

Final project report

by Brian Jones

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Major Project Final Report, Log Book & Viva Voce

Industrial Coffee Machine System Upgrade

BSc (Hons) Electrical &
Electronic Engineering Year
3

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With Bill McIntyre & Robert Davies. 26th April
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Abstract

Project?

This report, using project management techniques, has shown how an engineering solution was used to solve an industry problem. The problem involved outdated machinery systems used to produce roasted coffee beans on an industrial scale. During a callout to a breakdown with the roasting system, it was discovered that the outdated kit required modernising to comply with current safety standards as the existing system was produced in the 1960's. The system currently has several motors and a gas burner, one motor, star/delta, is used to turn the roasting drum situated above the gas burner. Another star delta motor is used to operate an extractor flue system to exhaust the coffee smoke to the outside atmosphere. Two direct-on-line motors are used to firstly blow the unroasted raw beans around a pipe network and secondly turn the roasted beans on a cooling bed.

The actual problems that required engineering solutions included, a temperature measuring system capable of indicating and then isolating the gas burner on over temperature, methods of isolating the various motors and connected parts during an emergency and a usable system that doesn't put the operator and maintenance personnel at risk while using and maintaining the machine.

Specifications have been produced following consultations with the proprietor and from these specifications a flow chart was obtained and used to draft a concept design. A materials list of hardware and software was produced and used to cost the project and hence establish an overall time scale with an end of April deadline.

A Siemens 1214 FC PLC with a SIL (safety integrity level) 3 has been used as the main hardware component of the project. The PLC has a 0 to 10v analogue input that is used to obtain as the method of shutting the system down in the event of a drum over temperature. A facility has been provided to connect a J type thermocouple to produce the analogue input signal via a signal conditioning unit. Facilities have been provided to connect the various emergency stops and failsafe inductor switches that have been designed to SIL level 2 and therefore required 2 inputs supplying 2 contacts on each cut-out system.

The panel was produced using high quality products as a method of providing quality assurance in the first instance and following layout and wiring drawings created from the specifications. Quality assurance in the second instance was provided by rigorous

testing of the final design. Conclusions and recommendations were drawn and any suggested improvements for future projects discussed.

Acknowledgements

This project has taken large efforts and dedication by myself but would not be possible without the kind support and help of certain individuals and organisations. I would like to extend my thanks and gratitude to all who have helped and that have been patient throughout.

I would like to extend my gratitude to my supervisors Bill McIntyre and Robert Davies from Coleg Sir Gar without whom this project would not be possible.

To my lovely and patient wife and children, Julia, Holly, Jessica and Lucy who have put up with countless hours of study and time spent in the workshop building the project.

I would like to that Phil Smith of Capital Roaster for the opportunity and faith he has put in me for allowing me to undertake the project for his facility.

*Good general abstract and acknowledgements shown
which allows the reader to understand the project / report
contents*

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1. Introduction

1.1 Aims and objectives

The aims and objectives of this project are to provide a competent approach to a major project, using current project management techniques to an engineering problem that requires solving. During a routine call out to a local factory, Capital Roasters Ltd, that produces roasted coffee beans using a 1960's gas burner type coffee roaster it was discovered, the equipment used to control and power the machine required modernising to current safety standards. The objectives include, providing a system that is safe and maintenance friendly, reliable and straightforward to bring back on line in the event of any component failures. A system that limits the hazards involved in working with relatively high temperatures.

The project will be used to assess project management skills, such as defining outcome results identified through the scope of works, specification and schedule to be completed while staying in budget and delivering a quality product on time.

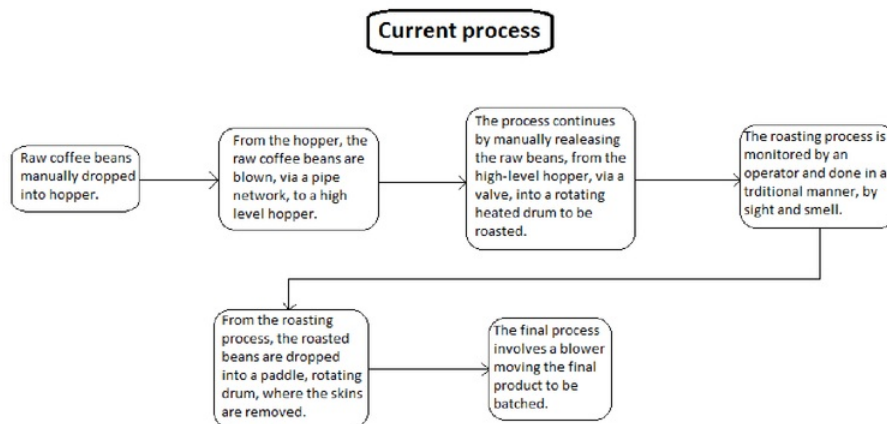
These planning skills will be assessed throughout and will be identified through monitoring and tracking methods that are popular with current project managerial processes, linking the business requirements while considering the time and financial constraints and adhering to a strict quality assurance regime.

A major part of the project will be to undertake research into different methods of solving technical problems and to see what tools are available and can be utilised by the project manager. Research into different methods will lead into considerations of reliability, maintainability and operational practicalities and what are the positive and negative environmental protections in place while deliberating on its sustainability. As will be expected from any project manager, leading by example, professional conduct, in parallel with health and safety considerations through mitigation of risk by assessment must be at the forefront of the project manager's mind.

Following this comprehensive report, there will be a brief presentation on the outcomes of the project and a discussion on whether the outcomes laid out in the specification were achieved.

Detailed aims and objectives noted which were realistic

2. Background research and literature review



Very good flow sequence which clearly indicates the current process

Figure 1: A block diagram of the existing process used to produce the roasted coffee beans.

As seen in Figure 1, the process is undertaken in a traditional manner, meaning without full automation. Current modern methods are totally automated, but the traditional approach involves using sight and smell to produce high quality beans that are highly sort after. Automation, according to the operator, takes some of the quality out of the finished product.

The first stage of the process is to manually transfer the raw coffee bean into a hopper, the hopper can be seen in the Figure 2. There is a blower motor connected to a pipe



Figure 2: The hopper and blower for the raw beans, the start of the process.

-network, this is responsible for transporting the raw coffee beans to a high-level hopper



Figure 3: The riser pipe off the blower

Figure 3 shows the rising pipe work leaving the hopper, this is used to transport the raw beans to the next stage in the process, the high-level hopper.

Following the transportation of the raw beans to the high-level hopper, a manual lever is pulled, which is attached to the high-level hopper, and used to open the way for the raw beans to be dropped into a heated rotating drum where the beans are roasted. The heat source is gas and is activated in parallel with the rotating drum activation. Like all the parts of the roasting process, each section activation is by manual controls from a control switching console as shown in Figure 4. The controls console requires upgrading or repair as it has the potential to become a dangerous hazard.



Figure 4: The existing control console.

The top of the control console is not actually attached to the wiring panel enclosure, also several of the buttons and indicators are missing, and the console itself is not fixed by any fastener to the base enclosure and can be pull-off without the use of a tool. On activation of the rotating drum, a solenoid valve is energised to allow the gas fuel used to roast the beans, to flow. Currently, there is no safety feature that isolates the heat source if the drum is prevented from rotating, this also requires improvement. Figure 5 shows the gas ignition system.



Figure 5: The gas system including the solenoid and ignitor connected to the roasting drum.

Figure 6 shows the pulley system connected to the roasting drum motor. This pulley system also runs the drum cooling system and is also used later in the process when the cooling air is diverted via a lever and is used to suck the roasted beans to the last hopper before packing. The objective here would be to reattach the belt barrier/guard and provide interlocks to prevent the guard being removed whilst the motor is running.



Figure 6: The motor pulley system used to rotate the roasting drum

The skill involved in producing the optimum roasted bean is controlled by the operator, currently, systems exist that automatically control the process, but this machine is not one of them. This process, controlled by the operator, involves watching and sampling the beans at stages, dictated by the smell and look of the bean during the roasting process and is one of the main successes of the company and therefore it is essential that it remains that way.

Following the roasting process, the roasted coffee beans are transferred to a part of the apparatus where they are cooled and the outer skin is removed. This happens in the paddle drum. Parallel to the roasting process, a fan motor is started which produces airflow that is used as a draw to increase the heat in the roasting drum, when the beans are sent to the paddle cooling bed, there is a two-way valve which is adjusted and used to divert the airflow which is then used to cool the beans in the cooling bed.

There is currently a hinged window on the cooling bed apparatus which can be opened by the operator when the motor is running and is used to check the temperature of the bean, by hand. This scenario presents a danger as there is nothing preventing someone or something accessing the moving parts of the cooling bed paddle system. Figure 7 shows the cooling bed.



Figure 7: Shows the cooling bed used to cool the roasted beans.



Figure 8: Shows the access hatch used to check the bean temperature.



Figure 9: Shows how moving parts can be accessed during operation through the hatch.



Figure 10 shown here is of a part of the process following the cooling and deshelling of the roasted coffee beans. At the bottom of the image can be seen the door that allows the shell and bean to be released into a section that can be controlled manually. An airflow is created, by another blower that lifts the roasted beans while leaving the shells behind to be remove by hand. Figure 10 shows the riser that the beans are blown up and then Figure 11 shows where the beans are loaded into the bins to be ground at different grades or packaged in bean form depending on the order specifications.



Figure 10: The exit door from the paddle. Figure 11: The riser from the paddle to filling section of the process.

The existing contactor panel is, as previously mentioned, from the 1960's. It consists of several contactors with the coils energised from the 24volt control panel. There are timers controlling the duration of the of the star/delta contactors, starting in star then when timed out switching to delta. Figure 12, show the existing panel which also consists of ceramic bottle fuses.



Figure 12: Current panel used to operate the coffee roasting process.

The age of this control panel makes sourcing replacement parts difficult. By upgrading the contactors and overload devices the overall size of the panel can be dramatically reduced while addressing safety issues and making obtaining replacement parts straight forward. The purpose of the project is to modernise the electrical system and introduce modern safety systems, also introduce modern control in the form of human machine interface (HMI) if the budget can be agreed with the client and a formal contract drawn up.

Excellent detail on problems within the existing system and how it needs to be upgraded

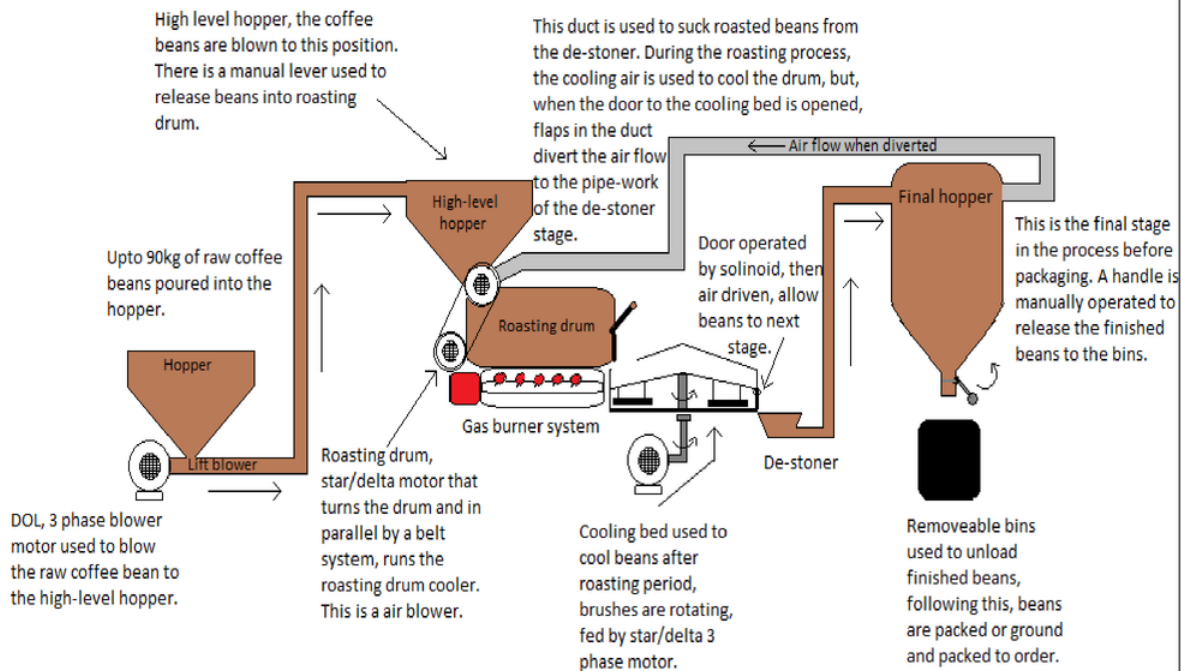


Figure 13: Shows the current process with brief descriptions

Very good block diagram which clearly shows the current process.

2.1 Literature review including potential solutions

2.1.1 Solution 1 Relays

A potential solution to the coffee roasting machine control, safety and power issues is to use a relay logic. The power hardware would be the same for all three solutions i.e. circuit breakers & contactors etc... as would the type of indicators, panel and panel trunking etc...

The relay logic would be used instead of the PLC or other potential hardware solution.

The benefit of using relay logic over other potential solutions would be cheaper material costs for smaller projects and the availability of off the shelf spare parts.

There would be less need for specialist help with maintenance, either on going or reactive, as local electrical contractors could potentially solve any hardware issues.

The moving parts of the relays would be more prone to breakdown than say a PLC solution, but replacements are readily available.

Using relays as a means of controlling the process wouldn't require a software program, and thus cutting down on, as previously mentioned, specialist personnel to

maintain or solve any running issues that ultimately arise over a long enough time scale. Having no software means that any changes required would involve rewiring of the panel which would be costly both in the time and materials used with larger projects, but also in down time of the process.

Using a software solution would be more easily adaptable and cheaper to adjust by simply rewriting the program to suit the required changes.

Advantages of relays	Disadvantages of relays
Cheaper on smaller projects.	More expensive with larger projects.
Easier fault diagnosis.	Contacts more prone to damage.
More maintainable.	Modifications require rewiring.
Off the shelf replacements.	Banks of relays consume space.
Requires non-specialist involvement.	Prone to tripping, down time of process.
Capable of switching various voltages.	

Table 1: Advantages and disadvantages of relays.

2.1.2 Solution 2 PLC

Following on from the relay design is a method of control that has naturally evolved from relay logic and whose designing methods include ladder drawings, as well as function block and instruction lists. This method of control is to use a PLC. This common hardware/software solution, as previously mentioned would still require all the power hardware such as contactors, circuit breakers, indicators as well as the panel and containment systems etc... but would involve an adaptable software program to design and control the process instead of hardwired relays.

Using a PLC would also allow for a more adaptable form of control and hence testing the designs to see how they operate and undertaking any changes without the need to rewire relays or other costly changes that may be required. Simply adapting the program can solve any issues before parts are sourced hence, saving money.

The costs of the PLC hardware and software would be more than the relay solution for smaller projects but would be more reliable and the original upfront costs of the PLC software/hardware could be made back by the adaptability of the PLC.

From the ladder drawing of the relay solution, the PLC design can be undertaken.

Advantages of PLC	Disadvantages of PLC
Easily adaptable through software.	Expensive upfront software costs.
Consumes less space.	Expensive upfront hardware costs.
Robust & reliable.	Require more specialist experience.
Lower maintenance costs.	
Easier to integrate components.	
Ability to monitor systems.	

Table 2: Advantages and disadvantages of PLC.

2.1.3 Solution 3 FPGA

As a PLC is designed for robust industrial environments, it is more suited to the project currently being investigated. A FPGA is a field programmable gate array that requires a lot of effort to interface and extra hardware for industrial tasks. Both PLC and relays are designed for industrial processes and therefore have an advantage over FGPA for this sort of application.

FPGA's are high speed parallel chips that are made up from configurable logic blocks, input/output blocks, RAM blocks and have interconnections between the configurable logic blocks. For most process control & automation applications, PLC's have been the reliable, relatively low-cost approach for many years, evolving from relay logic. They have a proven track record as discrete analogue and I/O functions that meet most applications requirements.

Evolving process control and automation architectures, require a new approach and this is where FPGA's offer high speed, greater performance with better flexibility and reliability.

Advantages of FPGA	Disadvantages of FPGA
High performance parallel processing.	Loss of memory when power lost.
Custom hardware flexibility.	Require more specialist experience.
Hardware logic reliability.	Less robust.
Adaptable software.	Harder to interlace in industrial environments.

Table 3: Advantages and disadvantages of FPGA's.

2.2 Comparison of solutions

2.2.1 Comparison matrix

Where is the legend? i.e. is 1 good

	Relay	PLC	FPGA
Maintainability	7	8	8
Reliability	6	9	8
Modifications	4	9	5
Safety standards	6	8	6
Ergonomics	8	7	6
Functionality	8	8	8
Costs	8	7	7
Total	47	56	48

Table 4: Comparison matrix results

2.2.2 Solution taken forward

As can be seen for the comparison matrix, the PLC is the present choice that will be taken forward and ultimately will be the hardware choice for this project.

The following figure shows the potential I/O's possibilities determined during the ladder design. The ladder design was taken from the information gathered during the procurement of the general specifications and completed using the test and design software National Instruments Multisim.

Realistic solutions noted and explained in detail.

Good reasoned choice made as to which solution to take forward.

3. Specification and test planning

3.1 General specification

The general specification has been generated following a consultation with the client and must include;

- A system that must comply with current health and safety regulations.
- A system that must comply with current wiring regulations and standards, certification must be provided of all works completed and any recommendations documented.
- A system that provides a universally maintainable approach, something that can be maintained without specialist involvement where possible.
- The system should have the ability to provide real time data such as current energy usage, power-factor ratio and amount of product produced.
- A possibility, if the budget is available, is a method of observing the process remotely, in an animated form. This could be achievable through a SCADA system.
- A system that must be deliverable on time and to a budget.
- Local control from a remote-control station must be provided. If the budget allows, this could be achieved via an interface such as a HMI, if not, a push button system will require to be designed.
- A safety control system must be provided that will comply with current EN 62061 machine control safety regulations.
- A system that must detect the temperature of the roasting drum and that must display the temperature. This display must be visible from various stations within the factory.
- A three-stage alarm must be provided that activates at pre-set temperatures. The alarm system must give, at first alarm a visual warning, at second alarm a visual and auditable indication and finally the gas system should shut-down without shutting down the roasting drum and cooling system.

- A method must be provided that prevents the gas burner being started without first starting the flue, roasting drum and cooling system.
- The electrical control of existing solenoids that currently don't operate and thus require attention would be a desirable outcome.
- Guard lockouts, required by EN 62061, must be provided to the cooling bed inspection door and roasting drum/cooling belt system.
- A provision must be made for the supply of up to date drawings, user instructions, technical data sheets, fault diagnosis & possible solution information, planned maintenance requirements, test results & certification and any other data/information relevant to the handover pack on completion of the project.

