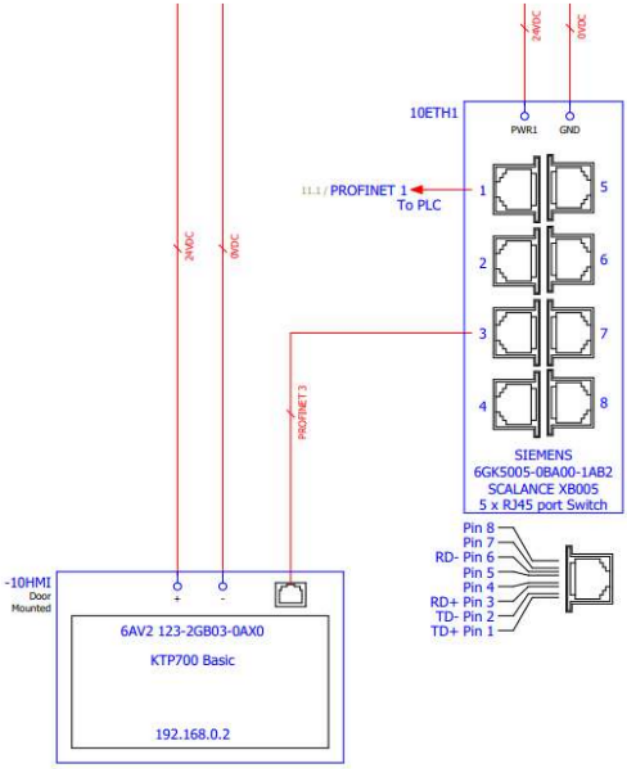


Figure 22 - 24VDC Circuit Drawing

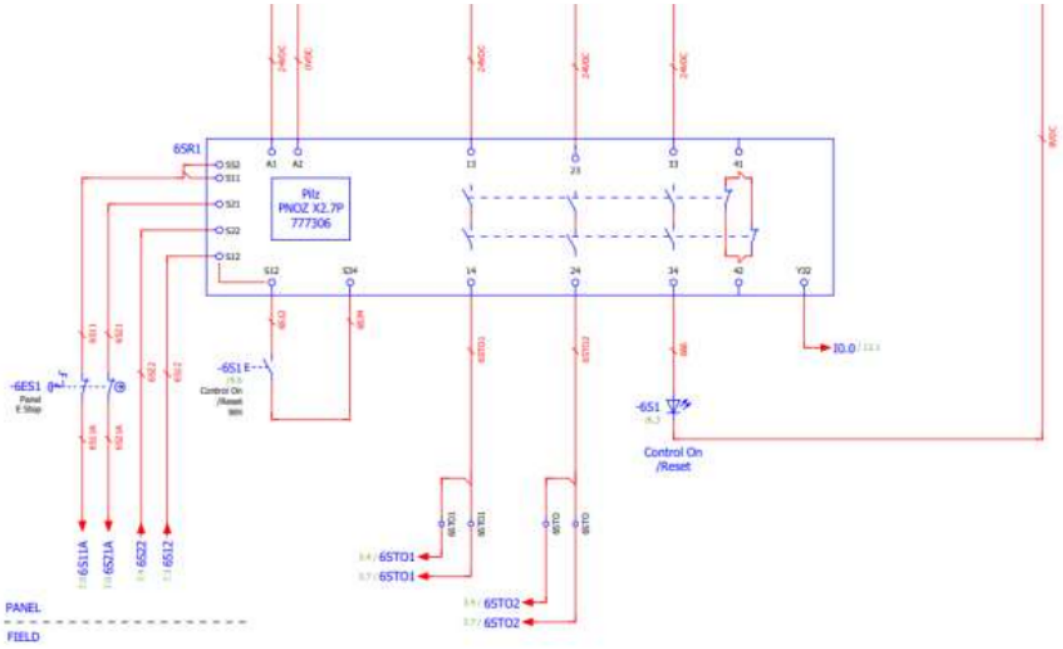


Figure 23 - Safety Circuit Drawing

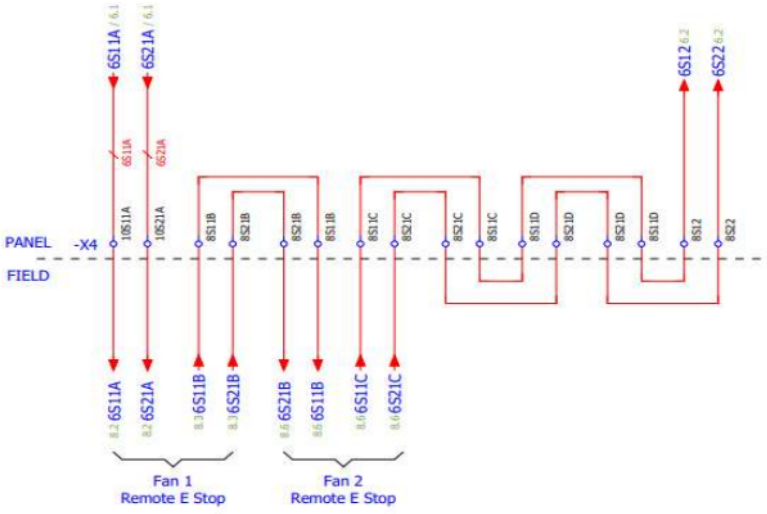


Figure 24 - Safety Circuit Drawing

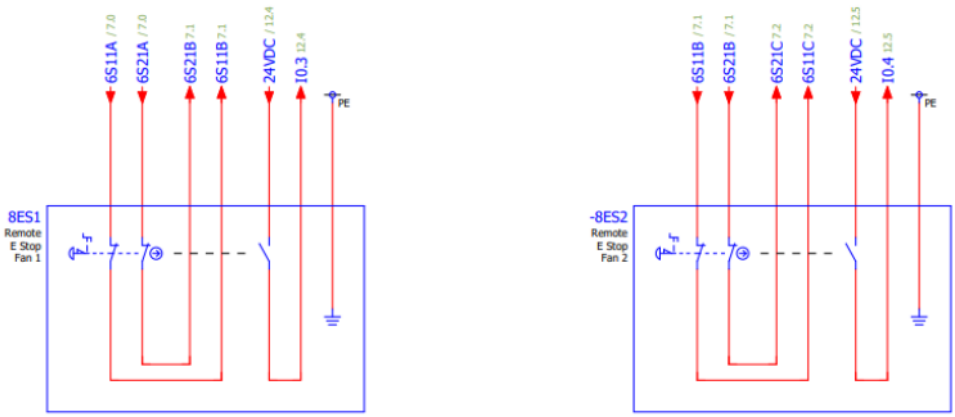


Figure 25 - Safety Circuit Drawing

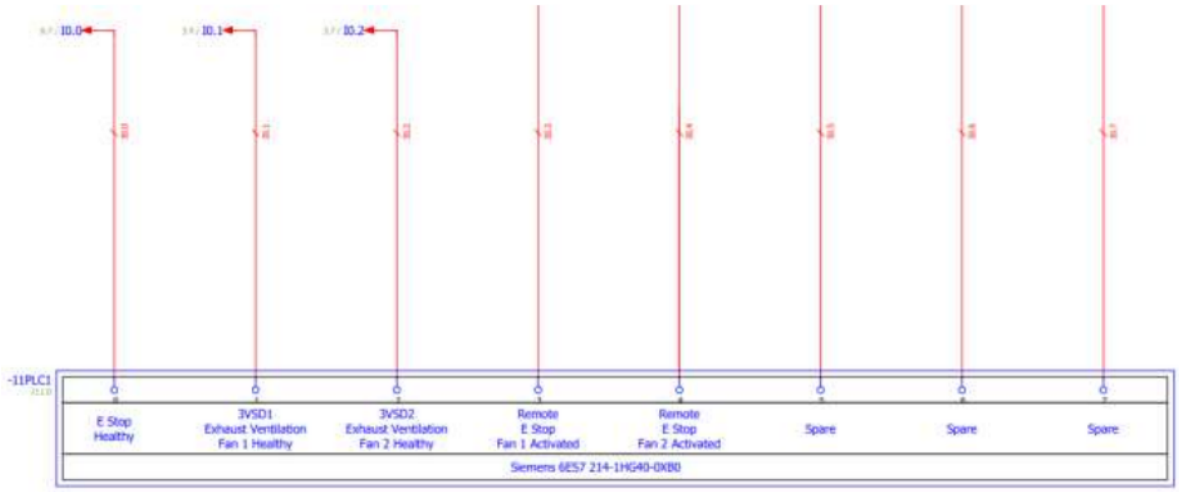


Figure 26 - Digital Input Circuit Drawing

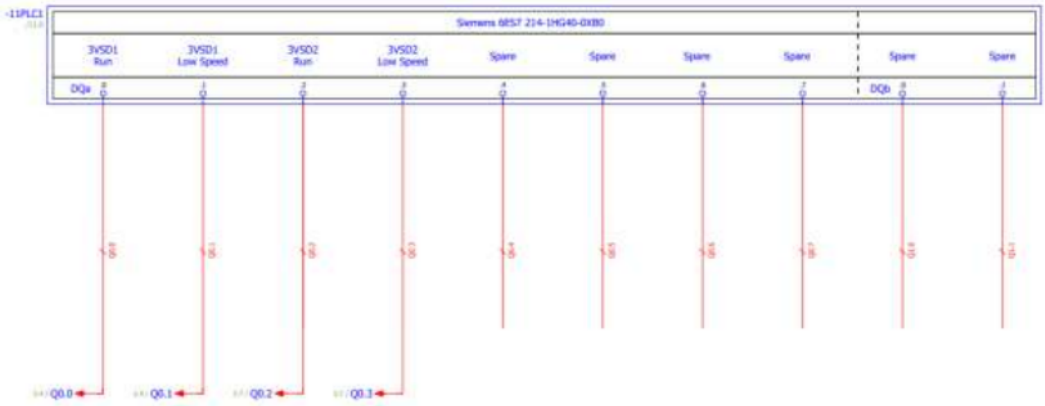


Figure 27 - Digital Output Circuit Drawing

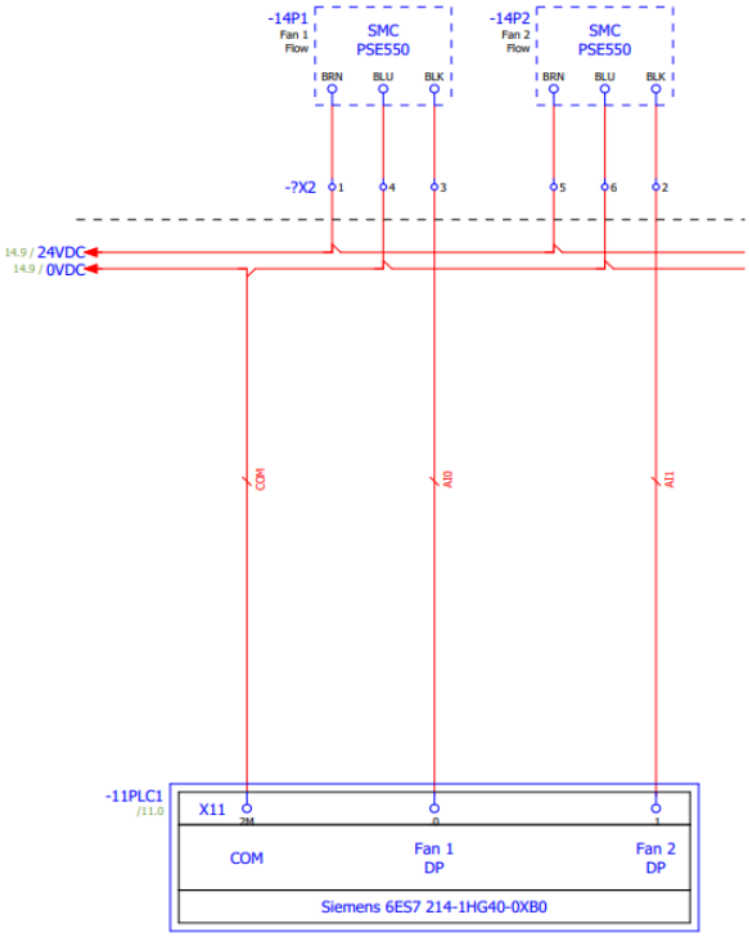


Figure 28 - Analogue Circuit Drawing

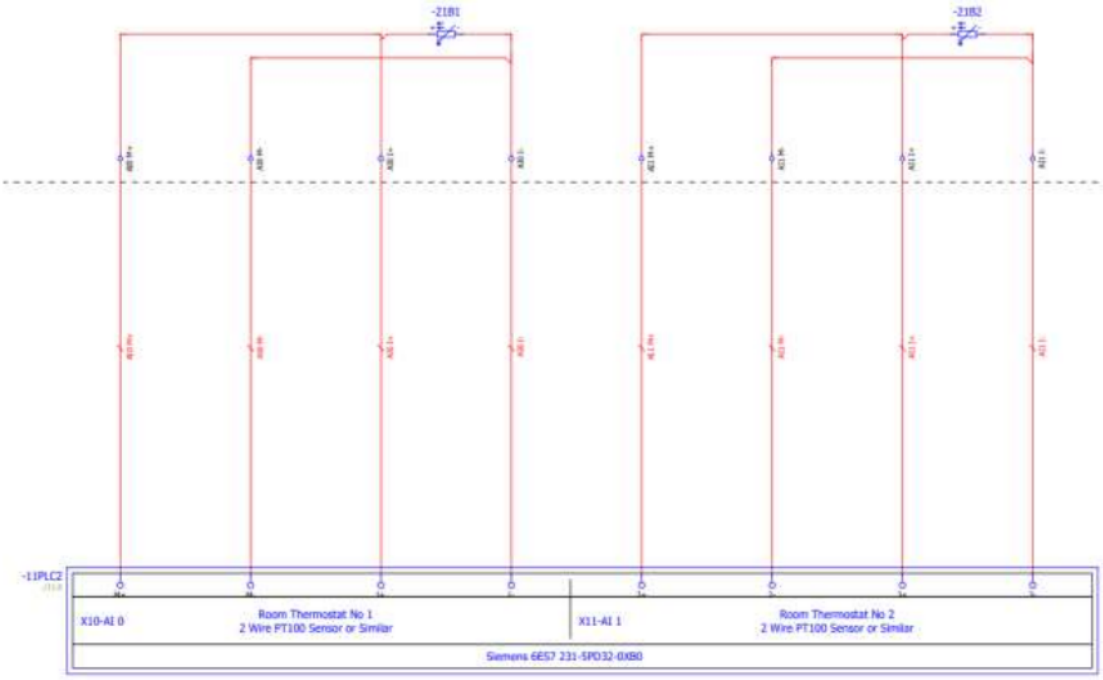


Figure 29 - Analogue Circuit Drawing

10.6. Electrical Panel Drawing

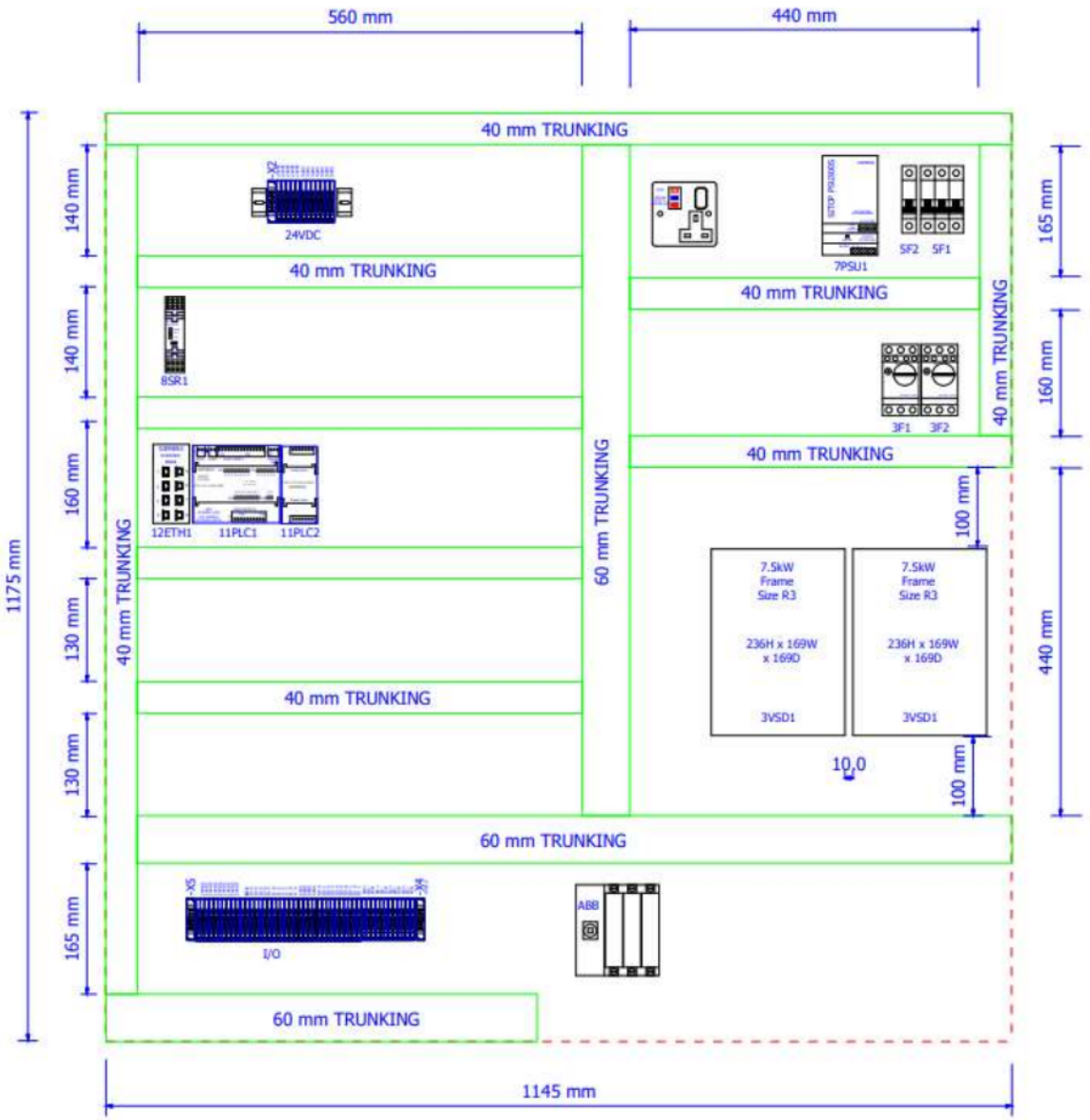


Figure 30 - Vent Panel Schematic

10.7. PLC Logic Programming & Design

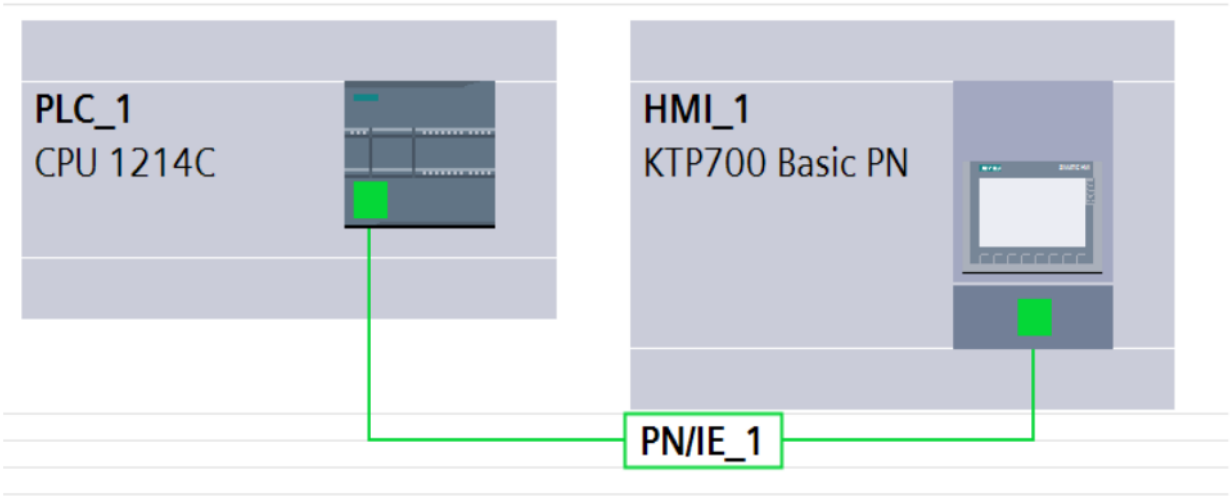


Figure 31 - TIA Portal Devices and Network

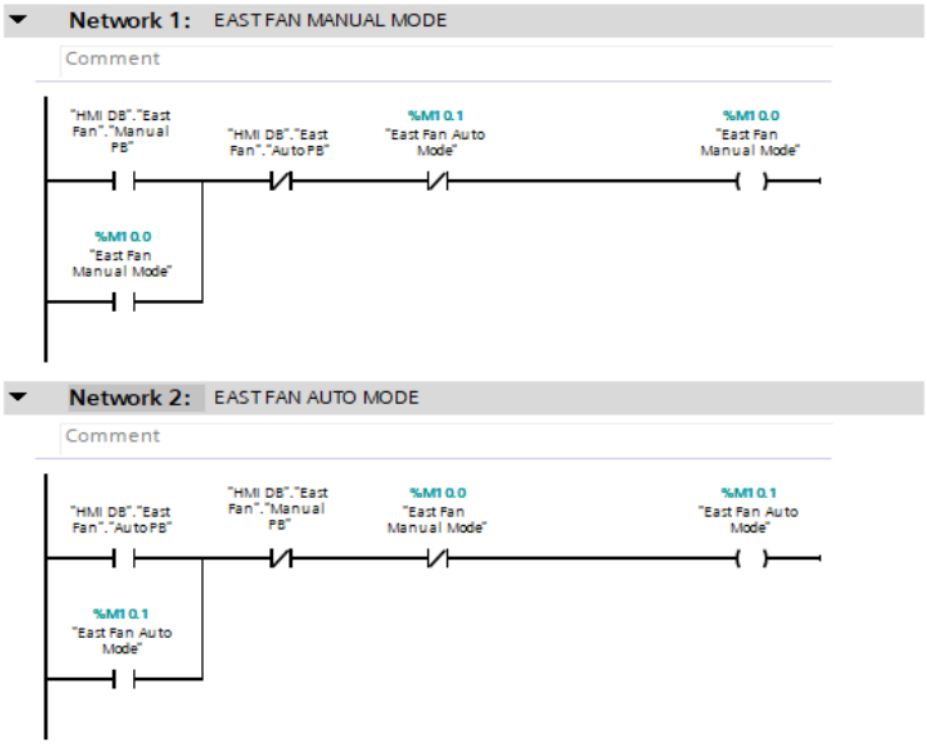


Figure 32 - TIA Portal Organization Block

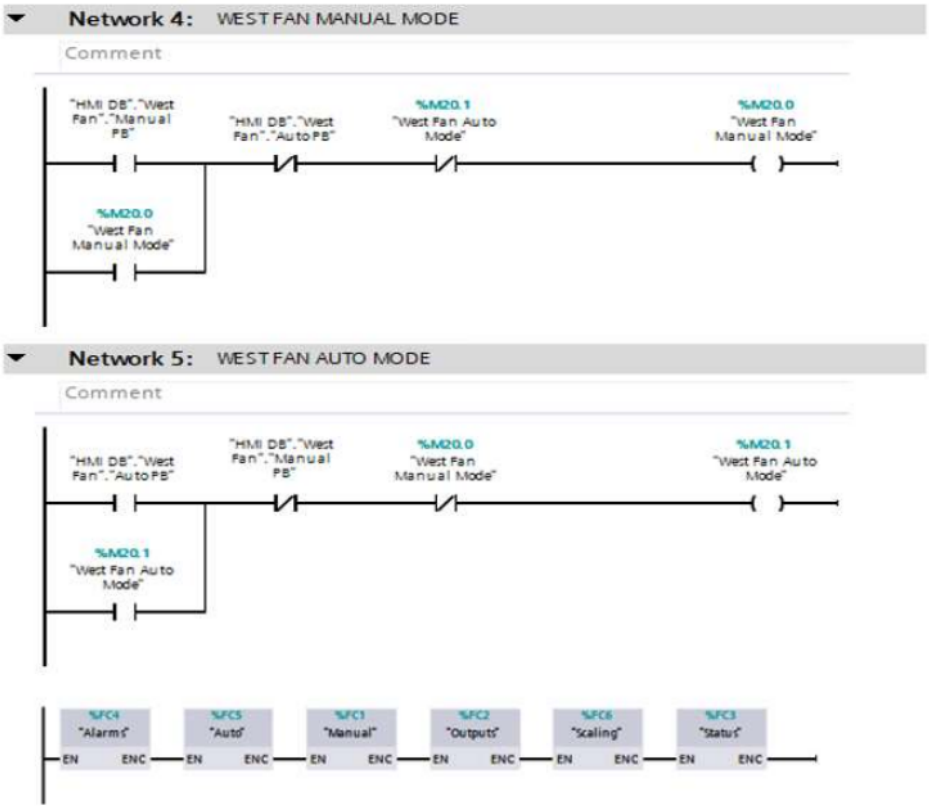


Figure 33 - TIA Portal Organization Block

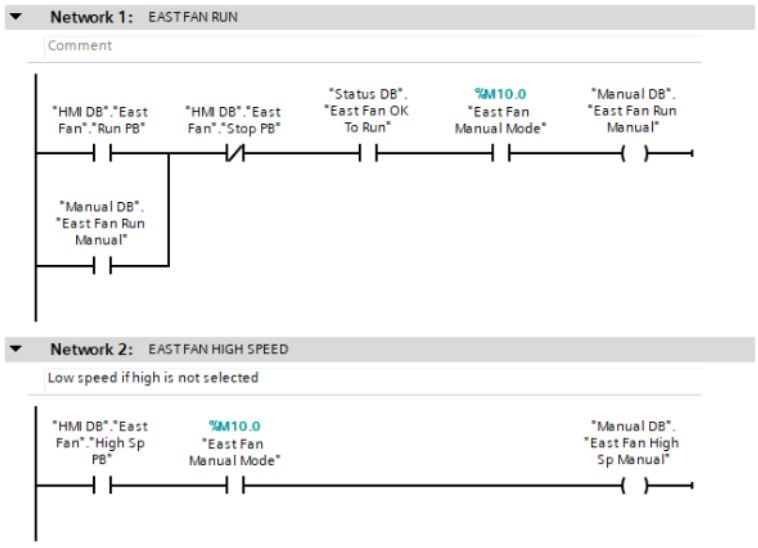


Figure 34 - TIA Portal Function Call 1 - Manual

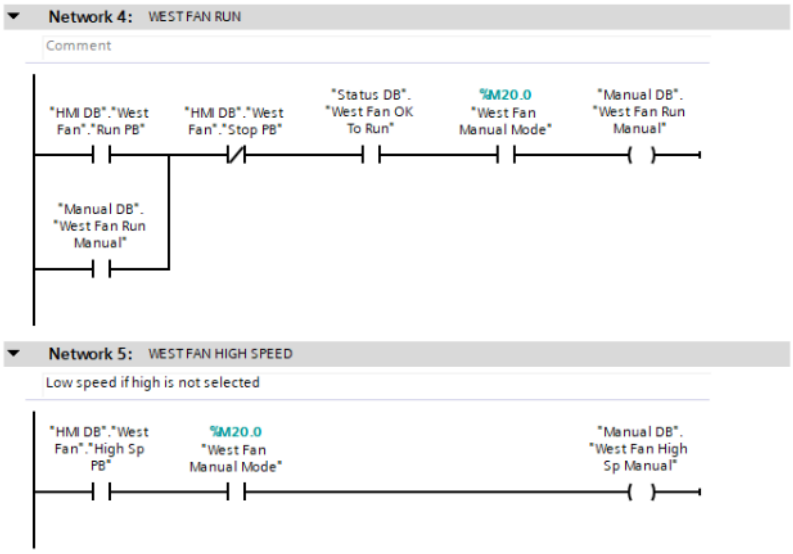


Figure 35 - TIA Portal Function Call 1 - Manual

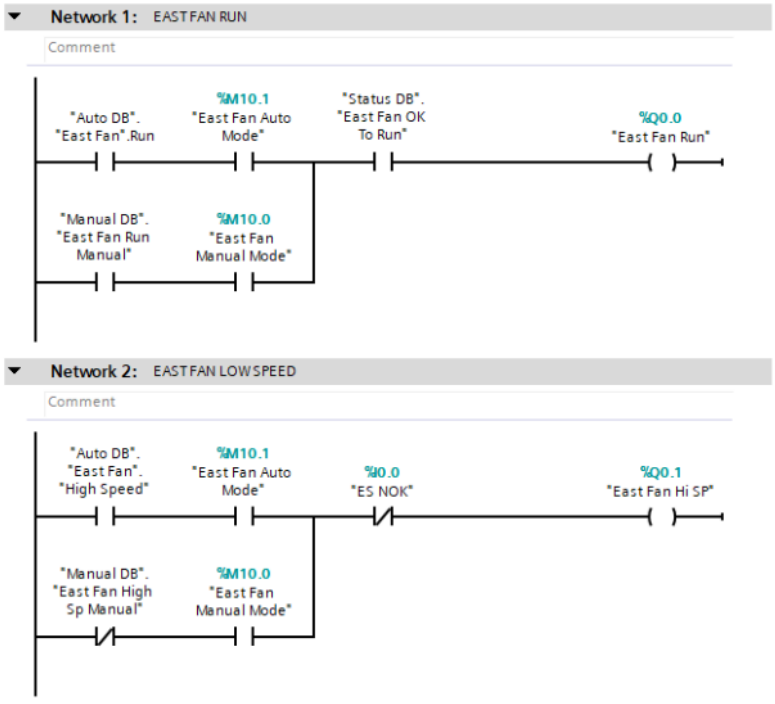


Figure 36 - TIA Portal Function Call 2 - Outputs

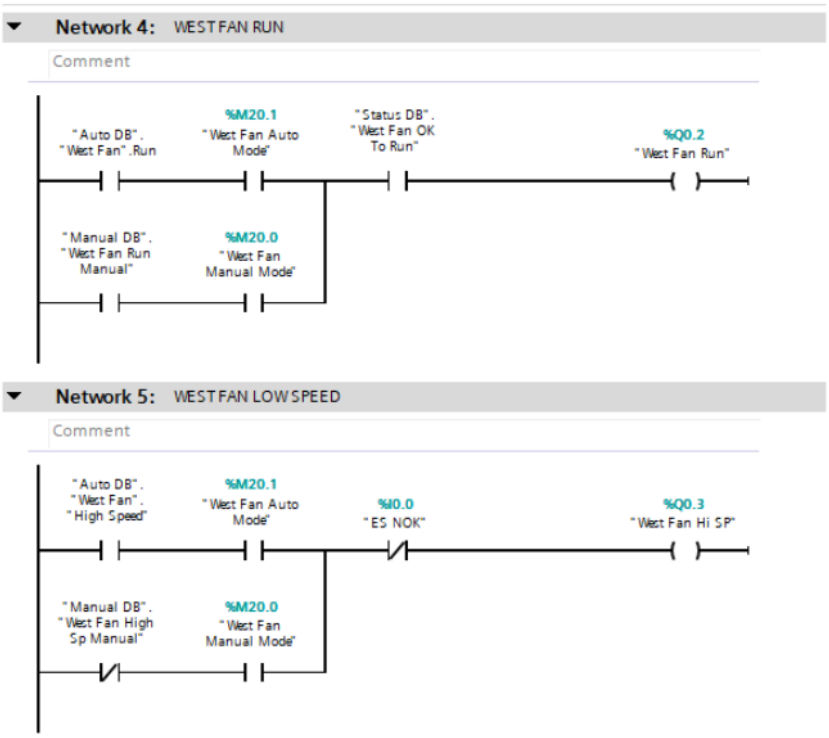


Figure 37 - TIA Portal Function Call 2 - Outputs

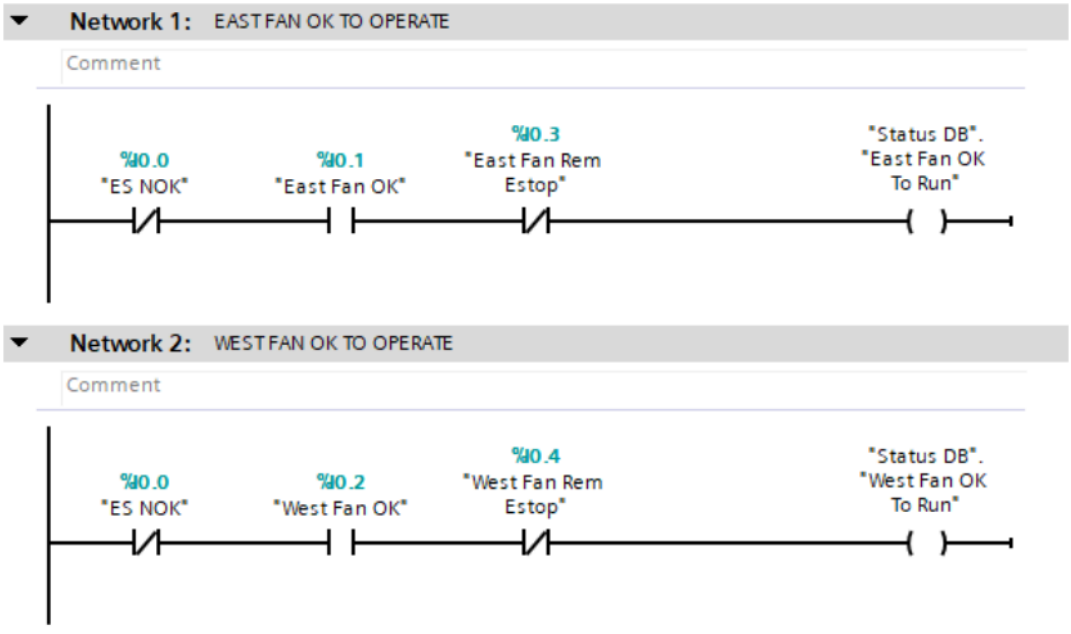


Figure 38 - TIA Portal Function Call 3 - Status

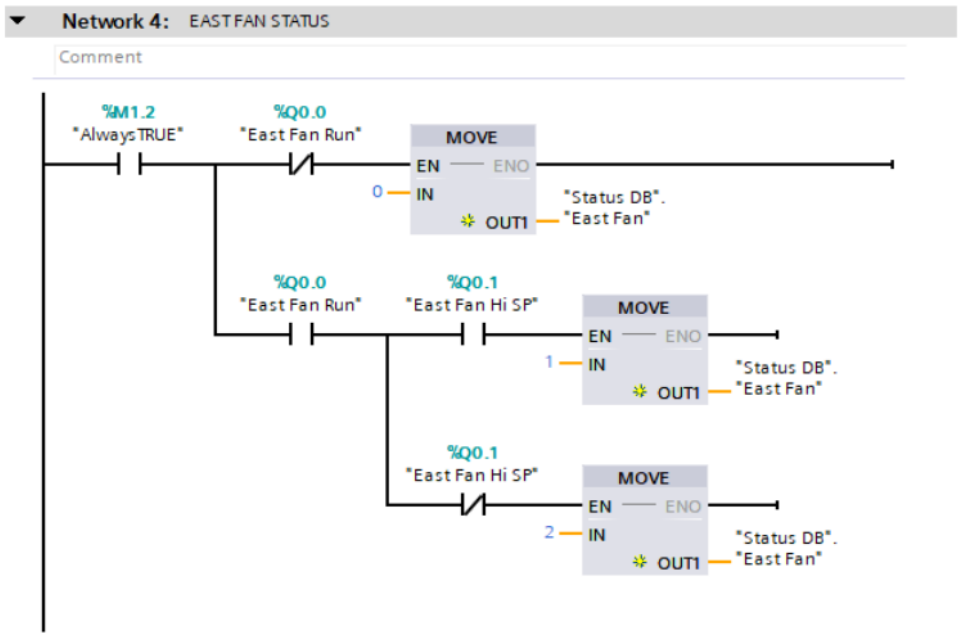


Figure 39 - TIA Portal Function Call 3 - Status

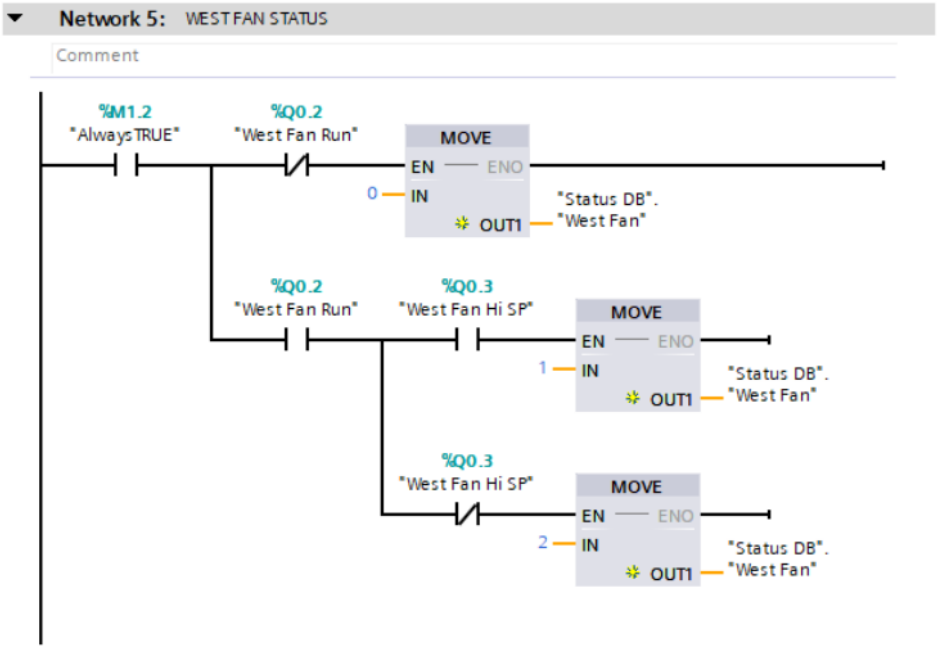


Figure 40 - TIA Portal Function Call 3 - Status

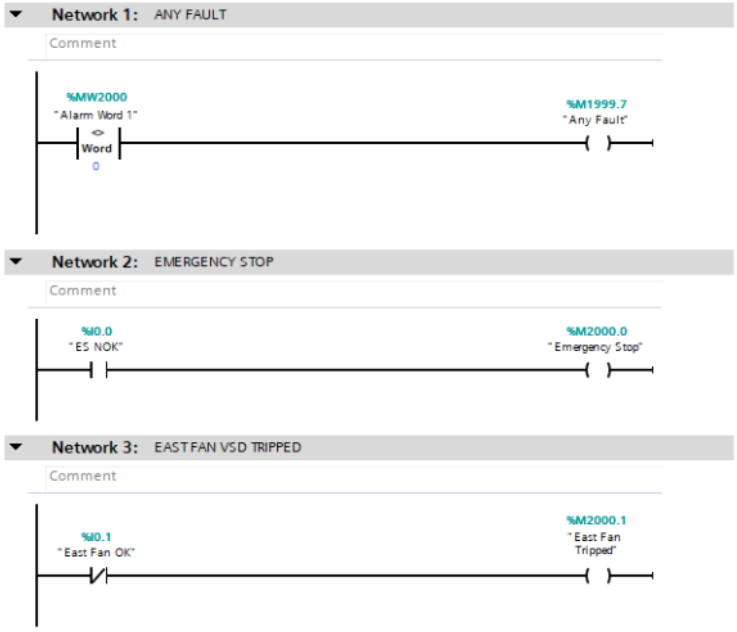


Figure 41 - TIA Portal Function Call 4 - Alarms

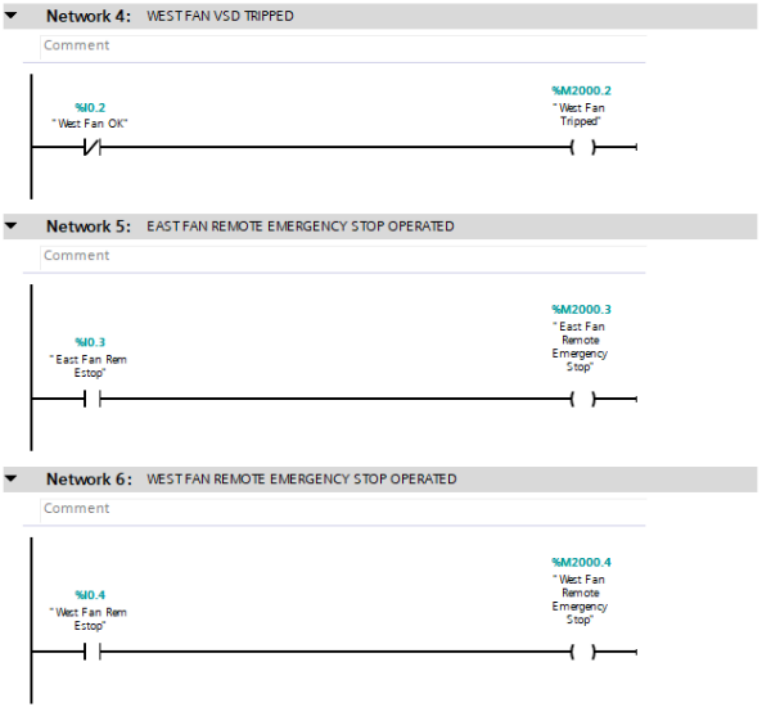


Figure 42 - TIA Portal Function Call 4 - Alarms

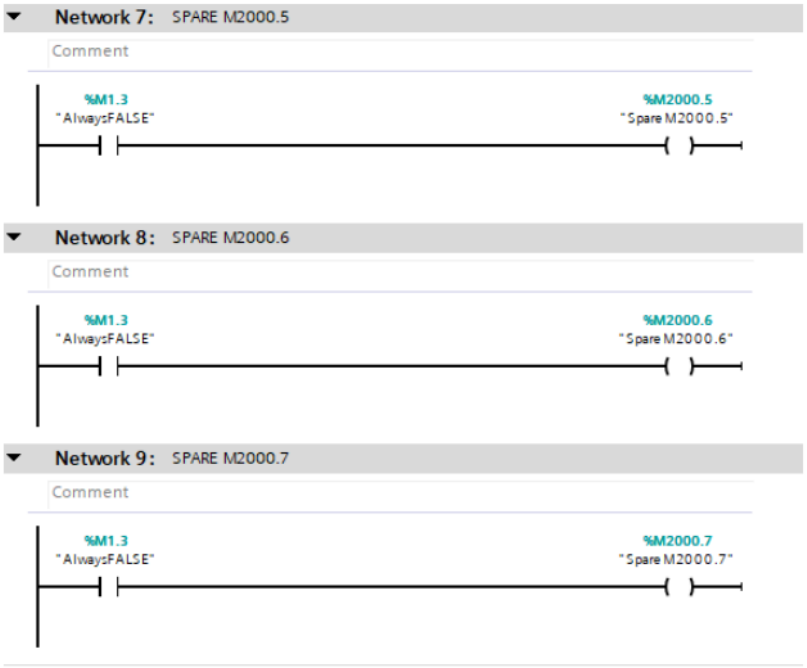


Figure 43 - TIA Portal Function Call 4 - Alarms

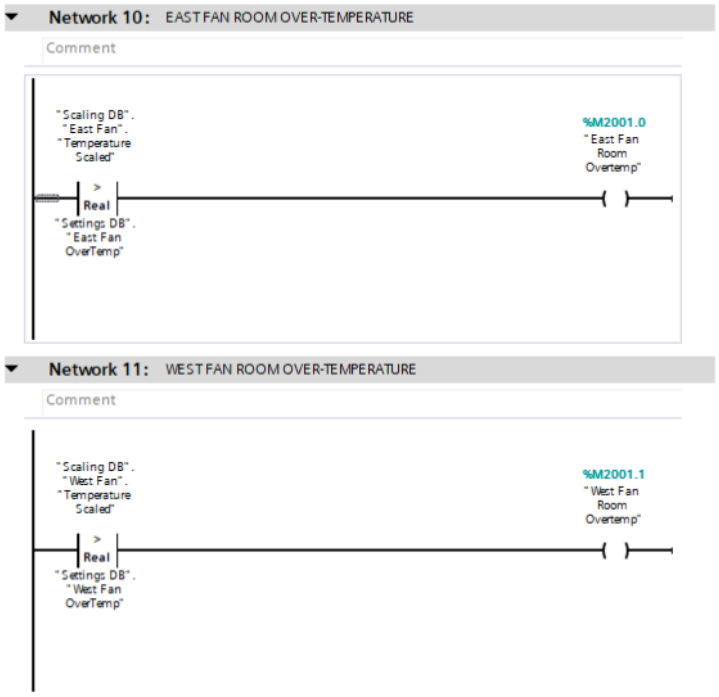


Figure 44 - TIA Portal Function Call 4 - Alarms

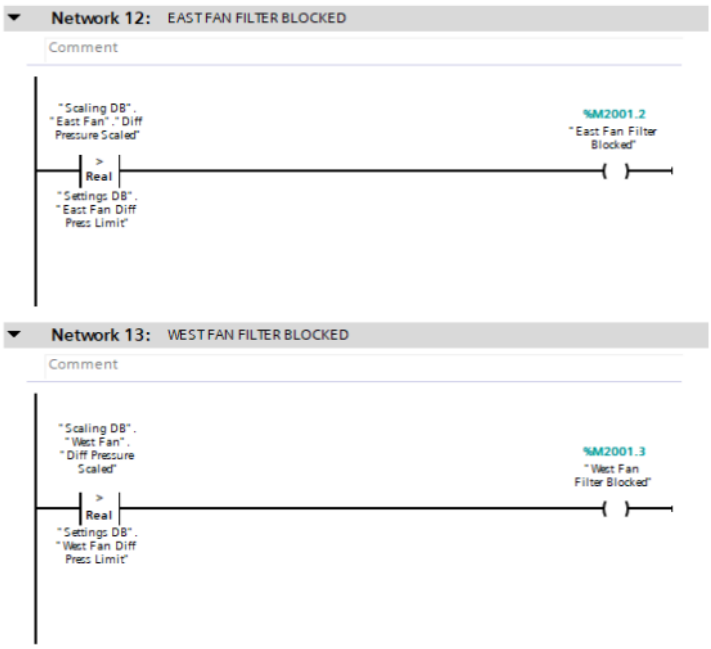


Figure 45 - TIA Portal Function Call 4 - Alarms

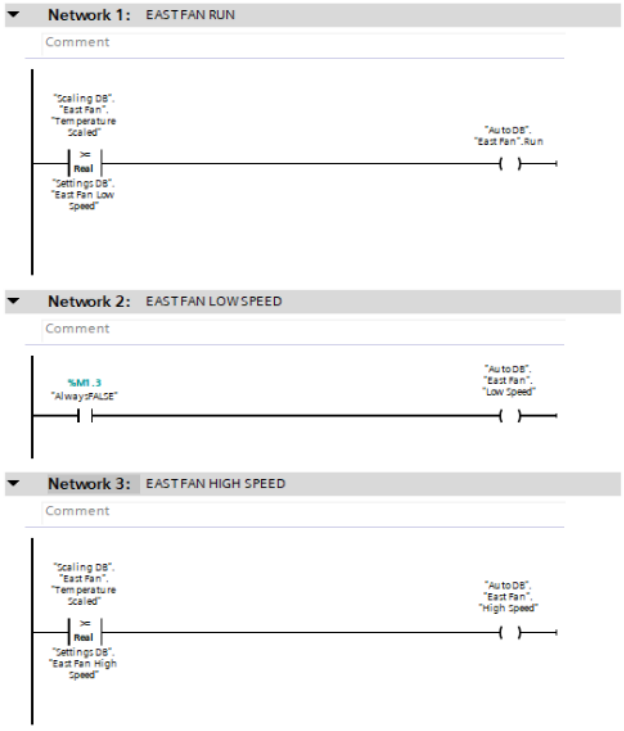


Figure 46 - TIA Portal Function Call 5 - Automatic

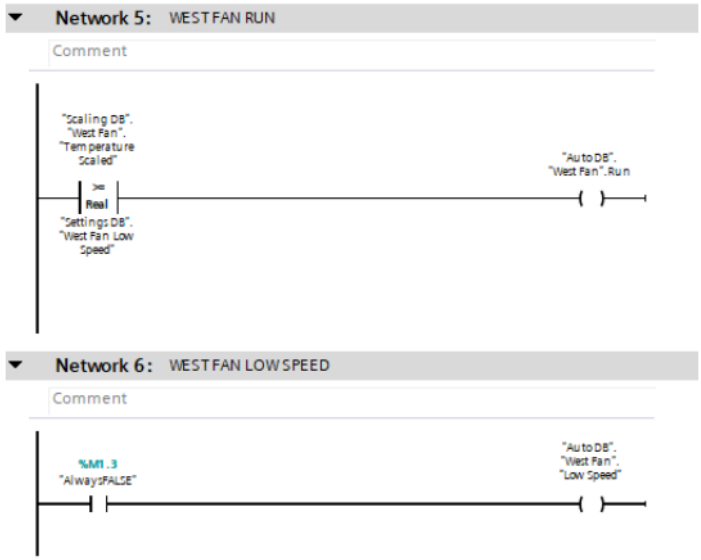


Figure 47 - TIA Portal Function Call 5 - Automatic

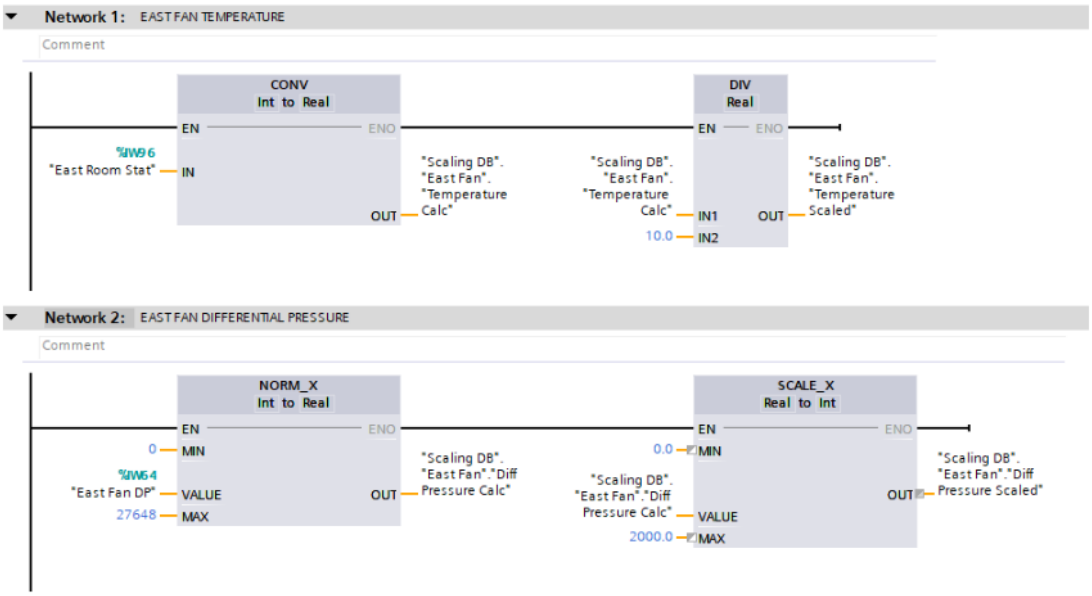


Figure 48 - TIA Portal Function Call 6 - Scaling

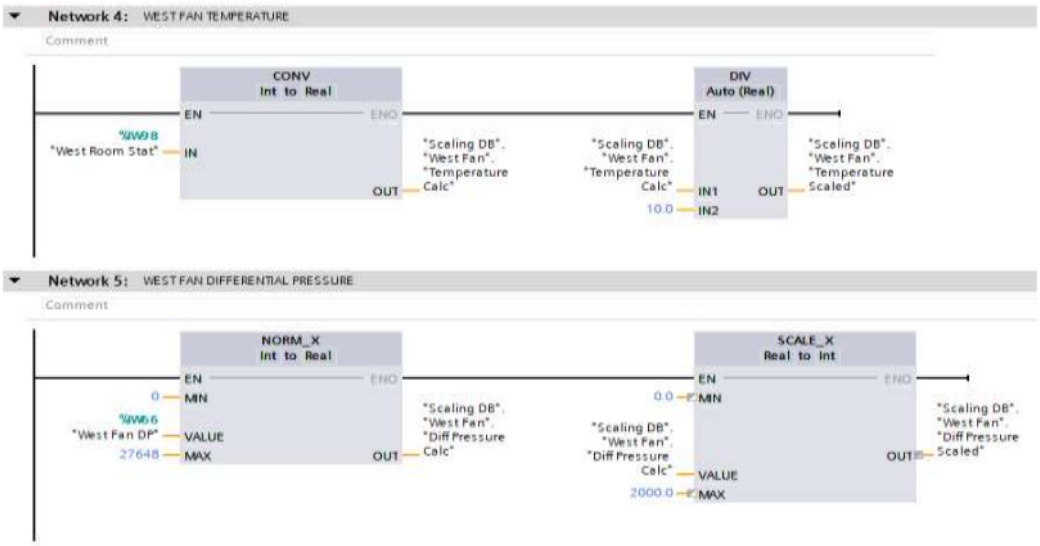


Figure 49 - TIA Portal Function Call 6 - Scaling

Manual DB

	Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint	Comment
1	Static								
2	East Fan Run Manual	Bool	false						
3	East Fan High Sp Man...	Bool	false						
4	West Fan Run Manual	Bool	false						
5	West Fan High Sp Man...	Bool	false						

Figure 50 - TIA Portal Data Block 1 - Manual

HMI DB

	Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint	Comment
1	Static								
2	East Fan	Struct							
3	Manual PB	Bool	false						
4	Auto PB	Bool	false						
5	Run PB	Bool	false						
6	Stop PB	Bool	false						
7	High Sp PB	Bool	false						
8	VSD Reset PB	Bool	false						
9	West Fan	Struct							
10	Manual PB	Bool	false						
11	Auto PB	Bool	false						
12	Run PB	Bool	false						
13	Stop PB	Bool	false						
14	High Sp PB	Bool	false						
15	VSD Reset PB	Bool	false						
16	Global Reset PB	Bool	false						

Figure 51 - TIA Portal Data Block 2 - HMI

Settings DB

	Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint	Comment
1	Static								
2	East Fan Low Speed	Real	10.0	☑	☑	☑	☑	☐	
3	East Fan High Speed	Real	20.0	☑	☑	☑	☑	☐	
4	East Fan OverTemp	Real	30.0	☑	☑	☑	☑	☐	
5	East Fan Diff Press Limit	Real	1000.0	☑	☑	☑	☑	☐	
6	West Fan Low Speed	Real	10.0	☑	☑	☑	☑	☐	
7	West Fan High Speed	Real	20.0	☑	☑	☑	☑	☐	
8	West Fan OverTemp	Real	30.0	☑	☑	☑	☑	☐	
9	West Fan Diff Press Li...	Real	1000.0	☑	☑	☑	☑	☐	

Figure 52 - TIA Portal Data Block 3 - Settings

Status DB

	Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint	Comment
1	Static								
2	East Fan	Int	0	☐	☑	☑	☑	☐	
3	West Fan	Int	0	☐	☑	☑	☑	☐	
4	East Fan OK To Run	Bool	false	☐	☑	☑	☑	☐	
5	West Fan OK To Run	Bool	false	☐	☑	☑	☑	☐	

Figure 53 - TIA Portal Data Block 4 - Status

Auto DB

	Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint	Comment
1	Static								
2	East Fan	Struct			☑	☑	☑		
3	Run	Bool	false	☐	☑	☑	☑	☐	
4	Low Speed	Bool	false	☐	☑	☑	☑	☐	
5	High Speed	Bool	false	☐	☑	☑	☑	☐	
6	West Fan	Struct			☑	☑	☑		
7	Run	Bool	false	☐	☑	☑	☑	☐	
8	Low Speed	Bool	false	☐	☑	☑	☑	☐	
9	High Speed	Bool	false	☐	☑	☑	☑	☐	

Figure 54 - TIA Portal Data Block 5 - Auto

Scaling DB

	Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint	Comment
1	Static								
2	East Fan	Struct			☑	☑	☑		
3	Temperature Calc	Real	0.0	☐	☑	☑	☑	☐	
4	Temperature Scaled	Real	0.0	☐	☑	☑	☑	☐	
5	Diff Pressure Calc	Real	0.0	☐	☑	☑	☑	☐	
6	Diff Pressure Scaled	Real	0.0	☐	☑	☑	☑	☐	
7	West Fan	Struct			☑	☑	☑		
8	Temperature Calc	Real	0.0	☐	☑	☑	☑	☐	
9	Temperature Scaled	Real	0.0	☐	☑	☑	☑	☐	
10	Diff Pressure Calc	Real	0.0	☐	☑	☑	☑	☐	
11	Diff Pressure Scaled	Real	0.0	☐	☑	☑	☑	☐	

Figure 55 - TIA Portal Data Block 6 - Scaling

Auto Reset Timer 1

	Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint	Comment
1	Static								
2	PT	Time	T#0ms		☑	☑	☑		
3	ET	Time	T#0ms		☑		☑		
4	IN	Bool	false		☑	☑	☑		
5	Q	Bool	false		☑		☑		

Figure 56 - TIA Portal Auto Timer Reset 1

Auto Reset Timer 2

	Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint	Comment
1	Static								
2	PT	Time	T#0ms		☑	☑	☑		
3	ET	Time	T#0ms		☑		☑		
4	IN	Bool	false		☑	☑	☑		
5	Q	Bool	false		☑		☑		

Figure 57 - TIA Portal Auto Timer Reset 2

Default tag table

		Name	Data type	Address	Retain	Acces...	Writa...	Visibl...	Comment
41		East Room Stat	Word	%IW96		☑	☑	☑	
42		West Room Stat	Word	%IW98		☑	☑	☑	
43		Spare AI100	Word	%IW100		☑	☑	☑	
44		Spare AI102	Word	%IW102		☑	☑	☑	
45		East Fan Manual Mode	Bool	%M10.0	☑	☑	☑	☑	
46		East Fan Auto Mode	Bool	%M10.1	☑	☑	☑	☑	
47		Emergency Stop	Bool	%M2000.0		☑	☑	☑	
48		East Fan Tripped	Bool	%M2000.1		☑	☑	☑	
49		West Fan Tripped	Bool	%M2000.2		☑	☑	☑	
50		East Fan Remote Emergency St..	Bool	%M2000.3		☑	☑	☑	
51		West Fan Remote Emergency St.	Bool	%M2000.4		☑	☑	☑	
52		Spare M2000.5	Bool	%M2000.5		☑	☑	☑	
53		Spare M2000.6	Bool	%M2000.6		☑	☑	☑	
54		Spare M2000.7	Bool	%M2000.7		☑	☑	☑	
55		East Fan Room Overtemp	Bool	%M2001.0		☑	☑	☑	
56		West Fan Room Overtemp	Bool	%M2001.1		☑	☑	☑	
57		East Fan Filter Blocked	Bool	%M2001.2		☑	☑	☑	
58		West Fan Filter Blocked	Bool	%M2001.3		☑	☑	☑	
59		Spare M2001.4	Bool	%M2001.4		☑	☑	☑	
60		Spare M2001.5	Bool	%M2001.5		☑	☑	☑	
61		Spare M2001.6	Bool	%M2001.6		☑	☑	☑	
62		Spare M2001.7	Bool	%M2001.7		☑	☑	☑	
63		Alarm Word 1	Word	%MW2000		☑	☑	☑	
64		West Fan Manual Mode	Bool	%M20.0		☑	☑	☑	
65		West Fan Auto Mode	Bool	%M20.1		☑	☑	☑	
66		Auto Reset	Bool	%M30.0		☑	☑	☑	
67		Any Fault	Bool	%M1999.7		☑	☑	☑	
68		ES Reset Pulse	Bool	%M1000.0		☑	☑	☑	
69		<Add new>				☑	☑	☑	

Figure 58 - TIA Portal Default PLC Tags

Default tag table

	Name	Data type	Address	Retain	Acces...	Writa...	Visibl...	Comment
1	System_Byte	Byte	%MB1	☑	☑	☑	☑	
2	FirstScan	Bool	%M1.0	☑	☑	☑	☑	
3	DiagStatusUpdate	Bool	%M1.1	☑	☑	☑	☑	
4	AlwaysTRUE	Bool	%M1.2	☑	☑	☑	☑	
5	AlwaysFALSE	Bool	%M1.3	☑	☑	☑	☑	
6	Clock_Byte	Byte	%MB0	☑	☑	☑	☑	
7	Clock_10Hz	Bool	%M0.0	☑	☑	☑	☑	
8	Clock_5Hz	Bool	%M0.1	☑	☑	☑	☑	
9	Clock_2.5Hz	Bool	%M0.2	☑	☑	☑	☑	
10	Clock_2Hz	Bool	%M0.3	☑	☑	☑	☑	
11	Clock_1.25Hz	Bool	%M0.4	☑	☑	☑	☑	
12	Clock_1Hz	Bool	%M0.5	☑	☑	☑	☑	
13	Clock_0.625Hz	Bool	%M0.6	☑	☑	☑	☑	
14	Clock_0.5Hz	Bool	%M0.7	☑	☑	☑	☑	
15	ES NOK	Bool	%I0.0	☐	☑	☑	☑	
16	East Fan OK	Bool	%I0.1	☐	☑	☑	☑	
17	West Fan OK	Bool	%I0.2	☐	☑	☑	☑	
18	East Fan Rem Estop	Bool	%I0.3	☐	☑	☑	☑	
19	West Fan Rem Estop	Bool	%I0.4	☐	☑	☑	☑	
20	Spare I0.5	Bool	%I0.5	☐	☑	☑	☑	
21	Spare I0.6	Bool	%I0.6	☐	☑	☑	☑	
22	Spare I0.7	Bool	%I0.7	☐	☑	☑	☑	
23	Spare I1.0	Bool	%I1.0	☐	☑	☑	☑	
24	Spare I1.1	Bool	%I1.1	☐	☑	☑	☑	
25	Spare I1.2	Bool	%I1.2	☐	☑	☑	☑	
26	Spare I1.3	Bool	%I1.3	☐	☑	☑	☑	
27	Spare I1.4	Bool	%I1.4	☐	☑	☑	☑	
28	Spare I1.5	Bool	%I1.5	☐	☑	☑	☑	
29	East Fan DP	Word	%IW64	☐	☑	☑	☑	
30	West Fan DP	Word	%IW66	☐	☑	☑	☑	
31	East Fan Run	Bool	%Q0.0	☐	☑	☑	☑	
32	East Fan Hi SP	Bool	%Q0.1	☐	☑	☑	☑	
33	West Fan Run	Bool	%Q0.2	☐	☑	☑	☑	
34	West Fan Hi SP	Bool	%Q0.3	☐	☑	☑	☑	
35	East Fan VSD Reset	Bool	%Q0.4	☐	☑	☑	☑	
36	West Fan VSD Reset	Bool	%Q0.5	☐	☑	☑	☑	
37	Spare Q0.6	Bool	%Q0.6	☐	☑	☑	☑	
38	Spare Q0.7	Bool	%Q0.7	☐	☑	☑	☑	
39	Spare Q1.0	Bool	%Q1.0	☐	☑	☑	☑	
40	Spare Q1.1	Bool	%Q1.1	☐	☑	☑	☑	