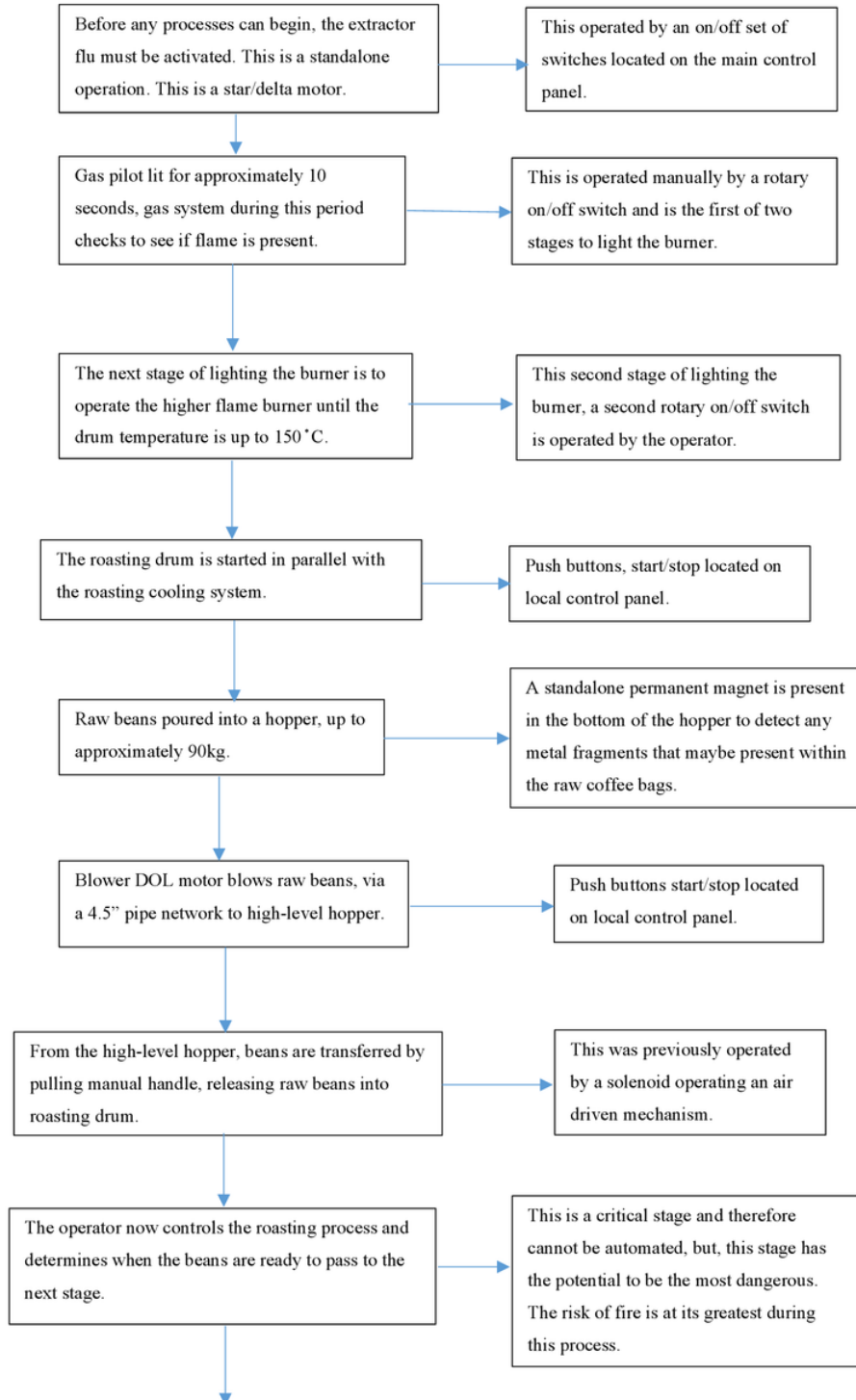
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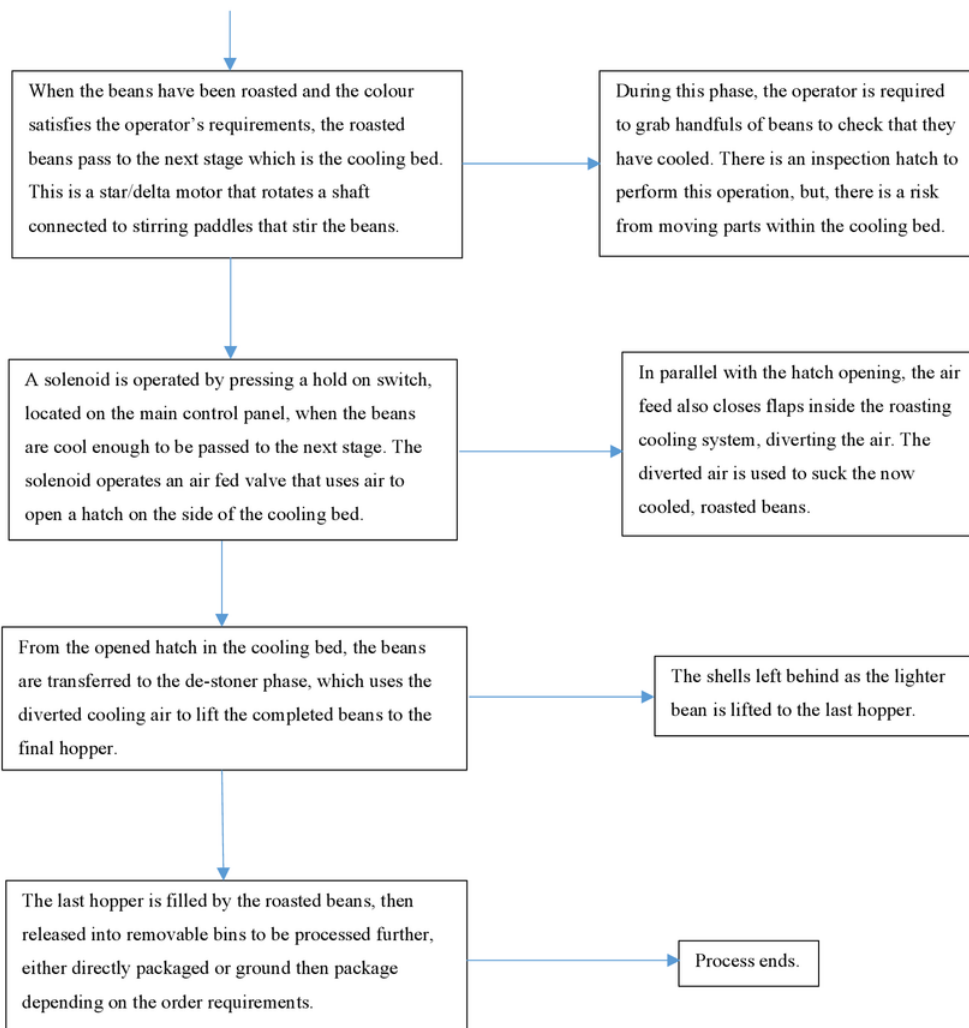
According to (Robinson, 2016), hardware selection and verification for machine design safety and machine control systems safety has for many years been dealt with by the body responsible for harmonised European standards. Publications such as the then EN ISO 13849-1 (Safety of machinery, Safety related parts of control systems, General principles for design) has been replaced by first the EN 954-1 (Safety of machinery, Safety related parts of control systems, General principles for design) and currently, from 2011, EN 62061 (Safety of machinery, functional safety of safety-related electrical, electronic and programmable electronic control systems).

The current publication of the EN 62061 regulations will need to be used as a guide when designing the safety control system of the coffee roasting machine. Project management techniques will need to include the current methods used to highlight risk when undertaking the safety control system. Such modern design techniques employed during the design process of safety control systems include SIL (Safety Integrated Levels) and PL (Performance Levels). SIL and PL assessments are two methods of risk analysis through verification and calculations that identify hazards and allow the designer to evaluate and thus integrate functional safety into either the machine safety design or machine safety control systems.

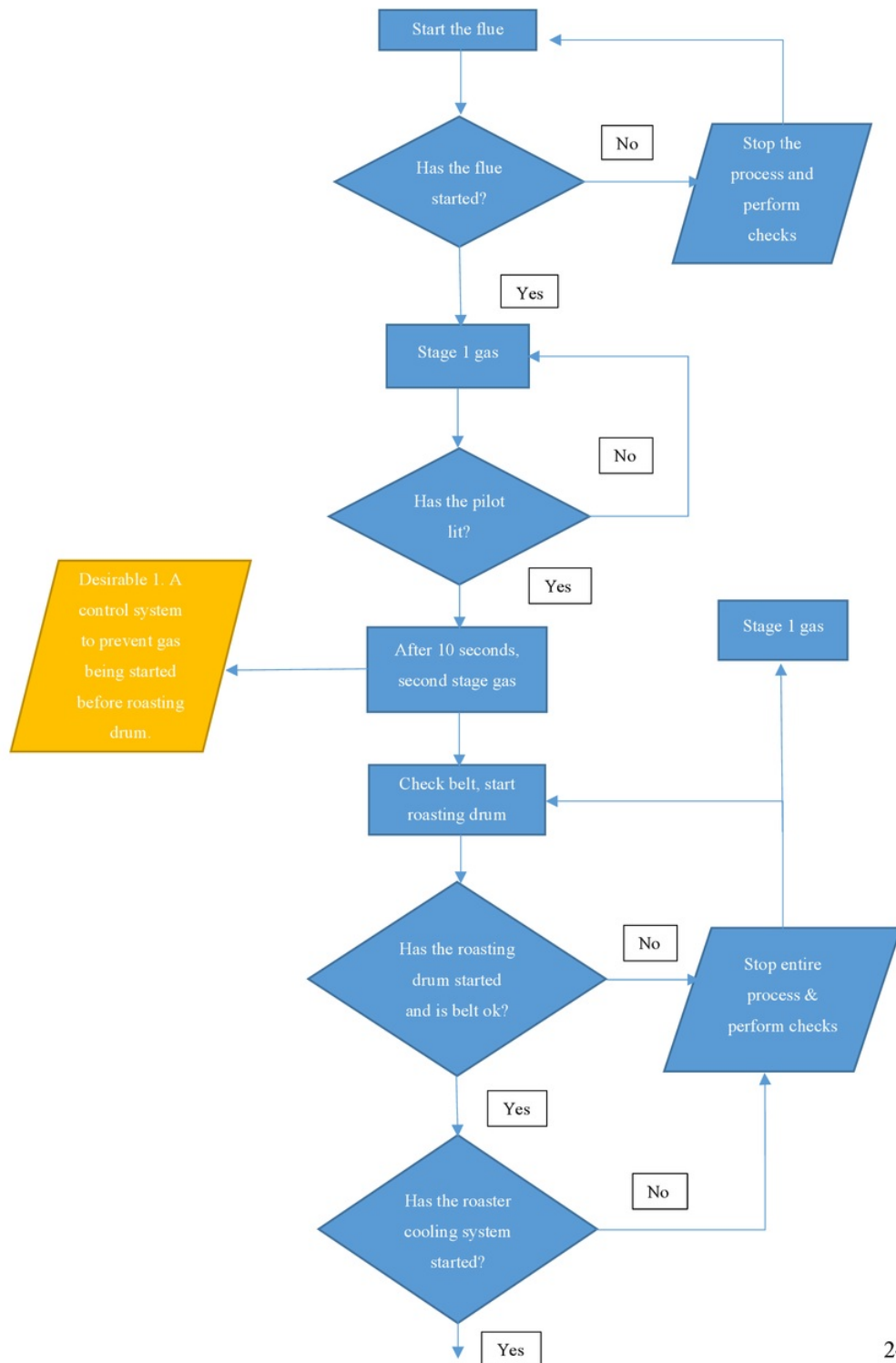
Very detailed general specification noted

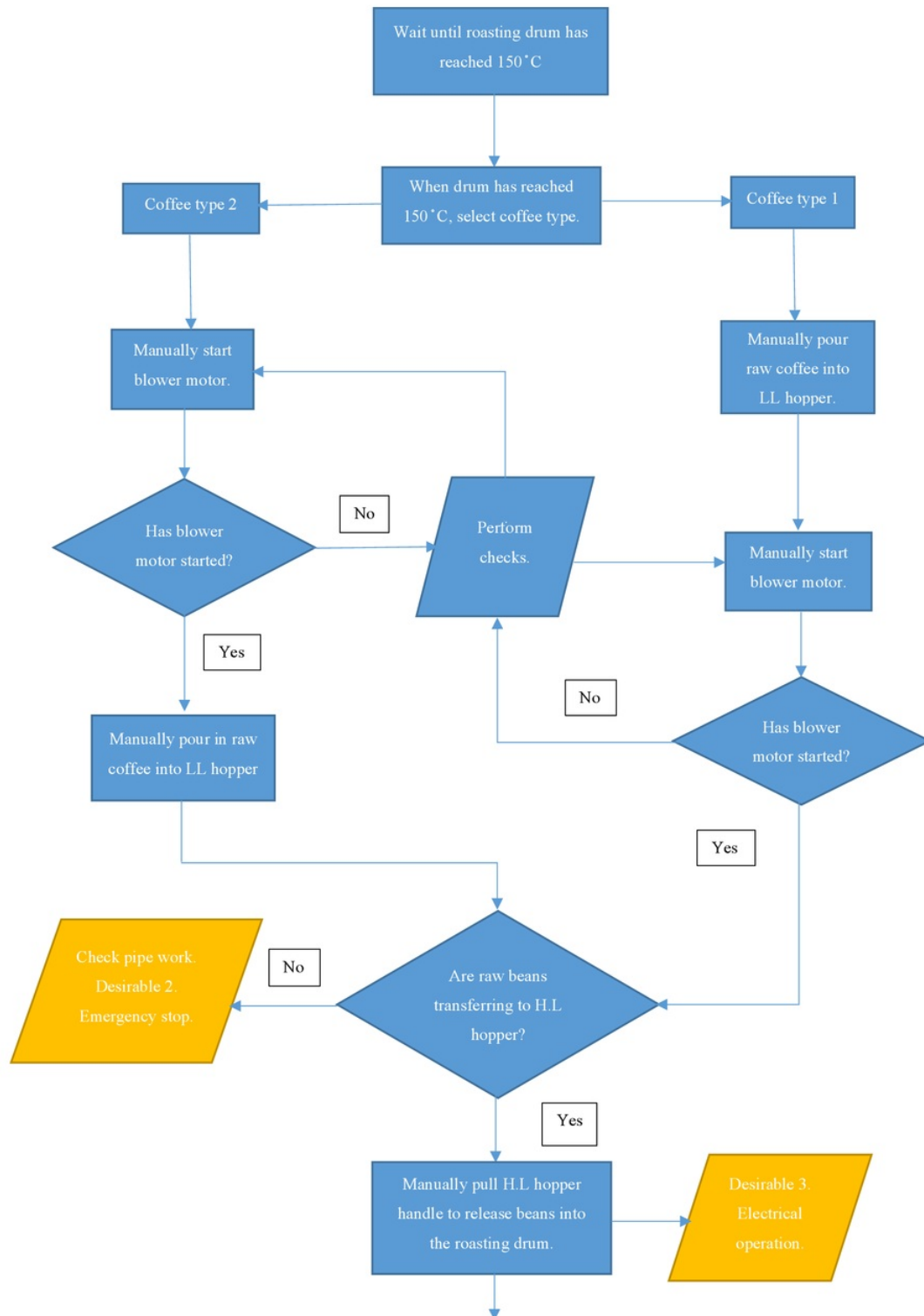
3.2 Flow diagrams of the current process.

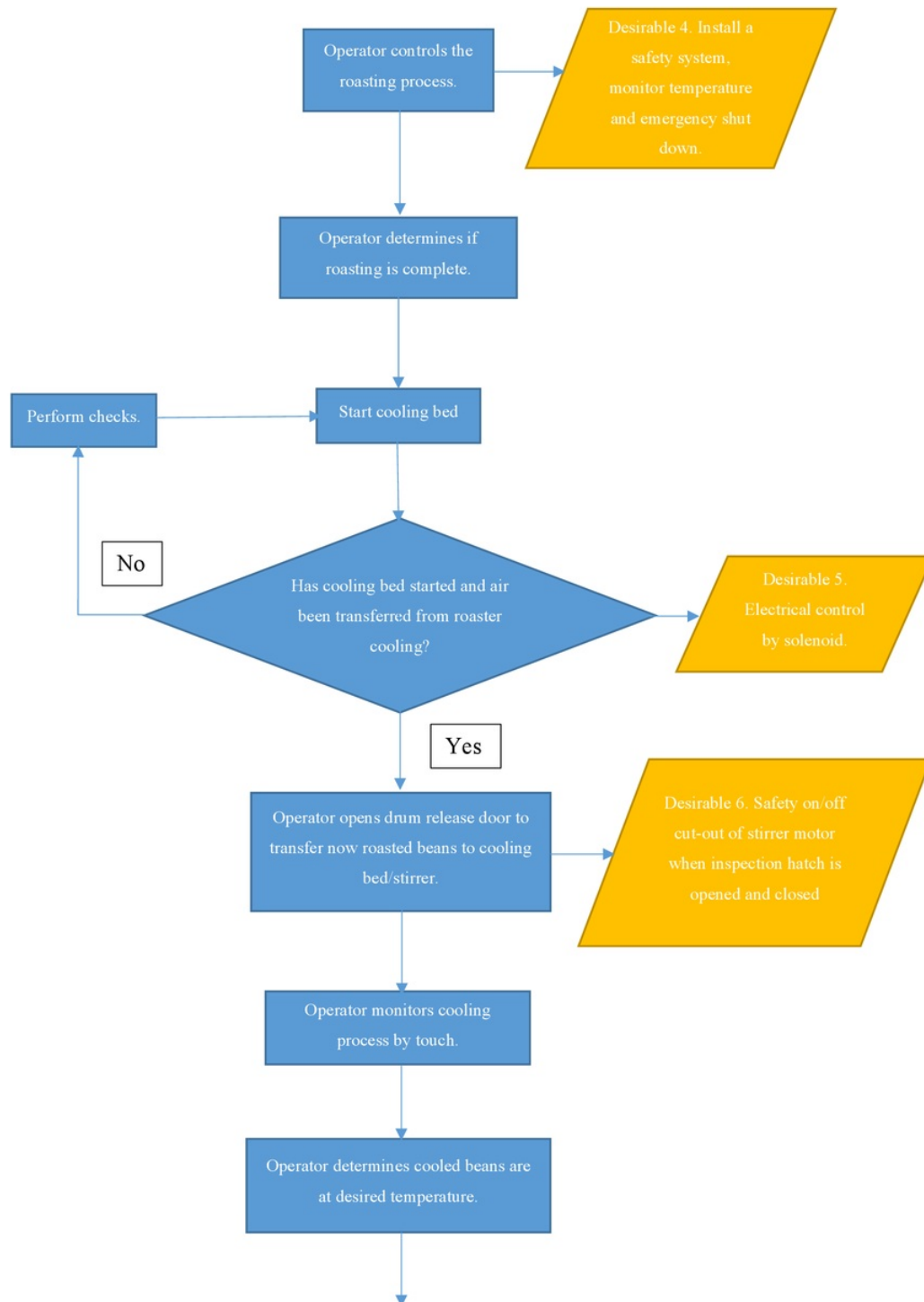


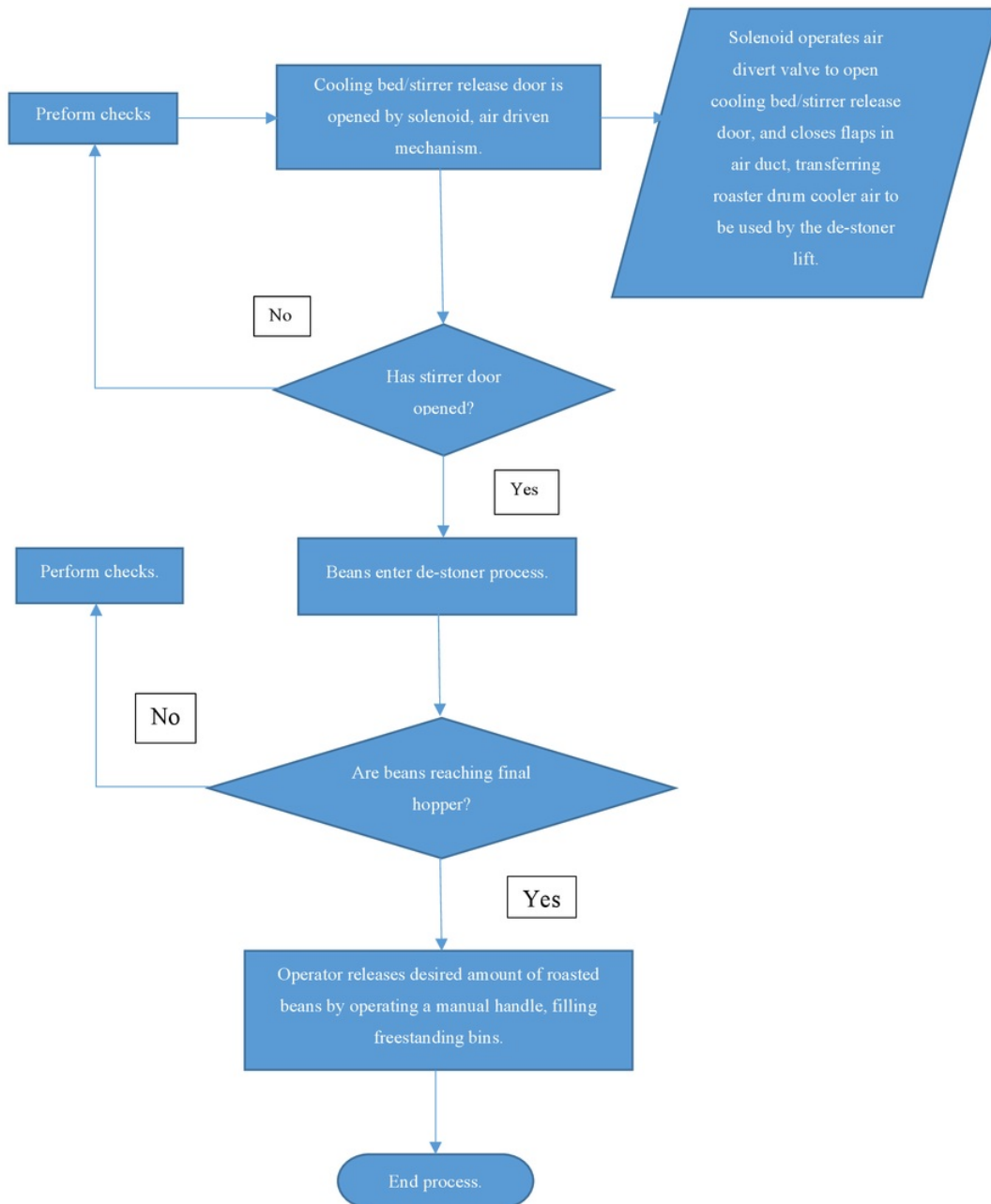


3.3 Flow chart of process









Excellent Flow sequence showing current system and desired additions to upgrade

3.4 Chosen solution specifications

- ❖ BS 7671:2008 (Requirements for Electrical Installations IET Wiring Regulations 17th Edition)
- ❖ EN 62061 (Safety of machinery, functional safety of safety-related electrical, electronic and programmable electronic control systems).
- ❖ EN ISO 13849-1 (Safety of machinery, Safety related parts of control systems, General principles for design)
- ❖ Selection & Erection IET Guidance Note 1
- ❖ Inspection & Testing IET Guidance Note 3
- ❖ Health & Safety at Work Act 1974
- ❖ Memorandum of Guidance on the Electricity at Work Regulations 1989
- ❖ Electricity at Work Safe Working Practices
- ❖ National Inspection Council for Electrical Installation Contractors
- ❖ Electrical Contractors Association

3.4.1 Objectives

3.4.1.1 Improve current safety levels of the existing control system

1. Provide local emergency stop system to loading hopper blower motor.
2. Provide local electrical isolation to loading hopper blower motor.
 - a. Isolation must be capable of being secured in the lock position.
3. Provide equipotential earth-bonding to all exposed conductive parts of coffee roaster metal framework.
4. A method must be provided that prevents the burner system starting without first starting the roasting drum and cooling system.
 - a. Provide normally open relay contacts within stage 1 and stage 2 of burner circuit, linked to roasting drum starting coil.
5. A method must be provided that cuts out the burner, manually and/or automatically, during an emergency, but keeps the roaster drum & cooling system running.

- a. Provide an independent normal closed series contact within burners 1 & 2 stop circuits. This stop circuit must include an emergency stop, both local and remote, that shuts down the gas supply via an electrical held on solenoid valve.
6. A provision must be provided that cuts out the burner following a 2-stage alarm, the alarm must be activated at predetermined temperatures, measured within the roasting drum. Stage 1 must of a visual strobe type alarm. Stage 2 must be a combination of the visual alarm with a sounder also being activated, finally the burner should shut down, but again, the roasting drum must still operate.
 - a. By means of a thermocouple located within the roasting drum, used to obtain the internal temperature, produce an analogue signal via a signal conditioning unit. The output signal produced by the signal conditioning unit, either 4 to 20mA or 0 to 10V, will both provide a temperature reference input to activate the alarms and a means of indicating the current drum temperature.
 - b. Output to strobe alarm at a predetermined temperature measured within roasting drum.
 - c. Output to both strobe and audible alarms at a predetermined temperature measured within roasting drum.
 - d. Activate the stop circuit of the burner that shuts down the gas supply via an electrical held on solenoid valve.
 - e. Following the shutdown alarm of the burner, restart should be prevented until the drum has reached a low enough safe temperature.
7. A guard must be provided with an electrical lockout, activated when opened, for the roaster drum motor/cooling motor pulley belt.
 - a. With the aid of an inductive sensor switch, the switch must open when the guard is opened.
 - b. The burner system must shutdown with the interlock to prevent a dangerous situation.
 - c. The roaster drum/cooling system, must require restarting via the start push-button following the lockout activation.
8. A provision must be provided for an electrical lockout, activated when opened, for the cooling bed motor when the inspection hatch is opened.
 - a. With the aid of an inductive sensor switch, the switch must open when the guard is opened.