Figure 59 - TIA Portal Default PLC Tags

10.8. HMI Logic and Design

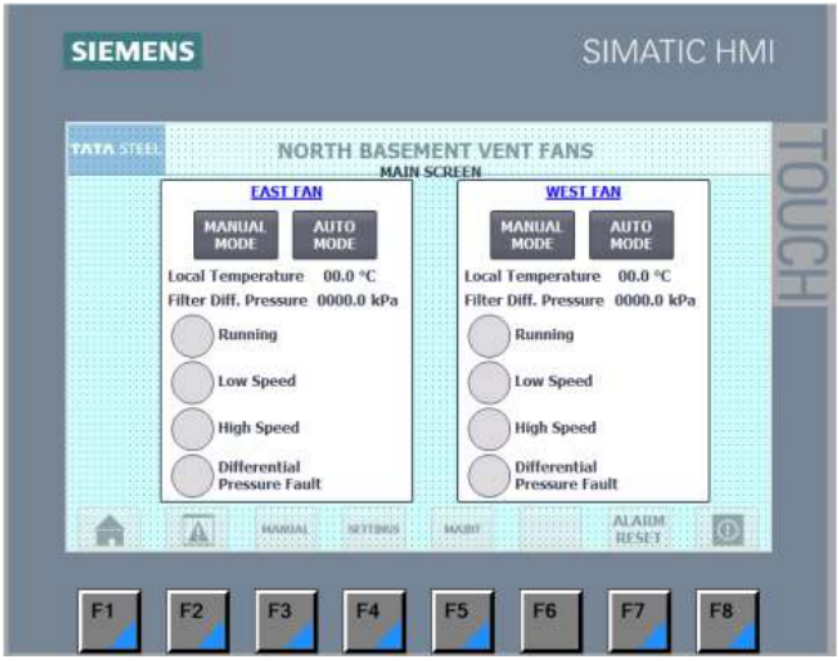


Figure 60 - TIA Portal HMI Root Screen

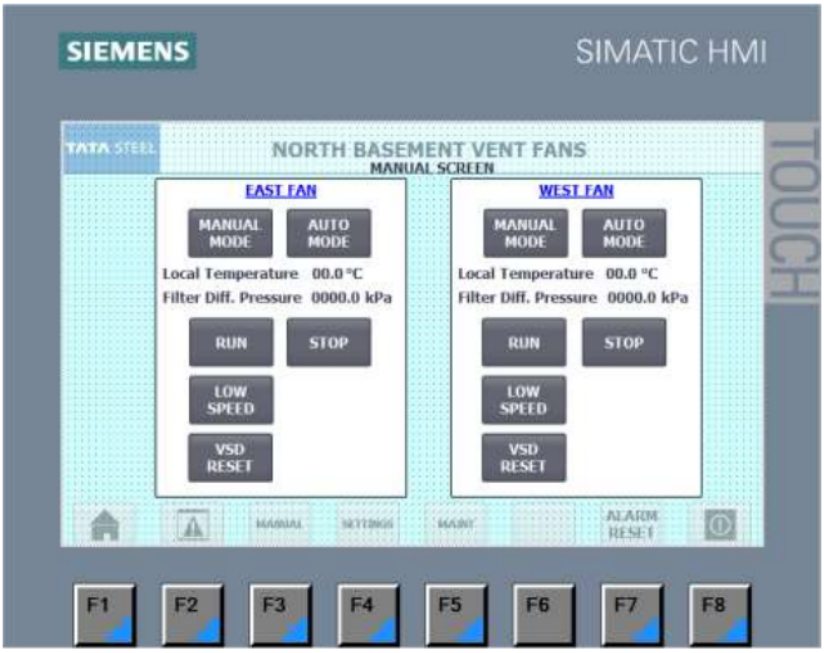


Figure 61 - TIA Portal HMI Manual Screen

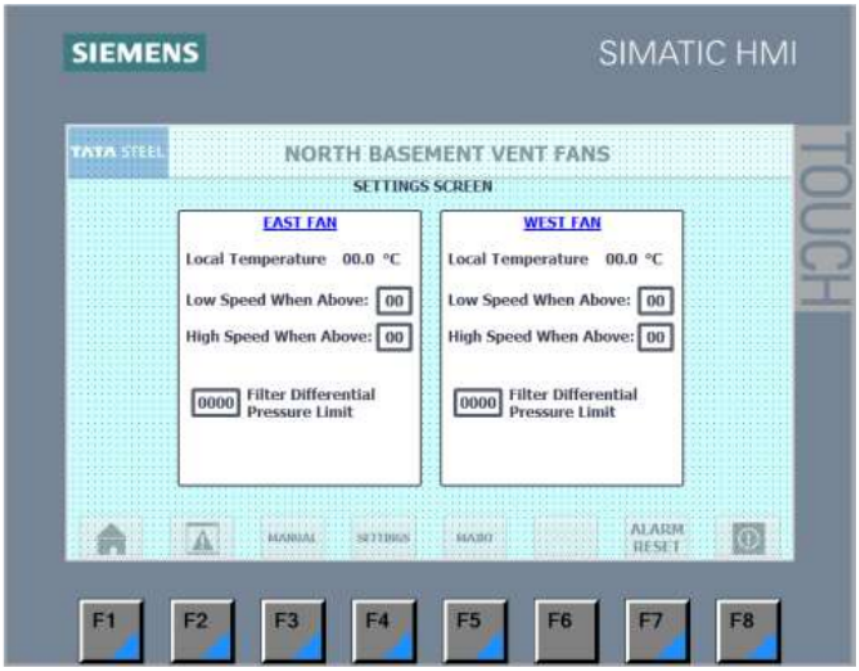


Figure 62 - TIA Portal HMI Settings Screen



Figure 63 - TIA Portal HMI Alarm History Screen

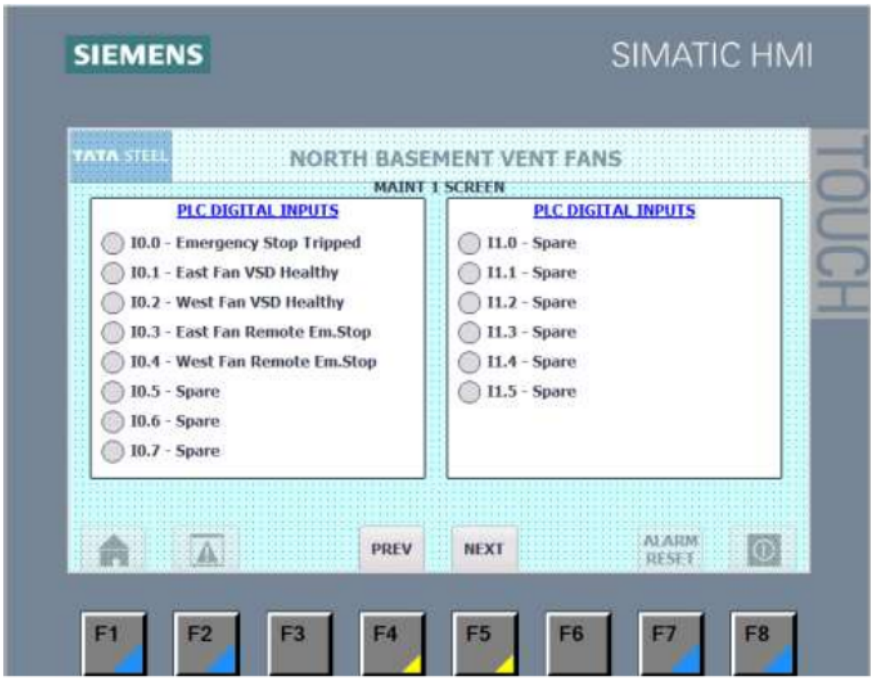


Figure 64 - TIA Portal HMI Maintenance Screen 1

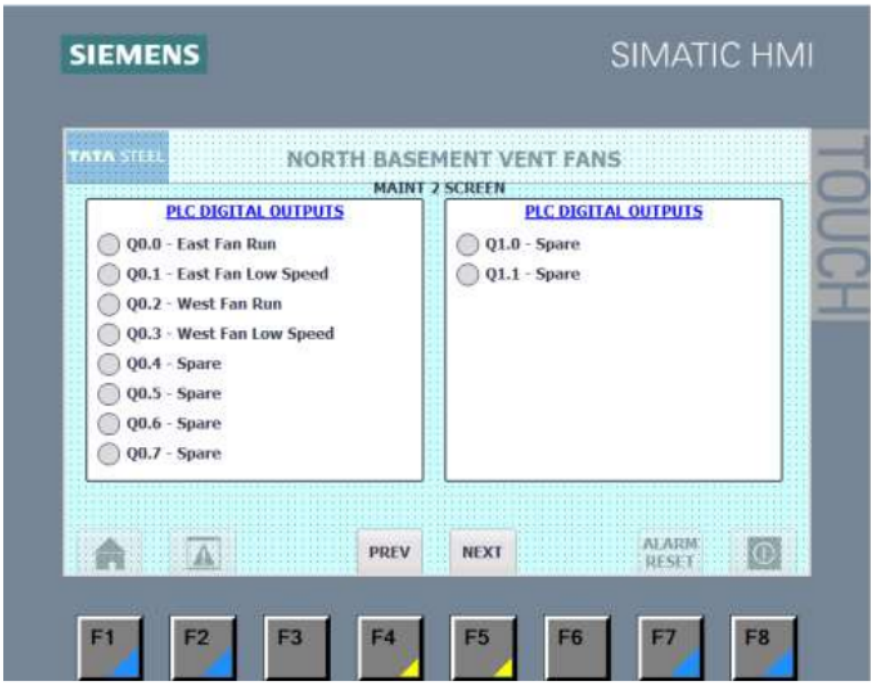


Figure 65 - TIA Portal HMI Maintenance Screen 2

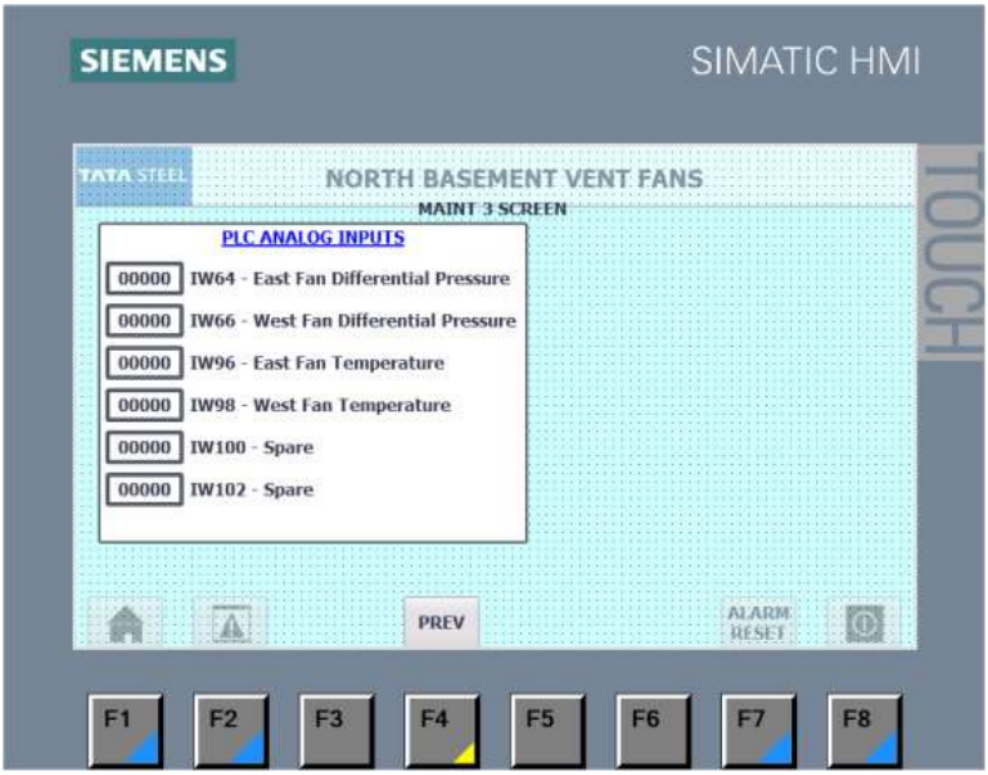


Figure 66 - TIA Portal HMI Maintenance Screen 3

Default tag table

Name	Data type	Connection	PLC name	PLC tag	Address	Access mode	Acquisition cycle
Alarm Word 1	Word	HMI_Conne...	PLC_1	"Alarm Word 1"		<symbolic access>	1 s
Any Fault	Bool	HMI_Connectio...	PLC_1	"Any Fault"		<symbolic access>	1 s
East Fan 1 DP	Word	HMI_Connectio...	PLC_1	"East Fan DP"		<symbolic access>	1 s
East Fan Auto Mode	Bool	HMI_Connectio...	PLC_1	"East Fan Auto Mode"		<symbolic access>	1 s
East Fan Filter Blocked	Bool	HMI_Connectio...	PLC_1	"East Fan Filter Blocked"		<symbolic access>	1 s
East Fan Low SP	Bool	HMI_Connectio...	PLC_1	"East Fan Hi SP"		<symbolic access>	1 s
East Fan Manual Mode	Bool	HMI_Connectio...	PLC_1	"East Fan Manual Mode"		<symbolic access>	1 s
East Fan OK	Bool	HMI_Connectio...	PLC_1	"East Fan OK"		<symbolic access>	1 s
East Fan Rem Estop	Bool	HMI_Connectio...	PLC_1	"East Fan Rem Estop"		<symbolic access>	1 s
East Fan Run	Bool	HMI_Connectio...	PLC_1	"East Fan Run"		<symbolic access>	1 s
East Room Stat	Word	HMI_Connectio...	PLC_1	"East Room Stat"		<symbolic access>	1 s
ES OK	Bool	HMI_Connectio...	PLC_1	"ES NOK"		<symbolic access>	1 s
HMI DB_East Fan_Auto PB	Bool	HMI_Connectio...	PLC_1	"HMI DB"."East Fan"."Aut...		<symbolic access>	1 s
HMI DB_East Fan_High Sp PB	Bool	HMI_Connectio...	PLC_1	"HMI DB"."East Fan"."High...		<symbolic access>	1 s
HMI DB_East Fan_Manual PB	Bool	HMI_Connectio...	PLC_1	"HMI DB"."East Fan"."Man...		<symbolic access>	1 s
HMI DB_East Fan_Run PB	Bool	HMI_Connectio...	PLC_1	"HMI DB"."East Fan"."Run...		<symbolic access>	1 s
HMI DB_East Fan_Stop PB	Bool	HMI_Connectio...	PLC_1	"HMI DB"."East Fan"."Stop...		<symbolic access>	1 s
HMI DB_East Fan_VSD Reset PB	Bool	HMI_Connectio...	PLC_1	"HMI DB"."East Fan"."VSD...		<symbolic access>	1 s
HMI DB_Global Reset PB	Bool	HMI_Connectio...	PLC_1	"HMI DB"."Global Reset PB"		<symbolic access>	1 s
HMI DB_West Fan_Auto PB	Bool	HMI_Connectio...	PLC_1	"HMI DB"."West Fan"."Aut...		<symbolic access>	1 s
HMI DB_West Fan_High Sp PB	Bool	HMI_Connectio...	PLC_1	"HMI DB"."West Fan"."Hig...		<symbolic access>	1 s
HMI DB_West Fan_Manual PB	Bool	HMI_Connectio...	PLC_1	"HMI DB"."West Fan"."Ma...		<symbolic access>	1 s
HMI DB_West Fan_Run PB	Bool	HMI_Connectio...	PLC_1	"HMI DB"."West Fan"."Run...		<symbolic access>	1 s
HMI DB_West Fan_Stop PB	Bool	HMI_Connectio...	PLC_1	"HMI DB"."West Fan"."Sto...		<symbolic access>	1 s
HMI DB_West Fan_VSD Reset PB	Bool	HMI_Connectio...	PLC_1	"HMI DB"."West Fan"."VSD...		<symbolic access>	1 s
Manual DB_East Fan High Sp M...	Bool	HMI_Connectio...	PLC_1	"Manual DB"."East Fan Hi...		<symbolic access>	1 s
Manual DB_East Fan Run Manual	Bool	HMI_Connectio...	PLC_1	"Manual DB"."East Fan Ru...		<symbolic access>	1 s

Figure 67 - TIA Portal HMI Default Tags

Default tag table

Name	Data type	Connection	PLC name	PLC tag	Address	Access mode	Acqui
Scaling DB_East Fan_Diff Press...	Real	HM_Connectio...	PLC_1	"Scaling DB"."East Fan"."D		<symbolic access>	1 s
Scaling DB_East Fan_Temperat...	Real	HM_Connectio...	PLC_1	"Scaling DB"."East Fan"."T		<symbolic access>	1 s
Scaling DB_West Fan_Diff Press...	Real	HM_Connectio...	PLC_1	"Scaling DB"."West Fan"."...		<symbolic access>	1 s
Scaling DB_West Fan_Temperat...	Real	HM_Connectio...	PLC_1	"Scaling DB"."West Fan"."...		<symbolic access>	1 s
Settings DB_East Fan Diff Press ...	Real	HM_Connectio...	PLC_1	"Settings DB"."East Fan Di		<symbolic access>	1 s
Settings DB_East Fan High Spee	Real	HM_Connectio...	PLC_1	"Settings DB"."East Fan Hi		<symbolic access>	1 s
Settings DB_East Fan Low Speed	Real	HM_Connectio...	PLC_1	"Settings DB"."East Fan L...		<symbolic access>	1 s
Settings DB_West Fan Diff Press...	Real	HM_Connectio...	PLC_1	"Settings DB"."West Fan D...		<symbolic access>	1 s
Settings DB_West Fan High Spe...	Real	HM_Connectio...	PLC_1	"Settings DB"."West Fan H...		<symbolic access>	1 s
Settings DB_West Fan Low Speed	Real	HM_Connectio...	PLC_1	"Settings DB"."West Fan L...		<symbolic access>	1 s
Spare AI100	Word	HM_Connectio...	PLC_1	"Spare AI100"		<symbolic access>	1 s
Spare AI102	Word	HM_Connectio...	PLC_1	"Spare AI102"		<symbolic access>	1 s
Spare I0.5	Bool	HM_Connectio...	PLC_1	"Spare I0.5"		<symbolic access>	1 s
Spare I0.6	Bool	HM_Connectio...	PLC_1	"Spare I0.6"		<symbolic access>	1 s
Spare I0.7	Bool	HM_Connectio...	PLC_1	"Spare I0.7"		<symbolic access>	1 s
Spare I1.0	Bool	HM_Connectio...	PLC_1	"Spare I1.0"		<symbolic access>	1 s
Spare I1.1	Bool	HM_Connectio...	PLC_1	"Spare I1.1"		<symbolic access>	1 s
Spare I1.2	Bool	HM_Connectio...	PLC_1	"Spare I1.2"		<symbolic access>	1 s
Spare I1.3	Bool	HM_Connectio...	PLC_1	"Spare I1.3"		<symbolic access>	1 s
Spare I1.4	Bool	HM_Connectio...	PLC_1	"Spare I1.4"		<symbolic access>	1 s
Spare I1.5	Bool	HM_Connectio...	PLC_1	"Spare I1.5"		<symbolic access>	1 s
Spare Q0.4	Bool	HM_Connectio...	PLC_1	"East Fan VSD Reset"		<symbolic access>	1 s
Spare Q0.5	Bool	HM_Connectio...	PLC_1	"West Fan VSD Reset"		<symbolic access>	1 s
Spare Q0.6	Bool	HM_Connectio...	PLC_1	"Spare Q0.6"		<symbolic access>	1 s
Spare Q0.7	Bool	HM_Connectio...	PLC_1	"Spare Q0.7"		<symbolic access>	1 s
Spare Q1.0	Bool	HM_Connectio...	PLC_1	"Spare Q1.0"		<symbolic access>	1 s
Spare Q1.1	Bool	HM_Connectio...	PLC_1	"Spare Q1.1"		<symbolic access>	1 s
Status DB_East Fan	Int	HM_Connectio...	PLC_1	"Status DB"."East Fan"		<symbolic access>	1 s
Status DB_West Fan	Int	HM_Connectio...	PLC_1	"Status DB"."West Fan"		<symbolic access>	1 s

Figure 68 - TIA Portal HMI Default Tags

Default tag table

Name	Data type	Connection	PLC name	PLC tag	Address	Access mode	Acquisition cycle
West Fan 2 DP	Word	HM_Connectio...	PLC_1	"West Fan DP"		<symbolic access>	1 s
West Fan Auto Mode	Bool	HM_Connectio...	PLC_1	"West Fan Auto Mode"		<symbolic access>	1 s
West Fan Filter Blocked	Bool	HM_Connectio...	PLC_1	"West Fan Filter Blocked"		<symbolic access>	1 s
West Fan Low SP	Bool	HM_Connectio...	PLC_1	"West Fan Hi SP"		<symbolic access>	1 s
West Fan Manual Mode	Bool	HM_Connectio...	PLC_1	"West Fan Manual Mode"		<symbolic access>	1 s
West Fan OK	Bool	HM_Connectio...	PLC_1	"West Fan OK"		<symbolic access>	1 s
West Fan Rem Estop	Bool	HM_Connectio...	PLC_1	"West Fan Rem Estop"		<symbolic access>	1 s
West Fan Run	Bool	HM_Connectio...	PLC_1	"West Fan Run"		<symbolic access>	1 s
West Room Stat	Word	HM_Connectio...	PLC_1	"West Room Stat"		<symbolic access>	1 s

Figure 69 - TIA Portal HMI Default Tags

Discrete alarms

ID	Name	Alarm text	Alarm class	Trigger tag	Trigge...	Trigger address	HMI acknowl...	HMI a...	HMI acknowl...
1	East Fan Room Ove...	East Fan Room Overtemp	Errors	Alarm Wor...	0	*Alarm Word ...	<No tag>	0	
2	West Fan Room Ov...	West Fan Room Overtemp	Errors	Alarm Word 1	1	*Alarm Word ...	<No tag>	0	
3	East Fan Filter Bloc...	East Fan Filter Blocked	Errors	Alarm Word 1	2	*Alarm Word ...	<No tag>	0	
4	West Fan Filter Bloc...	West Fan Filter Blocked	Errors	Alarm Word 1	3	*Alarm Word ...	<No tag>	0	
5	Spare M2001.4	Spare M2001.4	Errors	Alarm Word 1	4	*Alarm Word ...	<No tag>	0	
6	Spare M2001.5	Spare M2001.5	Errors	Alarm Word 1	5	*Alarm Word ...	<No tag>	0	
7	Spare M2001.6	Spare M2001.6	Errors	Alarm Word 1	6	*Alarm Word ...	<No tag>	0	
8	Spare M2001.7	Spare M2001.7	Errors	Alarm Word 1	7	*Alarm Word ...	<No tag>	0	
9	Emergency Stop	Emergency Stop	Errors	Alarm Word 1	8	*Alarm Word ...	<No tag>	0	
10	East Fan Tripped	East Fan Tripped	Errors	Alarm Word 1	9	*Alarm Word ...	<No tag>	0	
11	West Fan Tripped	West Fan Tripped	Errors	Alarm Word 1	10	*Alarm Word ...	<No tag>	0	
12	East Fan Remote E...	East Fan Remote Emergency Stop	Errors	Alarm Word 1	11	*Alarm Word ...	<No tag>	0	
13	West Fan Remote E...	West Fan Remote Emergency Stop	Errors	Alarm Word 1	12	*Alarm Word ...	<No tag>	0	
14	Spare M2000.5	Spare M2000.5	Errors	Alarm Word 1	13	*Alarm Word ...	<No tag>	0	
15	Spare M2000.6	Spare M2000.6	Errors	Alarm Word 1	14	*Alarm Word ...	<No tag>	0	
16	Spare M2000.7	Spare M2000.7	Errors	Alarm Word 1	15	*Alarm Word ...	<No tag>	0	
<Add new>									

Figure 70 - TIA Portal HMI Alarms

10.9. TIA Portal Project Simulation

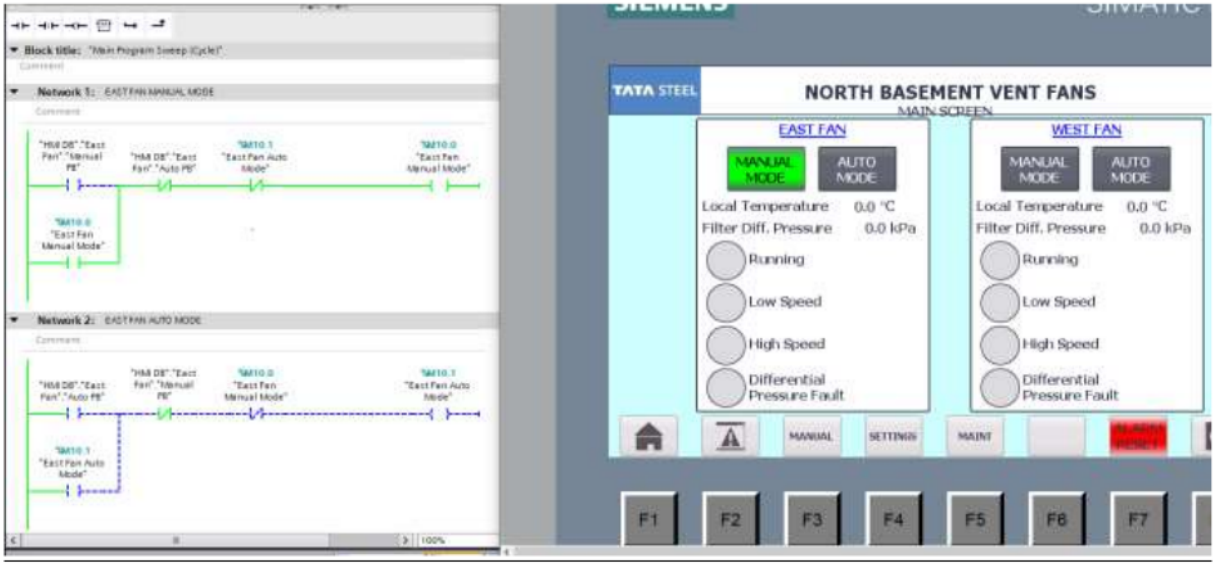


Figure 71 - TIA Portal East Fan Manual Mode Simulation

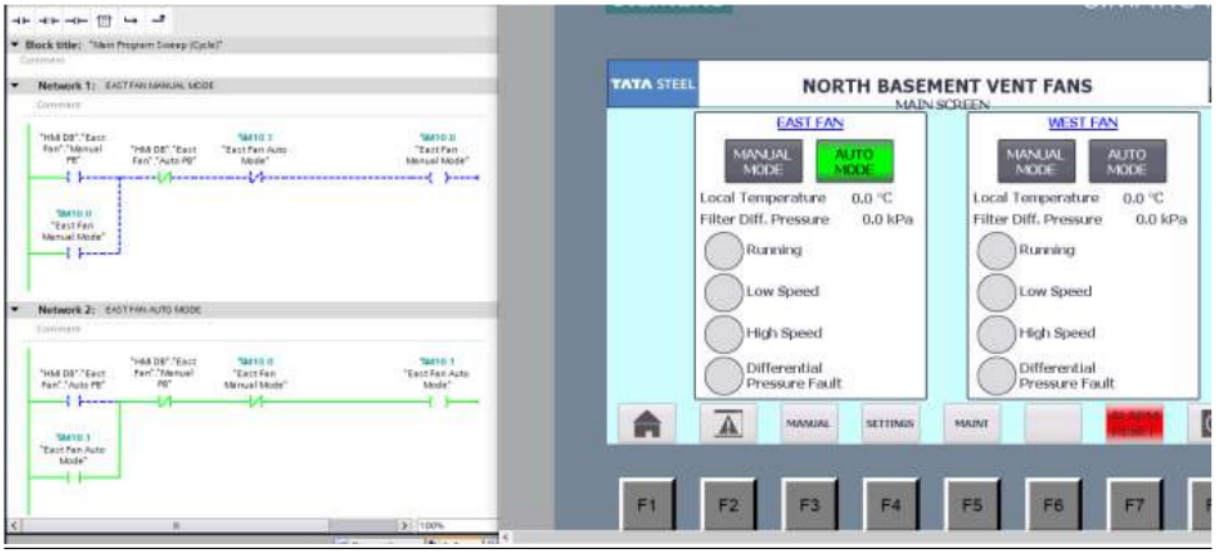


Figure 72 - TIA Portal East Fan Automatic Mode Simulation

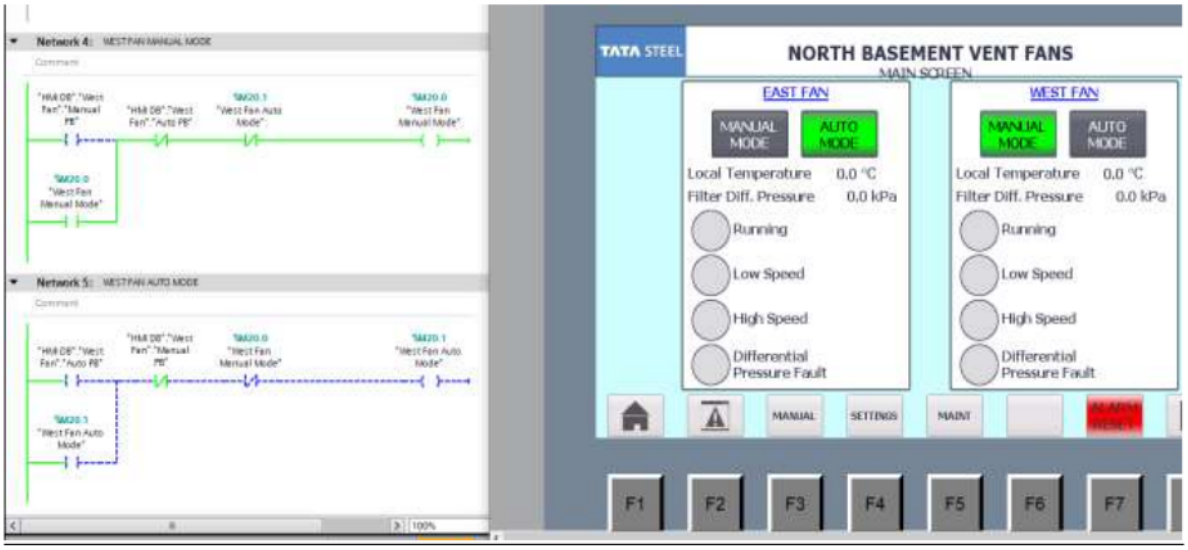


Figure 73 - TIA Portal West Fan Manual Mode Simulation

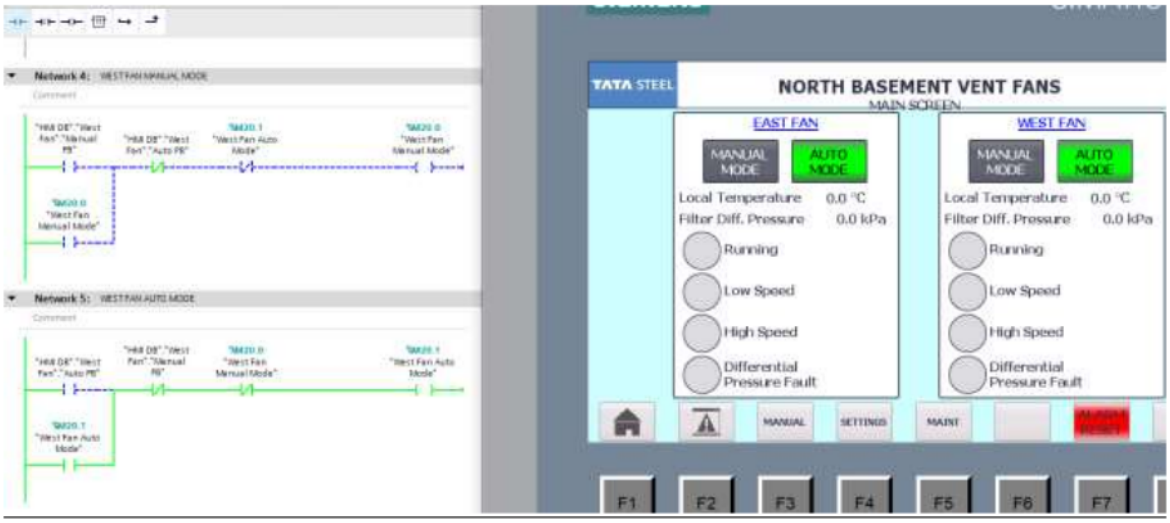


Figure 74 - TIA Portal West Fan Automatic Mode Simulation

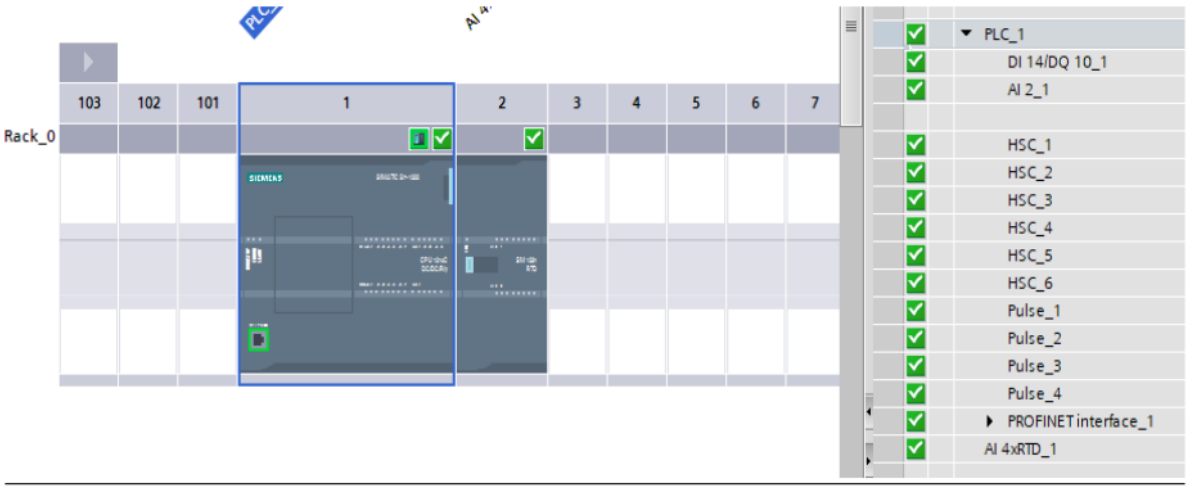


Figure 75 - TIA Portal Project Simulation



Figure 76 - TIA Portal Project Simulation VSD not healthy feedback.

Datasheets are not required in a report at this level. It would have been better to have extracted the information and cited the datasheet as a source.

10.10. Programming Component Data Sheet

Transmitter		Output 4 ... 20 mA	Output 0 ... 10 V
	Input		
	Measuring input	Pt100 (DIN EN 60751)	
	Probe current	≤ 0.5 mA	
	Measuring range	Permanent measurement due to analog signal path	
	Measuring circuit monitoring		
	Underrange	dropping to ≤ 3.6 mA	0 V
	Overrange	increasing to ÷ 22 mA ... < 28 mA (typical 24 mA)	increasing to ÷ 11 V... < 14 V (typical 12 V)
	Probe short-circuit	≤ 3.6 mA	0 V
	Probe and wire break	÷ 22 mA ... < 28 mA (typical 24 mA)	÷ 11 V... < 14 V (typical 12 V)
	Output		
	Output signal	load-independent direct current 4 ... 20 mA	Direct current 0 ... 10 V
	Transmission behavior	temperature linear	
	Transmission accuracy	≤ ± 0.1 %	≤ ± 0.2 %
	Damping of the residual ripple of a voltage supply of 24 V, amplitude 10 V/50 Hz, burden 470 Ω/Load 10MΩ	37 dB	40 dB
	Burden (Rb)	Rb = (Ub - 7.5 V) / 22 mA	-
	Burden influence	≤ ± 0.02 % / 100 Ω[1]	-
	Load/load influence	-	÷ 10 kΩ / ≤ ± 0.1 %
	Setting time for temperature changes	≤ 10 ms	
	Adjustment conditions	DC 24 V / approx. 22 °C	
	Calibration accuracy	≤ ± 0.2 %[1,2] or ≤ ± 0.2 K	
	Overall accuracy, probe/calibration	± 0.4 K (typical) at 20 °C / 24 V voltage supply	
	Voltage supply		
	Voltage supply (Ub)	DC 7.5 ... 30 V	DC 15 ... 30 V
	Reverse voltage protection	yes	
	Voltage supply influence	≤ ± 0.01 %/V deviation from 24 V[1]	
	Environmental influences		
	Operating temperature range	-40 ...+ 85 °C	
	Storage temperature range	-40 ... +100 °C	
	Temperature coefficient	≤ ± 0.01 %/K deviation from 22 °C[1]	
	Ambient conditions similar to DIN EN 60654 Kl. C1	relative humidity ≤ 95 % annual average, no condensation	
	EMC Interference emission/ resistance	EN 61326 class B/Industrial requirements	

1. All specifications referring to the measuring range limit value of 20mA. 2. The higher value is valid.

Figure 77 - PT100 RTD Sensor

(JUMO Instrument, 2011)

2 Specifications

2.1 General Specifications

Model		PSE550	PSE550-28
Rated Pressure range		0 to 2 kPa	
Operating pressure range		-50 to 50 kPa	
Extended Analogue output range		-0.2 to 0 kPa	-
Withstand pressure		65 kPa	
Applicable fluid		Air, inert gases and incombustible gases	
Power supply voltage		12 to 24 VDC ±10% (with 10% max. voltage ripple)	
Current consumption		15 mA or less	
Analogue output specification		Voltage output: 1 to 5 VDC (rated pressure range) 0.6 to 1 VDC (extended analogue output range) Output impedance: approx. 1 kΩ	Current output: 4 to 20 mA (rated differential pressure range) Maximum allowable load impedance: 500 Ω (at 24 VDC) 100 Ω (at 12 VDC)
Accuracy (at 25°C)		±1% F.S. (rated pressure range) ±3% F.S. (extended analogue output range)	
Linearity		±0.5% F.S.	
Repeatability		±0.3% F.S.	
Indicator light		Orange LED is ON when energized	
Environmental	Enclosure	IP40	
	Ambient temperature	Operation: 0 to 50°C Storage: -20 to 70°C (no condensation or freezing)	
	Ambient humidity	Operation, Storage: 35 to 85% RH (no condensation)	
	Withstand voltage	1000 VAC or more (50/60 Hz), 1 minute (between lead block and case)	
	Insulation resistance	50 MΩ or more at 500 VDC (between lead block and case)	
Temperature characteristics		±3% F.S. (at 25°C)	
Port size		ø4.8 (ø4.4 at the end) resin piping (suitable for ø4 I.D. air tubing)	
Material of parts in contact with fluid		Resin pipe: Nylon, Piston area of sensor: Silicon	
Weight with cable		75 g	
Weight without cable		35 g	

2.2 Cable Specification

Cable details	3 cores	2 cores
Wire cross section	0.15 mm²	
Insulator O/D	0.9 mm	
Sheath material	Oil resistant heavy-duty vinyl chloride	
Sheath outside dimension	2.7 x 3.2 mm	
Cable Length	3 m	

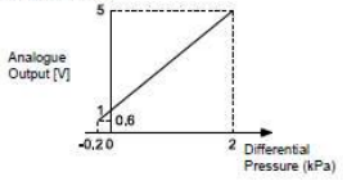
2.3 Specification when combined with PSE300 monitor

Setting pressure range		Differential pressure range
Rated pressure range		0 to 2 kPa
Set resolution		0.01 kPa
Switch	Repeatability	±0.4% F.S.
Analogue output	Linearity	±0.7% F.S.
	Accuracy (Display)	±1.5% F.S.
Accuracy (Operating temperature)		±1.5% F.S. ±1 digit
Temperature characteristic		±3.5% F.S. (25 °C standard)

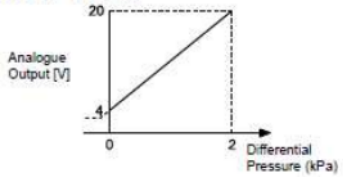
2 Specifications (continued)

2.4 Analogue Output

PSE550: 1 to 5 VDC



PSE550-28: 4 to 20 mA



3 Installation

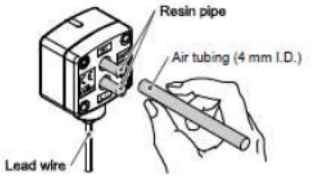
⚠ Warning

Do not install the product unless the safety instructions have been read and understood.

3.1 Piping

⚠ Caution

- Before piping make sure to clean up chips, cutting oil, dust etc.
- Install the piping correctly in a safe place away from water and dust.
- Cut the air tube perpendicularly.
- Grip the air tube and insert it into the resin pipe firmly by 8 mm or more from the end of the resin piping. The pulling force necessary for the piping inserted by 8 mm or more is approximate 25 N.
- Insert the air tube for low pressure to piping marked 'Lo' and the air tube for high pressure to piping marked 'Hi'.



3.2 Environment

⚠ Warning

- Do not use in an environment where corrosive gases, chemicals, salt water or steam are present.
- Do not use in an explosive atmosphere.
- Do not expose to direct sunlight. Use a suitable protective cover.
- Do not install in a location subject to vibration or impact in excess of

Figure 78 - Differential Pressure Sensor Data Sheet

(SMC Corporation, 2021)

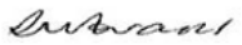
10.11. Factory Acceptance Test

Mathew,

Second ABB VSD Delivery 06/04/23.
As discussed, we can install at a later date.

We are available for FAT 23/02/23.
Does that date suit you?

Regards



RW Evans

Electechs Ltd
Tel: 01792775055
Fax: 01792 700035

Mobile: 07870619909
wayne@electechs.co.uk

From: Thomas, Mathew <Mathew.Thomas@tatasteeleurope.com>
Sent: 20 February 2023 09:05
To: Wayne Evans <Wayne@electechs.co.uk>
Subject: RE: Fan Drawings

Hi Wayne.

Following our recent conversation.

Have you been able to confirm the delivery date of the second VSD?
That date will determine if we push ahead or temporarily hold off.

Sorry to be a pain, but time is pushing on.

PBS Attached for the JMS.

Mathew Thomas
HV Engineering Services

Tata Steel
T: +44 (0)1554 712274 (ext: 2274)
M: +44 (0)7375 373417
E: mathew.thomas@tatasteeleurope.com
W: www.tatasteeleurope.com
A: Trostre Works, Trostre, Llanelli, Carmarthenshire, SA14 9SD

Figure 79 - Contractor Email Arranging FAT



Figure 80 - Project Panel FAT



Figure 81 - Project Panel FAT



Figure 82 - Project Panel FAT



Figure 83 - Project Panel FAT

10.12. Factory Acceptance Test Plan

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

Table 8 - FAT Test Plan - General

(Thomas, 2023)

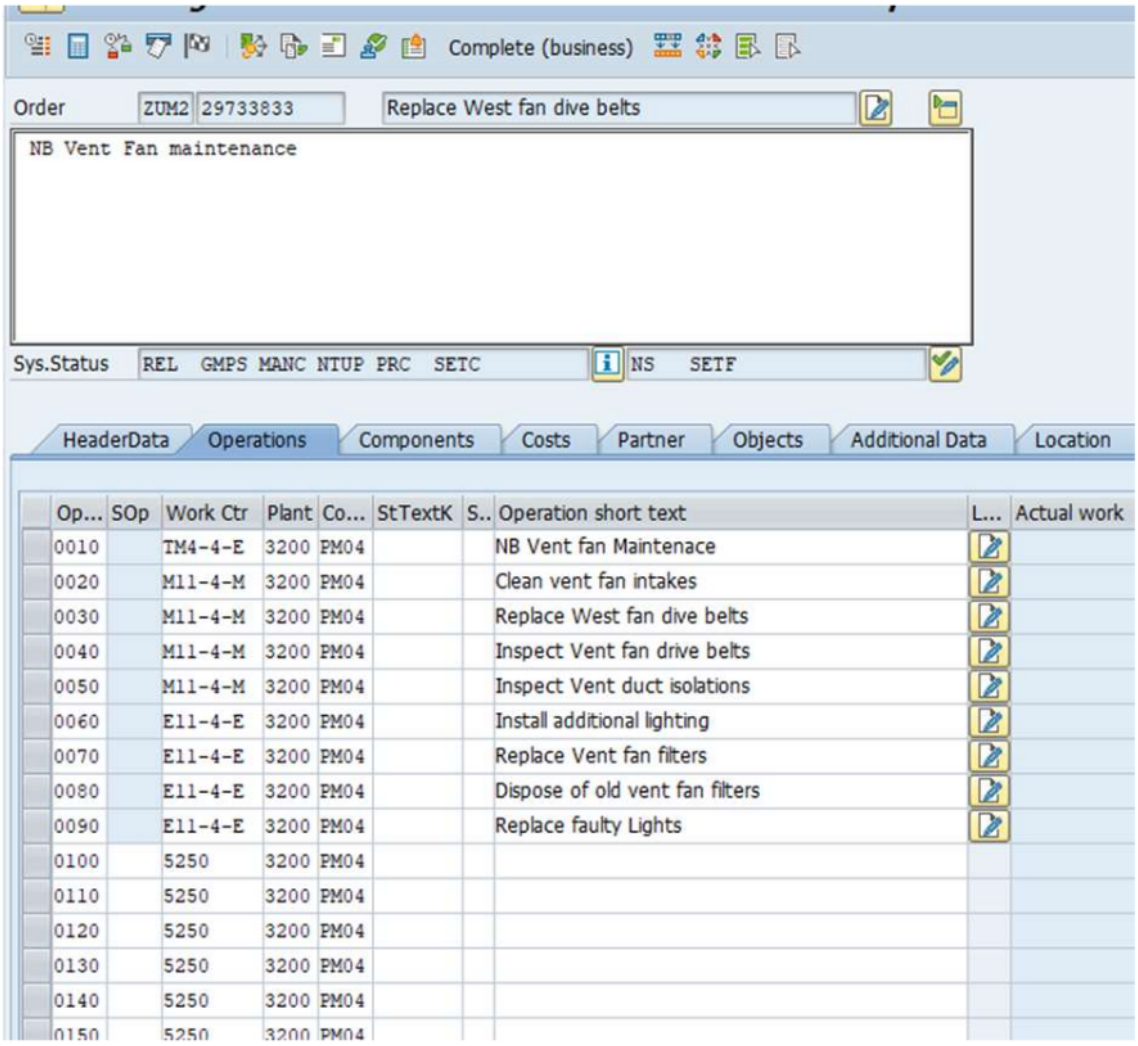
10.13. FAT Standards & Specifications

	Standards & Specifications	Relevance to Project	Citation
1	BS7671:2022 Requirements for Electrical Installations	Apply to design, erection, and verification of electrical installations, including additions and alterations to existing installations	(IET, 2022)
2	IEC60085 Electrical insulation:	Distinguishing between thermal classes of electrical insulation systems and electrical insulating materials. Establishes criteria for evaluating thermal endurance of electrical insulating materials	(iTeh,Inc, 2013)
3	BSEN 60529 Degree of Protection Provided by Enclosure	Providing adequate degree of protection against access to hazardous parts, protection of equipment against ingress of foreign objects	(British Standards Institution, 1992)
4	BSEN 13602 Copper & Alloys for conductors	Specifies composition, property requirements including electrical properties, and dimensional tolerances for drawn round copper wire. Manufacture of electrical conductors intended for production of bare and insulated cables and flexible	(European Standards, 2022)
5	BSEN 61439 Low Voltage Switchgear and Control Gear Assemblies:	Standard that low-voltage switchgear and motor control panels must be manufactured to	(Michael Smith Switchgear, 2022)
6	BSEN 60947 Low Voltage Switch Gear and Control Gear:	Applies to equipment with rated voltage not exceeding 1000VAC or 1500VDC	(BSI, 2021)

Table 9 - FAT Standards & Specifications

(Thomas, 2023)

10.14. Installation Maintenance



Op...	SOp	Work Ctr	Plant	Co...	StTextK	S..	Operation short text	L...	Actual work
0010		TM4-4-E	3200	PM04			NB Vent fan Maintenace		
0020		M11-4-M	3200	PM04			Clean vent fan intakes		
0030		M11-4-M	3200	PM04			Replace West fan dive belts		
0040		M11-4-M	3200	PM04			Inspect Vent fan drive belts		
0050		M11-4-M	3200	PM04			Inspect Vent duct isolations		
0060		E11-4-E	3200	PM04			Install additional lighting		
0070		E11-4-E	3200	PM04			Replace Vent fan filters		
0080		E11-4-E	3200	PM04			Dispose of old vent fan filters		
0090		E11-4-E	3200	PM04			Replace faulty Lights		
0100		5250	3200	PM04					
0110		5250	3200	PM04					
0120		5250	3200	PM04					
0130		5250	3200	PM04					
0140		5250	3200	PM04					
0150		5250	3200	PM04					

Figure 84 - SAP Maintenance Work



Figure 85 - Ventilation Duct Isolation Points



Figure 86 - Ventilation Filters & Drive Belt Replacements

10.15. Contractor Safety Documents & Communications

TATA

Pre Work Briefing Sheet (PBS)

PBS No : PB5030066
PO No : 4101112849
Job Owner : Mathew Thomas

PREPARATION, IDENTIFICATION OF HAZARDS AND CONTROLS		
1.	**Name of Company or Service Dept.**	Electechs
2.	**Contractors Serial No.**	2452111
3.	**Date From**	2023-02-20
4.	**Date To**	2023-03-06
5.	**Description of Work**	Installation of ventilation fan panel with associated cabling and containment.
6.	**Location of Work**	North Basement Substation
7.	**Establish the number of men employed on contract and level of supervision**	Up to 4 men
8.	**Name Sub-contractors to be used on the contract**	
9.	**Does this work involve COMAH substances and is it a safety critical task?**	N/A
10.	**Are there any job hazards? - PRECAUTIONS TO BE TAKEN**	
	Moving Machinery	No
	OH cranes & Gantry - working on or near	Yes Access and egress to and from substation. Designated foot paths/safe walkways to be used at all times, green walkways are safe walkways, red walkways are in crane flight path. Be alert for plant activity in area, general works traffic, use of maintenance vehicles, crane and fork trucks and delivery vehicle operations in area. Maintain 5M exclusion rule to all vehicles in operation. High vis to be worn at all times
	Lifting / Slinging	Yes Panel, Cable and Containment Installation - Manual handling regulations/guidelines to be followed. Where possible use lifting aids, all lifting aids to be load certified, fit for purpose, carry out pre use checks. All lifting equipment compliance certifications to be provided for all lifting equipment. Complete 1 min RA/POWRA prior to starting works
	Working at Height	Yes Correct PPE to be worn at all times, chin strap required with hard hat. Ensure handrails are present for working at height. Ladder/step ladder, complete pre use checks prior to use, ensure that they are in good working order and fit for purpose, maintain three points of contact, ladders are only to be used for access, not as a working platform. Complete 1 min RA/POWRA prior to starting works
	Work on Roof	No
	O.H. Work	Yes No work is permitted to take place under suspended loads or under mobile scaffold tower. Eye protection to be worn in basement at all times. Complete 1 min RA/POWRA prior to starting works
	Scaffolding	No
	Power Tools - Electric, Compressed Air and Gas	Yes Power Tools - All power tools to be 110v or battery, 240v power tools are not permitted. All tools to be PAT tested, in good working order and fit for purpose, carry out pre use inspections prior to use. HAVs register to be updated daily for power tool use. Correct PPE to be worn as required for power tools. Calibration/conformity certificated to be provided for specialist tools, such as hydraulic crimper, torque wrench. Complete 1 min RA/POWRA prior to starting works
	Jetting Operations	No
	Diesel Generator - fumes/location	No
	Traffic - Road/Rail/Plant/Cranes	Yes Road traffic - Care to be taken on site. High vis to be worn at all times, designated foot paths/safe walkways to be used. Give way to vehicles and cranes as crossings. Green walkways are safe walk ways, red walkways are in crane flight path.
	Electrical including High Voltage	Yes Tata engineer to provide isolations required, work is in substations in and around live equipment and apparatus. Limitation of access to be issued for work in substation. Tata engineer to test for dead at point of work, prior to any works on existing electrical infrastructure and provide required safety documentation (LV permit) Complete 1 min RA/POWRA prior to starting works
	Are there any live conductors within 2 metres of the working area	Yes - 240v DC exposed conductors. Area to be sectioned off appropriately. Limitation of access to be provided for substation access
	Pressure Systems - Steam/Gas/C.Air/Hydraulics	No
	Pipe Services	No
	Stored Energy	No
	Hot Work	Yes Any hot works required a hot works permit is to be provided by Tata engineer. All hot works rules are to be followed. Fire watcher to be present at point of work and for a minimum of 60 mins following completion of hot works. Fire extinguisher to present for all hot works. Work are to be clear of all flammable debris prior to hot work starting. All flamable debris that can not be removed are to be covered with fire blanket, all open ducts and trenches are to be covered/closed prior to starting hot works. Correct PPE to be worn for all hot works, flame resistant clothing required as minimum level of protection. Complete 1 min RA?POWRA prior to starting work
	Fire/Explosion	No
	Auto Fire Systems - Deluge/CO2	No
	Hazardous Substances	Yes Correct PPE also to be worn, RPE or dust mask. COSHH assessments to be provided for all hazardous substances. COSHH and MSDS assessments to be followed for all hazardous substances used. Complete 1 min RA?POWRA prior to starting work
	Chrome Work / Chemical Work	No
	Asbestos	No

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Figure 87 - Contractor Pre Briefing Sheet

Tata Steel Packaging
Trostre Works
Job Method Statement

Contractor:	Electechs Ltd
Order / Reference No:	PO 4101112849
PBS No.	PBS 030066
Exact Location	North Basement Substation
Brief description of work to be undertaken:	Installation of ventilation fan panel & cabling
Estimated Start & Finish Date:	06/03/23 - 17/03/23
Print Name of Contractor JMS	Wayne Evans
Signature of Contractor JMS Author:	
Position in company:	Project Engineer
Date:	07-02-23
Name of Working Party Leader:	Ryan Mead (07507676871)

TATA EMERGENCY TELEPHONE No 3333. 01554 712223 from mobile.
IN CASE OF MAJOR EMERGENCY GO TO ASSEMBLY POINTS 1, 2, 3 or 4 AND MAKE YOURSELF ACCOUNTABLE TO THE PERSON IN CHARGE.

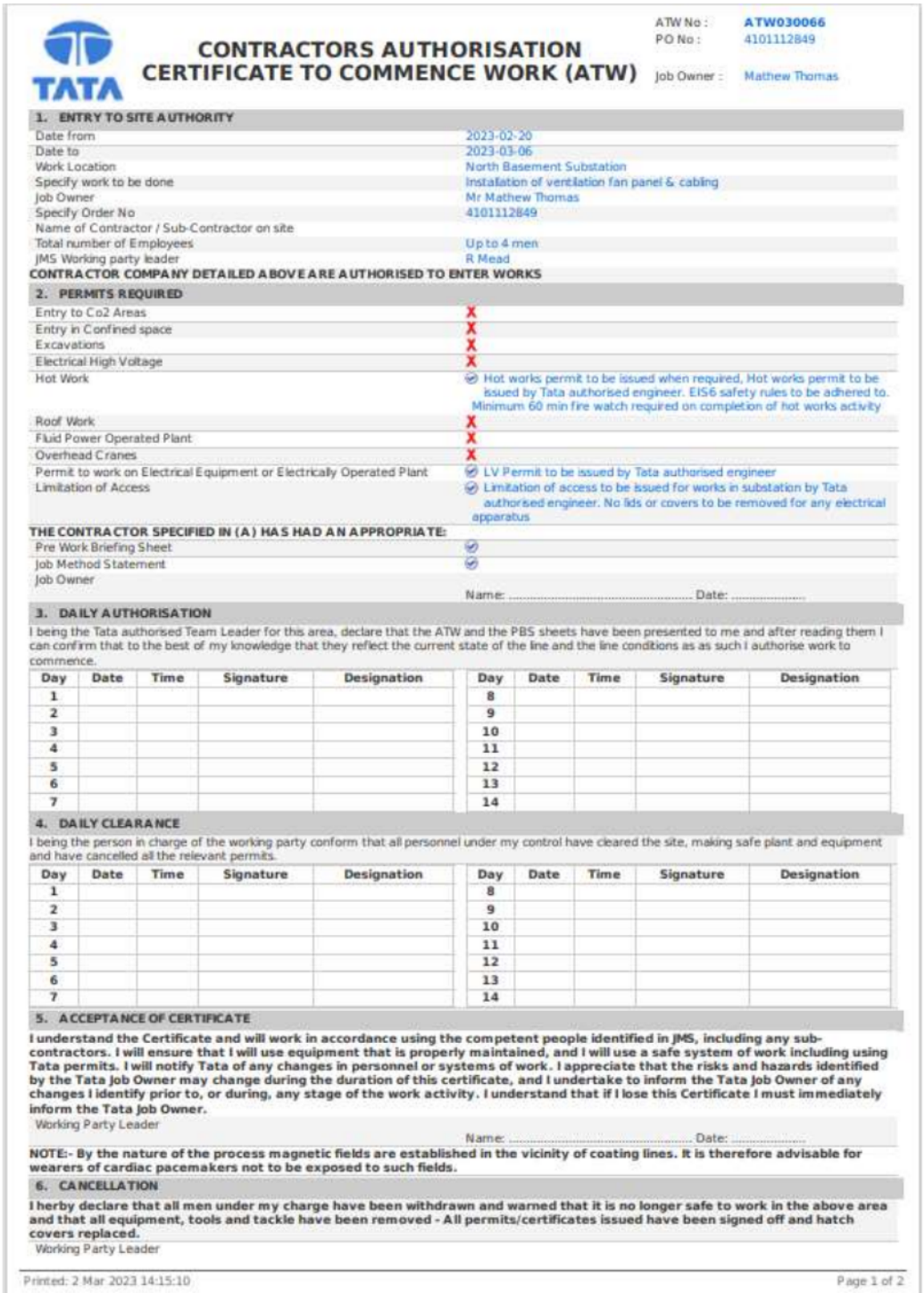
TSP Trostre requires contractors coming onto site to have thought in depth about the activities they are going to perform at Trostre, this will probably take the form of a Risk Assessment and will require dialog with the Tata Job Owner.

Please read this document carefully and complete all the relevant sections by typing or clicking in the grey boxes. The document has been designed specifically to be completed electronically, but can also be printed out and handwritten, by adding spaces in the relevant boxes then printing out.

Complete as accurately as possible making reference, where appropriate to Statutory Regulations, Tata Steel Packaging Site Regulations, Tata Steel Packaging Health and Safety Rules for Contractors and Standard Operating Procedures.

This document must be returned to TSP Job Owner together with your Tender

Figure 88 - Contractor Job Method Statement



TATA

CONTRACTORS AUTHORISATION CERTIFICATE TO COMMENCE WORK (ATW)

ATW No : **ATW030066**
PO No : 4101112849
Job Owner : Mathew Thomas

1. ENTRY TO SITE AUTHORITY

Date from	2023-02-20
Date to	2023-03-06
Work Location	North Basement Substation
Specify work to be done	Installation of ventilation fan panel & cabling
Job Owner	Mr Mathew Thomas
Specify Order No	4101112849
Name of Contractor / Sub-Contractor on site	
Total number of Employees	Up to 4 men
JMS Working party leader	R Mead

CONTRACTOR COMPANY DETAILED ABOVE ARE AUTHORISED TO ENTER WORKS

2. PERMITS REQUIRED

Entry to Co2 Areas	X
Entry in Confined space	X
Excavations	X
Electrical High Voltage	X
Hot Work	Hot works permit to be issued when required, Hot works permit to be issued by Tata authorised engineer. EIS6 safety rules to be adhered to. Minimum 60 min fire watch required on completion of hot works activity
Roof Work	X
Fluid Power Operated Plant	X
Overhead Cranes	X
Permit to work on Electrical Equipment or Electrically Operated Plant	LV Permit to be issued by Tata authorised engineer
Limitation of Access	Limitation of access to be issued for works in substation by Tata authorised engineer. No lids or covers to be removed for any electrical apparatus

THE CONTRACTOR SPECIFIED IN (A) HAS HAD AN APPROPRIATE:

Pre Work Briefing Sheet	✓
Job Method Statement	✓
Job Owner	Name: ..... Date: .....

3. DAILY AUTHORISATION

I being the Tata authorised Team Leader for this area, declare that the ATW and the PBS sheets have been presented to me and after reading them I can confirm that to the best of my knowledge that they reflect the current state of the line and the line conditions as as such I authorise work to commence.

Day	Date	Time	Signature	Designation	Day	Date	Time	Signature	Designation
1					8				
2					9				
3					10				
4					11				
5					12				
6					13				
7					14				

4. DAILY CLEARANCE

I being the person in charge of the working party conform that all personnel under my control have cleared the site, making safe plant and equipment and have cancelled all the relevant permits.

Day	Date	Time	Signature	Designation	Day	Date	Time	Signature	Designation
1					8				
2					9				
3					10				
4					11				
5					12				
6					13				
7					14				

5. ACCEPTANCE OF CERTIFICATE

I understand the Certificate and will work in accordance using the competent people identified in JMS, including any sub-contractors. I will ensure that I will use equipment that is properly maintained, and I will use a safe system of work including using Tata permits. I will notify Tata of any changes in personnel or systems of work. I appreciate that the risks and hazards identified by the Tata Job Owner may change during the duration of this certificate, and I undertake to inform the Tata Job Owner of any changes I identify prior to, or during, any stage of the work activity. I understand that if I lose this Certificate I must immediately inform the Tata Job Owner.

Working Party Leader

Name: ..... Date: .....

NOTE:- By the nature of the process magnetic fields are established in the vicinity of coating lines. It is therefore advisable for wearers of cardiac pacemakers not to be exposed to such fields.