- b. The cooler bed motor must restart immediately following the closing of the inspection hatch.
- 9. Provide local emergency stop system to cooling bed motor circuit.
- 10. Provide local emergency stop system to roasting drum motor circuit.
- 11. Provide local emergency stop system to flue motor circuit.

3.4.1.2 Remote control station, pushbutton or HMI

- 12. Provide, either HMI control station or pushbutton/indicator control panel local to roaster drum for use by operator.
 - a. Mount HMI within metal enclosure or provide metal enclosure to house pushbuttons and operation indicators.
- 13. Provide green momentary pushbutton or HMI function button to start loading blower motor.
 - a. Prior to blower motor starting via pushbutton/HMI function, illuminate red stop light to indicate motor state.
 - b. Following the depressing of the green momentary start button/HMI function, extinguish red stopped light and illuminate green running indicator to denote motors state.
 - c. Provide parallel running (green)/stopped (red) indicators for loading blower motor current state, mounted on main panel door.
 - d. Provide red momentary pushbutton/HMI function to de-energise running loading blower motor, thereby extinguishing green running lights and illuminating red stopped lights.
- 14. Provide green momentary pushbutton or HMI function button to start roasting drum/cooling system motor.
 - a. Prior to roasting drum/cooling system starting via pushbutton/HMI function, illuminate red stop light to indicate motor state.
 - b. Following the depressing of the green momentary start button/HMI function, extinguish red stopped light and illuminate green running indicator to denote motors state.
 - c. Provide parallel running (green)/stopped (red) indicators for roasting drum/cooling system motor current state, mounted on main panel door.

- d. Provide red momentary pushbutton/HMI function to de-energise running roasting drum/cooling system motor, thereby extinguishing green running lights and illuminating red stopped lights.
- 15. Provide green momentary pushbutton or HMI function button to start flue motor.
 - a. Prior to flue starting via pushbutton/HMI function, illuminate red stop light to indicate motor state.
 - b. Following the depressing of the green momentary start button/HMI function, extinguish red stopped light and illuminate green running indicator to denote motors state.
 - c. Provide parallel running (green)/stopped (red) indicators for flue motor current state, mounted on main panel door.
 - d. Provide red momentary pushbutton/HMI function to de-energise running flue motor, thereby extinguishing green running lights and illuminating red stopped lights.
- 16. Provide green momentary pushbutton or HMI function button to start cooling bed motor.
 - a. Prior to flue starting via pushbutton/HMI function, illuminate red stop light to indicate motor state.
 - b. Following the depressing of the green momentary start button/HMI function, extinguish red stopped light and illuminate green running indicator to denote motors state.
 - c. Provide parallel running (green)/stopped (red) indicators for cooling bed motor current state, mounted on main panel door.
 - d. Provide red momentary pushbutton/HMI function to de-energise running cooling bed motor, thereby extinguishing green running lights and illuminating red stopped lights.
- 17. Provide 2 position (on/off) selector switch or HMI function to energise first high-level, raw coffee, hopper release door. Solenoid 1.
 - a. On energising of solenoid 1, illuminate green indicator light on remote panel to show operation of function element.
- 18. Provide 2 position (on/off) selector switch or HMI function to energise second low-level, roasted coffee, hopper release door. Solenoid 2.

- a. On energising of solenoid 2, illuminate green indicator light on remote panel to show operation of function element.
- 19. Provide 2 position (on/off) selector switch or HMI function to energise cooling bed low-level de-stoner hopper release door, solenoid 3.
 - a. On energising of solenoid 3, illuminate green indicator light on remote panel to show operation of function element.
- 20. Provide 2 position (on/off) selector switch or HMI function to energise first stage burner operation.
 - a. On energising of first stage burner circuit, illuminate green indicator light on remote panel to show operation of function element.
- 21. Provide 2 position (on/off) selector switch or HMI function to energise second stage burner operation.
 - a. On energising of second stage burner circuit, illuminate green indicator light on remote panel to show operation of function element.

3.4.1.3 Main panel requirements

- 22. A provision must be made that allows total isolation of the entire 400-volt power system prior to the main panel door being open, but, with no loss of power to the 24-volt control system.
 - a. Provide an 80 amp 3 phase rotary panel mounted isolator to cut-off mains supply to main panel.
 - b. Take a 400-volt supply off the supply side of the main rotary isolator, through a double pole miniature circuit breaker (MCB), to feed a 100VA, din-rail mountable, 400/24-volt ac control transformer.
 - c. Attach appropriate warning notices to main panel, i.e. 'Isolate main supply before opening cover', 'Warning, control supplies remain live until isolated internally'.
 - d. Provide a safety relay to hold off all contactor coils while the main panel 400-volt supply is de-energised during mains isolation. (This must be undertaken to prevent the burner starting without first engaging the roaster drum motor and cooling system).

23. Provide, following appropriate calculations, motor rated circuit breakers at the front end, but, in series with correctly sized contactors and adjustable contactor overloads, to each motor circuit, thereby allowing the various motors to be isolate in the event of an overload or short-circuit.
- a. Obtain full load currents of all existing motors and establish the existing motor feed cable sizes, rectify any issues with any undersize cables if required.
24. Provide a programmable logic controller (PLC) hardware to be used as the main control element and relevant software to undertake all control operations as required.
- a. Provide a PLC with 230 to 24-volt ac power supply and all necessary digital input/outputs. The PLC must be capable of receiving an analogue input to be used following the thermocouple signal conditioning, this will form part of the temperature alarm and shutdown system.
- b. Provide a PLC that can receive an I/O extension pack if required in future developments.
- c. Provide, following calculations, correctly rated glass fuses and din-rail mountable fuse holders to receive fuses on the output side of the PLC as protection before any load connections.
- d. Provide, following calculations, correctly rated glass fuse and din-rail mountable fuse holder to receive a protection fuse supply side of the PLC as protection to the PLC for overload or short circuit currents.
- e. Provide a PLC with internal battery backup to hold uploaded software memory in the event of total power failure.
25. A provision must be made for the display of the current amperage usage at the front of the main panel.
- a. Provide, one for each phase conductor, analogue ammeters to display current usage of each phase.
- b. Provide current transformers to be clamped to each supply cable, used to provide signal to each ammeter display.
26. A provision must be made to indicate the current power status of the mains supply and control supply into the main panel.
- a. Provide a green illuminated lamp that illuminates when the switch on of mains rotary isolator is activated and extinguishes when the mains supply to the main panel is switched off.

- b. Provide a green illuminated lamp that illuminates when the switch on of mains rotary isolator is activated and extinguishes when the supply to the control transformer is switched off via the double pole transformer circuit breaker.
27. Provisions must be made for all external power and control cables to be connected within the main panel.
- a. Provide the correct number and correct current rating, din-rail mountable, connectors to receive incoming and outgoing cabling.
28. Provisions must be made for the cables identification and cable containment systems within the main and remote panels.
- a. Provide 50mm by 25mm panel trunking to house all cabling within main and remote panels, affixed to the removable back-panel of steel enclosures.
 - b. Provide spiral wrap or cable sleeve to support and house control cables from the panel's trunking, to the doors of the main and remote panels.
 - c. Provide 0.75mm² red, tri-rated control cable for all control wiring and provide the appropriate size, following calculations, black, tri-rated cables for all power connection wiring.
 - d. A suitable numbering/lettering identification system is to be adopted to all control and power wiring. This system must be transferred to all relevant wiring and schematic drawings.
 - e. All stranded cables within main and remote panels, enclosures and isolators are to be ferruled as per 28/d of this specifications and ends affixed with the correct size crimp/ bootlace-crimp to suit cable sizes.
29. Provide, upon completion of the contract, all relevant drawings and data sheets, user instructions, advised maintenance procedures, certification and inspection & test results.
30. The contract must be awarded to electrical contractors who hold current annual assessment procedures with a recognised organisation such as the NICEIC or ECA.

Excellent realistic detail on the chosen solution specification with a clear set of testing to be carried out

4. Safety, sustainability, Environment, Professionalism, maintenance and reliability.

During the project process from the initial enquiry through to the final product, a massive effort has been made to provide a professional service and to act with due care and diligence. Engineering codes of conduct have been adhered to in accordance with the latest versions BS7671 wiring regulations, National inspection council for electrical installation contracting and electrical contractors association. References through research of EN 62061 has been obtained to reduce the risk through dangerous failures of the system and the information gathered has been used to produce a system on this basis.

The system has been designed and built with considerations towards health and safety. Standards set by the health and safety at work act 1974 and the electricity at work regulations 1989 have been adhered to. A risk assessment has been produced and can be seen in the appendix section of this report. A formal contract has been provided in the form of a quotation which sets out the exact nature of the project in terms of the product and service being provided and has been signed by the client and project manager.

While the materials for the project have been sourced from reputable manufactures of market leading brand names, such as Schneider Electric and Siemens that guarantee a genuine and a more reliable product, a balance has been struck with regards to value for money and not succumbing to false economy.

*General comments made in relation to safety,
professionalism, maintenance and reliability
No information related to sustainability or
environmental protection*

5. Project Design

5.1 Input/output list

From the specification and planning stage, it is possible to create an input/output list. As shown in Table 5, this table can then be used to create the tag list in the chosen software package, Siemens (Totally Integrated Automation) TIA V15. From the tag list created within TIA, the programming can be started.

INPUTS	ADDRESS	OUTPUTS	ADDRESS
Start Roaster	%M0.0	Roaster main coil	%Q0.0
Stop Roaster	%M0.1	Roaster star coil	%Q0.1
Start Flue	%M0.2	Roaster delta coil	%Q0.2
Stop Flue	%M0.3	Flue main coil	%Q0.3
Start Lifter	%M0.4	Flue star coil	%Q0.4
Stop Lifter	%M0.5	Flue delta coil	%Q0.5
Start Cooling Bed	%M0.6	Lifter coil	%Q0.6
Stop Cooling Bed	%M0.7	Cooler bed coil	%Q0.7
Start Burner 1	%M1.0	Burner 1 relay	%Q1.0
Stop Burner 1	%M1.1	Burner 2 relay	%Q1.1
Start Burner 2	%M1.2	Solenoid 1	%Q14.0
Stop Burner 2	%M1.3	Solenoid 2	%Q14.1
Open Solenoid 1	%M1.4	Solenoid 3	%Q14.2
Close Solenoid 1	%M1.5	Health drum temp	%Q14.3
Open Solenoid 2	%M1.6	Caution drum temp	%Q14.4
Close Solenoid 2	%M1.7	Burner shutdown	%Q14.5
Open Solenoid 3	%M2.0		
Close Solenoid 3	%M2.1		
E-Stop 1	%I20.0		
E-Stop 2	%I20.1		
E-Stop 3	%I20.2		
E-Stop 4	%I20.3		
Interlock_1	%I20.4		
Interlock_2	%I20.5		

Interlock_3	%I20.6		
Interlock_4	%I20.7		
E-Stop 1 (1)	%I21.0		
E-Stop 2 (1)	%I21.1		
E-Stop 3 (1)	%I21.2		
E-Stop 4 (1)	%I21.3		
Interlock_1 (1)	%I21.4		
Interlock_2 (1)	%I21.5		
Interlock_3 (1)	%I21.6		
Interlock_4 (1)	%I21.7		
Interlock burner	%I18.0		
Interlock burner (1)	%I19.0		
E-Stop 5	%I18.1		
E-Stop 5 (1)	%I19.1		
O/L 1	%I0.0		
O/L 2	%I0.1		
O/L 3	%I0.2		
O/L 4	%I0.3		
Analogue Input	%MD66		

Table 5: List of input and outputs.

Good set of PLC I/O list shows implementation of the control / indication system

5.2 PLC tag list

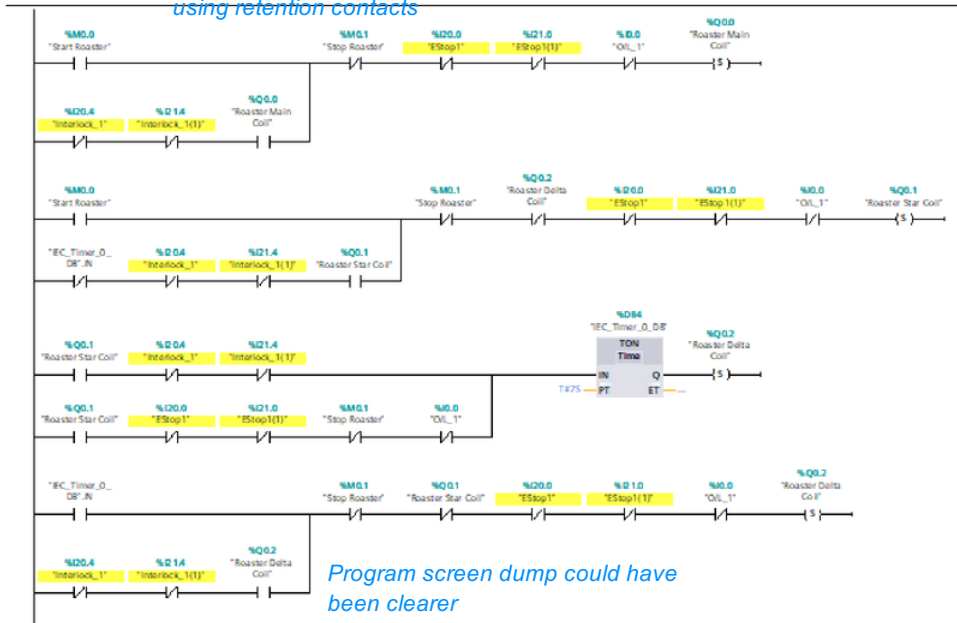
	Name	Data type	Address	Retain	Acces...	Writa...	Visibl...
PLC program	1 Start Roaster	Bool	%M0.0	☐	☒	☒	☒
	2 Stop Roaster	Bool	%M0.1	☐	☒	☒	☒
	3 Start Flue	Bool	%M0.2	☐	☒	☒	☒
	4 Stop Flue	Bool	%M0.3	☐	☒	☒	☒
	5 Start Lifter	Bool	%M0.4	☐	☒	☒	☒
	6 Stop Lifter	Bool	%M0.5	☐	☒	☒	☒
	7 Start Cooling Bed	Bool	%M0.6	☐	☒	☒	☒
	8 Stop Cooling Bed	Bool	%M0.7	☐	☒	☒	☒
PLC prog	9 Start Burner 1	Bool	%M1.0	☐	☒	☒	☒
	10 Stop Burner 1	Bool	%M1.1	☐	☒	☒	☒
	11 Start Burner 2	Bool	%M1.2	☐	☒	☒	☒
	12 Stop Burner 2	Bool	%M1.3	☐	☒	☒	☒
	13 Open Solenoid 1	Bool	%M1.4	☐	☒	☒	☒
	14 Close Solenoid 1	Bool	%M1.5	☐	☒	☒	☒
	15 Open Solenoid 2	Bool	%M1.6	☐	☒	☒	☒
	16 Close Solenoid 2	Bool	%M1.7	☐	☒	☒	☒
	17 Open Solenoid 3	Bool	%M2.0	☐	☒	☒	☒
	18 Close Solenoid 3	Bool	%M2.1	☐	☒	☒	☒
	19 Roaster Main Coil	Bool	%Q0.0	☐	☒	☒	☒
	20 Roaster Star Coil	Bool	%Q0.1	☐	☒	☒	☒
	21 Roaster Delta Coil	Bool	%Q0.2	☐	☒	☒	☒
	22 Flue Main Coil	Bool	%Q0.3	☐	☒	☒	☒
	23 Flue Star Coil	Bool	%Q0.4	☐	☒	☒	☒
	24 Flue Delta Coil	Bool	%Q0.5	☐	☒	☒	☒
	25 Lifter Coil	Bool	%Q0.6	☐	☒	☒	☒
	26 Cooler Bed Coil	Bool	%Q0.7	☐	☒	☒	☒
	27 Burner 1 Relay	Bool	%Q1.0	☐	☒	☒	☒
	28 Burner 2 Relay	Bool	%Q1.1	☐	☒	☒	☒
	29 Solenoid 1	Bool	%Q14.0	☐	☒	☒	☒
	30 Solenoid 2	Bool	%Q14.1	☐	☒	☒	☒
	31 Solenoid 3	Bool	%Q14.2	☐	☒	☒	☒
	32 Optimum drum temp	Bool	%Q14.3	☐	☒	☒	☒
	33 Caution drum temp	Bool	%Q14.4	☐	☒	☒	☒
	34 Burner shutdown	Bool	%Q14.5	☐	☒	☒	☒
	35 EStop1	Bool	%I20.0	☐	☒	☒	☒
	36 EStop2	Bool	%I20.1	☐	☒	☒	☒
	37 EStop3	Bool	%I20.2	☐	☒	☒	☒
	38 EStop4	Bool	%I20.3	☐	☒	☒	☒
PLC program	39 Interlock_1	Bool	%I20.4	☐	☒	☒	☒
	40 Interlock_2	Bool	%I20.5	☐	☒	☒	☒
	41 Interlock_3	Bool	%I20.6	☐	☒	☒	☒
	42 Interlock_4	Bool	%I20.7	☐	☒	☒	☒
	43 O/L_1	Bool	%I0.0	☐	☒	☒	☒
	44 O/L_2	Bool	%I0.1	☐	☒	☒	☒
	45 O/L_3	Bool	%I0.2	☐	☒	☒	☒
	46 O/L_4	Bool	%I0.3	☐	☒	☒	☒
	47 EStop1(1)	Bool	%I21.0	☐	☒	☒	☒
	48 EStop2(1)	Bool	%I21.1	☐	☒	☒	☒
	49 EStop3(1)	Bool	%I21.2	☐	☒	☒	☒
	50 EStop4(1)	Bool	%I21.3	☐	☒	☒	☒
	51 Interlock_1(1)	Bool	%I21.4	☐	☒	☒	☒
	52 Interlock_2(1)	Bool	%I21.5	☐	☒	☒	☒
	53 Interlock_3(1)	Bool	%I21.6	☐	☒	☒	☒
	54 Interlock_4(1)	Bool	%I21.7	☐	☒	☒	☒
	55 Interlock burners	Bool	%I8.0	☐	☒	☒	☒
	56 Interlock burners(1)	Bool	%I9.0	☐	☒	☒	☒
	57 EStop5	Bool	%I9.1	☐	☒	☒	☒
	58 EStop5 (1)	Bool	%I9.1	☐	☒	☒	☒
	59 Analogue input(1)	Real	%MD66	☐	☒	☒	☒
	60 Analogue output	Real	%MD70	☐	☒	☒	☒

Figure 14: Shows the tag list created within the Siemens software program TIA portal

Good set of PLC tags shows internal implementation of the control / indication system

5.3 PLC software programme

These output bit should not be 'set' bits if you are using retention contacts



Program screen dump could have been clearer

Figure 15: Shows the first section of the PLC programme.

Figure 15 shows the first section of the programme created within Siemens software package TIA portal. The tags were first created as seen in Figure 14. This network is used to start the roaster stat/delta motor. The start and stop buttons are tagged with an M prefix as they are memory elements and therefore are common to the HMI. When the start 'press and release' button is pressed on the HMI on the related screen, Figure 23, the relay coil causes a latch with its related normally open contact Q0.0, this allows the push button to be released.

Pressing the roaster start button, in parallel, starts the star section of the programme and the delay on timer. The timer has a normally closed contact to de-energise the star motor section when it has run its time and a normally open contact that closes when the time has run down, creating a latch on the delta coil motor section of the programme. This network therefore starts the roaster motor in star and then after a pre-set seven second period keeps the main contactor energised while de-energising the star contactor and energising the delta contactor. There is also, as a failsafe, a mechanical interlock between both star/delta contactors preventing them being energised at the same time.

The many normally closed contacts, including the failsafe highlighted in yellow giving the SIL 2 protection, are there to stop the motor by de-energising all the related contactors in the event of an emergency, hazardous situation or overload operation. The next network, network 2 flue motor Figure 16, is identical in its design as it is also a star delta motor. It has its own HMI screen, Figure 24, with a start/stop and indicators to identify an alarm or fault condition the same as the roaster network 1.

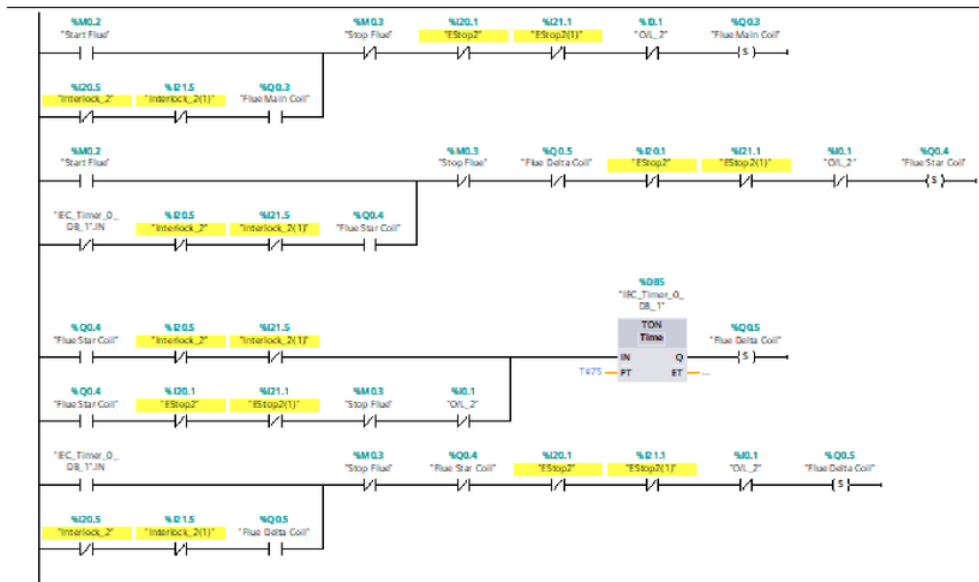


Figure 16: Flue motor programme, star/delta starter network.