6. CANCELLATION

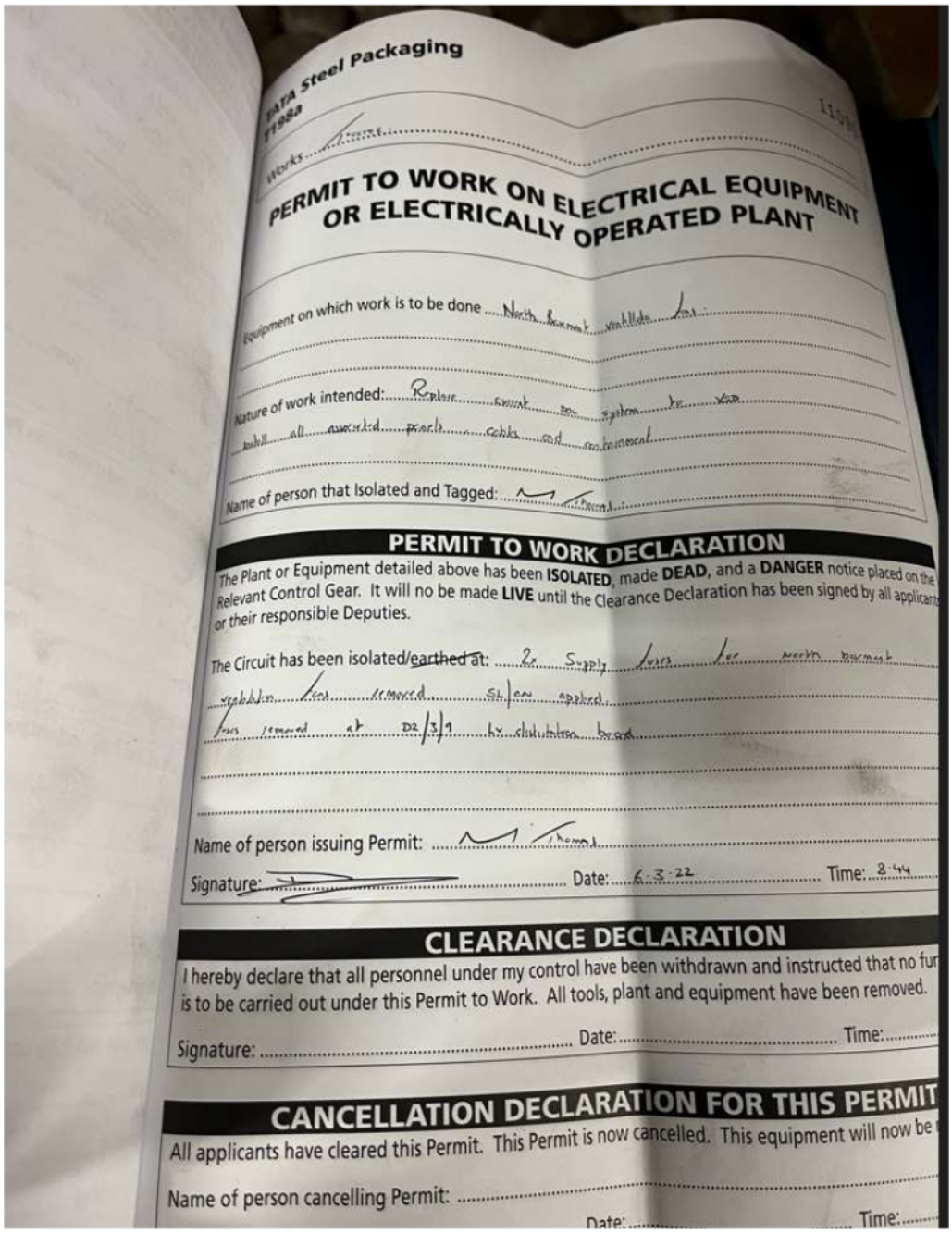
I herby declare that all men under my charge have been withdrawn and warned that it is no longer safe to work in the above area and that all equipment, tools and tackle have been removed - All permits/certificates issued have been signed off and hatch covers replaced.

Working Party Leader

Printed: 2 Mar 2023 14:15:10 Page 1 of 2

Figure 89 - Contractor Authorisation to Work

10.16. Project Implementation



TATA Steel Packaging
TT98a

Works ..... Issue .....

PERMIT TO WORK ON ELECTRICAL EQUIPMENT OR ELECTRICALLY OPERATED PLANT

Equipment on which work is to be done ..... North Barrack Wall Side Lights .....

Nature of work intended: ..... Replace ..... Cable ..... on ..... system ..... to ..... new .....
..... wall ..... all ..... wired ..... roof ..... lights ..... and ..... re-instated .....

Name of person that Isolated and Tagged: ..... [illegible] .....

PERMIT TO WORK DECLARATION

The Plant or Equipment detailed above has been **ISOLATED**, made **DEAD**, and a **DANGER** notice placed on the Relevant Control Gear. It will no be made **LIVE** until the Clearance Declaration has been signed by all applicants or their responsible Deputies.

The Circuit has been isolated/~~earthed~~ at: ..... 2x ..... Supply ..... wires ..... for ..... north ..... barrack .....
..... wall ..... wires ..... removed ..... Sign ..... applied .....
..... wires ..... removed ..... at ..... D2/3/1 ..... by ..... electrician ..... head .....

Name of person issuing Permit: ..... [illegible] .....

Signature: ..... Date: ..... 6.3.22 ..... Time: ..... 8.44 .....

CLEARANCE DECLARATION

I hereby declare that all personnel under my control have been withdrawn and instructed that no fur
is to be carried out under this Permit to Work. All tools, plant and equipment have been removed.

Signature: ..... Date: ..... Time: .....

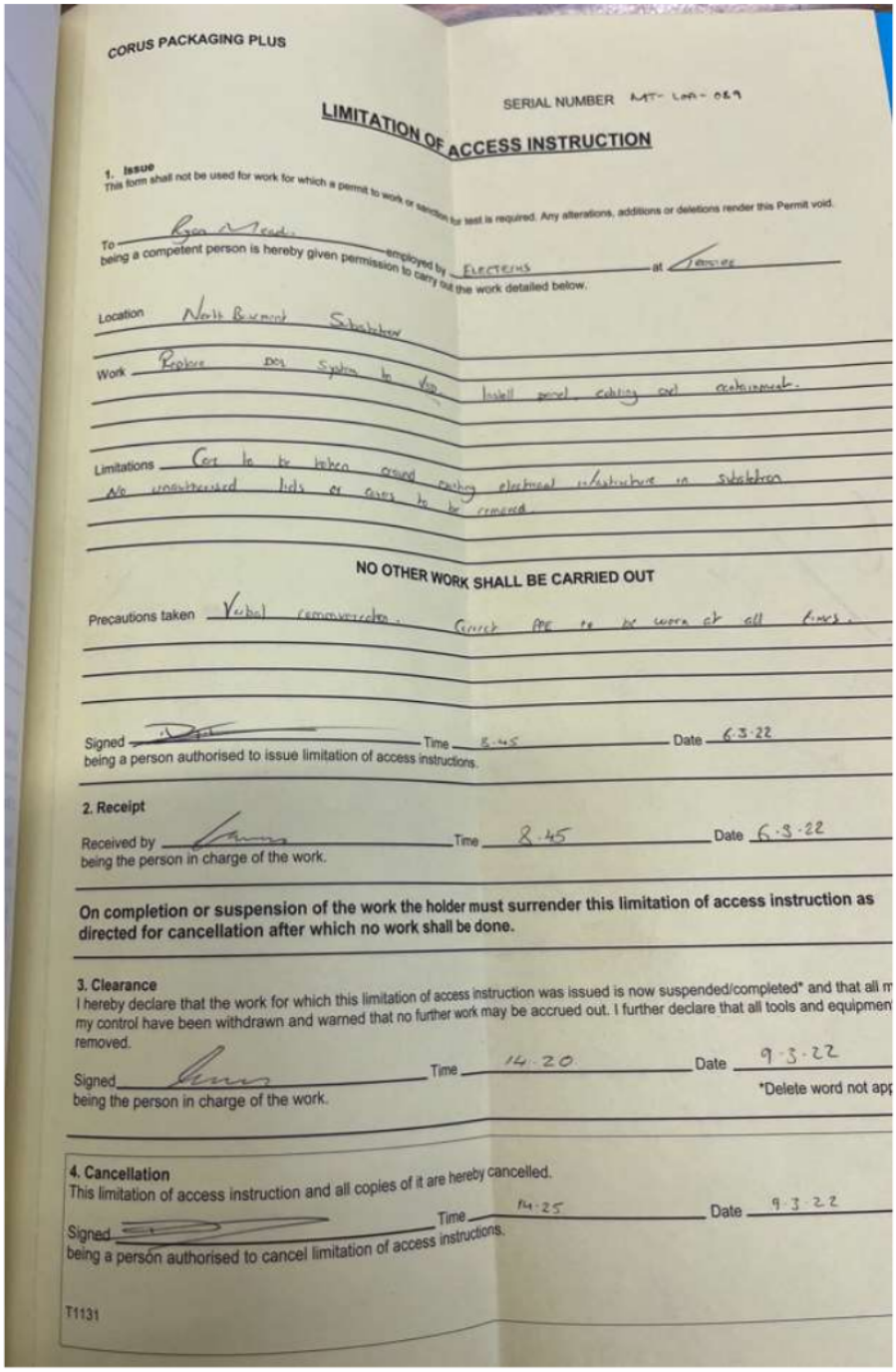
CANCELLATION DECLARATION FOR THIS PERMIT

All applicants have cleared this Permit. This Permit is now cancelled. This equipment will now be

Name of person cancelling Permit: .....

Date: ..... Time: .....

Figure 90 - Low Voltage Permit to Work



CORUS PACKAGING PLUS

SERIAL NUMBER MT- LOA- 089

LIMITATION OF ACCESS INSTRUCTION

1. Issue
This form shall not be used for work for which a permit to work or sanction for test is required. Any alterations, additions or deletions render this Permit void.

To Ryan Meade employed by Electrics at Tamworth
being a competent person is hereby given permission to carry out the work detailed below.

Location North Basement Substation

Work Replace dry system in Van. Install panel, cabling and containment.

Limitations Care to be taken around existing electrical infrastructure in substation
No unauthorised lifts or cages to be removed

NO OTHER WORK SHALL BE CARRIED OUT

Precautions taken Verbal communication. Correct PPE to be worn at all times.

Signed [signature] Time 8.45 Date 6.3.22
being a person authorised to issue limitation of access instructions.

2. Receipt

Received by [signature] Time 8.45 Date 6.3.22
being the person in charge of the work.

On completion or suspension of the work the holder must surrender this limitation of access instruction as directed for cancellation after which no work shall be done.

3. Clearance
I hereby declare that the work for which this limitation of access instruction was issued is now suspended/completed* and that all m
my control have been withdrawn and warned that no further work may be accrued out. I further declare that all tools and equipmen
removed.

Signed [signature] Time 14.20 Date 9.3.22
being the person in charge of the work. *Delete word not app

4. Cancellation
This limitation of access instruction and all copies of it are hereby cancelled.

Signed [signature] Time 14.25 Date 9.3.22
being a person authorised to cancel limitation of access instructions.

T1131

Figure 91 - Limitation of Access



Figure 92 - Installation Panel



Figure 93 - Installation Motor Local Isolators & Remote E Stop



Figure 94 - Installation PT100 & Remote E Stop



Figure 95 - Installation Pressure Sensors for Air Flow Indication



Figure 96 - Installation DB and Isolation

10.17. Contractor Project Modifications

To: Tata Steel Trostre

For the Attention of: Mr Mathew Thomas

From: Wayne Evans

Pages including this: 1

electechs Limited

Electrical, Control and Automation Engineers
Panel Manufacturers
Installation Contractors

Date: 7th March 2023

Quote ref. Q4107/WE

Subject: North Basement Vent Panel – Programming Socket Supply

Dear Mathew,

Thank you, for the enquiry regarding the above. I have pleasure in submitting the following quotation based on our site meeting dated Monday 6th March 2023.

Scope:

Supply & install SV single voltage 415V to 240V transformer 1kVA.
Supply and install DP MCB for transformer supply
Supply and install associated cabling, terminals etc.
Update project drawings as per requirement

Total Cost ex VAT £ 395.00

We trust we have interpreted your requirements correctly and hope to be favoured with your valued order, should you have any questions relating to this quotation, please feel free to contact the undersigned.

All prices subject to VAT

This quotation is valid for 30 days.

Yours faithfully

Figure 97 - Contractor Quote for Project Extras



Figure 98 - Project Alteration Transformer Addition

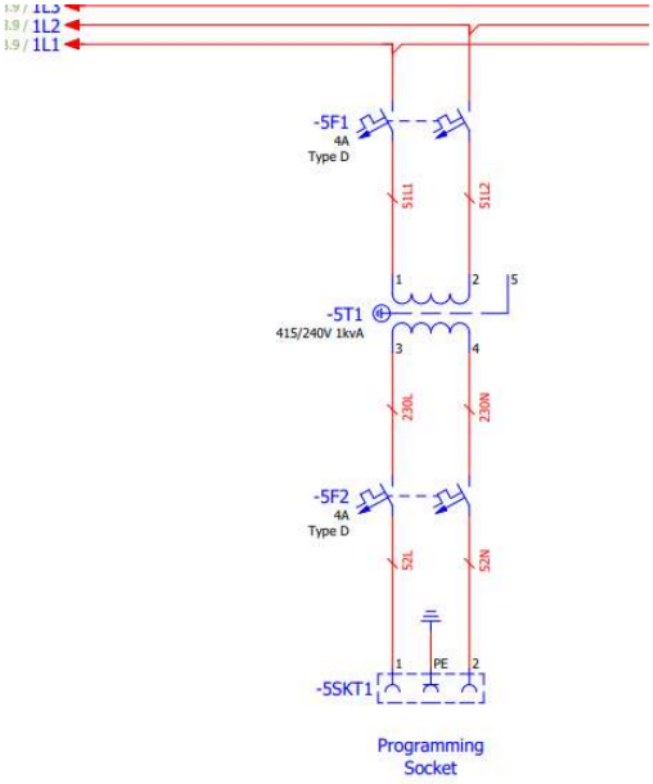


Figure 99 - Schematic alteration for Addition of Transformer

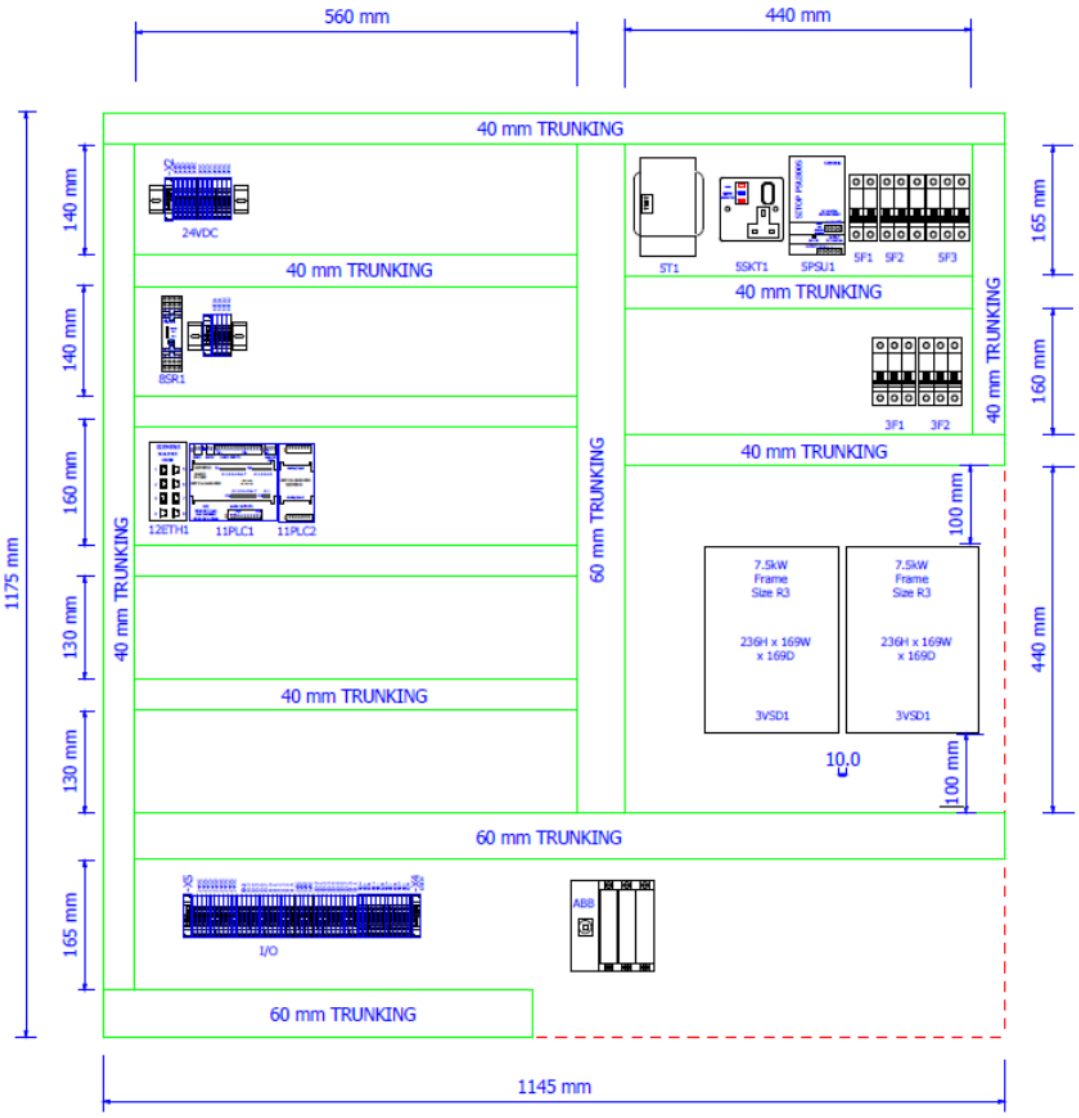


Figure 100 - Vent Panel Schematic Alteration

10.18. Site Acceptance Test Plan

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

Table 10 - SAT Test Plan – General

(Thomas, 2023)

10.19. SAT Standards & Specifications

	Standards & Specifications	Relevance to Project	Citation
1	BS7671:2022 Requirements for Electrical Installations	Apply to design, erection, and verification of electrical installations, including additions and alterations to existing installations	(IET, 2022)
2	IEC60085 Electrical insulation:	Distinguishing between thermal classes of electrical insulation systems and electrical insulating materials. Establishes criteria for evaluating thermal endurance of electrical insulating materials	(iTeh,Inc, 2013)
3	BSEN 60529 Degree of Protection Provided by Enclosure	Providing adequate degree of protection against access to hazardous parts, protection of equipment against ingress of foreign objects	(British Standards Institution, 1992)
4	BSEN 13602 Copper & Alloys for conductors	Specifies composition, property requirements including electrical properties, and dimensional tolerances for drawn round copper wire. Manufacture of electrical conductors intended for production of bare and insulated cables and flexible	(European Standards, 2022)
5	BSEN 61439 Low Voltage Switchgear and Control Gear Assemblies:	Standard that low-voltage switchgear and motor control panels must be manufactured to	(Michael Smith Switchgear, 2022)
6	BSEN 60947 Low Voltage Switch Gear and Control Gear:	Applies to equipment with rated voltage not exceeding 1000VAC or 1500VDC	(BSI, 2021)

Table 11 - SAT Standards & Specifications

(Thomas, 2023)

10.20. Project Commissioning

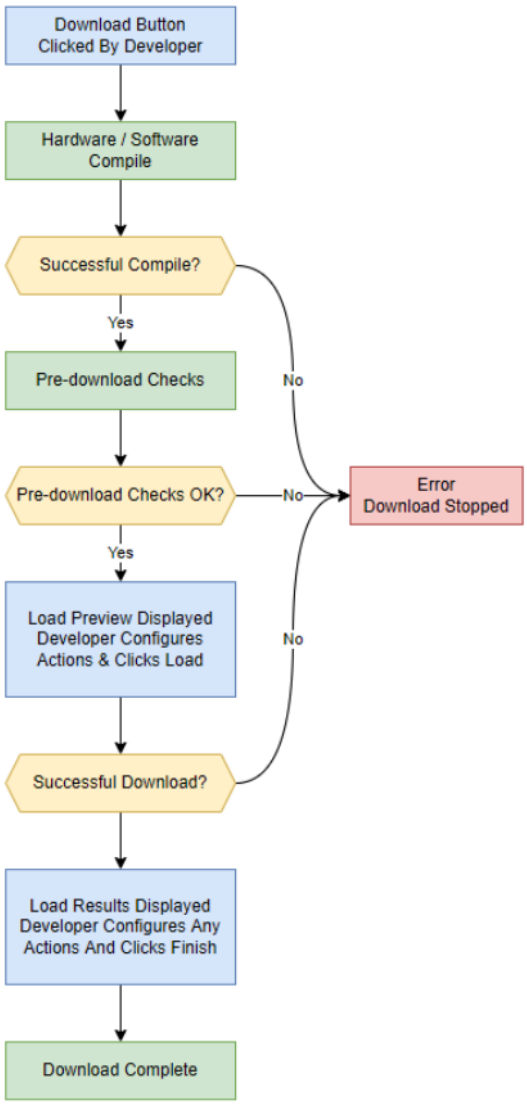


Figure 101 - PLC Download Sequence

(Bee, 2022)

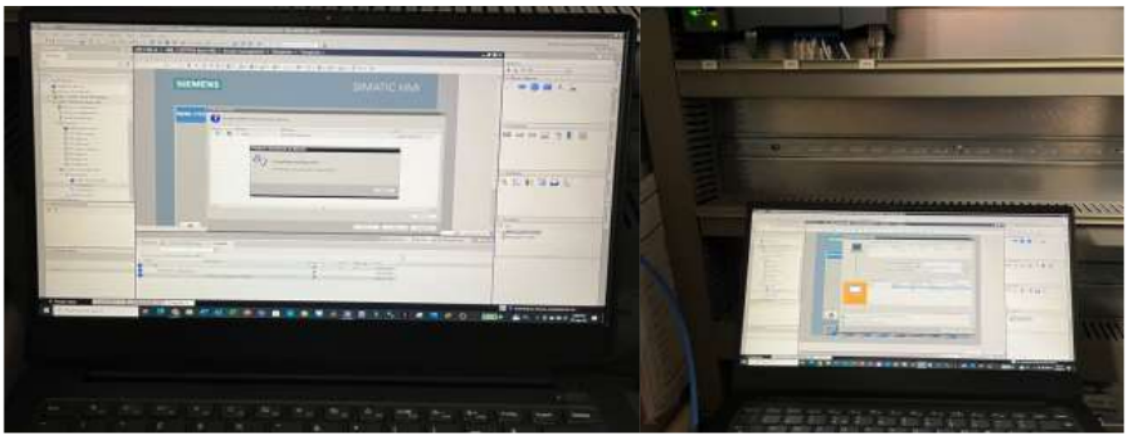


Figure 102 - Program Implementation



Figure 103 - Program Implementation

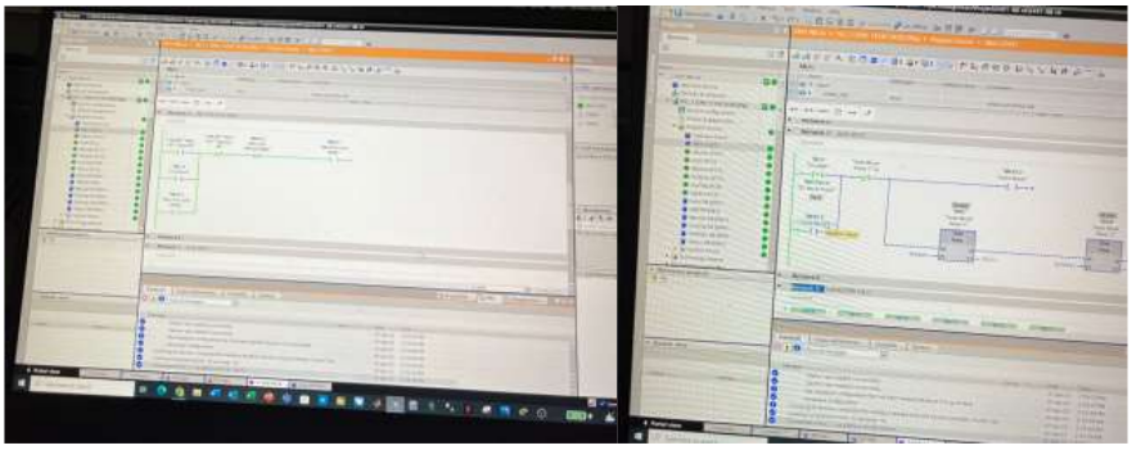


Figure 104 - Program Implementation

10.21. Variable Speed Drive Commissioning



Figure 105 - VSD Motor Parameter Settings



Figure 106 - VSD Motor Parameter Settings



Figure 107 - VSD Motor Parameter Settings

96.04 Macro select	1 = ABB standard	5 = AC500 Modbus RTU	12 = Alternate	13 = Motor potentiometer	14 = PID	28 = Torque control
22.71 Motor potentiometer function	0 = Disabled	0 = Disabled	0 = Disabled	1 = Enabled (init at power-up)	0 = Disabled	0 = Disabled
22.73 Motor potentiometer up source	0 = Not selected	0 = Not selected	0 = Not selected	4 = DI3	0 = Not selected	Not used
22.74 Motor potentiometer down source	0 = Not selected	0 = Not selected	0 = Not selected	5 = DI4	0 = Not selected	Not used
23.11 Ramp set selection	10 = DIO1	0 = Acc/Dec time 1	10 = DIO1	0 = Acc/Dec time 1	0 = Acc/Dec time 1	10 = DIO1
28.11 Ext1 frequency ref1	1 = AI1 scaled	8 = EFB ref1	1 = AI1 scaled	15 = Motor potentiomet	16 = PID	1 = AI1 scaled
28.15 Ext1 frequency ref2	0 = Zero	0 = Zero	0 = Zero	0 = Zero	0 = Zero	0 = Zero
28.22 Constant frequency sel1	4 = DI3	0 = Always off	4 = DI3	10 = DIO1	5 = DI4	4 = DI3
28.23 Constant frequency sel2	5 = DI4	0 = Always off	5 = DI4	0 = Always off	0 = Always off	5 = DI4
28.71 Freq ramp set	10 = DIO1	0 = Acc/Dec	10 = DIO1	0 = Acc/Dec	0 = Acc/Dec	0 = Acc/Dec

Figure 108 - ABB Macro Parameter Settings

(ABB, 2021)

No.	Name/Value	Description	Default FbEq 16
28.22	*Constant frequency sel1*	When bit 0 of parameter *28.21 Constant frequency function* is 0 (Separate), selects a source that activates constant frequency 1. **Note:** The default value depends on the selected macro. See chapter *Control macros* on page *31*. When bit 0 of parameter *28.21 Constant frequency function* is 1 (Packed), this parameter and parameters *28.23 Constant frequency sel2* and *28.24 Constant frequency sel3* select three sources whose states activate constant frequencies as follows:	*DI2*

Source defined by par. *28.22*	Source defined by par. *28.23*	Source defined by par. *28.24*	Constant frequency active
0	0	0	None
1	0	0	Constant frequency 1
0	1	0	Constant frequency 2
1	1	0	Constant frequency 3
0	0	1	Constant frequency 4
1	0	1	Constant frequency 5
0	1	1	Constant frequency 6
1	1	1	Constant frequency 7

Figure 109 - ABB Parameter Settings

(ABB, 2021)

28.23	*Constant frequency sel2*	When bit 0 of parameter *28.21 Constant frequency function* is 0 (Separate), selects a source that activates constant frequency 2. When bit 0 of parameter *28.21 Constant frequency function* is 1 (Packed), this parameter and parameters *28.22 Constant frequency sel1* and *28.24 Constant frequency sel3* select three sources that are used to activate constant frequencies. See table at parameter *28.22 Constant frequency sel1*. For the selections, see parameter *28.22 Constant frequency sel1*. **Note:** The default value depends on the selected macro. See *Control macros* on page *31*.	*Always off*

Figure 110 - ABB Parameter Settings

(ABB, 2021)

28.27	*Constant frequency 2*	Defines constant frequency 2.	10.00 Hz
	-500.00…500.00 Hz	Constant frequency 2.	See par. *46.02*
28.28	*Constant frequency 3*	Defines constant frequency 3.	15.00 Hz
	-500.00…500.00 Hz	Constant frequency 3.	See par. *46.02*

Figure 111 - ABB Parameter Settings

(ABB, 2021)



Figure 112 - ABB Drive Parameter Settings

10.22. Energy Costing

UK NO2

TABLE CHART

HOURLY DAILY WEEKLY MONTHLY YEARLY OCT 2022 GBP

GBP/MWh

	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Jan	182,80	80,26	35,72	60,84	49,80	52,86	36,32	39,31	47,16	48,65
Feb	161,94	54,42	30,62	50,18	51,15	49,19	33,37	42,94	44,81	51,14
Mar	250,41	57,04	31,69	44,30	57,03	41,92	34,23	40,45	44,07	60,24
Apr	176,78	66,36	24,18	43,55	50,70	41,07	33,48	44,11	41,29	51,96
May	124,81	74,39	22,17	41,36	53,29	41,11	34,40	40,46	39,50	48,26
Jun	159,55	78,24	26,49	39,70	53,94	37,88	37,30	41,36	36,72	47,37
Jul	242,72	93,52	29,45	41,05	56,87	40,82	37,53	42,04	35,42	48,53
Aug	370,28	106,83	36,28	38,15	60,59	42,43	35,57	40,62	37,82	46,85
Sep	270,71	189,11	43,78	36,20	66,47	45,98	45,63	41,55	42,96	48,94
Oct	119,25	179,32	43,39	36,87	64,31	45,70	49,26	40,23	44,25	47,35
Nov	-	185,01	44,01	44,43	61,94	50,24	59,71	37,63	47,29	52,24
Dec	-	244,69	54,98	39,11	62,63	54,79	48,44	34,82	44,14	50,37
	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013

Figure 113 - Company Electricity Prices per MWh

Average electricity cost per kWh to date for 2022,

$$\frac{182.80 + 161.94 + 250.41 + 176.78 + 124.81 + 159.55 + 242.72 + 370.28 + 270.71 + 119.25}{10}$$
$$= £205.968MWh$$

Equation 1 - Mean Electricity Cost per MWh

$$\frac{(205.968)}{1000} = £0.206/kWh$$

Equation 2 - Mean Electricity Cost per kWh

10.23. Commissioning Modifications

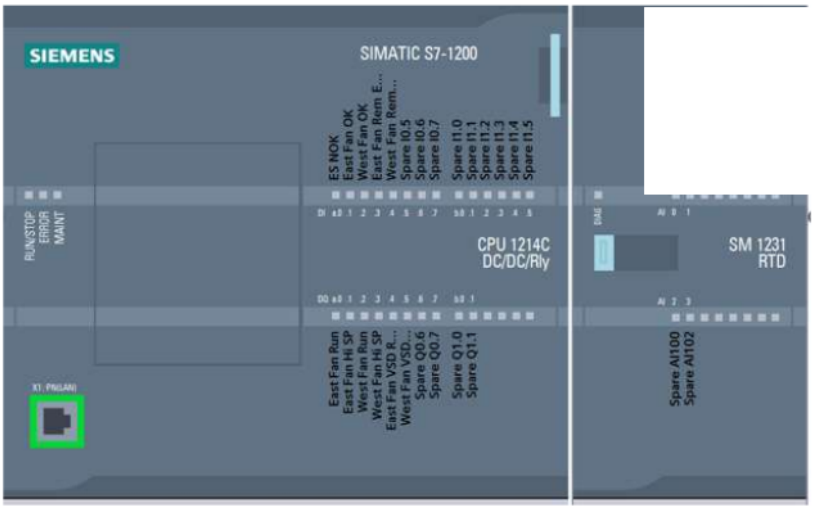


Figure 114 - TIA Portal Amended Device

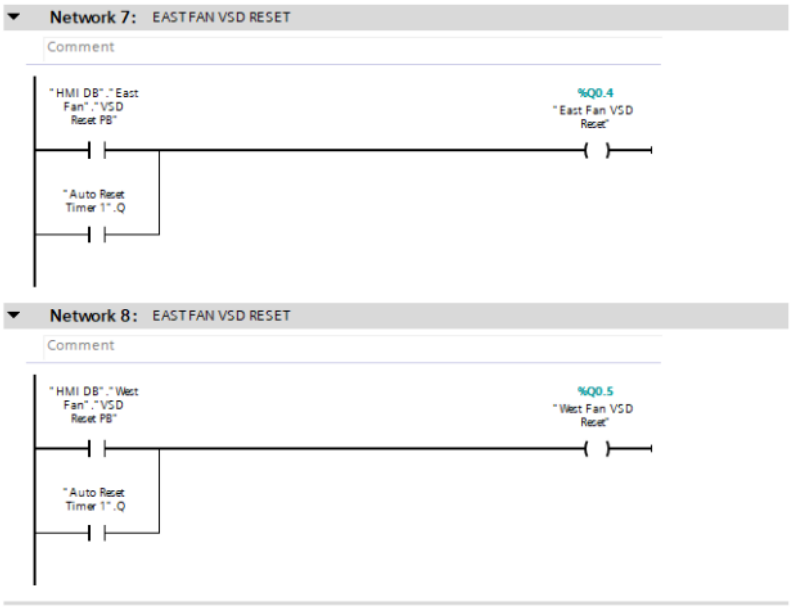


Figure 115 - TIA Portal Additional Function Call 2 - Outputs for VSD Reset Output



Figure 116 - TIA Portal Default Tag Addition

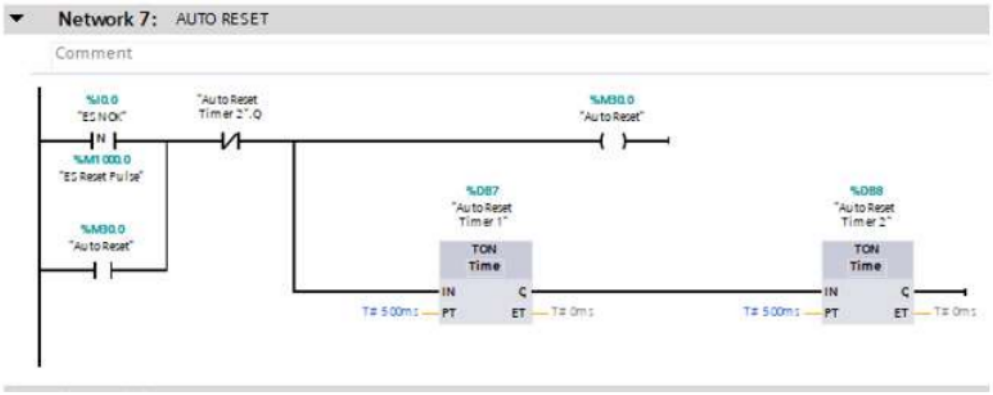


Figure 117 - TIA Portal Additional Function Call 2 - Timed delay for VSD STO Reset Output

31.11	*Fault reset selection*	Selects the source of an external fault reset signal. The signal resets the drive after a fault trip if the cause of the fault no longer exists. 0 -> 1 = Reset **Note:** A fault reset via FBA A and EFB MCW bit 7 is useful when the start stop signal is through DIs (parameter *20.01* or *20.06*) or from local control mode and the user wants a fault reset through the fieldbus. Whenever the remote control mode is in fieldbus (Start stop command and reference is through fieldbus), the fault can be reset from the fieldbus regardless of the selection of the parameter.	*Not used*
	Not used	Not used	0

Figure 118 - ABB Parameter Settings

(ABB, 2021)



Figure 119 - ABB Drive Parameter Additional Setting

10.24. Further Commissioning Modifications

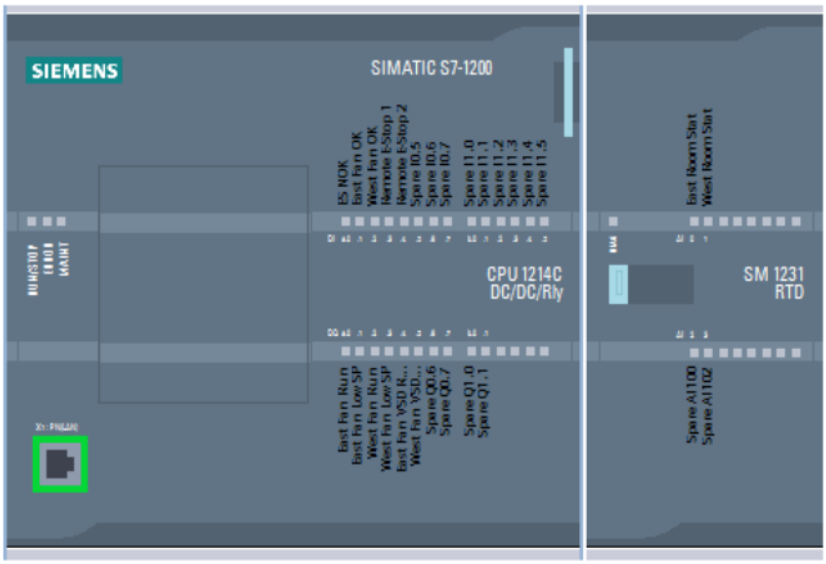


Figure 120 - TIA Portal Amended Device

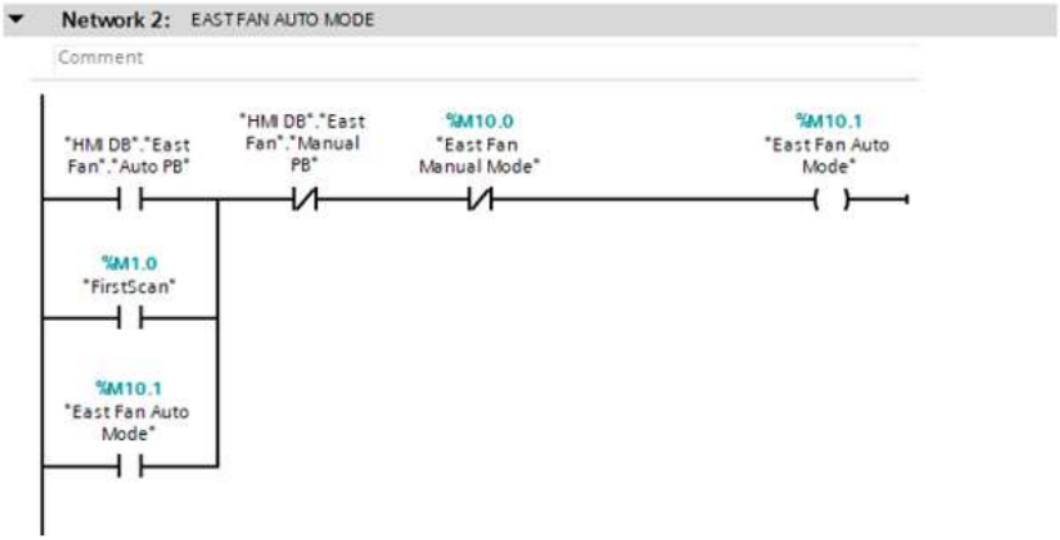


Figure 121 - TIA Portal East Fan First Scan Addition

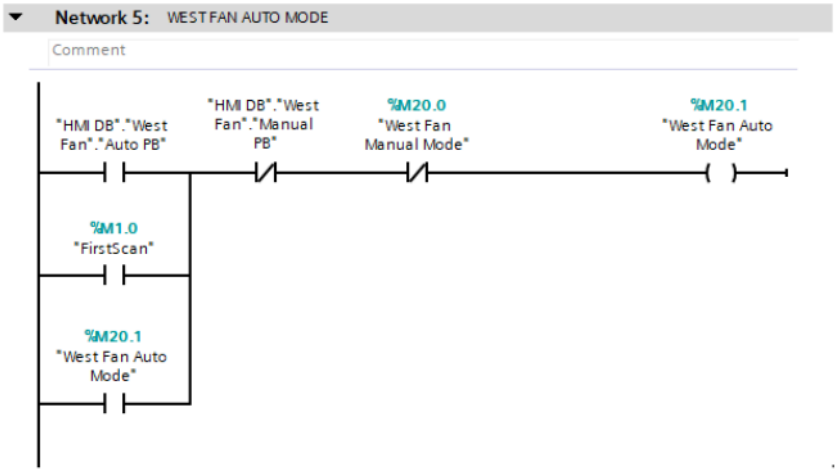


Figure 122 - TIA Portal West Fan First Scan Addition

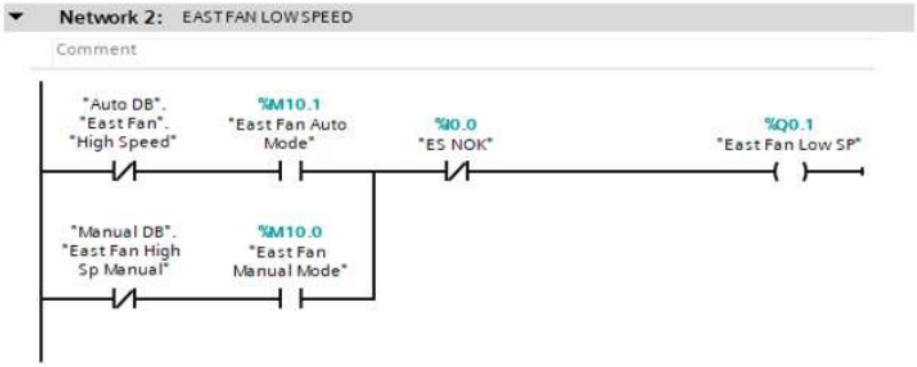


Figure 123 - TIA Portal Function Call 2 - Auto DB Changed to NC

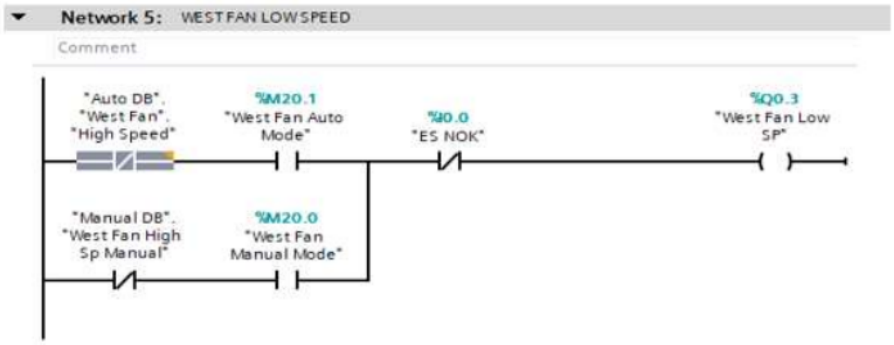


Figure 124 - TIA Portal Function Call 2 - Auto DB Changed to NC

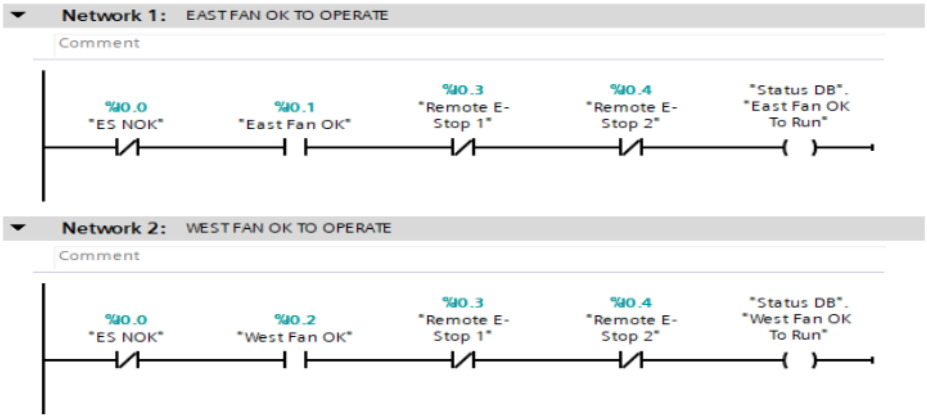


Figure 125 - TIA Portal Function Call 3 - Addition of NC Remote E-Stop

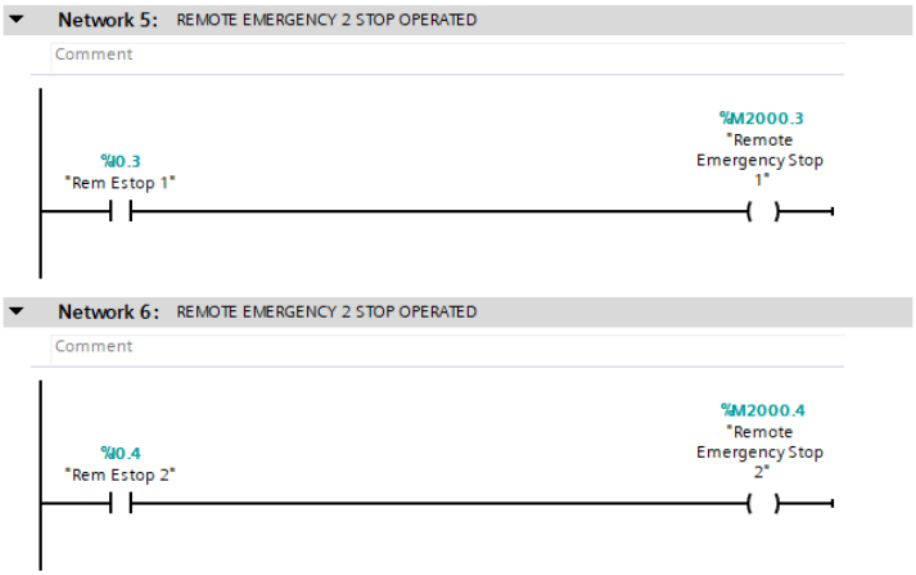


Figure 126 - TIA Portal Function Call 4 - E-Stop Tags Changed

18	Remote E-Stop 1	Default tag table	Bool	%I0.3					
19	Remote E-Stop 2	Default tag table	Bool	%I0.4					
47	Emergency Stop - Panel	Default tag table	Bool	%M2000.0					
48	East Fan Tripped	Default tag table	Bool	%M2000.1					
49	West Fan Tripped	Default tag table	Bool	%M2000.2					
50	Remote Emergency Stop 1	Default tag table	Bool	%M2000.3					
51	Remote Emergency Stop 2	Default tag table	Bool	%M2000.4					

Figure 127 - TIA Portal - Alteration to PLC Tag List



Figure 128 - TIA Portal HMI Maintenance Screen 1 Alteration

East Fan OK	Default tag table	Bool	HMI_Connectio...	PLC_1	"East Fan OK"
Remote E-Stop 1	Default tag table	Bool	HMI_Connectio...	PLC_1	"Remote E-Stop 1"
East Fan Run	Default tag table	Bool	HMI_Connectio...	PLC_1	"East Fan Run"
East Room Stat	Default tag table	Word	HMI_Connectio...	PLC_1	"East Room Stat"
West Fan Manual Mode	Default tag table	Bool	HMI_Connectio...	PLC_1	"West Fan Manual Mode"
West Fan OK	Default tag table	Bool	HMI_Connectio...	PLC_1	"West Fan OK"
Remote E-Stop 2	Default tag table	Bool	HMI_Connectio...	PLC_1	"Remote E-Stop 2"
West Fan Run	Default tag table	Bool	HMI_Connectio...	PLC_1	"West Fan Run"
West Room Stat	Default tag table	Word	HMI_Connectio...	PLC_1	"West Room Stat"

Figure 129 - TIA Portal - Alteration to HMI Tag List



Figure 130 - TIA Portal HMI Maintenance Screen 2 Alteration

10.25. Test Plan

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 higher than previous but within range. Supply voltage 251.5VAC	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 present on VSD	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. Power present on PLC PLC LED indications on.	Pass	
1.7	Main Isolator - Power ON	Power on Display/Indication	Supply energised. Power present on HMI	Pass	
1.8	Main Isolator - Power ON	No operation of Fans	Supply energised. No operation of fans	Pass	
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-Stops individually operated. Each operation shutdown installation.	Pass	

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	

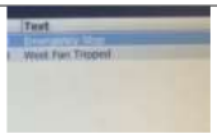
2.8	System Run - Simulate air flow reduction <70% for Intake 1	Indication requiring for intake 1 filter change	Intake air pressure increased, simulating blocked filters	Pass	
2.9	System Run - Simulate nominal air flow for intake 1	Indication for intake 1 filter change reset	Alarm indication on HMI indicating blocked filters.	Pass	
2.10	System Run - Simulate no air flow for Intake 1	Indication for belt failure for motor 1	Feature removed during design phase. Feature was not feasible with air pressure monitoring	N/A	N/A
2.11	System Run - Simulate nominal air flow for intake 1	Indication for motor 1 belt failure reset		N/A	N/A
2.12	System Run - Simulate air flow reduction <70% for Intake 2	Indication requiring for intake 2 filter change	VSD 2 is not currently in place. Delay on component	N/A	N/A
2.13	System Run - Simulate nominal air flow for intake 2	Indication for intake 2 filter change reset	VSD 2 is not currently in place. Delay on component	N/A	N/A
2.14	System Run - Simulate no air flow for Intake 2	Indication for belt failure for motor 2	Feature removed during design phase. Feature was not feasible with air pressure monitoring	N/A	N/A
	System Run - Simulate nominal air flow for intake 2	Indication for motor 2 belt failure reset		N/A	N/A
2.15	System Run - Fans on. Press Emergency Stop	System shutdown. No restart whilst E-Stop is active. E-Stop indication	E-Stops individually operated with system in operation. Each operation shutdown installation.	Pass	
2.17	Operation - Energy Consumption	Monitor operation to calculate energy average consumption. Compare with previous energy usage	System currently under observation. Energy saving and consumption in need of monitoring to determine usage.	Pass 31-3-23	Calculations from monitoring proved savings of £90.94 during a 5-day period.

Table 12 - Test Plan

(Thomas, 2023)

10.26. Standards & Specifications

	Standards & Specifications	Relevance to Project	Citation
1	BSEN ISO 13850 Emergency Stops	Emergency Stop Function to stop hazardous functions of machinery as quickly as possible, without creating further risks.	(GT Engineering, 2015)
2	BS 5801:2017 Industrial fans - performance testing:	Specifying procedures to determine performance of fans of all types	(BSI, 2017)
3	BSEN 61800 - Adjustable speed electrical power drive systems:	Applies to adjustable speed power drive systems, including means for control, protection, monitoring, and measurement of AC motors.	(IEC, 2021)
4	BSEN 50598 - Eco-design for power drive systems, motor starters, power electronics and their driven applications:	Specifies a process and requirements to implement environmentally conscious product design principles, to evaluate eco-design performance	(iTeh, Inc, 2015)
5	BSEN 60204-1:2018 - Safety of machinery - Electrical equipment of machines:	Requirements and recommendations relating to electrical equipment of machines in order to promote safety of people and property, consistency of control responses, and ease of operation and maintenance	(Procter Brothers, 2018)
6	BSEN 60034-1:2022 - Rotating electrical machines rating and performance:	Applicable to all rotating electrical machines	(European Standards, 2022)
7	BSEN 13849 Safety of Machinery. Safety-related parts of control systems.	Safety standard which applies to parts of machinery control systems that are assigned to providing safety functions	(BSI., 2022)

Table 13 - Project Standards & Specifications

(Thomas, 2023)

10.27. Project Conformities

Conformity Table				
Item	Observation	Description of Observation	Pass/Fail	Comments
General				
1.0	General	Potential hazards relevant to the electrical equipment assessed. Adequate risk reduction and or protective measures been put in place	Pass	
1.1	General	All components suitable for their intended use, conform to relevant IEC standards and been applied in accordance with the manufacturer's instructions.	Pass	Comply with BSEN 13849 Safety of Machinery. Safety-related parts of control systems
1.2	General	Equipment been designed to operate correctly with the conditions of the mains supply.	Pass	Installed equipment is suitable for intended supply.
1.3	General	Ambient temperature between +5°C and +40°C. Average temperature <35°C	Pass	Internal substation. Ambient temperature not expected to outside of range
1.4	General	Will the equipment/product be operated at a suitable temperature range (i.e., not above 70°C)	Pass	
1.5	General	Is the unit protected against the ingress of solid bodies and liquids? IP rating e.g., IP 54/55?	Pass	Comply to BSEN 60529 Degree of Protection Provided by Enclosure
1.6	General	Is the equipment protected against the effect of contaminants that it may be potentially exposed to such as dusts, oil laden environment etc.	Pass	Equipment suitably IP rated environment. No oil/airborne oil in substation
1.7	General	Is the equipment protected against vibration, shock, and bump effects?	Pass	All equipment suitably located

Table 14 - Project Conformities - General

(Procter Brothers, 2018) (Thomas, 2020)

Equipment				
Item	Observation	Description of Observation	Pass/Fail	Comments
2.0	Equipment	All the electrical equipment suitable for use	Pass	Complies with BSEN 61439 Low Voltage Switchgear and Control Gear Assemblies:
2.1	Equipment	Is the machine connected to a single power supply	Pass	Single point of supply from local DB
2.2	Equipment	Main supply to be terminated at the supply disconnecting device?	Pass	
2.3	Equipment	Are all mains connection terminals clearly marked	Pass	All cores clearly identified
2.4	Equipment	Is the external protective earthing terminal close to the assigned mains supply terminals	Pass	
2.5	Equipment	Does the external protective conductor have the correct Cross-Sectional Area	Pass	
2.6	Equipment	Has the external protective conductor terminal been identified with the letters PE	Pass	
2.7	Equipment	Have all other protective bonding terminals been identified by the preferred graphical symbol 604172-IEC-5019 or the letters PE or by use of Green / Yellow combination	Pass	All CPC's are Green/Yellow sheathed
2.8	Equipment	Does the supply-disconnecting device isolate the equipment from the supply and have one "ON" position marked "I" and one "OFF" position marked "O"	Pass	Complies with BSEN 60204-1:2018 - Safety of machinery - Electrical equipment of machines:
2.9	Equipment	Does the supply-disconnecting device have a means for locking in the OFF position	Pass	
2.10	Equipment	Does the supply-disconnecting device disconnect all live conductors from its power supply circuit	Pass	Disconnects from supply
2.11	Equipment	Is the disconnection device situated between 0.6m and 1.9m above floor level? 1.7M is recommended	Pass	
2.12	Equipment	Operates with a nominal supply voltage less than 1000VAC, 1500VDC.	Pass	Complies with BSEN 60947 Low Voltage Switch Gear and Control Gear. BSEN 60947 Low Voltage Switch Gear and Control Gear:

Table 15 - Project Conformities - Equipment

(Procter Brothers, 2018) (Thomas, 2020)

Protection Against Electric Shock & Protection of Equipment				
Item	Observation	Description of Observation	Pass/Fail	Comments
3.0	Protection Against Electric Shock & Protection of Equipment	Are live parts located inside an enclosure with controlled access by, appropriate persons, allowed only by means of a key or a tool.	Pass	Complies with BSEN 61439 Low Voltage Switchgear and Control Gear Assemblies:
3.1	Protection Against Electric Shock & Protection of Equipment	If a key or a tool is not required to gain access, is it possible to disconnect all live parts inside the enclosure before it is opened.	Pass	Door only opens when power is isolated, interlock in place
3.2	Protection Against Electric Shock & Protection of Equipment	If opening without the use of a key or tool and without disconnection of live parts is allowable, are all live parts protected by at least IP2X.	N/A	
3.3	Protection Against Electric Shock & Protection of Equipment	If live parts are protected by insulation, can the insulation only be removed by destroying it.	Pass	
3.4	Protection Against Electric Shock & Protection of Equipment	Is overcurrent protection provided where conductors and / or components are not rated for the potential overcurrent.	Pass	Suitably rated MCB's in situ
3.5	Protection Against Electric Shock & Protection of Equipment	Has overcurrent detection been applied to all live conductors?	Pass	Suitably rated MCB's in situ Complies with BS7671:2022 Requirements for Electrical Installations
3.6	Protection Against Electric Shock & Protection of Equipment	Are overcurrent protective devices located at the point where the conductor to be protected is connected to its supply?	Pass	
3.7	Protection Against Electric Shock & Protection of Equipment	Is there protection provided for mains failure or voltage reduction?	Pass	Mains failure. In programming. Manual reset required
3.8	Protection Against Electric Shock & Protection of Equipment	Has the automatic or unexpected restarting of the machine been prevented when the power is restored?	Pass	In programming. Manual reset required
3.9	Protection Against Electric Shock & Protection of Equipment	Is all protective bonding conductors' copper?	Pass	BSEN 13602 Copper & Alloys for conductors

3.10	Protection Against Electric Shock & Protection of Equipment	If conductive parts are removed for maintenance purposes, will the protective bonding circuit remain uninterrupted.	Pass	
3.11	Protection Against Electric Shock & Protection of Equipment	Are all bonding points free from mechanical, chemical or electromechanical damage and corrosion?	Pass	
3.12	Protection Against Electric Shock & Protection of Equipment	Are metal ducts and cable sheaths connected to the protective bonding circuit only and not used as protective conductors.	Pass	Complies with BS7671:2022 Requirements for Electrical Installations

Table 16 - Project Conformities - Protection Against Electric Shock & Protection of Equipment

(Procter Brothers, 2018) (Thomas, 2020)

Machine Mounted Control Devices				
Item	Observation	Description of Observation	Pass/Fail	Comments
4.0	Machine Mounted Control Devices	Are machine mounted control devices accessible for normal use.	Pass	Complies with BSEN 61439 Low Voltage Switchgear and Control Gear Assemblies:
4.1	Machine Mounted Control Devices	Are push buttons colour coded in accordance with BS EN 60204-1:2018	Pass	Correct EPO's used Complies with BSEN ISO 13850 Emergency Stops
4.2	Machine Mounted Control Devices	Are push buttons marked with the recommended IEC symbols in accordance with BS EN 60204-1:2018	Pass	Complies with BSEN 60204-1:2018 - Safety of machinery - Electrical equipment of machines
4.3	Machine Mounted Control Devices	Are indicators correctly coloured in accordance with BS EN 60204-1:2018	Pass	Complies with BSEN 60204-1:2018 - Safety of machinery - Electrical equipment of machines
4.4	Machine Mounted Control Devices	Have illuminated push buttons been colour coded in accordance with BS EN 60204.	Pass	Complies with BSEN 60204-1:2018 - Safety of machinery - Electrical equipment of machines:
4.5	Machine Mounted Control Devices	Are start devices mounted to minimise inadvertent operation.	Pass	
4.6	Machine Mounted Control Devices	Are emergency stop devices easily accessible.	Pass	3 easily accessible EPO's
4.7	Machine Mounted Control Devices	Are all emergency stop devices self-latching with positive operation?	Pass	All self-latching Complies with BSEN ISO 13850 Emergency Stops
4.8	Machine Mounted Control Devices	Is it possible to restore the emergency stop circuit only after the emergency stop device has been manually reset?	Pass	Complies with BSEN 13849 Safety of Machinery. Safety-related parts of control systems.
4.9	Machine Mounted Control Devices	Do the emergency stop devices have a red actuator with a yellow background.	Pass	
4.10	Machine Mounted Control Devices	Is it possible to restore the emergency switching off circuit only after the emergency switching off device has been manually reset?	Pass	Complies with BSEN 61800 - Adjustable speed electrical power drive systems

Table 17 - Project Conformities - Machine Mounted Control Devices

(Procter Brothers, 2018) (Thomas, 2020)

Cables & Conductors				
Item	Observation	Description of Observation	Pass/Fail	Comments
5.0	Cables & Conductors	Are conductors and cables suitable for operating conditions?	Pass	Complies with BS7671:2022 Requirements for Electrical Installations
5.1	Cables & Conductors	Do conductors have adequate current carrying capacity in accordance with BSEN 60204	Pass	Complies with BS7671:2022 Requirements for Electrical Installations
5.2	Cables & Conductors	Are all connections secured against accidental loosening, especially the protective grounding system?	Pass	All cables secured. Comply with BS7671:2022 Requirements for Electrical Installations
5.3	Cables & Conductors	Are terminals suitable for the cross-sectional area of the conductor being terminated.	Pass	Suitably rated cables in situ
5.4	Cables & Conductors	Does the installation of conductors and cables run from terminal to terminal without splices or joints?	Pass	Complies with IEC60085 Electrical insulation:
5.5	Cables & Conductors	Are terminations of cables supported to prevent mechanical stress on the conductors.	Pass	
5.6	Cables & Conductors	Are protective conductors readily distinguishable by shape, location, marking or colour.	Pass	
5.7	Cables & Conductors	Are other conductors identified by coloured stripes, number, alphanumeric or a combination.	Pass	
5.8	Cables & Conductors	Is wiring inside enclosures supported?	Pass	
5.9	Cables & Conductors	Is wiring outside of enclosures mechanically protected.	Pass	Complies with BS7671:2022 Requirements for Electrical Installations
5.10	Cables & Conductors	Are conductors and their connections external to the electrical enclosure enclosed in suitable ducts or of a type of cable able to withstand the duty required.	Pass	
5.11	Cables & Conductors	Are ducts and cable trays rigidly supported and positioned away from moving parts to prevent damage and wear.	Pass	
5.12	Cables & Conductors	Are connection boxes readily accessible for maintenance purposes?	Pass	
5.13	Cables & Conductors	Are connection boxes protected to the same IP rating as the machine.	Pass	Complies with BSEN 60529 Degree of Protection Provided by Enclosure
5.14	Cables & Conductors	Do motor connection boxes contain connections for the motor and motor mounted devices only.	Pass	

Table 18 - Project Conformities - Cables & Conductors

(Procter Brothers, 2018) (Thomas, 2020)

Motors & Associated Equipment				
Item	Observation	Description of Observation	Pass/Fail	Comments
6.0	Motors & Associated Equipment	Do electric motors conform to EN 60034-1?	Pass	Comply with BSEN 60034-1:2022 - Rotating electrical machines rating and performance:
6.1	Motors & Associated Equipment	Is the degree of protection provided by the motor at least IP23?	Pass	
6.2	Motors & Associated Equipment	Is the motor mounted so inspection, maintenance adjustment and alignment, lubrication and replacement is possible?	Pass	
6.3	Motors & Associated Equipment	Is the motor mounted so that proper cooling is ensured, and that the temperature rise remains within the limits of the insulation class?	Pass	Comply with BSEN 60034-1:2022 - Rotating electrical machines rating and performance:

Table 19 - Project Conformities - Motors & Associated Equipment

(Procter Brothers, 2018) (Thomas, 2020)

Markings and Warning Signs				
Item	Observation	Description of Observation	Pass/Fail	Comments
8.0	Markings and Warning Signs	Warning signs or labels are manufactured to be suitably durable to withstand the operating environment and remain legible throughout its intended working life.	Pass	Complies with BSEN 61439 Low Voltage Switchgear and Control Gear Assemblies:
8.1	Markings and Warning Signs	Has a nameplate been fitted to the machine detailing the following information : Supplier name, serial name, rated voltage? etc.	Pass	
8.2	Markings and Warning Signs	Have all enclosures, assemblies, control devices and components been plainly identified.	Pass	Complies with BSEN 60204-1:2018 - Safety of machinery - Electrical equipment of machines:
8.3	Markings and Warning Signs	Where it is not clear that an enclosure contains electrical devices, has an electrical warning been fitted.	Pass	

Table 20 - Project Conformities - Markings & Warning Signs

(Procter Brothers, 2018) (Thomas, 2020)

Technical Documentation				
Item	Observation	Description of Observation	Pass/Fail	Comments
9.0	Technical Documentation	Is technical documentation provided with each item and available.	Pass	
9.1	Technical Documentation	Is documentation provided for installation, operation, and maintenance.	Pass	O&M manual is still in process of being constructed
9.2	Technical Documentation	Does the technical information include a description of the equipment?	Pass	Complies with BSEN 60204-1:2018 - Safety of machinery - Electrical equipment of machines:
9.3	Technical Documentation	Does the technical information include electrical supply requirements?	Pass	BSEN 60204-1:2018 - Safety of machinery - Electrical equipment of machines:
9.4	Technical Documentation	Does the technical information include a system (block) diagram where appropriate?	Pass	
9.5	Technical Documentation	Does the technical information include a circuit diagram	Pass	Drawings provided
9.6	Technical Documentation	Does the technical information include information on programming	Pass	
9.7	Technical Documentation	Does the technical information include information on the sequence of operation	Pass	Programming provided
9.8	Technical Documentation	Does the technical information include information on frequency of inspection	N/A	Project ongoing, VSD to be installed to complete project
9.9	Technical Documentation	Does the technical information include information on the frequency and method of functional testing	N/A	Project ongoing, VSD to be installed to complete project
9.10	Technical Documentation	Does the technical information include instruction for adjustment, maintenance, and repair	N/A	Project ongoing, VSD to be installed to complete project
9.11	Technical Documentation	Does the technical information include a description of protective devices	Pass	
9.12	Technical Documentation	Does the technical information include an installation diagram giving all information necessary for setting up the machine and preparing for use	Pass	Drawings included
9.13	Technical Documentation	Does the technical information include current diagrams where required	Pass	Drawings included
9.14	Technical Documentation	Does the technical information include an operating manual	N/A	Project ongoing, VSD to be installed to complete project
9.15	Technical Documentation	Does the technical information include a maintenance manual detailing procedures for adjustment, servicing and preventative inspection and repair	N/A	Project ongoing, VSD to be installed to complete project
9.16	Technical Documentation	Does the technical information include testing and reports as per BSEN60204?	Pass	