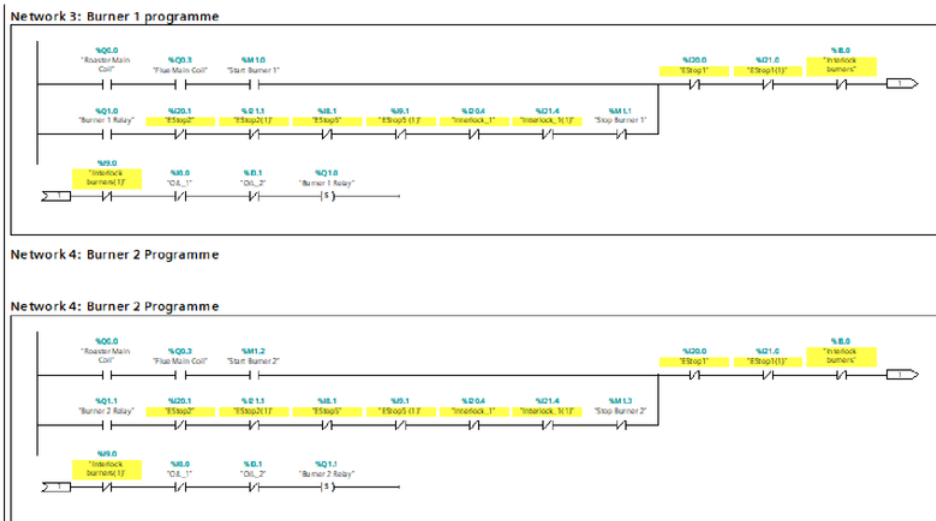


Figure 17: The burner system programme designed with Siemens TIA portal.

Figure 17 shows the 2 networks responsible for controlling the both burner stages of the process. This is done by a 'press and release' start button within the HMI, pressing this button energises a relay output coil ("burner 1 relay") within the programme. As standard, a stop 'press and release' button, normally closed contact is in series with the normally open start contact and, in parallel, a normally open contact assigned from the relay coil output swops state from open to closed when the relay coil is energised as a latch. This latching method is a common theme through all networks of the programme and therefore will be assumed to have been covered.

There are many normally closed contact inputs to the PLC and input extension pack that are used to de-energise the burner networks during an E-stop activation of either the roasting drum (E-stop 1 & (1)), the flue (E-stop 2 & (2)), the burners own E-stop 5 & (5) and the gas safety solenoid (interlock burners) being activated. If the overloads of either the roasting drum motor or the flue motor activate, then this also de-energises the burner networks. The importance of this scenario was highlighted within the specifications. The burner must stop operating if there is an issue with the drum or extraction system, but the drum must still operate to dissipate excess heat stored within the roasting drum.

Network 5: Cooler Bed D.O.L

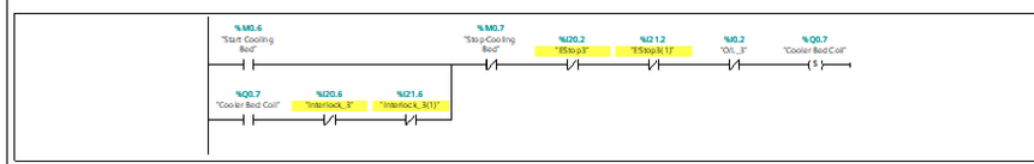


Figure 18: Shows the direct on-line motor network of the cooling bed motor.

The start/stop latching is the same as previous networks with the cut-outs being a local E-stop (E-stop 3 & (3)), and interlocks (interlock_3 & (3)) connected to the hinged door shown in Figure's 8 & 9. The overload, O/L_3 is connected to the cooling bed normally closed auxiliary contact within the overload of the cooling bed contactor.

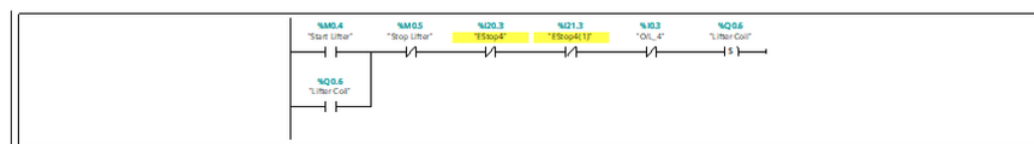
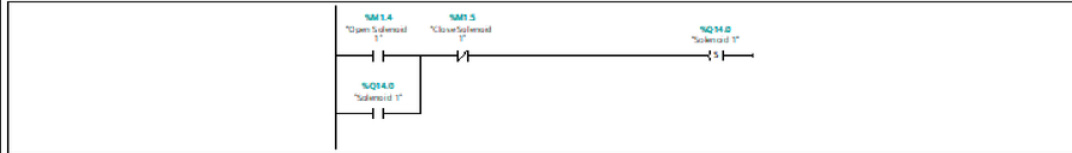


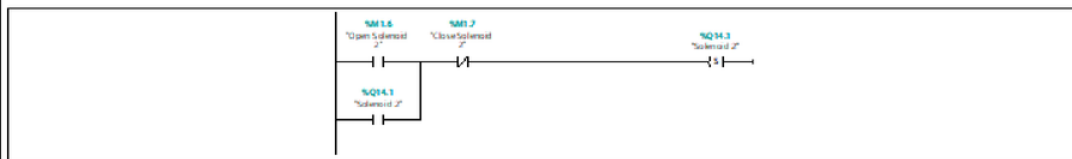
Figure 19: The blower/lifter motor network within the programme.

Figure 19 shows the latching start/stop and cut-outs of the DOL lifter/blower motor system, E-stops 4 & (4) and the related auxiliary overload contacts used to stop the motor in the event on the motor overloading above full run current or the emergency stop being activated.

Network 7: Solenoid 1



Network 8: Solenoid 2



Network 9: Solenoid 3

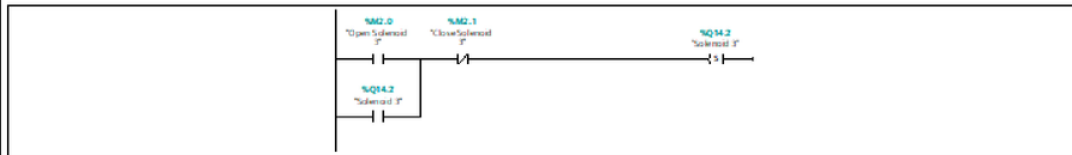


Figure 20: The solenoids, used to operate air driven valves to open and close various systems.

The three networks shown in Figure 20, as networks 7,8 & 9 are latching outputs used to operate various solenoids. The solenoids are used to operate air driven valves that drive several pistons to open and close doors to the process. These are currently not working as they require servicing by the proprietor, but will eventually be brought into service and therefore the facility has been provided within the project panel and software programme.

The final section of the programme shown in Figure 21 is related to the alarming section of the project. As is identified in the specifications, there is a requirement to firstly output the temperature on a display and when at a health temperature, operate a fixed visible green LED light as an indicator. Then when the drum temperature rises above a safe level, output an alarm state identified by an amber strobe LED light as a caution. Finally there should be a shut-down stage if the drum temperature is allowed

to rise to dangerous levels, this is indicated by a red strobe LED and the burner should shut-down without shutting down the roasting drum.



Network 11:

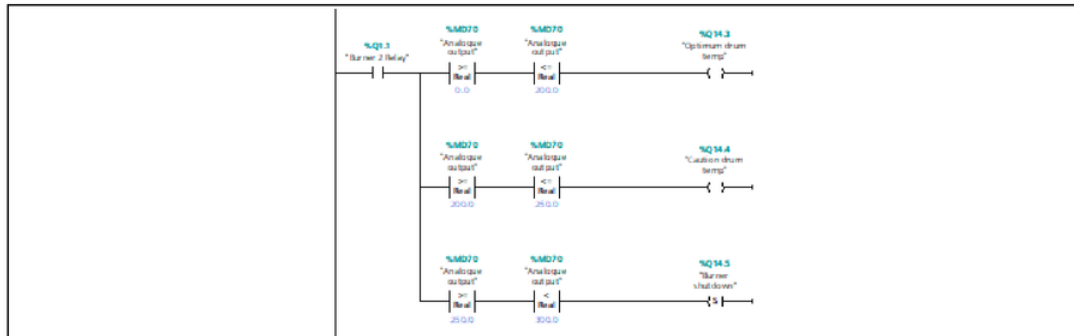
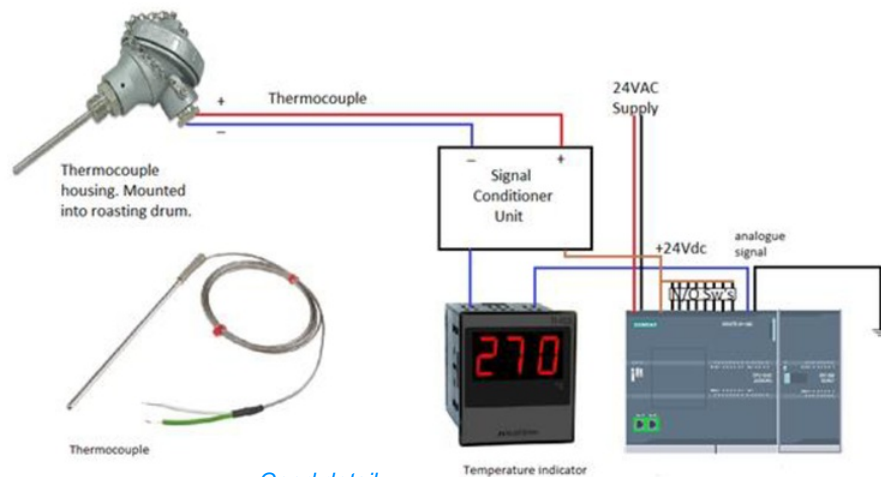


Figure 21: Shows the analogue network used for the alarm over-temperature system.

This is achieved within the programme using predefined function blocks called 'Norm_X' and 'Scale_X'. These functions allow you to select a range, which in this case is a 0 to 10v scale. The variable voltage is connected between minimum and maximum on the 'Norm_X' function block, the block then converts it to a range between 0 and 1 as a decimal on the output of the function block. The actual input value is connected as the variable analogue input tagged 'MD66 analogue input' into the value input on the function block with the changing scale outputted as a decimal value.

The decimal value is then transferred to the 'Scale_X' function block as 'Temp value', a scale is selected, in this case '0 to 300' denoting the require temperature range, that is an output of the actual temperature which is tagged to a display within the HMI. The 'analogue output %MD70' from the 'Scale_X' function block is then used with a math function to operate the various alarm output coils. The math function is only enabled when the second burner is started.

Very good detail on PLC program design but some mistakes noted.



Good detail

Figure 22: Shows the alarm system components using the thermocouple and signal conditioning unit.

Figure 22 shows how the analogue signal will be achieved in the field. A J type thermocouple will be used to detect variations in temperatures. These signal variations will be sent through a signal conditioning unit before being used as a 0 to 10v input to the PLC CPU. A panel mount display, as well as a virtual HMI temperature display will be made available for the operator's convenience.

5.4 HMI screens design

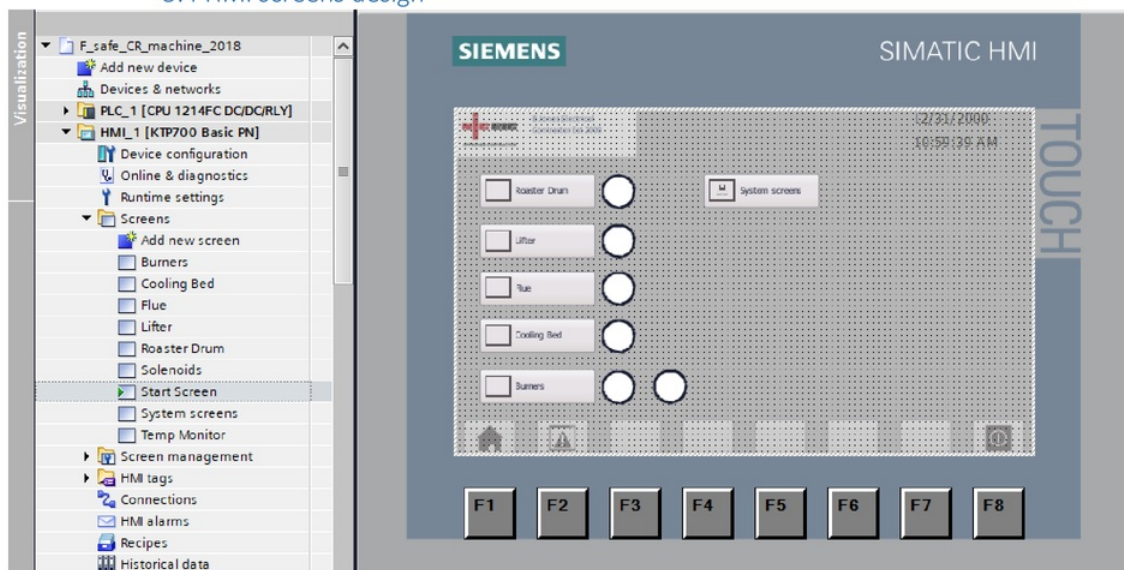


Figure 23: Shows the start HMI screen used to access all the function screens as well as the alarm screens.

Using the HMI tag list, Figure 32, the various control buttons, alarms and indicators have been created. Figure 23 shows the start screen which allows access to all other

screens that are used to control the process. The range of screens are shown in the following figures. The buttons were created using an event element within the software and the correct tags connected to its relevant control switch. Indicators were created using the animation events and relevant tags connected to relevant indicator or alarm to be displayed on the HMI screens.

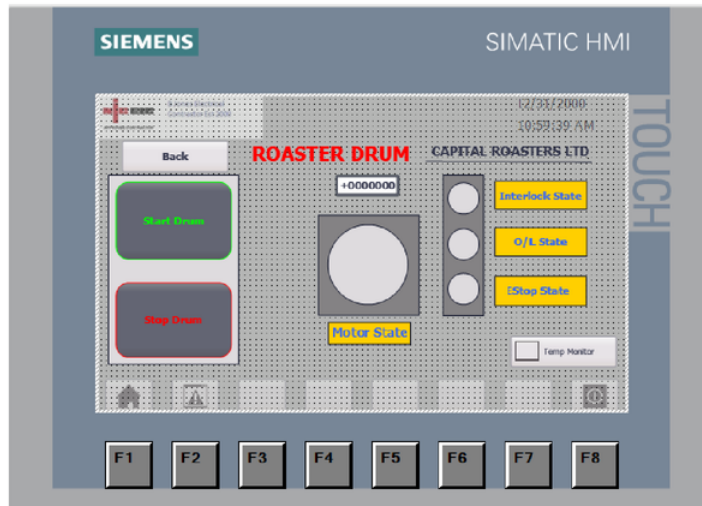


Figure 24: Shows the roaster drum screen.

Figure 24 shows the roaster drum screen that contains the press and release start/stop buttons. The state of the motor, running or stopped, will be display as green as running and red as stopped. The alarm states are show as lit when the field contacts are activated.

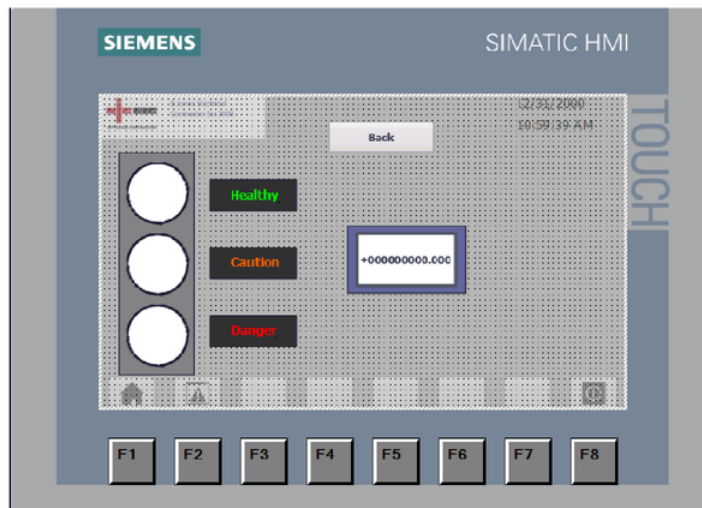


Figure 25: This shows the temperature alarm conditions

Figure 25 shows the screen responsible for outputting the condition of the temperature alarm display. The indicators will light during different stages to temperature rise along with the actual temperature being displayed.

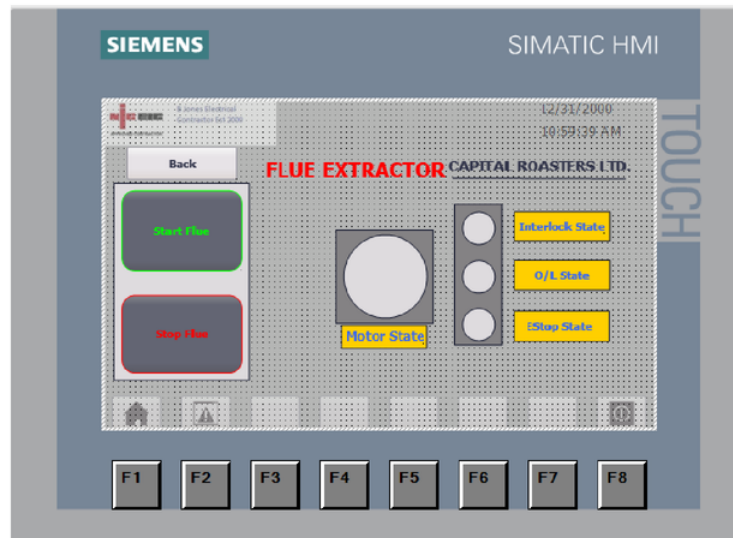


Figure 26: Shows the flue extractor starter screen.

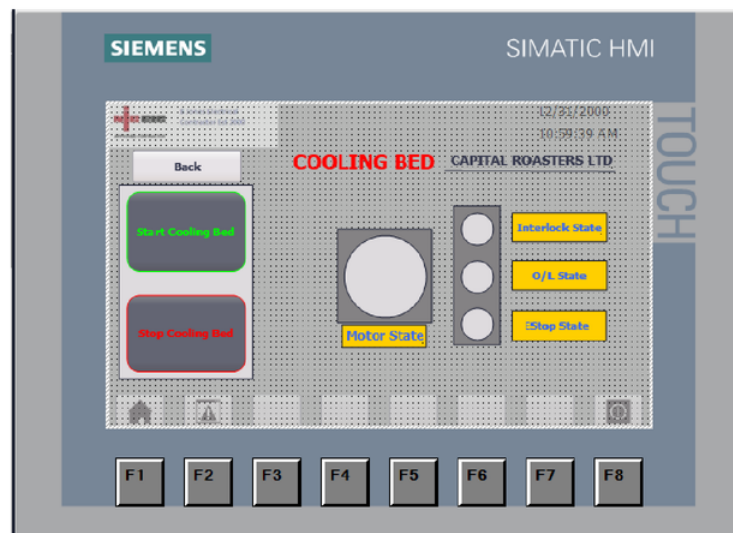


Figure 27: Shows the cooling bed starter screen.

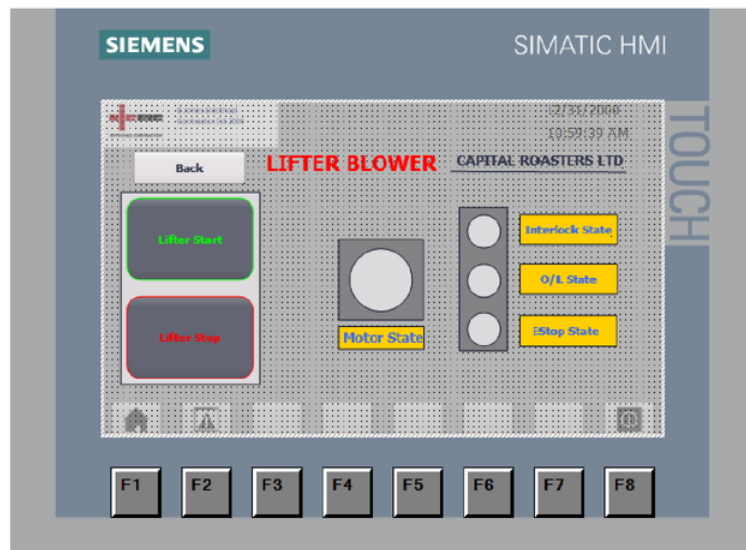


Figure 28: Shows the lifter/blower starter screen.

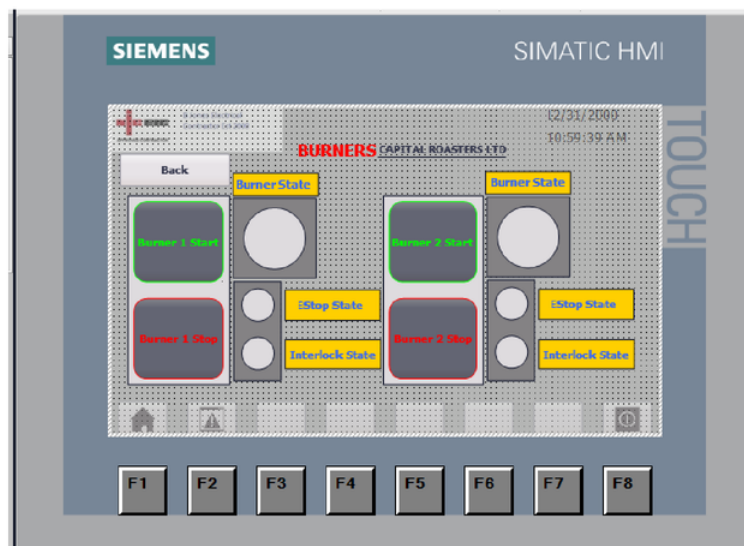


Figure 29: Shows the burners 1 & 2 starter screen.

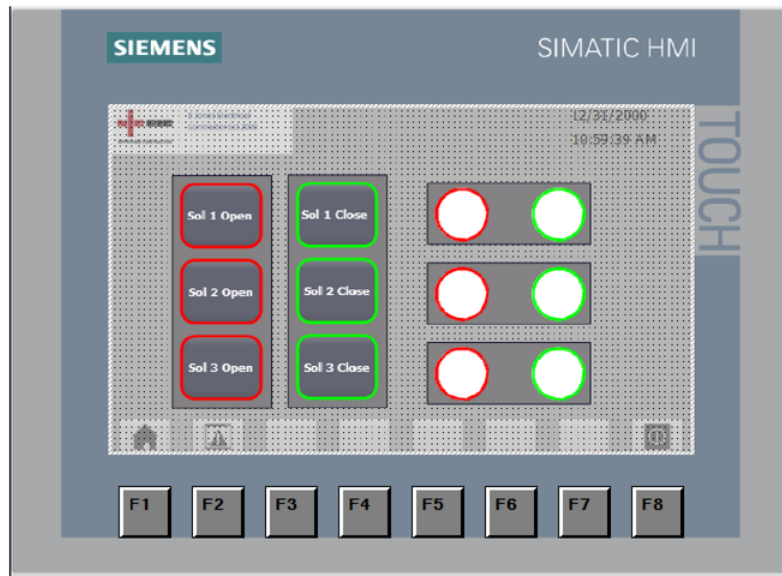


Figure 30: Shows the solenoids open and close screen.