Table 21 - Project Conformities - Technical Documentation

(Procter Brothers, 2018) (Thomas, 2020)

10.28. System Monitoring



Figure 131 - System Monitoring Power Quality Analyser

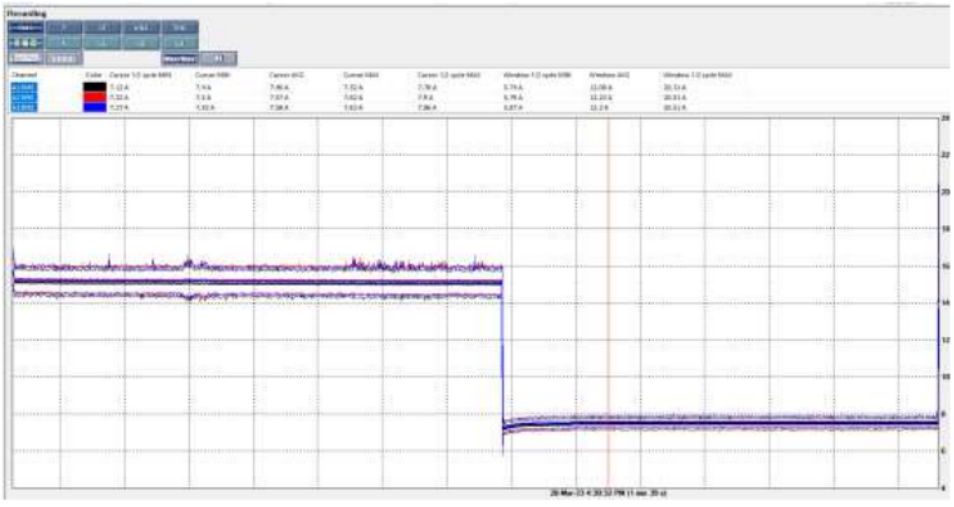


Figure 132 - System Monitoring Recorded Current Trend

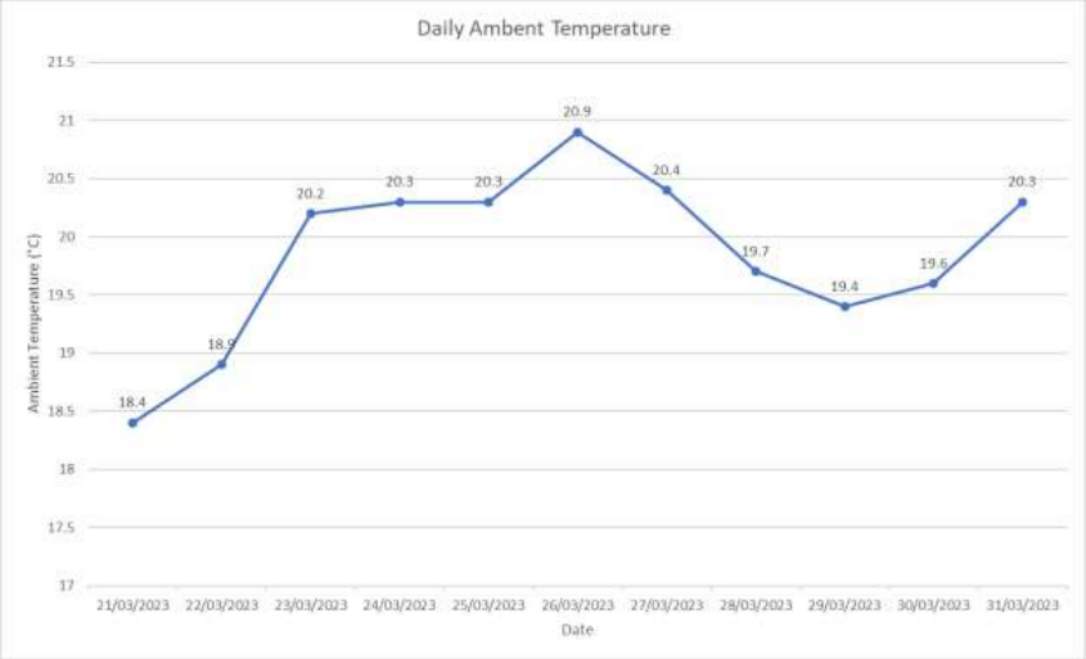


Figure 133 - System Monitoring - Daily Temperature

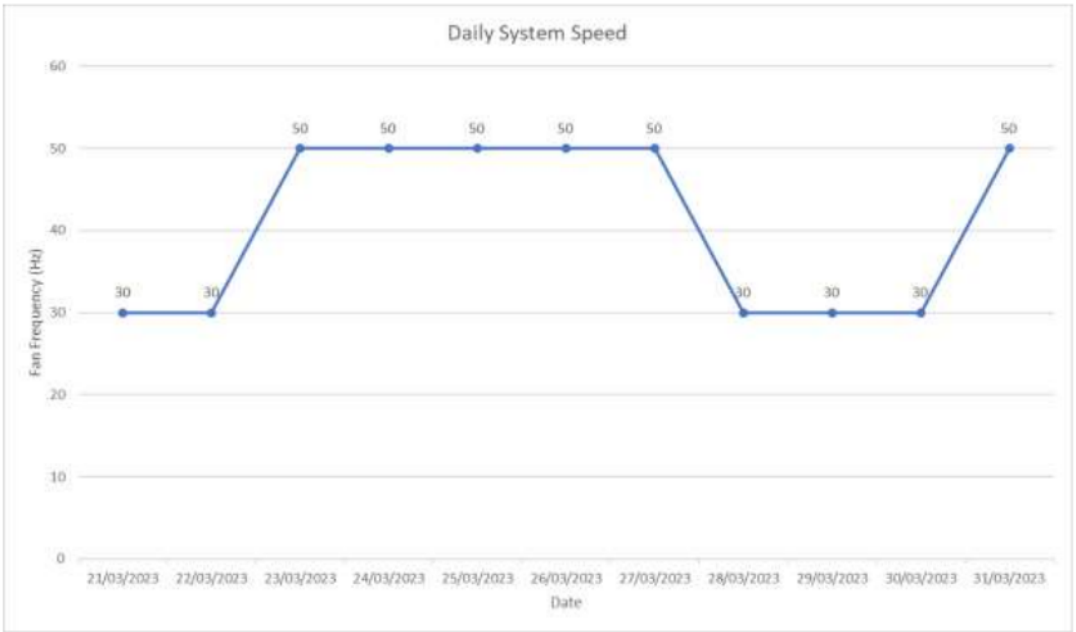


Figure 134 - System Monitoring - System Speed

Recorded Period - 94 Hours			
High Speed		Low Speed	
Recorded Period	19 Hours	Recorded Period	75 Hours
Voltage (V)	458.5	Voltage (V)	363.6
Current (A)	15.09	Current (A)	7.58
Efficiency (e)	0.82	Efficiency (e)	0.82
Mean £/KWh	0.206	Mean £/KWh	0.206

Table 22 - System Monitoring Recorded Data

$$\frac{I\ Line\ x\ VLine\ x\ \sqrt{3}\ x\ e}{1000} = kW = \frac{15.09\ x\ 458.5\ x\ \sqrt{3}\ x\ 0.82}{1000} = 9.83kW$$

Equation 3 - Motor High Speed Rating

$$\frac{I\ Line\ x\ VLine\ x\ \sqrt{3}\ x\ e}{1000} = kW = \frac{7.58\ x\ 363.6\ x\ \sqrt{3}\ x\ 0.82}{1000} = 3.91kW$$

Equation 4 - Motor Low Speed Rating

$$Calculated\ kW\ x\ £/kWh = 9.83kW\ x\ £0.206 = £2.03WH$$

Equation 5 - High Speed Hourly Cost

$$Calculated\ kW\ x\ £/kWh = 3.91kW\ x\ £0.206 = £0.82kWHh$$

Equation 6 - Low Speed Hourly Cost

$$High\ speed\ calculated\ cost/recorded\ period = 2.03\ x\ 19 = £38.38$$

Equation 7 - Recorded Period High Speed Cost

$$High\ speed\ calculated\ KW/recorded\ period = 9.83\ x\ 19 = 186.77Kw$$

Equation 8 - Recorded Period High Speed Energy

$$Low\ speed\ calculated\ cost/recorded\ period = 0.82\ x\ 75 = £61.50$$

Equation 9 - Recorded Period Low Speed Cost

$$Low\ speed\ calculated\ KW/recorded\ period = 3.91\ x\ 75 = 293.25Kw$$

Equation 10 - Recorded Period High Speed Energy

$$Recorded\ Period\ Calculated\ costs = £38.38 + £61.50 = £99.88$$

Equation 11 - Recorded Period Combined Speed Cost

$$Recorded\ Period\ Calculated\ Energy = 186.77 + 293.25 = 480.02Kw$$

Equation 12 - Recorded Period Combined Speed Cost

$$Recorded\ Period\ Maximum\ Calculated\ Energy = 9.83Kw\ x\ 94 = 924.02Kw$$

Equation 13 - Recorded Period Maximum Energy Consumption

$$\text{Maximum High speed calculated cost/recorded period} = 2.03\ \text{x}\ 94 = £190.82$$

Equation 14 - Recorded Period Maximum Operation Cost

$$\text{Energy savings provided} = 924.02\text{Kw} - 480.02\text{Kw} = 444\text{Kw}$$

Equation 15 - Calculated Energy Savings Provided

$$\text{Financial savings } provided = £190.82 - £99.88 = £90.94$$

Equation 16 - Calculated Financial Savings Provided

Recorded Period - 94 Hours			
Max Energy Consumption - (No Control applied)	924.02KW	Saving Provided	N/A
Max Operation Cost - (No Control applied)	£189.92	Saving Provided	N/A
Calculated Operation Consumption	480.02Kw	Calculated Operation Consumption	51.9%
Calculated Operation Costs	£99.88	Calculated Operation Costs Saved	52.6%
Calculated Energy Savings Provided	444KW	Calculated Energy Savings	48.1%
Calculated Cost Savings Provided	£90.04	Calculated Cost Savings Provided	47.4%

Table 23 - System Monitoring Calculated Savings



Figure 135 - VSD Calculated Energy Savings

10.29. Project Drawing Modifications

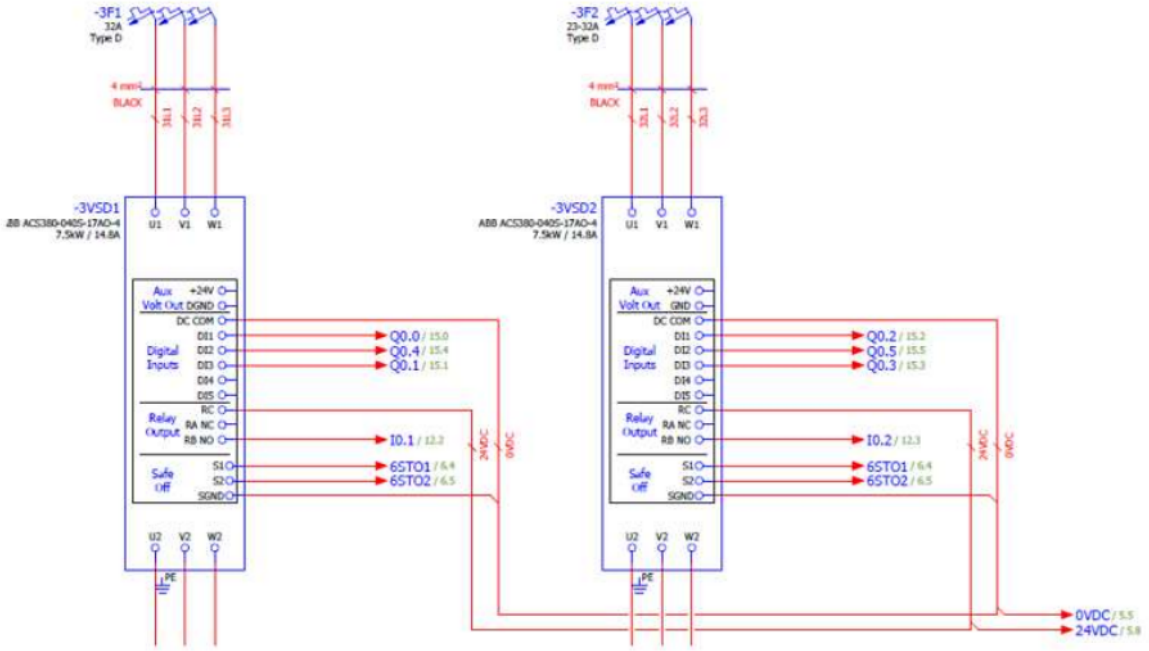


Figure 136 - Drawing Modification Additional Drive Inputs & Parameters

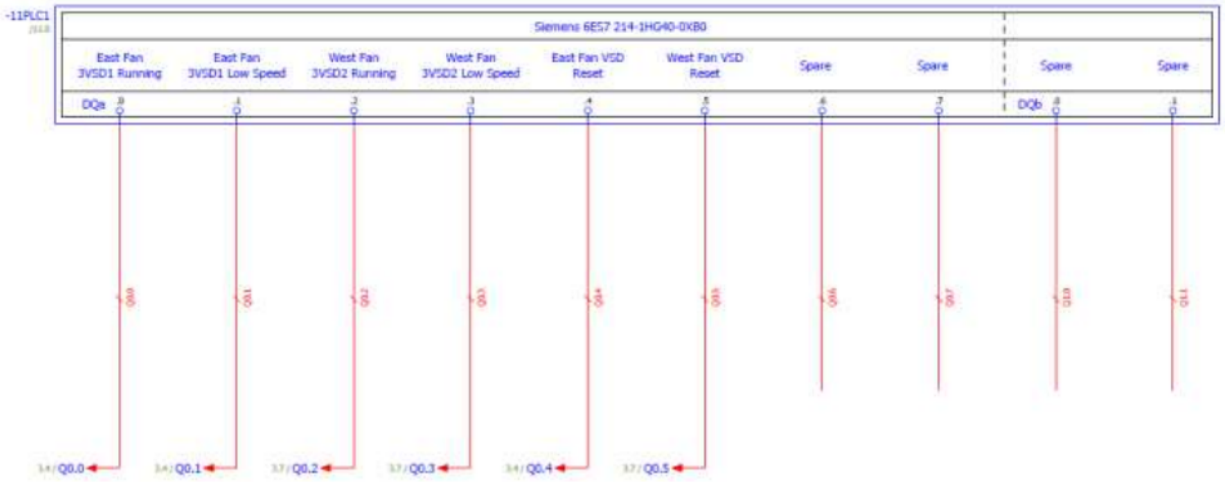


Figure 137 - Drawing Modification Additional PLC Output

10.30. Projected Gantt Chart

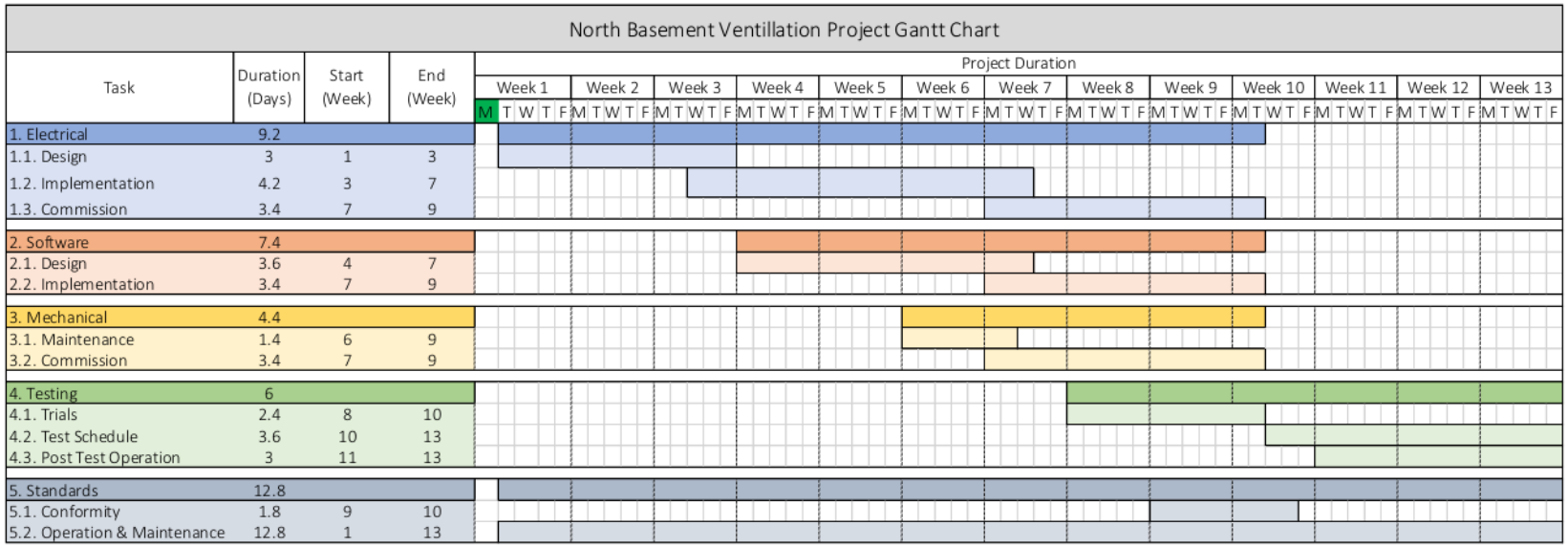


Figure 138 - Projected Gantt Chart

(Thomas, 2023)

10.31. Actual Project Gantt Chart

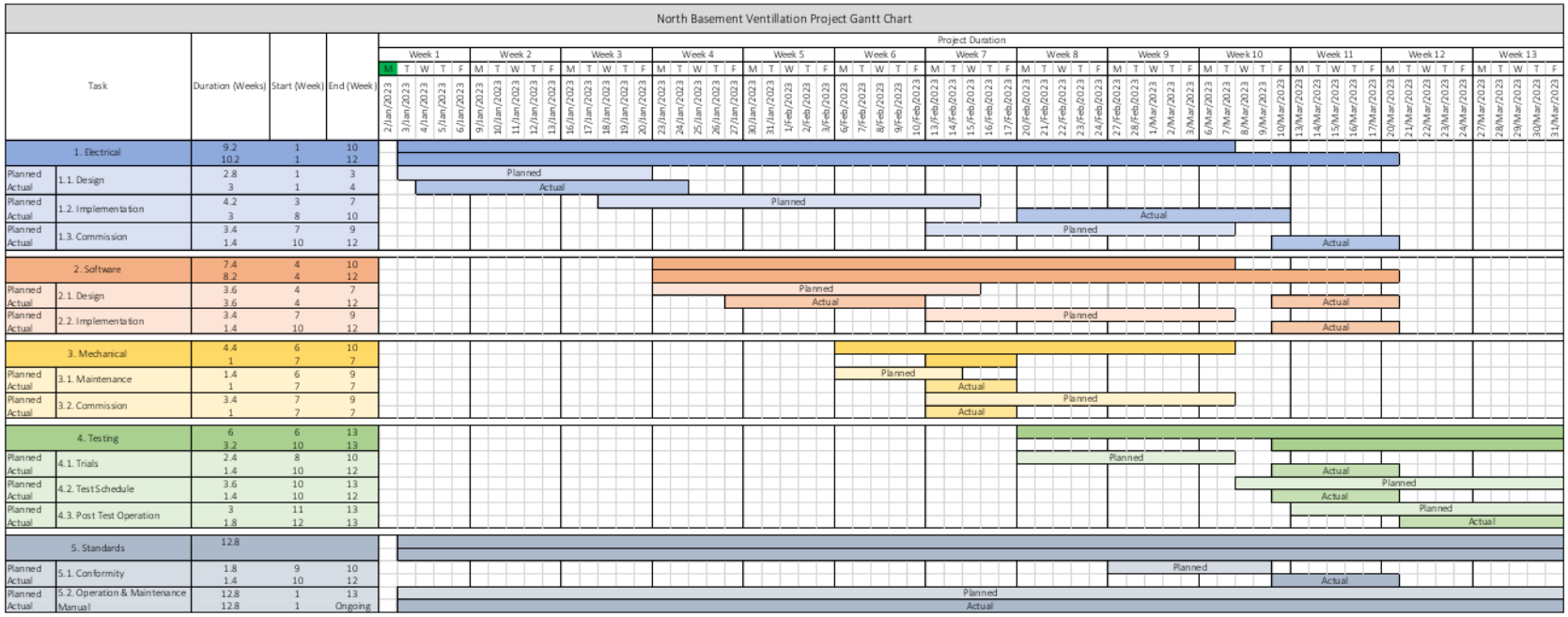


Figure 139 - Actual Project Gantt Chart

10.32. Project Costings

No	Product	Part Supplier	Quantity	Proposed Cost	Product	Date Purchased	Actual Spend
1	ABB ACS380 VSD	ABB	2	£1,778.14	Contractor Component Quote, Inclusive of all listed components	12/01/2023	£9,365.00
2	Siemens S7 PLC - 1214C	Parmley Graham	1	£512.40			
3	Siemens KTP700 HMI	Parmley Graham	1	£877.20			
4	Siemens Ethernet Switch	Parmley Graham	1	£103.92	Contractor Installation Quote, inclusive of labour costs and miscellaneous costs	12/01/2023	£7,150.00
5	Siemens 4x Analogue Input RTD	Parmley Graham	1	£426.00			
6	24VDC Power Supply	Parmley Graham	1	£304.80			
7	Pilz Safety Relay	Kempston Controls	1	£217.51	Contractor Extras Quote, programming socket transformer	07/03/2023	£395.00
8	Temperature Sensor	RS - Online	2	£130.13			
9	Pressure Sensors	Rubix	2	£195.46			
10	Cabinet - 1200x1200x400	RS - Online	1	£708.24			
11	63A Switch Fuse with Shaft	ilecsys	1	£136.94			
12	32A 15KW Manual Starter	RS - Online	2	£387.94			
13	E Stop	Automation 24	3	£277.99	Proposed Cost		£14,806.67
14	Cables, Containment & Miscellaneous	Rexel	1	£1,500.00	Actual Cost		£16,910.00
Total Materials Cost				£6,056.67	Actual Spend Difference		£2,103.33
Proposed Labour			250	£8,750.00	Project Budget		£18,750.00
Proposed Total Cost				£14,806.67	Under Budget		£1,840.00

Table 24 - Project Cost Comparison

(Thomas, 2023)

Project Budget	£	18,750.00	Budget %	100%
Proposed Spend	£	14,806.67	% Under Budget	78.97%
Actual Spend	£	16,910.00	% Under Budget	90.19%
Proposed Spend Saving	£	3,943.33	% Under Budget	21.03%
Actual Project Saving	£	1,840.00	% Under Budget	9.81%
Spend Difference	£	2,103.33	% Under Budget	11.22%

Table 25 - Project Cost Evaluation

10.33. Project Recommendations



Figure 140 - Recommendation Fan Belt Guarding Limit Switch

(RS Components Ltd, 2023)



Figure 141 - Recommendation Current reading at Low Speed



Figure 142 - Recommendation Current reading at High Speed

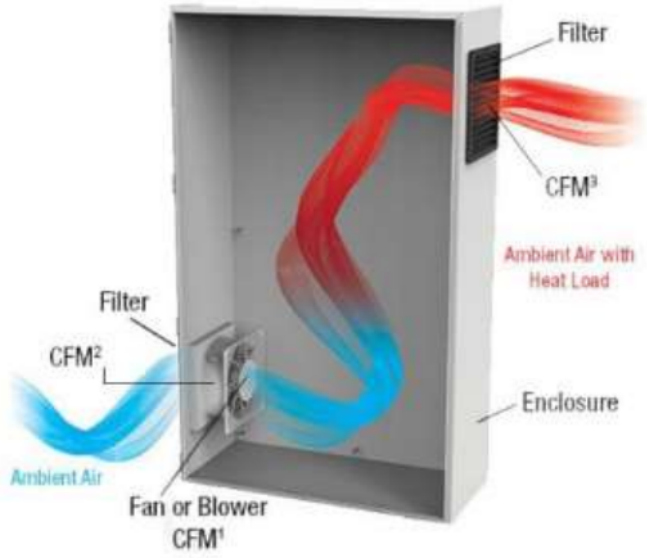


Figure 143 - Recommandation Panel Vent Fan

(Pfannenber, 2016)

Calculations for frequency alteration to 47Hz



Figure 144 - System Values at 47Hz

Recorded Period - 94 Hours			
High Speed		Low Speed	
Recorded Period	19 Hours	Recorded Period	75 Hours
Voltage (V)	448.6	Voltage (V)	363.6
Current (A)	13.68	Current (A)	7.58
Efficiency (e)	0.82	Efficiency (e)	0.82
Mean £/KWh	0.206	Mean £/KWh	0.206

Table 26 - Potential Savings at 47Hz

$$\frac{\text{I Line x VLine x } \sqrt{3} \text{ x e}}{1000} = \text{kW} = \frac{13.68 \text{ x } 448.6 \text{ x } \sqrt{3} \text{ x } 0.82}{1000} = 8.72\text{kW}$$

Equation 17 - Recommendation Motor Energy Usage at 47Hz

$$\text{Calculated KW x £/KWh} = 8.72\text{KW x £}0.206 = £1.80$$

Equation 18 - Recommendation Motor Energy Cost at 47Hz

$$\text{High speed calculated } cost/recorded \text{ period} = 1.80 \text{ x } 19 = £34.20$$

Equation 19 - Recommendation Total Motor Energy Cost at 47Hz

$$\text{High speed calculated } KW/recorded \text{ period} = 8.72 \text{ x } 19 = 165.68\text{w}$$

Equation 20 - Recommendation Total Motor Energy Usage at 47Hz

$$\text{Potential Calculated Costs} = £34.20 + £61.50 = £95.70$$

Equation 21 - Recommended Period Combined Speed Cost

$$\text{Potential Calculated Energy} = 165.68 + 293.25 = 458.93\text{Kw}$$

Equation 22 - Recommended Period Combined Speed Cost

Recorded Period - 94 Hours			
Max Energy Consumption - (No Control applied)	924.02KW	Saving Provided	N/A
Max Operation Cost - (No Control applied)	£189.92	Saving Provided	N/A
Calculated Operation Consumption	458.93KW	Calculated Operation Consumption	49.7%
Calculated Operation Costs	£95.70	Calculated Operation Costs Saved	50.4%
Calculated Total Energy Savings Provided	465.09KW	Calculated Total Energy Savings Provided	50.3%
Calculated Total Cost Savings Provided	£94.22	Calculated Total Cost Savings Provided	49.6%
Further Energy Savings Provided	21.09KW	Further Energy Savings Provided	2.3%
Further Cost Savings Provided	£5.66	Further Cost Savings Provided	3.0%

Figure 145 - Recommended Savings for Altering High Speed to 47Hz

Calculations for Increased Temperature Setpoints and Reduced Frequency

Spelling

$$\text{Potentail Operation } Energy = 94 \text{ x } 367.54\text{Kw} = 556.48\text{Kw}$$

Equation 23 - Potential Operation Energy Savings Provided

$$\text{Potential Financial } Operation = 94 \text{ x } £0.82 = £77.08$$

Equation 24 - Potential Operation Calculated Financial Savings Provided

$$\text{Potential Energy } savings\ provided = 924.02\text{Kw} - 367.54\text{Kw} = 556.48\text{Kw}$$

Equation 25 - Potential Calculated Energy Savings Provided

$$\text{Potential Financial } savings\ provided = £190.8 - £77.08 = £113.74$$

Equation 26 - Potential Calculated Financial Savings Provided

Recorded Period - 94 Hours			
Potential Energy Consumption	367.54KW	Potential Energy Consumption	39.8%
Potential Operation Costs	£77.08	Potential Operation Costs	40.8%
Potential Energy Savings	556.48KW	Potential Energy Savings	60.2%
Potential Financial Savings	£113.74	Potential Financial Savings	59.2%
Potential Overall Energy Savings Provided	112.48KW	Potential Overall Energy Savings Provided	25.3%
Potential Overall Cost Savings Provided	£22.80	Potential Overall Cost Savings Provided	25.3%

Table 27 - Recommended Savings for Altering High Speed & Setpoint Settings

SGEL6000

Independent Project

Logbook

David Mathew Thomas

North Basement Ventilation Fans

2022-2023

Summary of Entries

Log Entry	Date	Brief Description of Activity	Duration (hrs)	Accumulated time (hrs)
1	To date	Project Definition Research Quality Planning	80 Hours	80 Hours
2	06-02-23	Contractor meetings and Purchase order approval	11 hours	91 hours
3	13-01-23	Project Progress & Presentation Preparation	9 hours	100 hours
4	20-01-23	Presentation Preparation & Project Drawings	16 hours	116 hours
5	27-01-23	Power Savings Graph Explanation & Project Works - Project Design/Programming	47 hours	163 hours
6	03-02-23	Project Works - Project Design/Programming	23 hours	186 hours
7	10-02-23	Project Works - Project Design/Investigate Project contingency.	27 hours	213 hours
8	17-02-23	Project Works - Investigate Project contingency	18 hours	231 hours
9	24-02-23	Project Works - Factory Acceptance Test	33 hours	264 hours
10	03-03-23	Project Works - Installation Preparation & Safety Documents.	19 hours	283 hours
11	10-03-23	Project Works - Delivery and Installation	32 hours	315 hours
12	17-03-23	Project Works - Commissioning	28 hours	343 hours
13	24-03-23	Project Works - Alterations & Commissioning	23 hours	366 hours
14	31-03-23	Project Works - Monitoring	14 hours	380 hours

Log Entry Sheet

Log Number	1
Date	To date
Duration (hrs)	N/A
Accumulated time (hrs)	80 hours to date

This should be log entry number 16

Record of activities and achievements

Project Definition Research Quality Planning.

(Work to date)

Plans for next week

Begin Project Design, Implementation works

Signed: _____

Signed: _____

Log Entry Sheet

Log Number	2
Date	06-01-23
Duration (hrs)	11 hours
Accumulated time (hrs)	91 hours

Record of activities and achievements

Contractor meetings and Purchase order approval.

Meeting held with contractor to discuss project requirements and required components. Meeting is held to ensure that both company and contractor vision for the project are in line.

Contractor quotes evaluated for panel build and component acquisition.

Purchase orders released for contractors.

Project flow diagrams created for design process.

Components and panel drawings to date, reviewed.

Plans for next week

Begin Project Design, Implementation works

Signed: _____ Signed: _____

Log Entry Sheet

Log Number	3
Date	13-01-23
Duration (hrs)	9 hours
Accumulated time (hrs)	100 hours

Record of activities and achievements

Project Progress & Presentation Preparation.

Due to work commitments, project progress has been delayed. Plant start-up issues following a busy annual maintenance period have delayed planned works.