All the screens have been designed to control and monitor the condition of the coffee roasting process and to output any alarm conditions as indicators hence making maintenance and fault finding easier by the actual reason for the process shut-down being displayed on one of the control screens. A final screen, Figure 31, has been developed to allow skilled personnel to access the process with all interlocks and stopping elements disabled. This screen will only be accessible with an access code to prevent unauthorised personnel accessing the maintenance screen.

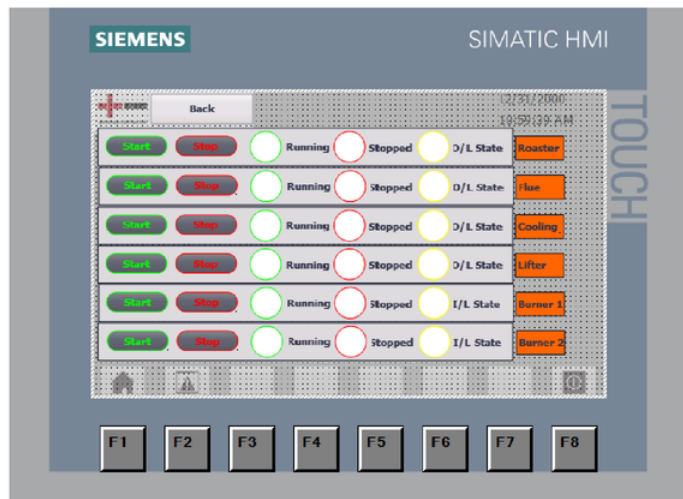


Figure 31: Show a maintenance screen for skilled operatives.

Very good detail on HMI screen design.

5.5 HMI tag list

Name	Data type	Connection	PLC name	PLC tag	Address
HMI Analogue output	Real	HMI_Connectio...	PLC_1	"Analogue output"	%MD70
HMI Burner 1 On	Bool	HMI_Connectio...	PLC_1	"Burner 1 Relay"	%Q1.0
HMI Burner 1 Start	Bool	HMI_Connectio...	PLC_1	"Start Burner 1"	%M1.0
HMI Burner 1 Stop	Bool	HMI_Connectio...	PLC_1	"Stop Burner 1"	%M1.1
HMI Burner 2 On	Bool	HMI_Connectio...	PLC_1	"Burner 2 Relay"	%Q1.1
HMI Burner 2 Start	Bool	HMI_Connectio...	PLC_1	"Start Burner 2"	%M1.2
HMI Burner 2 Stop	Bool	HMI_Connectio...	PLC_1	"Stop Burner 2"	%M1.3
HMI Burners Interlock	Bool	HMI_Connectio...	PLC_1	"Interlock burners"	%I8.0
HMI Burners Interlock (1)	Bool	HMI_Connectio...	PLC_1	"Interlock burners(1)"	%I9.0
HMI Cooling Bed Start	Bool	HMI_Connectio...	PLC_1	"Start Cooling Bed"	%M0.6
HMI Cooling Bed Stop	Bool	HMI_Connectio...	PLC_1	"Stop Cooling Bed"	%M0.7
HMI Cooling Coil	Bool	HMI_Connectio...	PLC_1	"Cooler Bed Coil"	%Q0.7
HMI Drum temp caution	Bool	HMI_Connectio...	PLC_1	"Caution drum temp"	%Q14.4
HMI Drum temp healthy	Bool	HMI_Connectio...	PLC_1	"Optimum drum temp"	%Q14.3
HMI Drum temp shutdown	Bool	HMI_Connectio...	PLC_1	"Burner shutdown"	%Q14.5
HMI EStop 1	Bool	HMI_Connectio...	PLC_1	EStop1	%I20.0
HMI EStop 1(1)	Bool	HMI_Connectio...	PLC_1	"EStop1(1)"	%I21.0
HMI EStop 2	Bool	HMI_Connectio...	PLC_1	EStop2	%I20.1
HMI EStop 2 (1)	Bool	HMI_Connectio...	PLC_1	"EStop2(1)"	%I21.1
HMI EStop 3	Bool	HMI_Connectio...	PLC_1	EStop3	%I20.2
HMI EStop 3 (1)	Bool	HMI_Connectio...	PLC_1	"EStop3(1)"	%I21.2
HMI EStop 4	Bool	HMI_Connectio...	PLC_1	EStop4	%I20.3
HMI EStop 4 (1)	Bool	HMI_Connectio...	PLC_1	"EStop4(1)"	%I21.3
HMI EStop 5	Bool	HMI_Connectio...	PLC_1	EStop5	%I20.4
HMI EStop 5 (1)	Bool	HMI_Connectio...	PLC_1	"EStop5 (1)"	%I21.4
HMI Flue Main	Bool	HMI_Connectio...	PLC_1	"Flue Main Coil"	%Q0.3
HMI Flue Start	Bool	HMI_Connectio...	PLC_1	"Start Flue"	%M0.2
HMI Flue Stop	Bool	HMI_Connectio...	PLC_1	"Stop Flue"	%M0.3
HMI Interlock 1	Bool	HMI_Connectio...	PLC_1	Interlock_1	%I20.4
HMI Interlock 1 (1)	Bool	HMI_Connectio...	PLC_1	"Interlock_1(1)"	%I21.4
HMI Interlock 2	Bool	HMI_Connectio...	PLC_1	Interlock_2	%I20.5
HMI Interlock 2 (1)	Bool	HMI_Connectio...	PLC_1	"Interlock_2(1)"	%I21.5
HMI Interlock 3	Bool	HMI_Connectio...	PLC_1	Interlock_3	%I20.6
HMI Interlock 3 (1)	Bool	HMI_Connectio...	PLC_1	"Interlock_3(1)"	%I21.6
HMI Interlock 4	Bool	HMI_Connectio...	PLC_1	Interlock_4	%I20.7
HMI Interlock 4 (1)	Bool	HMI_Connectio...	PLC_1	"Interlock_4(1)"	%I21.7
HMI Lifter Coil	Bool	HMI_Connectio...	PLC_1	"Lifter Coil"	%Q0.6
HMI Lifter Start	Bool	HMI_Connectio...	PLC_1	"Start Lifter"	%M0.4
HMI Lifter Stop	Bool	HMI_Connectio...	PLC_1	"Stop Lifter"	%M0.5
HMI OIL 1	Bool	HMI_Connectio...	PLC_1	"OIL_1"	%I0.0
HMI OIL 2	Bool	HMI_Connectio...	PLC_1	"OIL_2"	%I0.1
HMI OIL 3	Bool	HMI_Connectio...	PLC_1	"OIL_3"	%I0.2
HMI OIL 4	Bool	HMI_Connectio...	PLC_1	"OIL_4"	%I0.3
HMI Roaster Main	Bool	HMI_Connectio...	PLC_1	"Roaster Main Coil"	%Q0.0
HMI Roaster Start	Bool	HMI_Connectio...	PLC_1	"Start Roaster"	%M0.0
HMI Roaster Stop	Bool	HMI_Connectio...	PLC_1	"Stop Roaster"	%M0.1
HMI Sol1 Close	Bool	HMI_Connectio...	PLC_1	"Close Solenoid 1"	%M1.5
HMI Sol1 Coil	Bool	HMI_Connectio...	PLC_1	"Solenoid 1"	%Q14.0
HMI Sol1 Open	Bool	HMI_Connectio...	PLC_1	"Open Solenoid 1"	%M1.4
HMI Sol2 Close	Bool	HMI_Connectio...	PLC_1	"Close Solenoid 2"	%M1.7
HMI Sol2 Coil	Bool	HMI_Connectio...	PLC_1	"Solenoid 2"	%Q14.1
HMI Sol2 Open	Bool	HMI_Connectio...	PLC_1	"Open Solenoid 2"	%M1.6
HMI Sol3 Close	Bool	HMI_Connectio...	PLC_1	"Close Solenoid 3"	%M2.1
HMI Sol3 Coil	Bool	HMI_Connectio...	PLC_1	"Solenoid 3"	%Q14.2
HMI Sol3 Open	Bool	HMI_Connectio...	PLC_1	"Open Solenoid 3"	%M2.0

Figure 32: Shows the tag list used to link the I/O's with the HMI.

Figure 32 shows the HMI tag list used to create the link between the HMI and the programme I/O's.

Very good detail on HMI design and tag list.

5.6 Design drawings

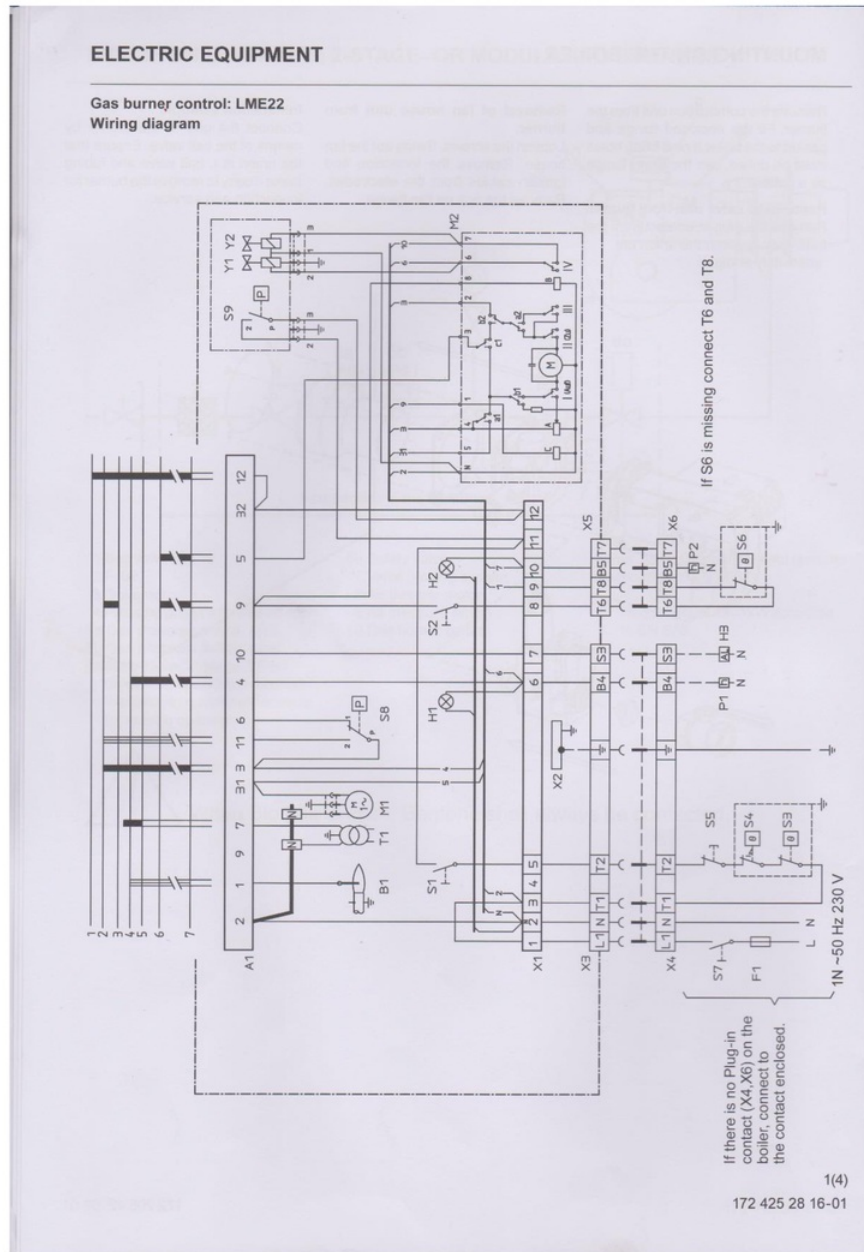


Figure 33: Shows the electrical drawings of the existing burner systems.

Figure 33 shows the gas boiler electrical drawings used to provide the design information required to create the software programme as well as how the field terminations are to be achieved.

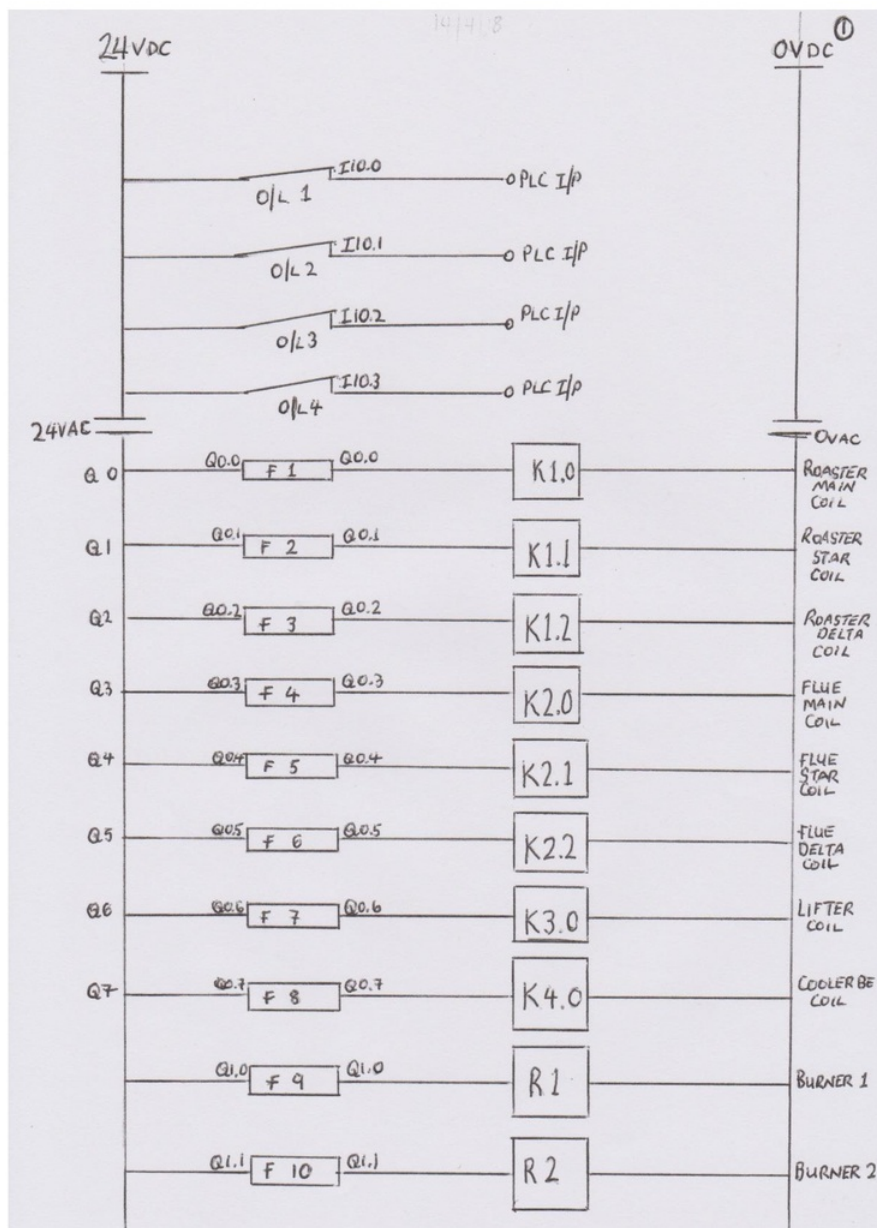


Figure 34: Shows the drawing design created to wire the panel.

Figure 34 shows the start of the electrical drawings created so to wire the panel. The following figures are the completed wiring diagrams produce so the build of the panel can commence. It has been created in a ladder style wiring diagram and will be included in the handover pack following completion of the commissioning process.

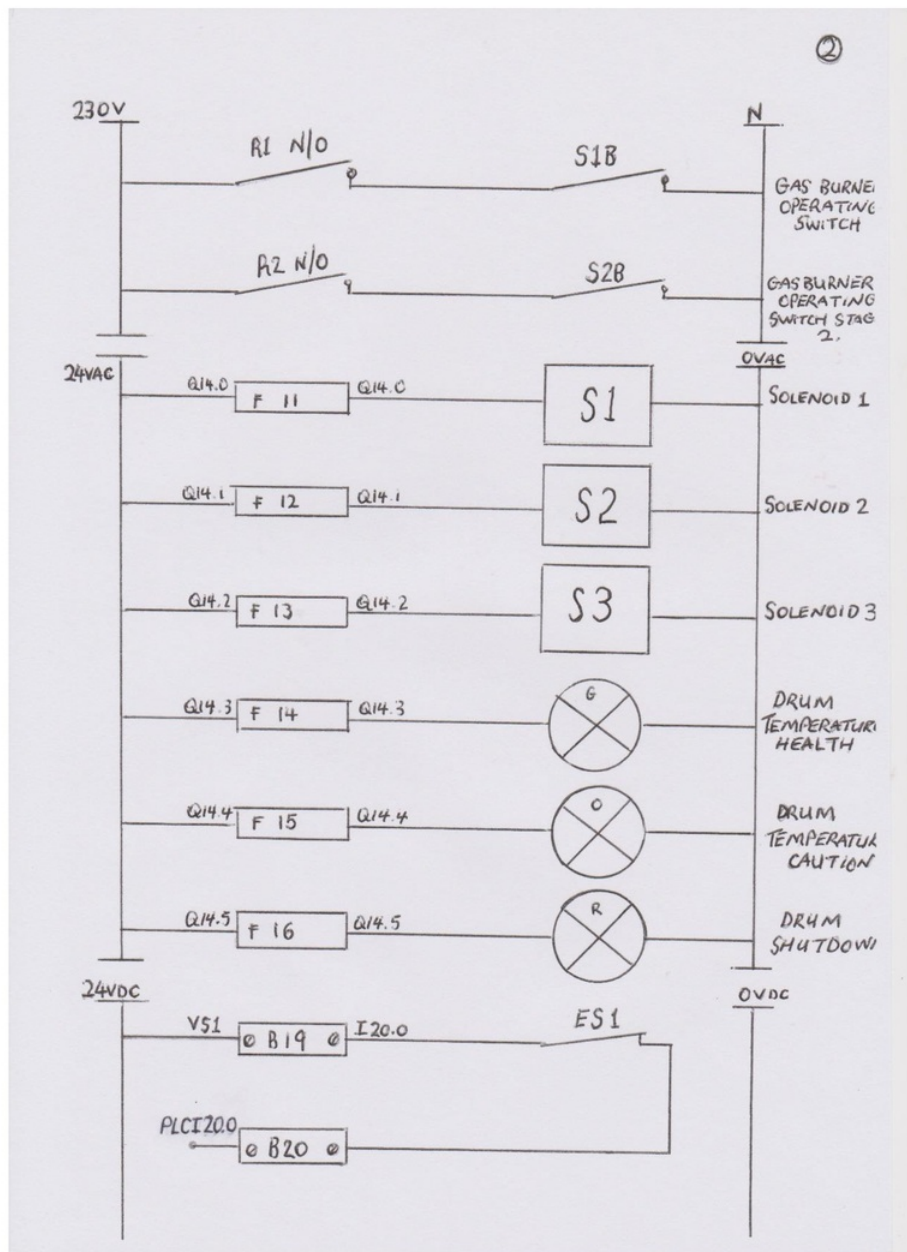


Figure 35: Shows the continuation of the ladder wiring drawing.

The ladder wiring drawings show all the termination positions, PLC connections, fuse carrier terminations, contactor coil connections as well as the related voltages present and all the wiring identification codes.

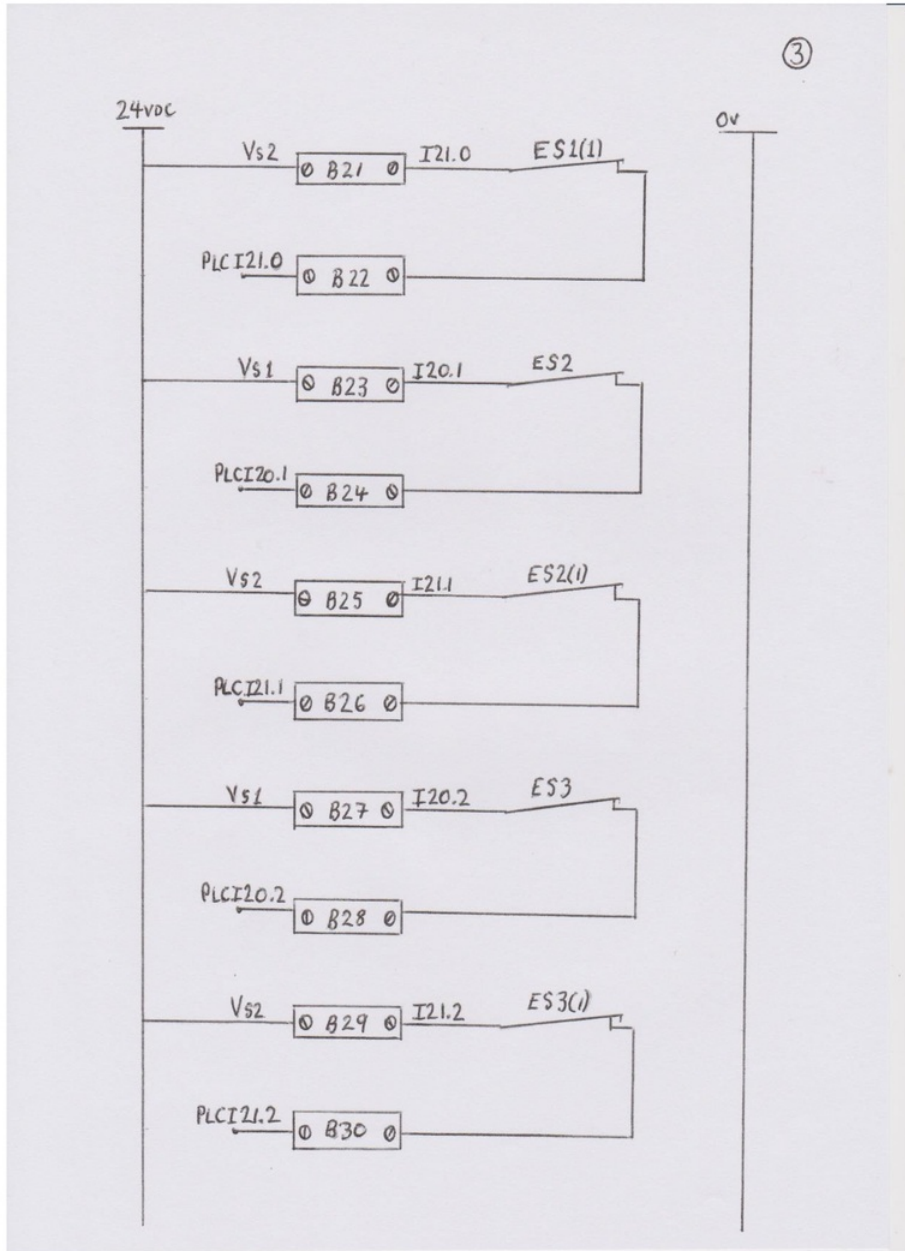


Figure 36: Shows the dual parallel E-stop terminations to be made within the panel.

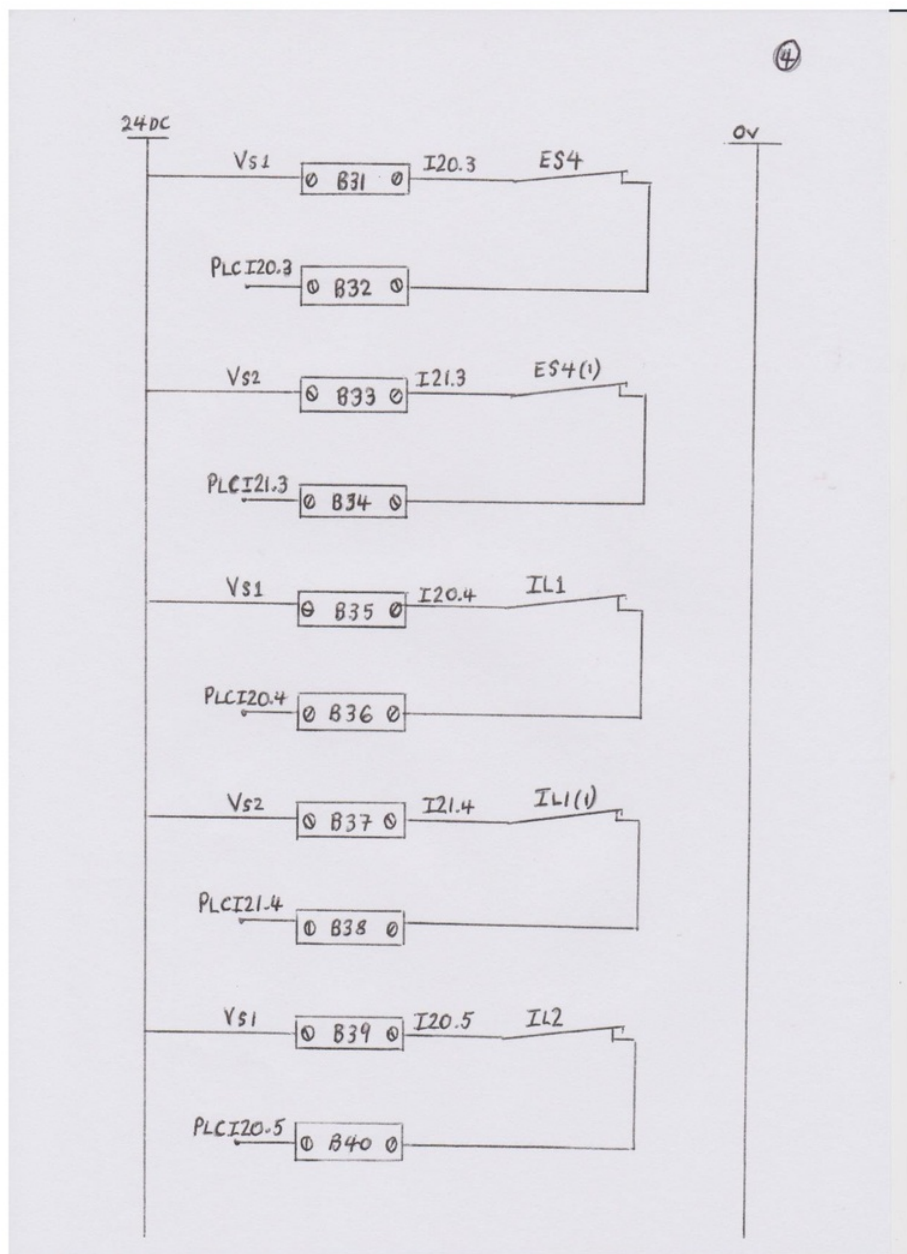


Figure 37: Shows the dual parallel E-stop terminations and failsafe interlocks to be made within the panel.

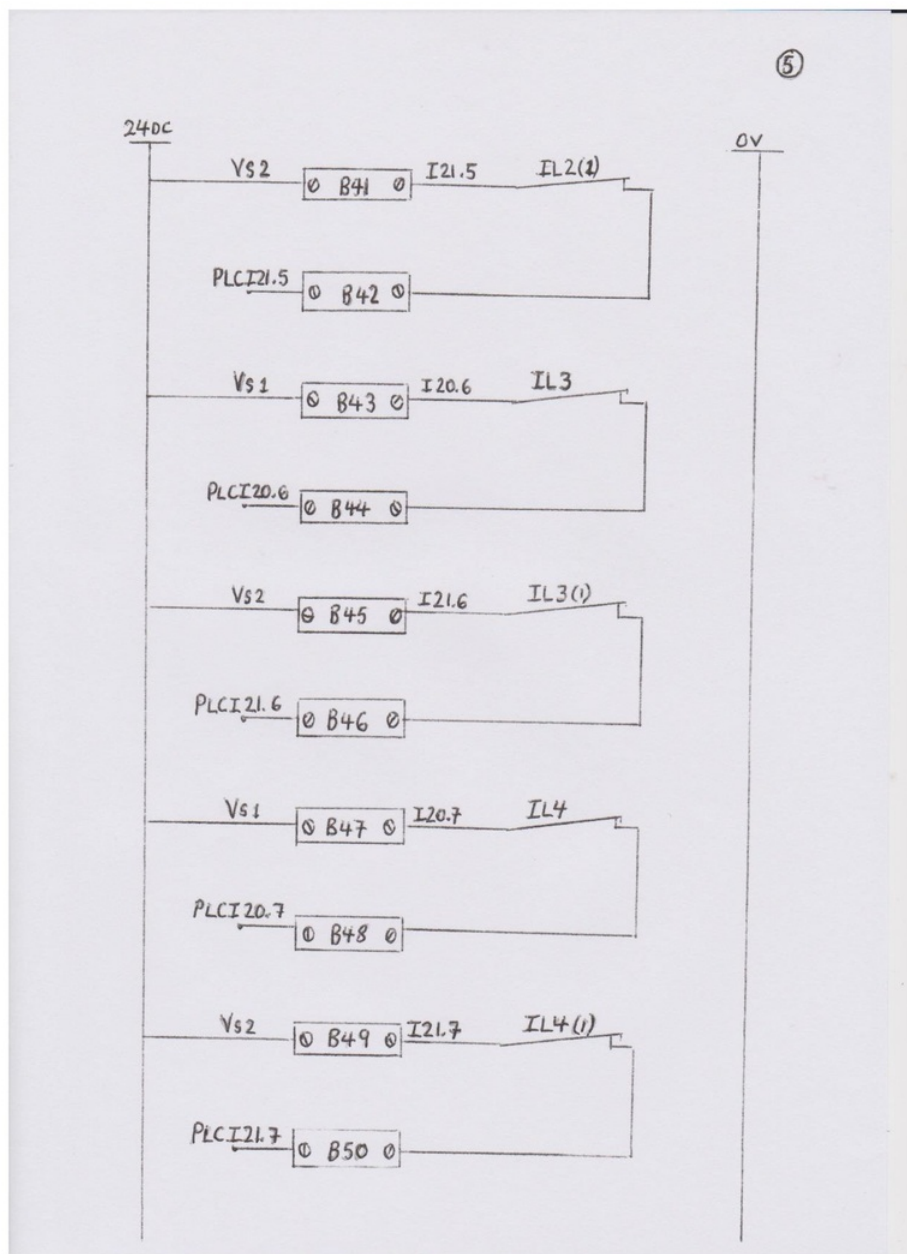


Figure 38: Shows the continued dual parallel E-stop terminations and failsafe interlocks to be made within the panel.

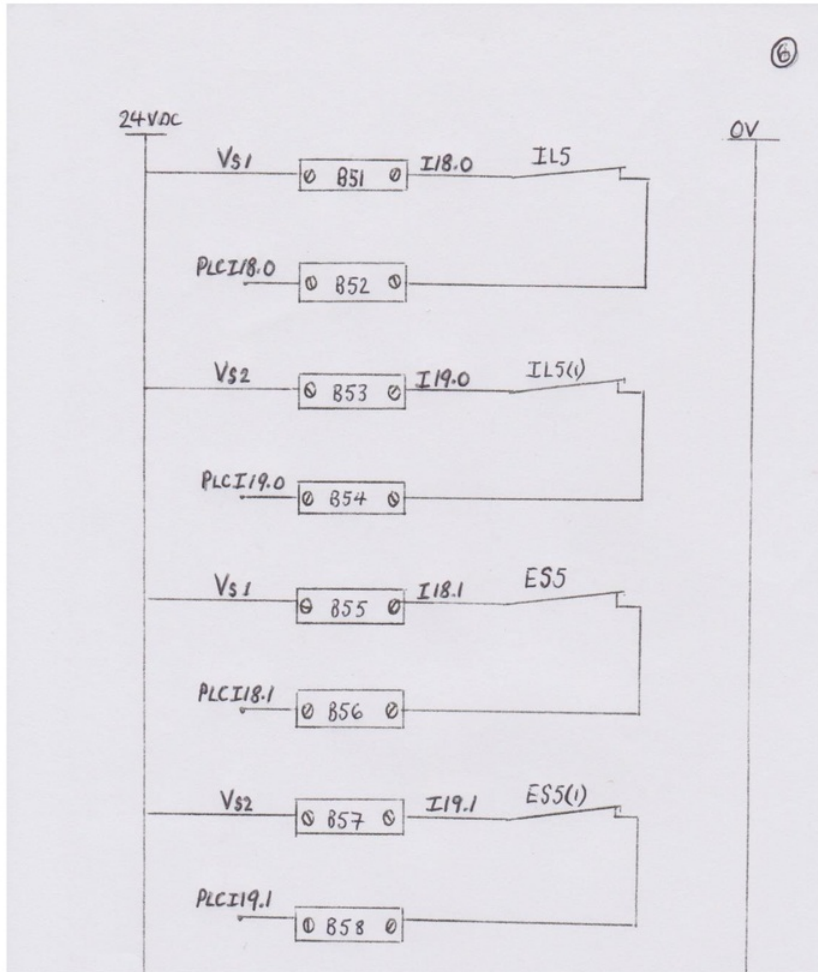


Figure 39: Shows the continued dual parallel E-stop terminations and failsafe interlocks to be made within the panel.

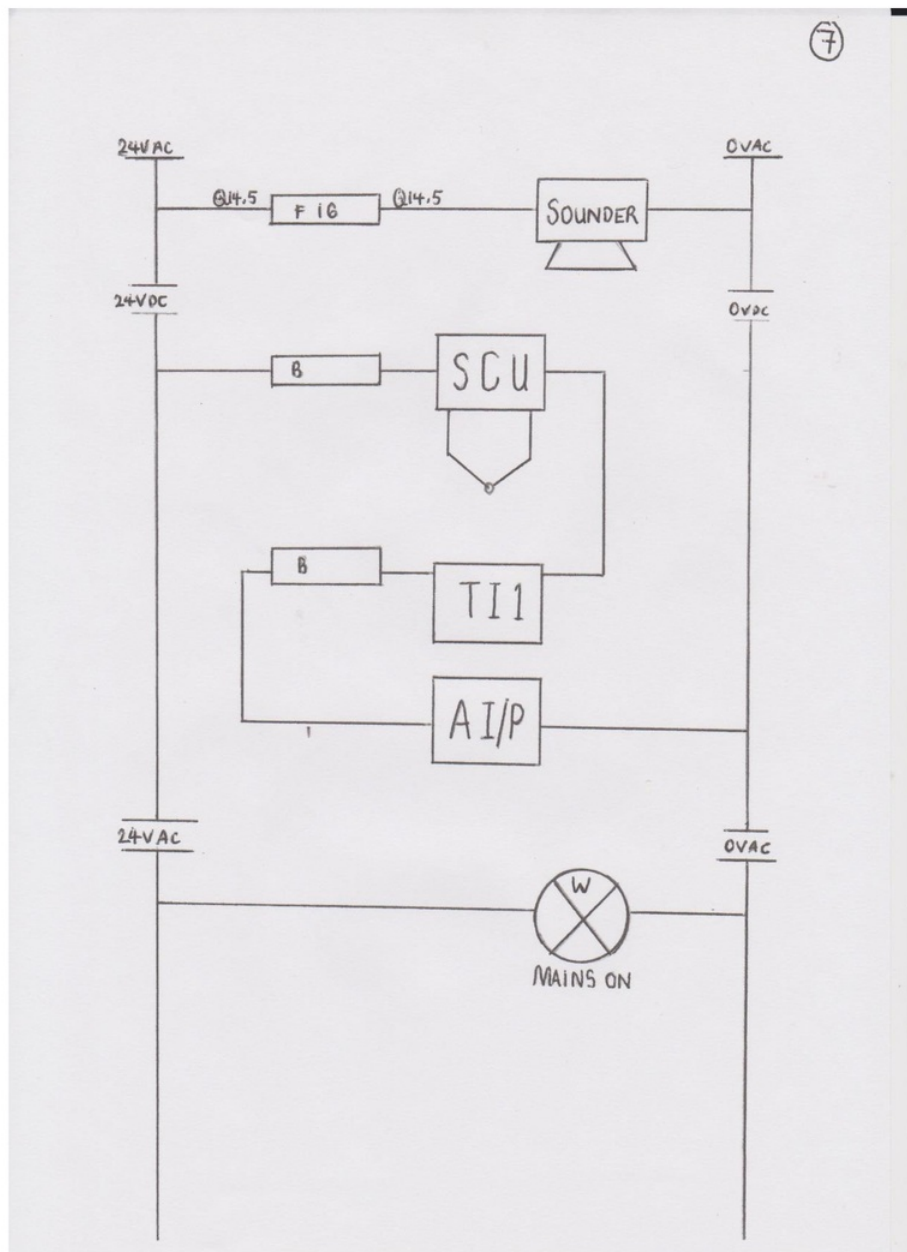


Figure 40: Shows the drawing produced to show how the analogue signal and conditioning circuit are to be connected.

Very good detailed wiring diagrams but they could have been presented better

5.7 Design considerations

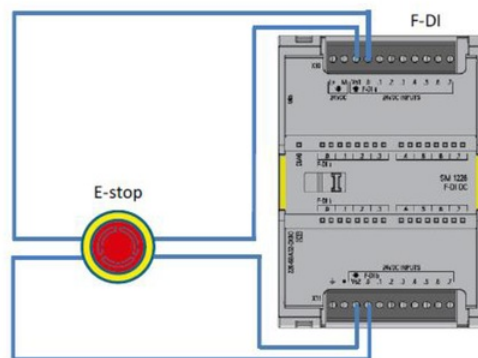


Figure 41: SIL 2 emergency stop system using failsafe input module

Figure 41 shows an example of an emergency stop signal to the failsafe PLC input module on a twin channel basis to achieve SIL 2.

You can assign the emergency stop to any provided channel pair (this is shown for the channel pair 0 and 8 in the below figure).

Figure 4-6 Settings of the F-DI for the emergency stop in the hardware configuration

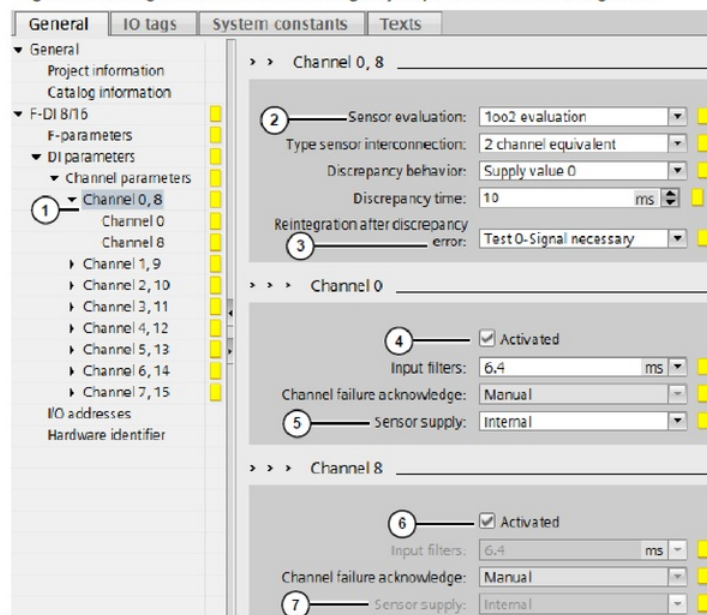


Figure 42: Show the software adjustments used to achieve the desired SIL level.

It is then possible to adjust the SIL level within the Siemens TIA software to achieve the desired SIL level. The example shown in Figure 42 shows how to gain SIL 2. The

sensor evaluation is set to 1oo2 which means 1 out of 2 for the two channels of the input module. Type sensor is set to 2-channel also with unused channels being disabled. The principle is the same for the failsafe inductions switches that will be used for removable guards and doors. As with the E-stops, being wired as 2 normal closed switches in parallel for each E-stop station, the same will be achieved with the failsafe induction switches, 2 interconnection switches for each guard or door over 2 channels of the failsafe input module to achieve SIL 2 as show in Figure 43.

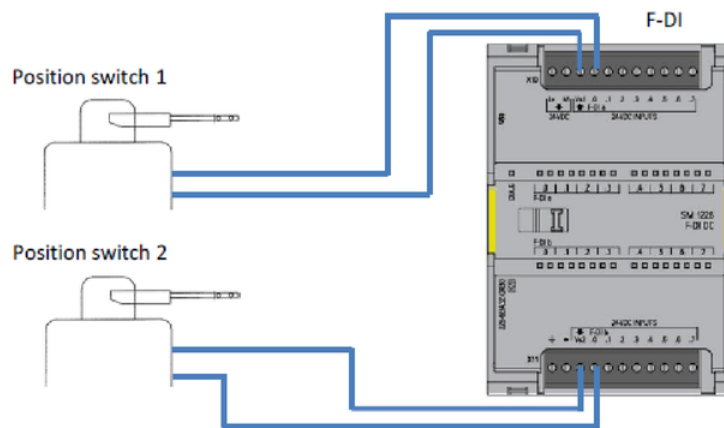


Figure 43: Similar to the E-stop SIL setup but using position switches.

Following the design of the software programmes through the I/O list and creating the wiring diagrams, assessment is needed to provide information on the general characteristics to prove the design has considered the purpose, supplies and structure of the installation and that these meet the requirements of the IEE wiring regulations. This is proceeded by design calculations to be able to select the correct accessories to complete the installation. A basic design procedure is shown in Table 7.

To establish the design would be suitable for its intended purpose, considerations of any external influences are necessary. The main hazards pertain to heat produced by the burner and coffee dust produced during the roasting process. Table 6 shows the considerations made with regards to the external influences which can affect the installation. The environment code AA4 denotes an ambient -5 to 40 °C, utilization code BA5 denotes that skilled operatives use the premise and building code CA1 denotes the structure of the building is industrial and therefore non-combustible.

Environmental	Utilization	Building
AA4 (-5 to 40 °C)	BA5 (Skilled)	CA1 (Non-combustible)
AE5 (Moderate dust)		

Table 6: List of external influences that could affect the installation. (IET & BSI, 2015)

The environmental code AE5 denotes moderate build-up of dust created by the coffee beans. Now the external influences have been established, the housing and infrastructure for the project can be selected. An enclosure to house the project components has been selected as ingress protection level (IP66) as a minimum to prevent the dust penetrating the enclosure and the location the enclosure is to be sited will be so as appropriate to limit exposure to higher ranges of temperatures.

Very good detail on SIL rated PLC used within the project

5.8 Design calculations

The next table, Table 7, contains a basic list of procedure as required during design and verifications of electrical installations. (Brian Scaddan, 2011).

DESIGN CALCULATIONS PROCEDURES

1	Assessment of general characteristics
2	Determination of design current I_b
3	Selection of protective devices having nominal rating I_n
4	Selection of appropriate correction factors
5	Calculation of tabulated conductor currents I_t
6	Selection of suitable conductor sizes
7	Calculation of voltage drop
8	Evaluation of shock risk

Table 7: Basic design procedures of electrical installations. (Brian Scaddan, 2011)

PLATE INFORMATION

ROASTER MOTOR	kW = 4, PF = 0.87, $V_L = 400$
FLUE MOTOR	kW = 4.5, PF = 0.88, $V_L = 400$
LIFTER MOTOR	kW = 1.5, PF = 0.89 $V_L = 400$
COOLING BED MOTOR	kW = 1.0, PF = 0.89 $V_L = 400$

Table 8: Shows the motor plate information gathered during site visit.

The assessment of general characteristics has been established, therefore the next stage is to determine the design current of the project installation. Table 9 is to show the motor plate information used to complete the calculations.