Prepare presentation

Plans for next week

Project presentation

Signed: _____ Signed: _____

Log Entry Sheet

Log Number	4
Date	20-01-23
Duration (hrs)	16 hours
Accumulated time (hrs)	116 hours

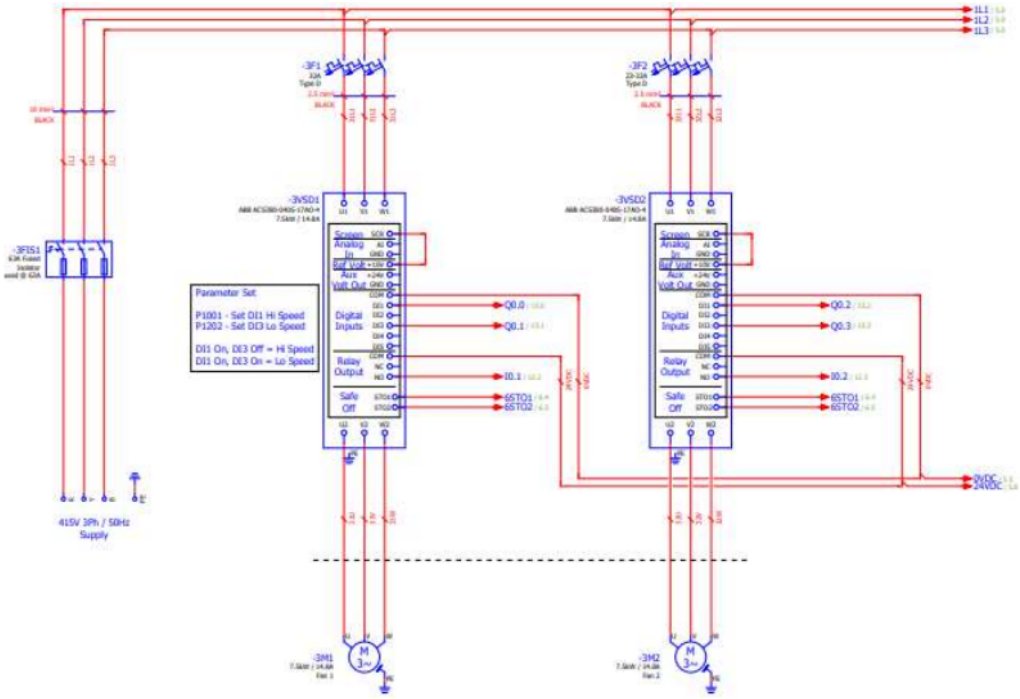
Record of activities and achievements

Presentation Preparation & Project Drawings

Continue with PowerPoint presentation preparation in readiness for presenting.

Continue with project drawings and design, Drawings reviewed with Graham Mathias.

Following drawing approval, Electechs assistance is required with producing the final drawings as they have the software (E-Plan) for developing the drawings.



Plans for next week
Continue project design works. Evaluate Gantt chart and make required adjustments to project plan Investigate Potential Savings from VSD drawing, due to confusion of graph

Signed: _____ Signed: _____

Log Entry Sheet

Log Number	5
Date	27-01-23
Duration (hrs)	47 hours
Accumulated time (hrs)	163 hours

Record of activities and achievements

Power Savings Graph Explanation & Project Works - Project Design

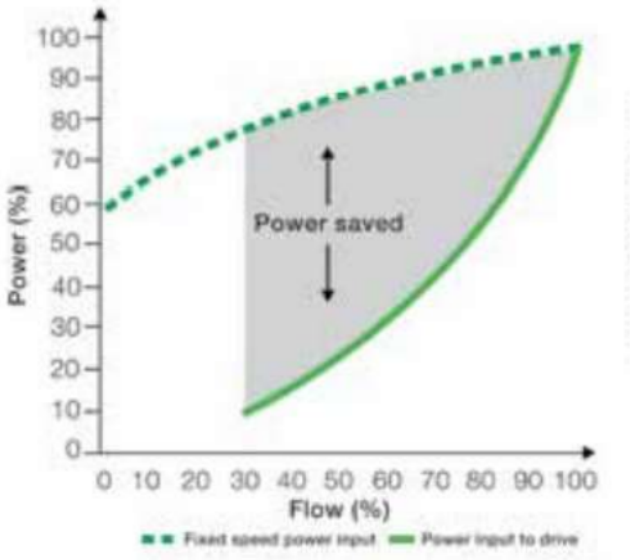
Begin project logic design.

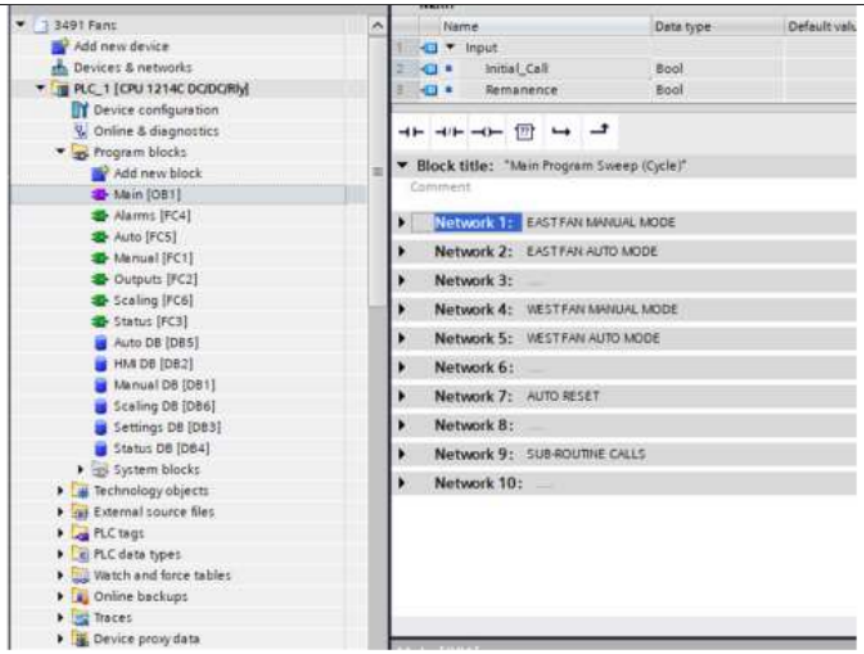
Graph is showing theoretical savings.

Overall savings are more conservative. In reality, savings will be less due to VSD losses, motor efficiency, installation conditions etc.

Dotted line is representing fixed speed (Full throttle) such as DOL

When speed control is applied, solid line on graph shows less power is needed to achieve the same air flow.





Held meeting with Electechs regarding panel build progress and component acquisition.

Materials for project have been purchased.

Most of the materials have been delivered.

One ABB drive is on back order, exact date for delivery is unknown

Plans for next week

Continue project design works.

Evaluate Gantt chart and make required adjustments to project plan

Signed: _____ Signed: _____

Log Entry Sheet

Log Number	6
Date	03-02-23
Duration (hrs)	23 hours
Accumulated time (hrs)	186 hours

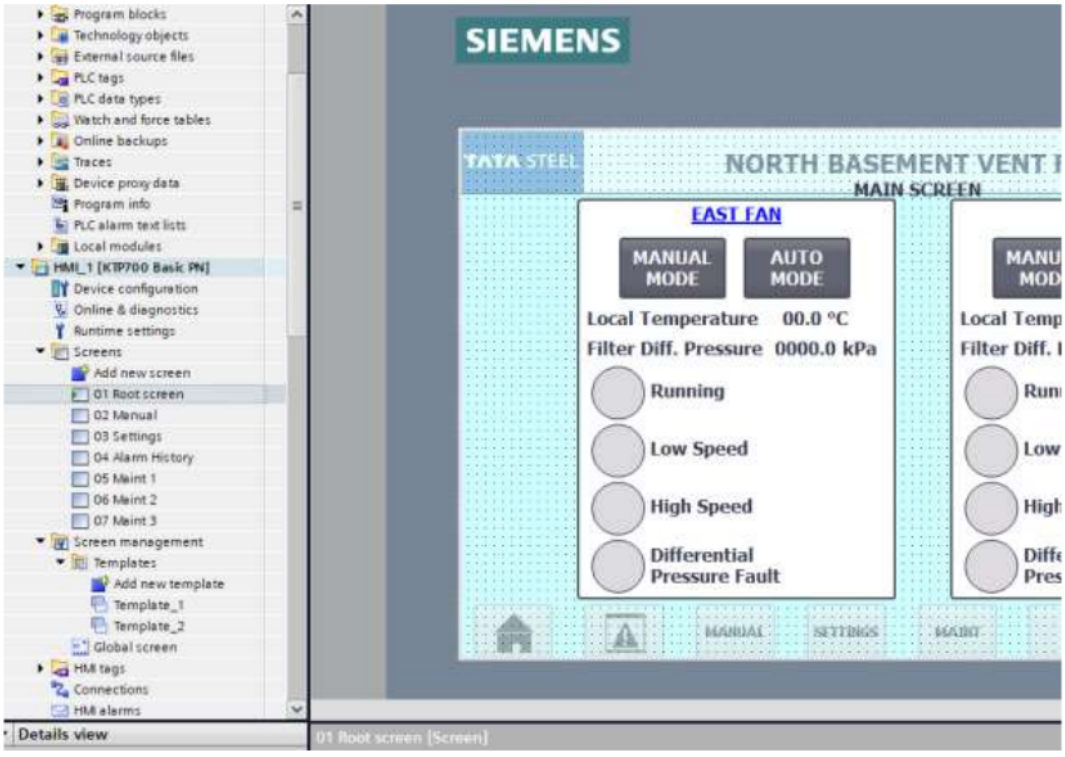
Record of activities and achievements

Project Works - Project Design/Programming.

Continue with project programming design,

Held meeting with Graham Mathias to review programming.

Programming appeared to be satisfactory.



Plans for next week
Finalise programming for simulation Evaluate Gantt chart and make required adjustments to project plan

Signed: _____ Signed: _____

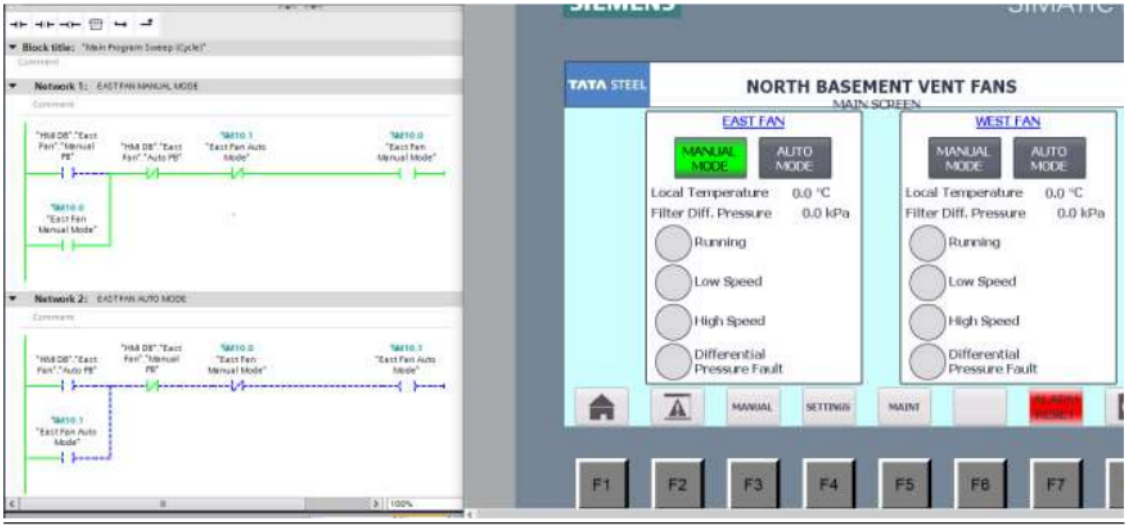
Log Entry Sheet

Log Number	7
Date	10-02-23
Duration (hrs)	27 hours
Accumulated time (hrs)	213 hours

Record of activities and achievements

Project Works – Project Design/Investigate Project contingency.

Continue/finalise with project programming design,
Held meeting with Graham Mathias to review programming.
Programming appeared to be satisfactory. Project simulation appears to be working without issues.



Held Meeting with contractor regarding panel progress and possible delivery date of second drive/project completions feasibility.

Plans for next week
Consider project contingency if second drive does not get delivered before project deadline. Begin installation maintenance . Evaluate Gantt chart and make required adjustments to project plan

Signed: _____ Signed: _____

Log Entry Sheet

Log Number	8
Date	17-02-23
Duration (hrs)	18 hours
Accumulated time (hrs)	231 hours

Record of activities and achievements

Project Works - Investigate Project contingency.

Following concerns raised by Robert Davies with component availability. Held project contingency meeting with Graham Mathias, Grant Markham and contractor building the panel. It was agreed that the project could be delivered and commence even though one drive would not be delivered in time for the project deadline.

Considerations raised around project feasibility.

- Will one drive be suitable to consider the project a success? (Cooling/Cost Saving)
- Will the project be considered a success if one motor is VSD and one is DOL? (Cost Saving)
- If one motor is used, will that cause air flow and circulation issues. Will the isolated motor free wheel?

Air flow and air circulation, if one motor and VSD option is used was investigated.

There are ducting isolation points in the ducting above the fans. The isolation points were tested to ensure that they function.

In turn, a motor and ducting were isolated to ensure that they functioned and there were no air circulation issues causing the isolated ventilation fan to free wheel.

Project will move forward if only one drive is available. Discussions held with the contractor regarding factory acceptance testing, FAT.



Plans for next week

Begin mechanical & electrical maintenance for mechanical components of installation.

Evaluate Gantt chart and make required adjustments to project plan

Factory Acceptance Test

Signed: _____ Signed: _____

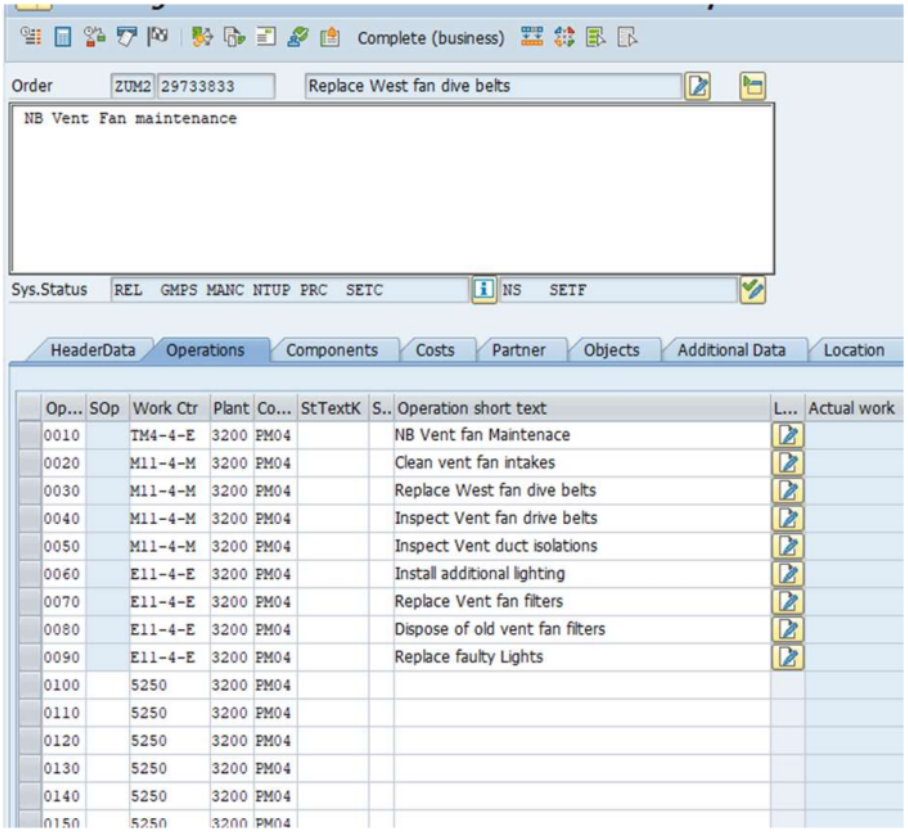
Log Entry Sheet

Log Number	9
Date	24-03-23
Duration (hrs)	33 hours
Accumulated time (hrs)	264 hours

Record of activities and achievements

Project Works - Factory Acceptance Test

Continued and completed infrastructure mechanical and electrical maintenance. Cleaned area within substation. Removed disused and discarded materials. Installed additional lighting in location the panel will be placed.



Op...	SOp	Work Ctr	Plant	Co...	StTextK	S..	Operation short text	L...	Actual work
0010		TM4-4-E	3200	PM04			NB Vent fan Maintenace		
0020		M11-4-M	3200	PM04			Clean vent fan intakes		
0030		M11-4-M	3200	PM04			Replace West fan dive belts		
0040		M11-4-M	3200	PM04			Inspect Vent fan drive belts		
0050		M11-4-M	3200	PM04			Inspect Vent duct isolations		
0060		E11-4-E	3200	PM04			Install additional lighting		
0070		E11-4-E	3200	PM04			Replace Vent fan filters		
0080		E11-4-E	3200	PM04			Dispose of old vent fan filters		
0090		E11-4-E	3200	PM04			Replace faulty Lights		
0100		5250	3200	PM04					
0110		5250	3200	PM04					
0120		5250	3200	PM04					
0130		5250	3200	PM04					
0140		5250	3200	PM04					
0150		5250	3200	PM04					

Held Factory Acceptance Test for panel.

Factory acceptance testing of project panel is considered a success.



Plans for next week

Complete mechanical & electrical maintenance for mechanical components of installation.

Organise for panel delivery and installation works. Create/evaluate required safety documentation

Evaluate Gantt chart and make required adjustments to project plan

Signed: _____ Signed: _____

Log Entry Sheet

Log Number	10
Date	03-03-23
Duration (hrs)	19 hours
Accumulated time (hrs)	283 hours

Record of activities and achievements
Project Works - Installation Preparation & Safety Documents. Create pre briefing sheet for Electechs to create job method statement JMS for panel and component installation. Review JMS from contractor. Create action to work, ATW for contractor be begin work on site. Held on site meeting with contractor and installation team to discuss locations

TATA

Pre Work Briefing Sheet (PBS)

Job Owner : Mathew Thomas

PREPARATION, IDENTIFICATION OF HAZARDS AND CONTROLS		
1.	**Name of Company or Service Dept.**	Electechs
2.	**Contractors Serial No.**	2452111
3.	**Date From**	2023-02-20
4.	**Date To**	2023-03-06
5.	**Description of Work**	Installation of ventilation fan panel with associated cabling and containment.
6.	**Location of Work**	North Basement Substation
7.	**Establish the number of men employed on contract and level of supervision**	Up to 4 men
8.	**Name Sub-contractors to be used on the contract**	
9.	**Does this work involve COMAH substances and is it a safety critical task?**	N/A
10.	**Are there any job hazards? - PRECAUTIONS TO BE TAKEN**	
	Moving Machinery	No
	OH cranes & Gantry - working on or near	Yes Access and egress to and from substation. Designated foot paths/safe walkways to be used at all times, green walkways are safe walkways, red walkways are in crane flight path. Be alert for plant activity in area, general works traffic, use of maintenance vehicles, crane and fork trucks and delivery vehicle operations in area. Maintain 5M exclusion rule to all vehicles in operation. High vis to be worn at all times
	Lifting / Slinging	Yes Panel, Cable and Containment Installation - Manual handling regulations/guidelines to be followed. Where possible use lifting aids, all lifting aids to be load certified, fit for purpose, carry out pre use checks. All lifting equipment compliance certifications to be provided for all lifting equipment. Complete 1 min RA/POWRA prior to starting works
	Working at Height	Yes Correct PPE to be worn at all times, chin strap required with hard hat. Ensure handrails are present for working at height. Ladder/step ladder, complete pre use checks prior to use, ensure that they are in good working order and fit for purpose, maintain three points of contact, ladders are only to be used for access, not as a working platform. Complete 1 min RA/POWRA prior to starting works
	Work on Roof	No
	O.H. Work	Yes No work is permitted to take place under suspended loads or under mobile scaffold tower. Eye protection to be worn in basement at all times. Complete 1 min RA/POWRA prior to starting works
	Scaffolding	No
	Power Tools - Electric, Compressed Air and Gas	Yes Power Tools - All power tools to be 110v or battery, 240v power tools are not permitted. All tools to be PAT tested, in good working order and fit for purpose, carry out pre use inspections prior to use. HAVs register to be updated daily for power tool use. Correct PPE to be worn as required for power tools. Calibration/conformity certificated to be provided for specialist tools, such as hydraulic crimper, torque wrench. Complete 1 min RA/POWRA prior to starting works
	Jetting Operations	No
	Diesel Generator - fumes/location	No
	Traffic - Road/Rail/Plant/Cranes	Yes Road traffic - Care to be taken on site. High vis to be worn at all times, designated foot paths/safe walkways to be used. Give way to vehicles and cranes as crossings. Green walkways are safe walk ways, red walkways are in crane flight path.
	Electrical including High Voltage	Yes Tata engineer to provide isolations required, work is in substations in and around live equipment and apparatus. Limitation of access to be issued for work in substation. Tata engineer to test for dead at point of work, prior to any works on existing electrical infrastructure and provide required safety documentation (LV permit) Complete 1 min RA/POWRA prior to starting works
	Are there any live conductors within 2 metres of the working area	Yes - 240v DC exposed conductors. Area to be sectioned off appropriately. Limitation of access to be provided for substation access
	Pressure Systems - Steam/Gas/C.Air/Hydraulics	No

Plans for next week

Installation works.

Site Acceptance Test.

Evaluate Gantt chart and make required adjustments to project plan

Signed: _____ Signed: _____

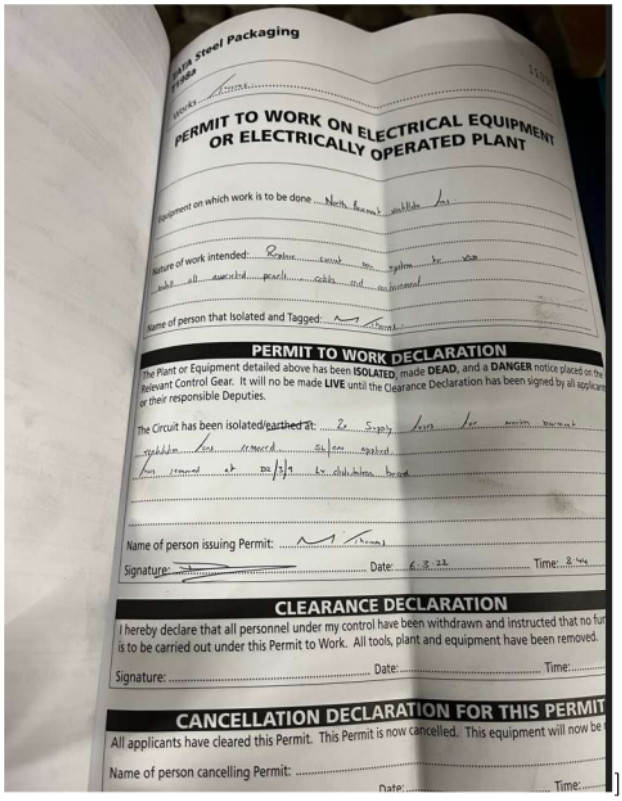
Log Entry Sheet

Log Number	11
Date	10-03-23
Duration (hrs)	32 hours
Accumulated time (hrs)	315 hours

Record of activities and achievements

Project Works - Delivery and Installation.

Contractor commences installation works.
Issue relevant safety documentation following required isolations.



Tata Steel Packaging

PERMIT TO WORK ON ELECTRICAL EQUIPMENT OR ELECTRICALLY OPERATED PLANT

Equipment on which work is to be done ... North Bound ...

Nature of work intended: ... Replace ... with ... be ...

Name of person that Isolated and Tagged: ...

PERMIT TO WORK DECLARATION

The Plant or Equipment detailed above has been ISOLATED, made DEAD, and a DANGER notice placed on the Relevant Control Gear. It will no be made LIVE until the Clearance Declaration has been signed by all applicants or their responsible Deputies.

The Circuit has been isolated/earthed at: ... Supply ... for ...

... removed ... by ...

Name of person issuing Permit: ...

Signature: ... Date: 6-3-22 Time: 8:44

CLEARANCE DECLARATION

I hereby declare that all personnel under my control have been withdrawn and instructed that no fur... is to be carried out under this Permit to Work. All tools, plant and equipment have been removed.

Signature: ... Date: ... Time: ...

CANCELLATION DECLARATION FOR THIS PERMIT

All applicants have cleared this Permit. This Permit is now cancelled. This equipment will now be ...

Name of person cancelling Permit: ...

Date: ... Time: ...

Held Site Acceptance Test on completion of panel and component installation

Site acceptance testing of project panel is considered a success.

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 434.9VAC 
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. 

Plans for next week

Commission installation.

Evaluate Gantt chart and make required adjustments to project plan

Signed: _____ Signed: _____

Log Entry Sheet

Log Number	12
Date	17-03-23
Duration (hrs)	28 hours
Accumulated time (hrs)	333 hours

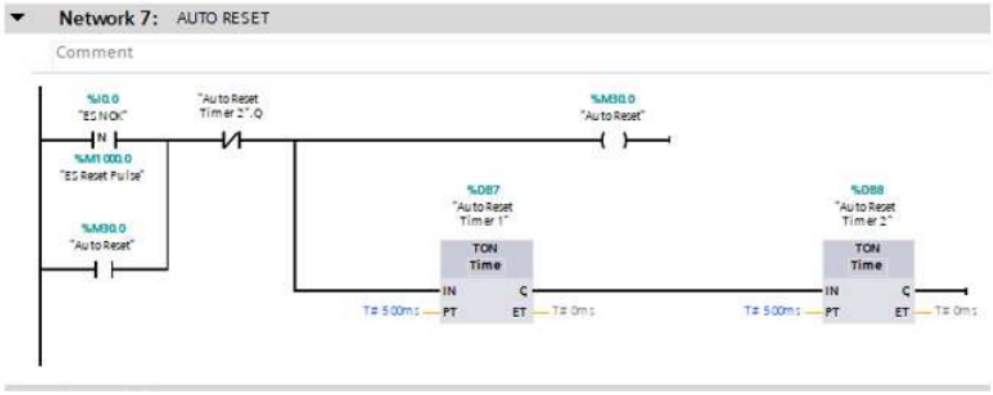
Record of activities and achievements

Project works - Commissioning.

Following a successful installation phase.
Software was downloaded to the PLC. Drive was programmed. Installation was commissioned.



Commissioning failed.
Issues uncovered. VSD failed to reset. Timer was put into the program to slightly delay safety circuit reset.



Following alterations to programming. Commissioning was restarted.

Second commissioning attempt uncovered an issue with automatic operation.
Low speed wouldn't function in automatic mode.
Further alterations required to software.

Plans for next week

Alterations to project following failed commissioning

Evaluate Gantt chart and make required adjustments to project plan.

Signed: _____ Signed: _____

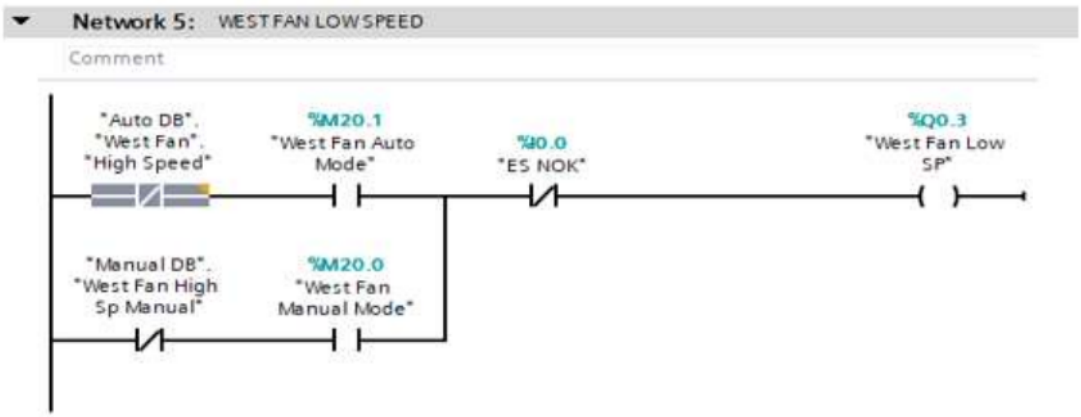
Log Entry Sheet

Log Number	13
Date	24-03-23
Duration (hrs)	23 hours
Accumulated time (hrs)	366 hours

Record of activities and achievements

Project works - Alterations & Commissioning.

Automatic mode operation fault found with N/O contact in place of N/C contact.
Following discussions with project engineer, first scan feature was added to software.
First scan allows system to automatically operate in automatic mode, when system has been reset.



Updated software downloaded to PLC for third commissioning attempt.

System successfully commissioned.

Project Test plan followed and completed.

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	

System to be monitored for remainder of project schedule.

Plans for next week

Monitor installation.

Evaluate Gantt chart and make required adjustments to project plan

Signed: _____ Signed: _____

Log Entry Sheet

Log Number	14
Date	31-03-23
Duration (hrs)	14 hours
Accumulated time (hrs)	380 hours

Record of activities and achievements

Project Works - Monitoring.

Monitor installation for remainder of project schedule.
Monitoring of power consumption and cost savings.



Plans for next week

Project completed as far as reasonably practicable

Evaluate Gantt chart and make required adjustments to project plan

Begin project design, implementation and evaluation assignment.

Signed: _____ Signed: _____

1809810

GRADEMARK REPORT

FINAL GRADE

78/100

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

QM

Good Structure

Report is structured exactly as stated in the assignment brief.

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PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

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PAGE 10

PAGE 11

QM

Spelling

Spelling error

PAGE 12

PAGE 13

PAGE 14

PAGE 15

Text Comment. This is a poor image, tags are blurred

PAGE 16

PAGE 17

PAGE 18

Text Comment. This is an unnecessary image

PAGE 19

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PAGE 31

Text Comment. you mean partial success

QM

Spelling

Spelling error

PAGE 32

QM

Punctuation Error

Punctuation error

QM

Punctuation Error

Punctuation error

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PAGE 34

PAGE 35

PAGE 36

PAGE 37

QM

Spelling

Spelling error

PAGE 38

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Text Comment. Datasheets are not required in a report at this level. It would have been better to have extracted the information and cited the datasheet as a source.

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QM

Spelling

Spelling error

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Text Comment. This should be log entry number 16

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GRADING FORM: NEW CSG-RUBRIC

DAVID THOMAS	**78**

1. ENGAGEMENT WITH LITERATURE

Section 3: Judicial use and critical evaluation of technical literature in the design of the project. There is excellent evidence of this through the	**8**

report. (4/5)
Section 8: Extent of reading, range of credible sources and use of Harvard method.
A very wide range of sources used correctly cited and listed. (4/5)

2. KNOWLEDGE AND UNDERSTANDING

Sections 3 and 4: Advanced knowledge and critical understanding demonstrated in the design and implementation of the project.
There is very good evidence of this in the report. (7/5)

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3. COGNITIVE AND INTELLECTUAL

Section 5: Testing and analysis of results.
Excellent evidence of testing with results. (8/10)
Section 5: Critical evaluation of the project outcomes.
Outcomes have been evaluated and compared with the FDS with a clear assessment of how much has been completed. (7/10)
Section 6: Conclusions and recommendations.
A very detailed and comprehensive section giving a clear way forward. (8/10)

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4. PRACTICAL APPLICATION

Section 4: Deployment method, use of material, tools, equipment and techniques in the construction of the project.
The project has been executed with the

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appropriate methods and equipment in a professional manner with the involvement of outside contractors. (7/10)
Section 4: Quality of the final product or system.
Very high quality end product. (8/10)
Sections 5, 6 and appendix: Management of the design process including use of plans, costing spreadsheet and log book.
Excellent methods employed throughout. (8/10)

5. TRANSFERABLE SKILLS



Section 1: Acknowledgements, executive summary and introduction.
Each of these sections are clear and give complete and relevant information making it easy for the reader to follow. (4/5)
All Sections: Presentation quality of the report, diagrams, charts, tables, figure numbering, page and section numbering etc..
Excellent quality of the report, structure and presentation. (4/5)
All Sections: Quality of the writing style, use of punctuation and grammar.
Generally, well written with a few punctuation and spelling errors. (4/5)
Word count limit not exceeded (5/5)

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