Roaster motor

Plate information: $V_L = 400$ ----- $P = 4000$ ----- $PF = 0.87$

Then as $I_b = P / \sqrt{3} \times V_L \times PF$

$$I_b = 4000 / \sqrt{3} \times 400 \times 0.87$$

$$I_b = 4000 / 1.73 \times 400 \times 0.87$$

$$I_b = 6.64 \text{ A}$$

Flue motor

Plate information: $V_L = 400$ ----- $P = 4500$ ----- $PF = 0.88$

Then as $I_b = P / \sqrt{3} \times V_L \times PF$

$$I_b = 4500 / \sqrt{3} \times 400 \times 0.88$$

$$I_b = 4500 / 1.73 \times 400 \times 0.88$$

$$I_b = 7.38 \text{ A}$$

Lifter motor

Plate information: $V_L = 400$ ----- $P = 1500$ ----- $PF = 0.89$

Then as $I_b = P / \sqrt{3} \times V_L \times PF$

$$I_b = 1500 / \sqrt{3} \times 400 \times 0.89$$

$$I_b = 1500 / 1.73 \times 400 \times 0.89$$

$$I_b = 2.43 \text{ A}$$

Cooling bed motor

Plate information: $V_L = 400$ ----- $P = 2000$ ----- $PF = 0.89$

Then as $I_b = P / \sqrt{3} \times V_L \times PF$

$$I_b = 2000 / \sqrt{3} \times 400 \times 0.89$$

$$I_b = 2000 / 1.73 \times 400 \times 0.89$$

$$I_b = 3.24 \text{ A}$$

Burner

Data sheet information: $V = 230$ ----- $P = 1200$

Then as $I_b = P / V$

$$I_b = 1200 / 230$$

$$I_b = 5.22 \text{ A}$$

PLC and accessories

Data sheet information:

35-watt power consumption

Selection of protective devices having nominal rating I_n

Therefore, the design current based on these calculations can be accessed as being $I_b = 27.91$ Amps. The supply can therefore be provided for a nominal full load current I_n of 32 amps and as there will be sub-transient current peaks then, the main circuit breaker will be a type C Schneider Electric capable of 19 times the FLC for short periods of time (data sheet available in the handover pack).

Tabulated current carrying capacity I_t

$$I_t = I_n / C_a \times C_g \times C_f \times C_i$$

Where C_a = Correction factor for ambient temperature (from IEE table 4B1 or 4B2),

C_g = Correction factor for groups of cables (from IEE table 4B3 & 4B5) C_f =

Correction factor for (BS 3036 re-wireable fuse only) and C_i = Correction factor for cables covered in thermal insulation (from IEE tables).

Therefore, $I_t = I_n / C_a$

$$= 32 / 0.87$$

$$= 36.78 \text{ amps}$$

Selection of suitable conductor sizes

As there is a high likelihood of all loads being energised at the same time, diversity is not being taken into consideration and the full tabulated current carrying capacity I_t will be used to select the appropriate conductor sizes. Using perforated metal tray, run vertically or horizontally and a multicore armoured 70 °C thermoplastic insulated copper cable, table 4D4A of the IEE wiring regulations can be used to select the correct cable size for the supply cable to the project panel. Table 4D4A requires the cable with a tabulated current carrying capacity of 36.87 to have a conductor size of 6mm².

Calculation of voltage drop

As stated by (Brian Scaddan, 2011), *“The regulations require that the voltage at the terminals of fixed equipment should be greater than the lower limit permitted by the British Standards for that equipment, or in the absence of a British Standard, that the safe functioning of the equipment should not be impaired”*. As stated in the IEE wiring regulations, volt-drop should not exceed 4% of the supply voltage. Using table 4D4B,

which gives the voltage drop per ampere per meter (mV/A/m) and with a cable run measured at 20 meters, the volt-drop can be calculated. For a 6.0mm² four core AC cable, (mV/A/m) = 6.4

Volt-drop = (mV/A/m) x I_b x length /1000 = 4.72 V (Acceptable)

Evaluation of shock risk

For an earthing system TN-S, the maximum permitted external earth fault loop impedance (Z_e) should not exceed 0.8 ohms. For a C type 40-amp circuit breaker, the maximum tabulated (table 41.3 IEE wiring regulations) internal earth fault impedance (Z_s) should not exceed 0.55 ohms.

Excellent detail on system design calculations but shouldn't this be in the design section?

5.9 Materials and labour costs

<i>Item description</i>	<i>Supplier/wholesaler</i>	<i>Order number/part code</i>	<i>Price</i>
Step 7 safety basic V15 software	Parmely Graham	6ES78331FB150YA5	196.00 x 1
Siemens 1214FC CPU PLC	Parmely Graham	6ES72141HF400XB0	532.00 x 1
Simatic Step 7 basic V15 floating licence	Parmely Graham	6ES78220AA050YA5	257.00 x 1
Failsafe SM 1226 F-DI (inputs)	Parmely Graham	6ES72266BA320XB0	173.00 x 1
Failsafe SM 1226 F-DQ (outputs)	Parmely Graham	6ES72266RA320XB0	238.00 x 1
KTP700 Basic – 7” colour touch. HMI	Parmely Graham	6AV21232GB03AX0	633.00 x 1
Schneider contactors	CEF	LC1D18BD	597.12 x 8
Schneider overloads	CEF	LRD21	165.08 x 4
Schneider 3 pole MCB	CEF	A9F55332	279.08 x 4
Schneider 2 pole MCB	CEF	A9F54206	48.96 x 1
Schneider 4 pole main switch	CEF	SEA9NCB1004	444.94 x 1
Eaton 3 pole & N panel mount non-fused isolator	RS	P3-63/M4/N/K2-PR	110.07 x 1
Schneider wall mount steel enclosure	RS	NSYS3DEX7525	195.71 x 1
Schneider red pushbutton head	RS	ZBAA434	56.10 x 10
Schneider green pushbutton head	RS	ZBAA333	56.10 x 10
Schneider body with N/C contact	RS	ZB5AZ102	57.00 x 12

Schneider body with N/O contact	RS	ZB5AZ101	47.50 x 10
Schneider red LED lamp 24V AC	RS	XB7EVO4BP	70.90 x 10
Schneider green LED lamp 24V AC	RS	XB7EVO3BP	70.90 x 10
Schneider E-stop head	RS	ZB5AS834	15.74 x 1
			4244.20
Item description	Supplier/wholesaler	Order number/part code	Price
Schneider beacon tower LED 24 V ac/dc	RS	XVC 4B3	112.38 x 1
Hobut analogue panel ammeter	RS	D72MIS60A/1-001	61.92 x 3
Hobut din rail mountable current transformer	RS	CT132M100/5-2.5/1	33.27 x 3
Eaton panel sounder 24V ac/dc	RS	AP/W/S/VC/24AC	19.98 x 1
RS Pro thermocouple temp transmitter	RS	381 - 7132	77.24 x 1
RS Pro thermocouple probe, K type 25mm	RS	872 - 2525	22.63 x 1
Bolt nozzle thermocouple FC style	TC.co.uk	Order enquired	Awaiting price
Murata PS, process temperature monitor	Farnell	1339305 order number DMS-20LCD-4/20S-C	38.11 x 1
Craig & Derricott 6 pole NF isolator	RS	RS stock 810 – 0751 Mfr part no SDDG206EBZ22	174.48 x 2
Craig & Derricott 3 pole NF isolator	RS	RS stock 810 – 0757 Mfr part no SDDG253EBZ22	151.36 x 2

Siemens E – stop twist reset SM	RS	RS stock 547 – 3330 Mfr part no 3SB3801DDF3	156.76 x 4
Weidmuller 2.5mm din-rail terminals	RS	RS stock no 718 – 1005 Mfr part no SAK 2.5/35 - 38046000	38.50 x 50
Weidmuller din-rail marker	RS	RS stock no 394 – 829	3.60 x 1
Weidmuller din-rail jumper bar	RS	RS stock no 475 – 268	19.27 x 1
Weidmuller din-rail end cover profile	RS	RS stock no 829 – 8700	22.10 x 1
Weidmuller din-rail end bracket	RS	RS stock no 335 – 4754	10.88 x 1
			942.48
<i>Item description</i>	<i>Supplier/wholesaler</i>	<i>Order number/part code</i>	<i>Price</i>
Weidmuller 2.5mm fused din-rail terminals	RS	RS stock no 829 – 6603	77.60 x 2
Weidmuller 4.0 mm din-rail terminals	RS	RS stock no 425 – 207	11.04 x 2
Schneider wall box backing plate	RS	RS stock no 375 – 8471	33.63 x 1
Schneider panel mount 400/24 V ac transformer	RS	RS stock no 608 – 6426	44.02 x 1
RS Pro 25 x 25 panel trunking	RS	RS stock no 301 – 1924	37.97 x 3
RS Pro 50 x 50 panel trunking	RS	RS stock no 301 – 1974	62.44 x 3
Cable 2.5mm, 7 core SWA	CEF	N/A	108.00 x 20
Cable 1.5mm, 5 core SWA	CEF	N/A	170.00 x 50
Cable 2.5mm, 5 core SWA	CEF	N/A	84.00 x 20
Cable black 1.0 mm, tri -rated panel cable	CEF	N/A	25.40 x 100

Cable red 1.0 mm, tri -rated panel cable	CEF	N/A	25.40 x 100
Cable black 2.5 mm, tri -rated panel cable	CEF	N/A	45.42 x 100
Cable red 2.5 mm, tri -rated panel cable	CEF	N/A	45.42 x 100
Cable 0.75mm, 2 core SWA	CEF	N/A	220.00 x 100
Cable G/Y 1.0 mm, tri -rated panel cable	CEF	N/A	25.40 x 100
Cable G/Y 2.5 mm, tri -rated panel cable	CEF	N/A	45.42 x 100
Cable black 16.0 mm, tri -rated panel cable	CEF	N/A	87.49 x 25
			1148.65
Item description	Supplier/wholesaler	Order number/part code	Price
Cable G/Y 16.0 mm, tri -rated panel cable	CEF	N/A	87.49 x 25
Cable G/Y 16.0 mm, bonding cable	CEF	N/A	56.77 x 50
Miscellaneous, including; Ferrell's, crimps and cable markers			45.00 approx
Miscellaneous, including; metal works materials			500.00 approx
Materials total			7006.59
Labour total			3293.41
Total costs			10300.00

Table 9: Materials list including costs and purchasing codes.

Excellent, detailed parts list and costs associated with the implementation of the project

6. Project Implementation

The implementation of the project involved building the panel from the designs and drawings. The hardware components were purchased following the quotation being agreed and signed and a down payment being made. The following figures show the process of building the panel. The panel size was selected once all the hardware components had been laid-out to establish the final size the panel could be while being the correct size to be able to fit on site in the desired location. It was established that a panel 1 m tall by 0.8 m wide and 0.25 m deep would be adequate.

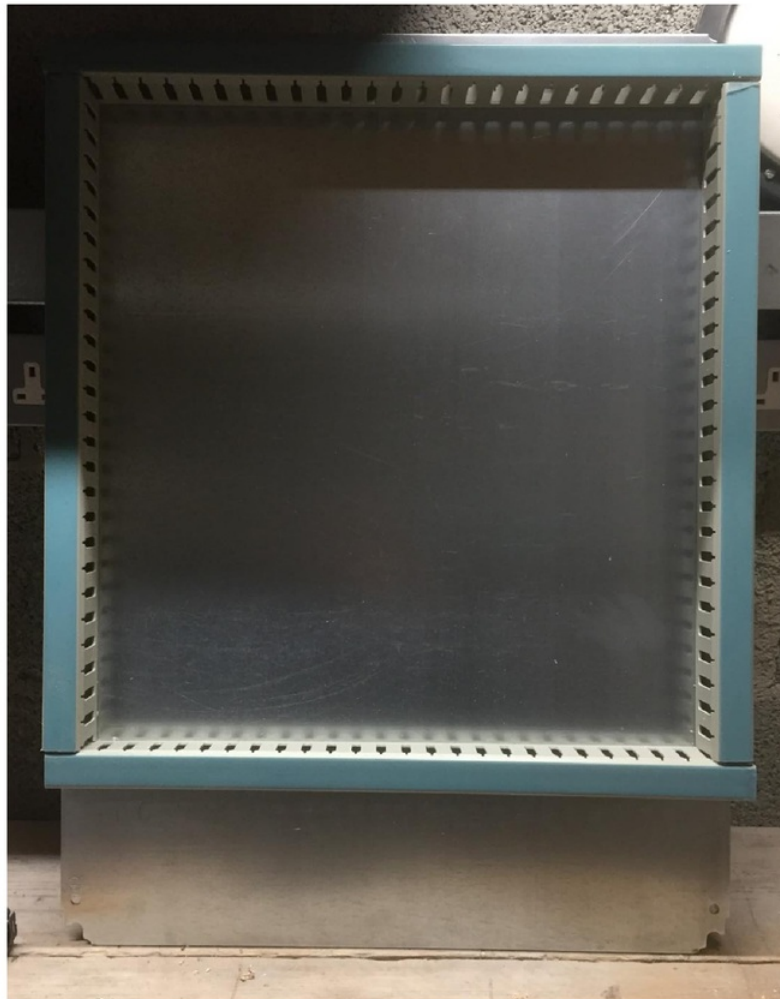


Figure 44: Shows the panel trunking fixed to the back plate.

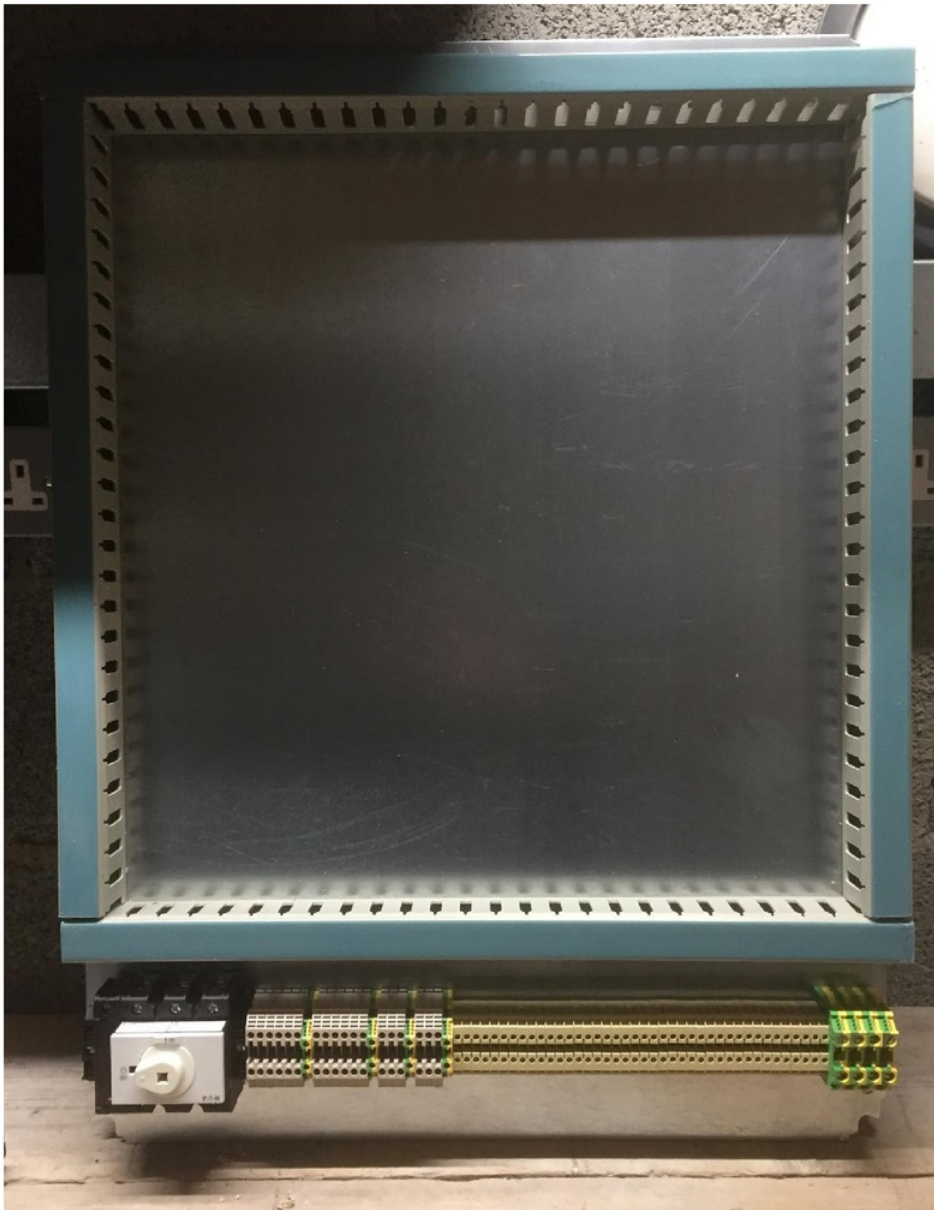


Figure 45: Shows the panel isolator and field terminals allocated for motor connections and failsafe terminations.

Figure 45 shows the terminal rail and main isolator of the panel. The terminals will accept the motor power connections and all the field emergency stops and interlocks required. These terminals are attached to a top-hat din-rail system.

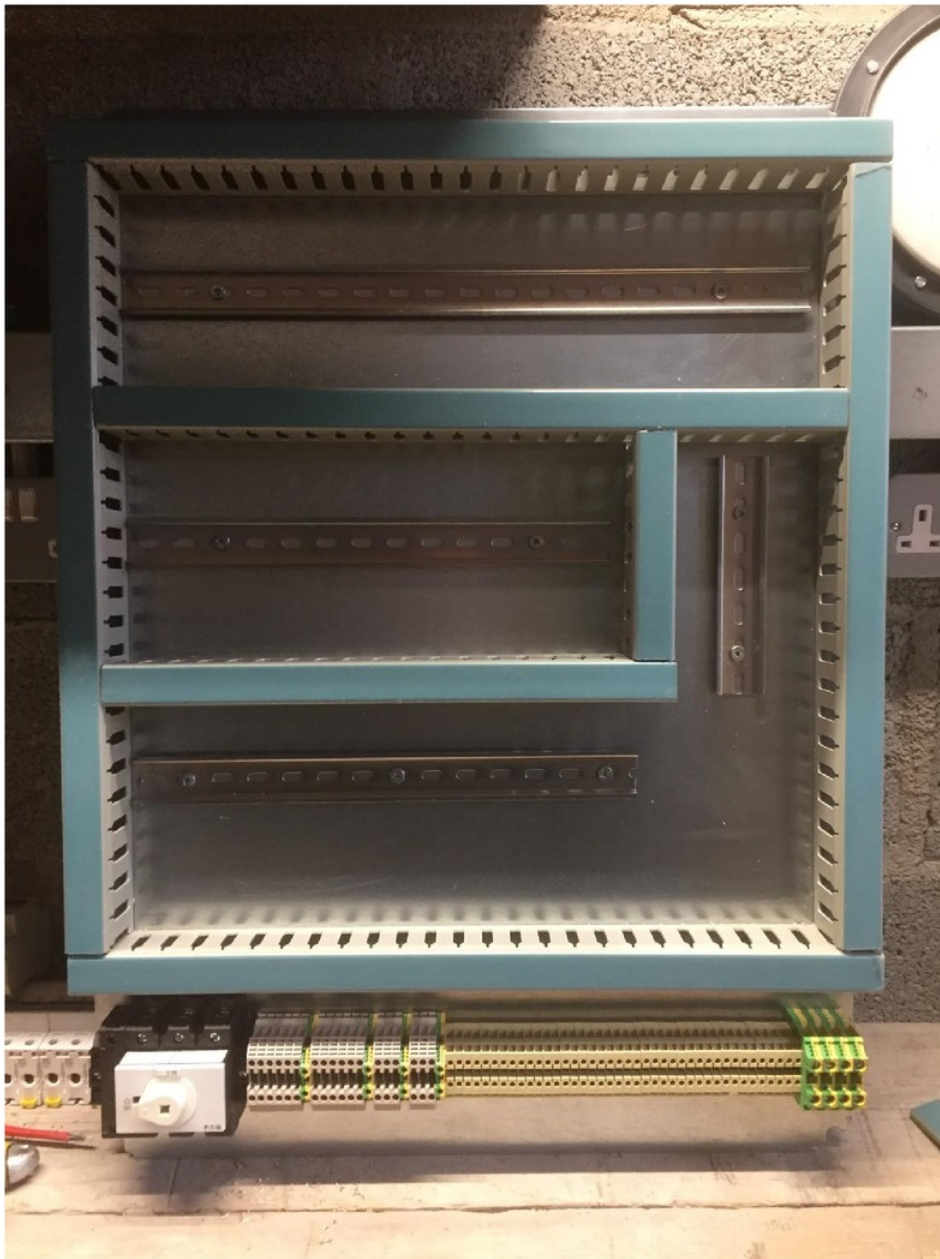


Figure 46: Shows the addition of extra slotted wiring trunking and din-rail to accept the hardware components.

Figure 46 shows the completed sections of slotted wiring trunking and din-rail that will be used to attach the hardware components of the panel.

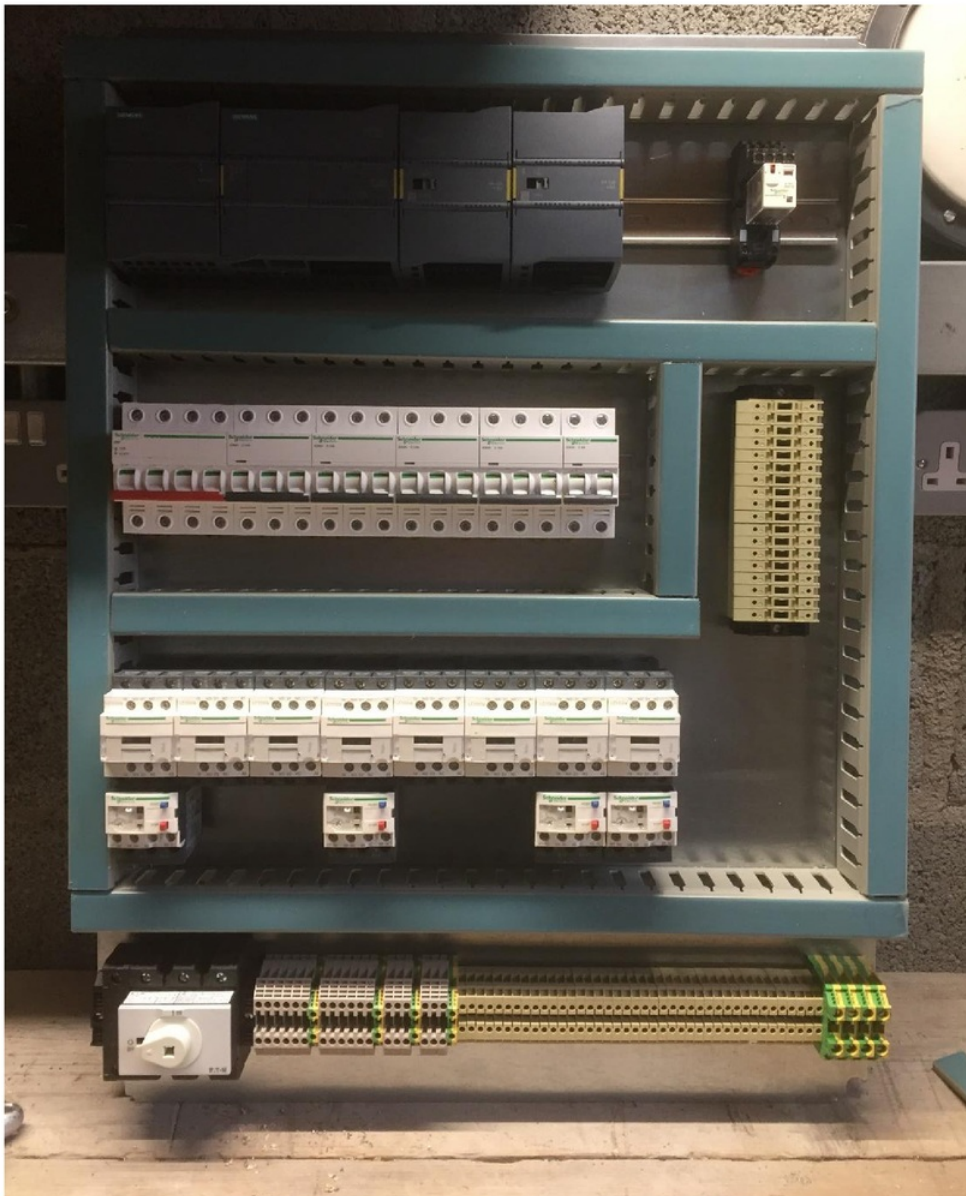


Figure 47: Shows the addition of hardware components to the project panel.

Figure 47 shows the addition of the hardware components to the panel, these include the PLC and extension modules, the motor and control circuit breakers, the motor contactors and overloads and the fused din-rail connection terminals that will be used

for the overload and short circuit protection of the PLC outputs thereby isolating the PLC from high currents.

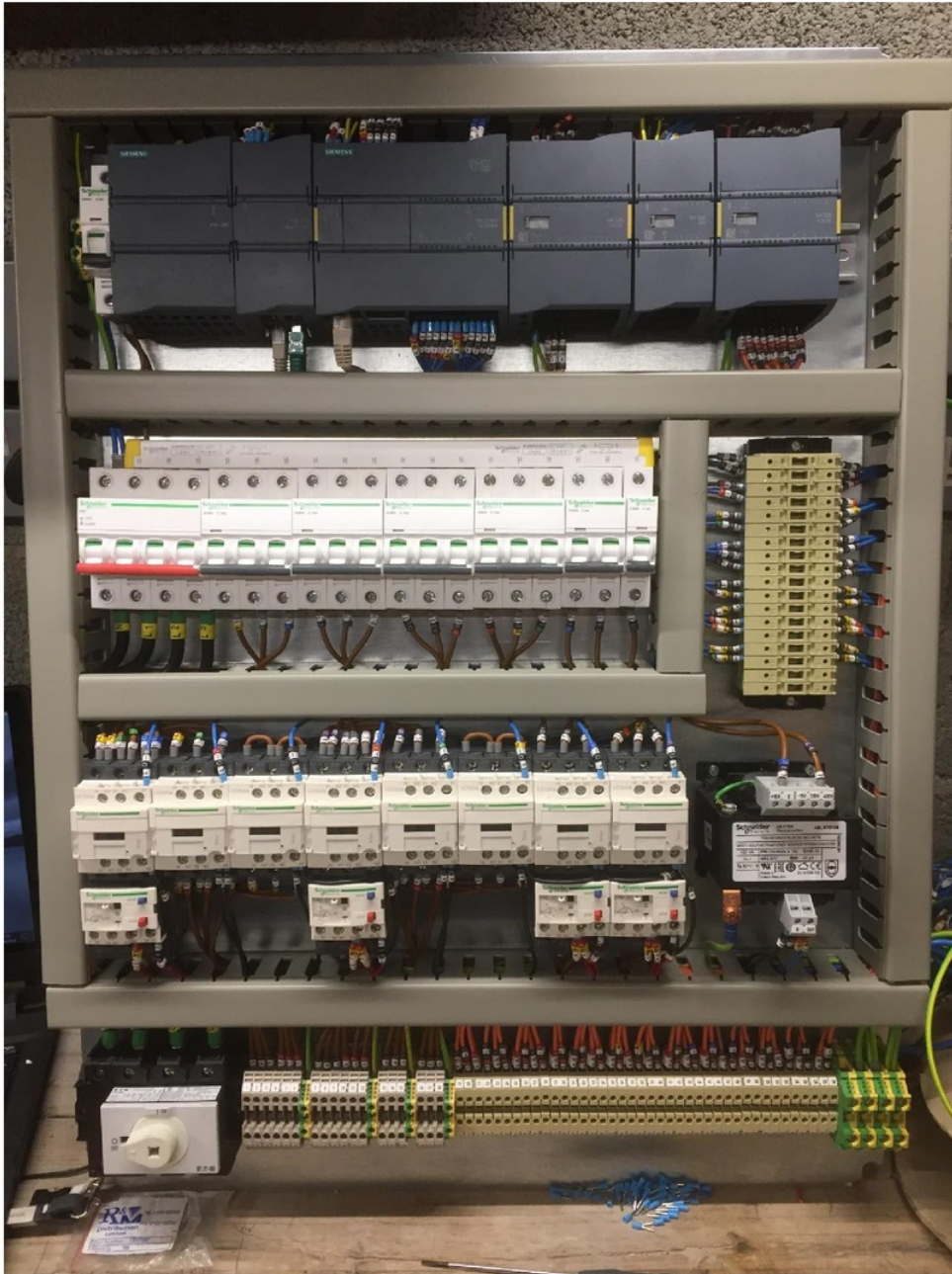


Figure 48: Shows the panel having been wired with all cables being identified.



Figure 49: Shows the completion of the back plate.



Figure 50: Shows the completed back plate fixed into the panel.



Figure 51: Shows the result of the holes being made for the door elements of the project.

Figure 51 shows the holes created to allow the HMI screen, temperature display, mains 'on' indicator and the various meters used to display the input voltage and current to be inserted into the outside of the panel door. The HMI will be used to control the process while the various meters will be used to aid fault diagnosis and maintenance.



Figure 52: Shows the door components fitted to the panel door.

Good pictorial evidence and detailed explanation given on the control panel build stage.

7. Project Testing / Evaluation

During the process of downloading the software to the PLC & HMI, issues with the IP addresses of the PLC, HMI and PC prevented the completion of the testing.

Eventually, the program was able to be transferred to the HMI but, problems occurred that prevented the PLC and HMI communicating with each other. The following testing, as shown in the Table 10, will be undertaken at a later date.

Project not tested or commissioned

Testing	Pass	Fail
<u>Roaster drum hardware</u>		
Start button roaster		
Stop button roaster		
Main contactor operation		
Star contactor operation		
Delta contactor operation		
Emergency stop operation		
Interlock operation		
Overload operation		
Indicators operate		
Drum temp health indicator		
Drum temp caution indicator		
Drum shutdown indicator and operation		
<u>Flue hardware</u>		
Start button flue		
Stop button flue		
Main contactor operation		
Star contactor operation		
Delta contactor operation		
Emergency stop operation		
Interlock operation		
Overload operation		
Indicators operate		
<u>Cooling bed hardware</u>		
Start button cooling bed		
Stop button cooling bed		
Main contactor operation		
Emergency stop operation		
Interlock operation		
Overload operation		

Indicators operate			
<u>Lifter hardware</u>			
Start button lifter			
Stop button lifter			
Main contactor operation			
Emergency stop operation			
Interlock operation			
Overload operation			
Indicators operate			
<u>Burner hardware</u>			
Start button burner			
Stop button burner			
Main contactor operation			
Emergency stop operation			
Interlock operation			
Overload operation			
Indicators operate			

Table 10: Shows the tests to be undertaken to prove functionality.

*Testing table clear but not complete as the project has
NOT been implemented*

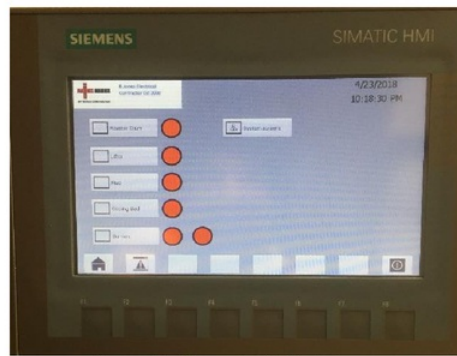


Figure 53: Shows the HMI start screen.

Figure 53 shows the start screen containing the function buttons used to access all other screens.

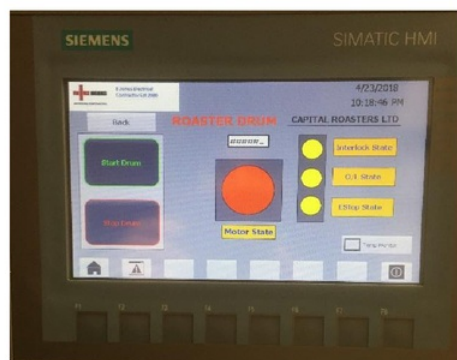


Figure 54: Shows the roasting drum HMI control screen.

Figure 54 shows the roasting drum control screen used to start/stop the motor. There is a motor state condition indicator to visually show the state of the motor and indicators to make the operator aware of any safety function failure or indication of the operation of emergency devices.



Figure 55: Shows the alarm screen of the roasting drum temperature alarm condition

Again no control or indication from the HMI as project not commissioned

8. Conclusions & Recommendations

During the aims and objectives section of the project report, it was sent out that the management of a project would be undertaken and that current management techniques would be used to solve the problem at hand. A scope of works was set out and from the scope of works specification were developed that reflected the clients desired outcomes. A set time to complete the project was agreed for the design, organisation, generation of specifications, pricing of materials, procurement of materials build and testing of the project, this fell short on the testing stage. Reflections have shown the scope of works was out of sync with the allocated time scale of the project given the late decisions by the client on confirming the project was to go forward.

A budget was eventually established and is currently on target. The initial payment of £4000.00 has been used to procure materials and complete the build of the motor panel and control element. The labour cost so far is £2000.00 leaving £4000.00 to install, complete live and functional testing and commission.

The project was undertaken with relevant health and safety conditions being met, a risk assessment is shown in appendix 10.2.

Improvements in the project management process to complete the tasks more efficiently would be an example of where the project could have benefited.

Establishing the budget from the beginning and commitment of the project by the client in advance of the project starting is essential to the overall success of the project and ultimately delays in either result in losses in profits and add to the stress levels of all involved.

A possibility, if the budget is available in the future, is a method of observing the process remotely, in an animated form. This could be achievable through a SCADA system.

Honest conclusion given which does show some reflection on what could have been done better

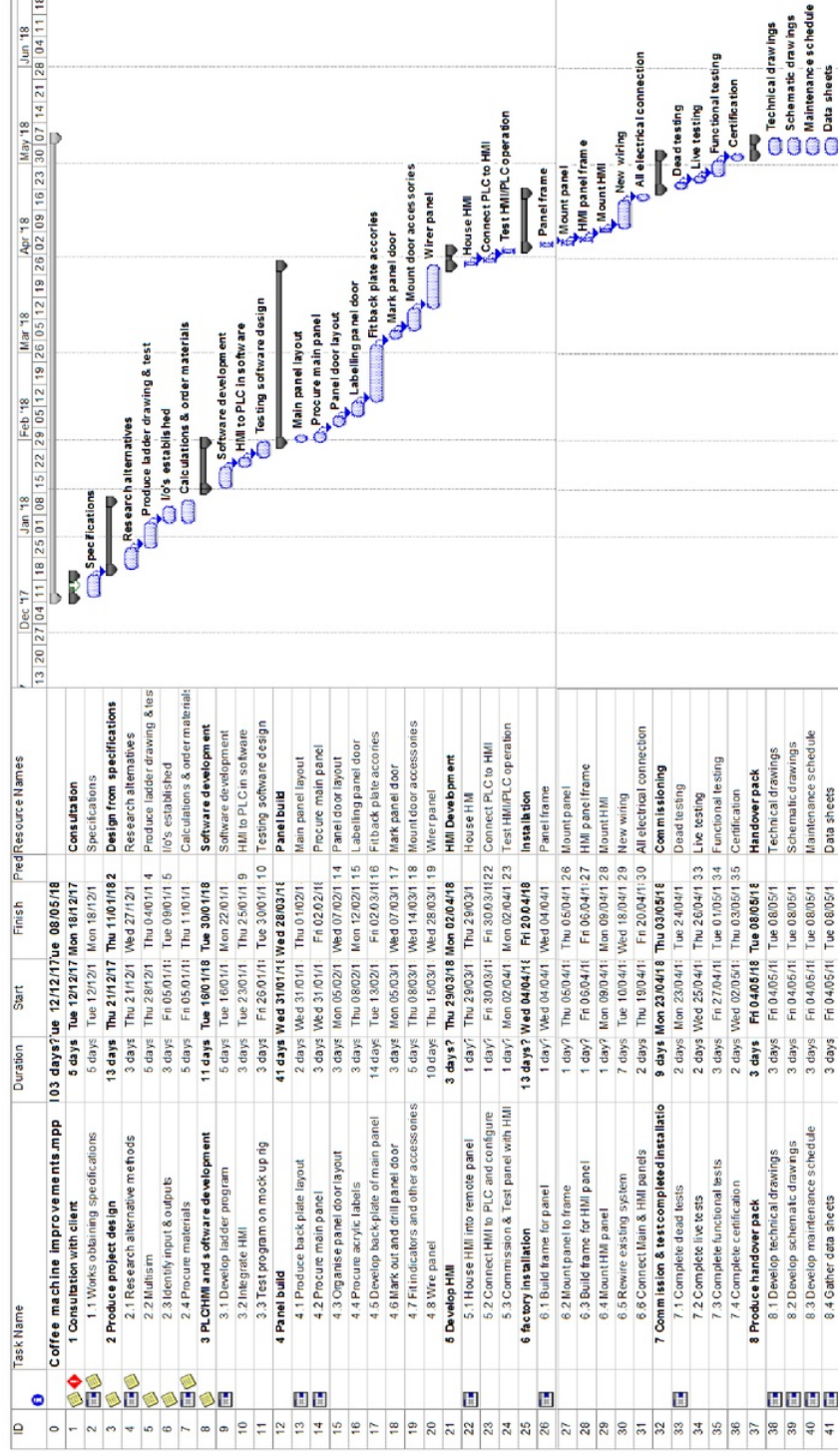
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Could have been more detailed and varied

10. Appendices

10.1 Appendix 1 Gantt Chart



No comparison to actual
Gantt chart, no WBS
and no contingencies
noted

Risk assessment

Note: You should review this risk assessment if you think it might no longer be valid (eg following an accident in the workplace or if there are any significant changes to hazards, such as new work equipment or work activities or adverse weather conditions)

Company name: B Jones Electrical Contractor

Date of risk assessment: 14th March 2018

What are the potential hazards?	Who might be harmed and how?	What are you already doing?	Do you need to do anything else to control this risk?	Action by who?	Action by when?	Done
Working with battery power tools	The operator of the power tools. Risk to eyes, hands and ears.	Wearing correct PPE and using equipment to manufacturer's instructions.	Keep a clean and tidy work space to avoid slip and trip hazards.	B Jones	During all works hours	Yes
Working with electricity.	The operator. Electrocution, electrical burns	Isolating the electrical supply where practical. All power tools to 110V and or battery powered.	Use proving unit and GS38 test equipment to prove supply has been isolated. All mains equipment to be P.A. Tested.	B Jones	During all works hours	Yes
Working in a workshop environment.	Work operatives. Slips, trips and falls.	Closing off private workshop to public and unskilled operatives.	Keep workshop clean and tidy.	B Jones	During all works hours	Yes
Working with heavy equipment.	Work operative. Hazardous to back, feet, hands and knees.	Lifting in the correct position and only recommend weights per person.	Lifting in pairs. Using correct PPE.	B Jones W Blunsden	During all works hours	Yes

Final project report

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

53/100

PAGE 1

PAGE 2

Text Comment. Project?

PAGE 3

Text Comment. Good general abstract and acknowledgements shown which allows the reader to understand the project / report contents

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

Text Comment. Detailed aims and objectives noted which were realistic

PAGE 10

Text Comment. Very good flow sequence which clearly indicates the current process

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

Text Comment. Excellent detail on problems within the existing system and how it needs to be upgraded

Text Comment. Very good block diagram which clearly shows the current process

Text Comment. Where is the legend? i.e. is 1 good or 10?

Text Comment. Realistic solutions noted and explained in detail. Good reasoned choice made as to which solution to take forward.

Text Comment. This is NOT 1.5 line spacing....

Text Comment. Very detailed general specification noted

Text Comment. Excellent Flow sequence showing current system and desired additions to upgrade

Text Comment. Excellent realistic detail on the chosen solution specification with a clear set of testing to be carried out

Text Comment. General comments made in relation to safety, professionalism, maintenance and reliability

Text Comment. No information related to sustainability or environmental protection

Text Comment. Good set of PLC I/O list shows implementation of the control / indication system

Text Comment. Good set of PLC tags shows internal implementation of the control / indication system

Text Comment. These output bit should not be 'set' bits if you are using retention contacts

Text Comment. Program screen dump could have been clearer

Text Comment. Very good detail on PLC program design but some mistakes noted.

Text Comment. Good detail

PAGE 47

PAGE 48

PAGE 49

Text Comment. Very good detail on HMI screen design.

PAGE 50

Text Comment. Very good detail on HMI design and tag list.

PAGE 51

PAGE 52

PAGE 53

PAGE 54

PAGE 55

PAGE 56

PAGE 57

PAGE 58

Text Comment. Very good detailed wiring diagrams but they could have been presented better

PAGE 59

PAGE 60

PAGE 61

Text Comment. Very good detail on SIL rated PLC used within the project

PAGE 62

PAGE 63

PAGE 64

Text Comment. Excellent detail on system design calculations but shouldn't this be in the design section?

PAGE 65

PAGE 66

Text Comment. Excellent, detailed parts list and costs associated with the implementation of the project

Text Comment. Good pictorial evidence and detailed explanation given on the control panel build stage.

Text Comment. Project not tested or commissioned

Text Comment. Testing table clear but not complete as the project has NOT been implemented

Text Comment. Again no control or indication from the HMI as project not commissioned

Text Comment. Honest conclusion given which does show some reflection on what could have been done better

Text Comment. Could have been more detailed and varied

Text Comment. No comparison to actual Gantt chart, no WBS and no contingencies noted

GRADING FORM: MAJOR PROJECT 2017_18

BRIAN JONES**52.60****RESEARCH (20%)**

Research Informed Literature: 1. Abstract, acknowledgements, introduction and setting out of aims and objectives. (/20) 2. Background research, setting the context of the project, statement of user or customer needs. (/30) 3. Literature review, solutions considered and choice made. (/40) 4. Use of Harvard Referencing for citing and listing sources. (/10)



1. Good general abstract and acknowledgements shown which allows the reader to understand the project / report contents. Detailed aims and objectives noted which were realistic. (13) 2. Very good flow sequence which clearly indicates the current process. Excellent detail on problems with the existing system and why it need upgrading. (21) 3. Realistic solutions noted and explained in detail. Good reasoned choice made as to which solution to take forward. No justification related to scores in comparison table. No referencing used in literature review. (19) 4. Range of sources listed. Limited works cited throughout the report. (5)

11.6**KNOWLEDGE (20%)**

Knowledge & Understanding of Subject: 1. Specification, design

requirements and project outcomes, time and financial constraints. (/30) 2. Test planning and procedures. (/20) 3. Formal project planning and identification of milestones. (/25) 4. Consideration of maintenance and reliability. (/25)



1. Very detailed general specification noted. Excellent flow sequence showing current systems and desirables for upgrade. Excellent realistic detail on the chosen solution specification. Very good detail on PLC program and HMI design but some mistakes noted i.e. output 'set' bits with no reset control. Excellent detail on system design calculations. No time or financial constraints stated. (22) 2. Clear set of criteria set out in specification objectives. (17) 3. Project Gantt chart noted in appendix but no comment on whether the project run to schedule or any contingencies noted. (14) 4. General comment made in Section 4. (12)

13

ANALYSIS (20%)

Analysis: 1. Evaluation of Implementation stage, monitoring of progress and milestone activities. (/20) 2. Testing & test results. (/30) 3. Comparison of project outcomes to specification. (/20) 4. Conclusions, recommendations and reflections. (/30)



1. Good set of PLC I/O list and tags shows implementation of the control / indication system. Very good detail related to the SIL rated PLC used within the project. Pictorial evidence and detailed explanation given on the control panel build stage. (10) 2. Project not tested or commissioned. HMI screen shown running. (5) 3. Project not tested or commissioned. Good comparison table noted showing clearly what tests needed to be carried out for project (8)commissioning. 4. Honest conclusion given which does show some reflection on what could have been done better. (14)

7.4

PRACTICAL APPLICATION (20%)

Practical Application & Deployment: 1. Quality, innovation and creativity of design solution. (/20) 2. Implementation stage, working independently with limited supervision. (/30) 3. Meeting customer or user needs, fitness of solution to purpose, working within time and financial constraints. (/20) 4. Log book. (/30)



1. Detailed design shown in relation to the control panel, HMI screens which was both innovative and creative. PLC program innovative in the use of safety features of the 'F' series but logic incorrect for setting output coils. (11) 2. Good detail on project build and programming which was carried out independently as the student was the main contractor for the project. (18) 3. Excellent, detailed costing exercise carried out. No commissioning carried out so not known whether the system worked as expected. Student was not able to work within the time constraints set. (10) 4. Log book shows how the project was developed over the time allocation given. Good pictorial evidence of panel build and PLC program development.(18)

11.4

PROFESSIONAL PRACTICE (20%)

Skills for Professional Practice: 1. Professionalism and ethical conduct. (/25) 2. Health and safety, assessment of risk. (/25) 3. Sustainability and environmental protection.. (/25) 4. Presentation and organisational quality of report. (/25)



1. General comment made on professionalism in Section 4. (11) 2. General comment made on safety in Section 4. Safety a major factor in the project. Risk assessment shown in appendix. (17) 3. No

9.2

comment made on sustainability and environmental protection. (0) 4. Report structure was good and covered most aspects of the project requirements. Good use made of pictorial evidence. Some screen dumps could have been clearer. (18)