

# B Jones Interim report

*by* Brian Jones

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colegsirgâr



# PSDE1619 Major Project Interim Report

Coffee Machine Improvements

*Coffee Machine System Upgrade?*

BSc (Hons) Electrical &  
Electronic Engineering  
Final Year 3

Uni number

*Incomplete!*

With Bill McIntyre & Robert Davies, January  
2018

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### 3. Introduction

#### 3.1 Aims and objectives

##### *Project!*

The aims and objectives of this document 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, 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 is in need of modernising to current safety standards.

Following the discussion with the project supervisor, it was established that the proposed improvements to the coffee roasting machine would be acceptable as having enough technical complexity to be used as a major project. 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 managers mind.

Following this comprehensive report, there will be a brief presentation on the project progress so far and what outstanding items have been identified to be able to deliver the project on time and to budget without compromising on safety and quality.

*Excellent project introduction, but should have concentrated on the project outcomes rather than the project process*

#### 4. Background information including project proposal

During a recent call-out to a local factory that produces high quality roasted coffee beans, I was put in a situation where I felt mine and other users of the apparatus, used to produce the high-grade coffee, safety maybe at risk. After mitigating the risk to myself by following safe isolation procedures, and solving the issue that I was called out to solve, I still felt that users of the equipment could be in danger from the dated apparatus. *Good detail*

Following a consultation with the owner of the company, it was established that the current system needs modernising. The existing machine has been used since the 1960's with only the control station being rewired in recent years.

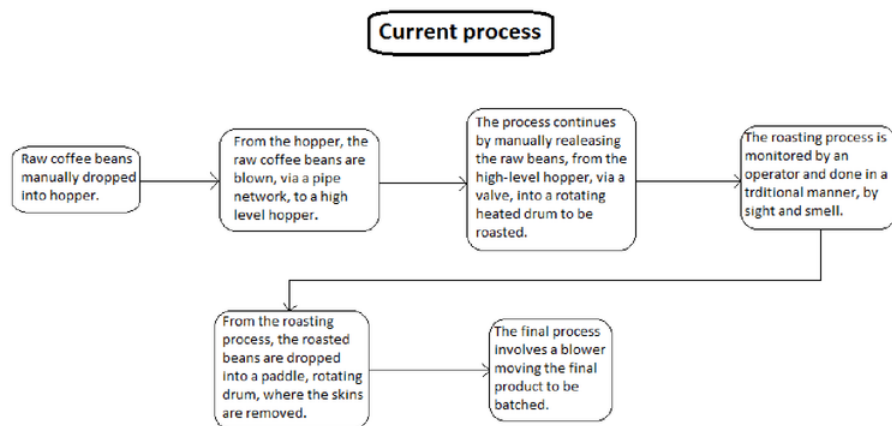


Figure 1: A block diagram of the existing process used to produce the roasted coffee beans.

*Very clear indication as to the operation of the*

*As mentioned in the process flow diagram, 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 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 following figure. There is a blower connected to a pipe network, this is responsible for transporting the raw coffee beans to a high-level hopper



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

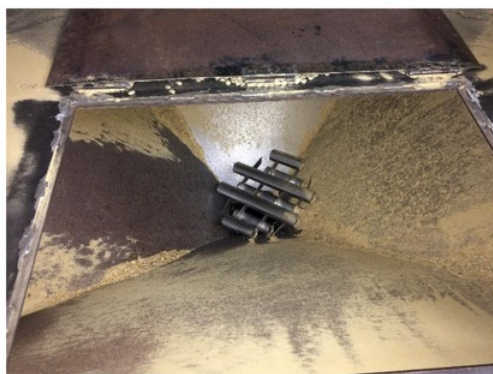


*Figure 3: The hopper shaft.*

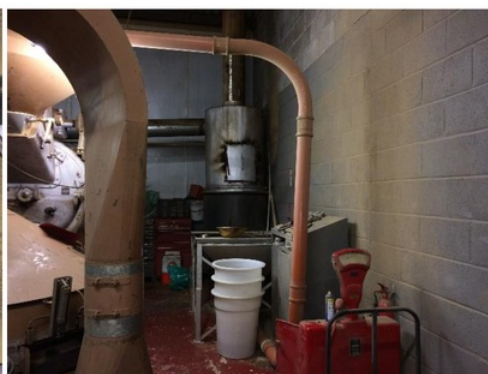


*Figure 4: The riser pipe off the blower*

Figures 3 & 4 show the inside of the hopper and the rising pipe work leaving the hopper, that is used to transport the raw beans to the next stage in the process.

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 switching console as shown in the following, Figure 5. It can be seen that the controls console is in need of repair and has potentially dangerous hazards.



Figure 5: 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, 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. The following figures show the gas ignition system and flow system and the motor/belt pulley system used to rotate the roasting drum, this belt also runs the cooling system to the roaster.



Figure 6: The gas system including the solenoid and ignitor connected to the roasting drum.



*Figure 7: 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 there are systems that are automatically controlled, 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 during the roasting process and is one of the main successes of the company and therefore it is essential that it remains that way. For this reason, the process doesn't require automating.

Following the roasting process, the then 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, 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 paddle.

There is currently a window on the paddle which has hinges and can be opened by the operator. This scenario presents a danger as there is nothing preventing someone or something falling or entering parts of the arm into a moving paddle drum. The following figures show the paddle drum and inspection window.



*Figure 8: This figure shows the process of the paddle stage used to de-shell and cool the beans.*

*Each figure should be labelled and explained seperately*



The figure 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 9 shows the riser that the beans are blown up and then Figure 10 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 9: The exit door from the paddle. Figure 10: 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. The next figure, Figure 11, show the existing panel which also consists of ceramic bottle fuses.



*Figure 11: 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. It is my intension to modernise the electrical system and introduce modern safety systems, and, 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.

*Good use made of pictorial evidence in showing how the system functions at present.*

## 5. 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. *This should be an addition and not part of the specification*
- 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 audible 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.

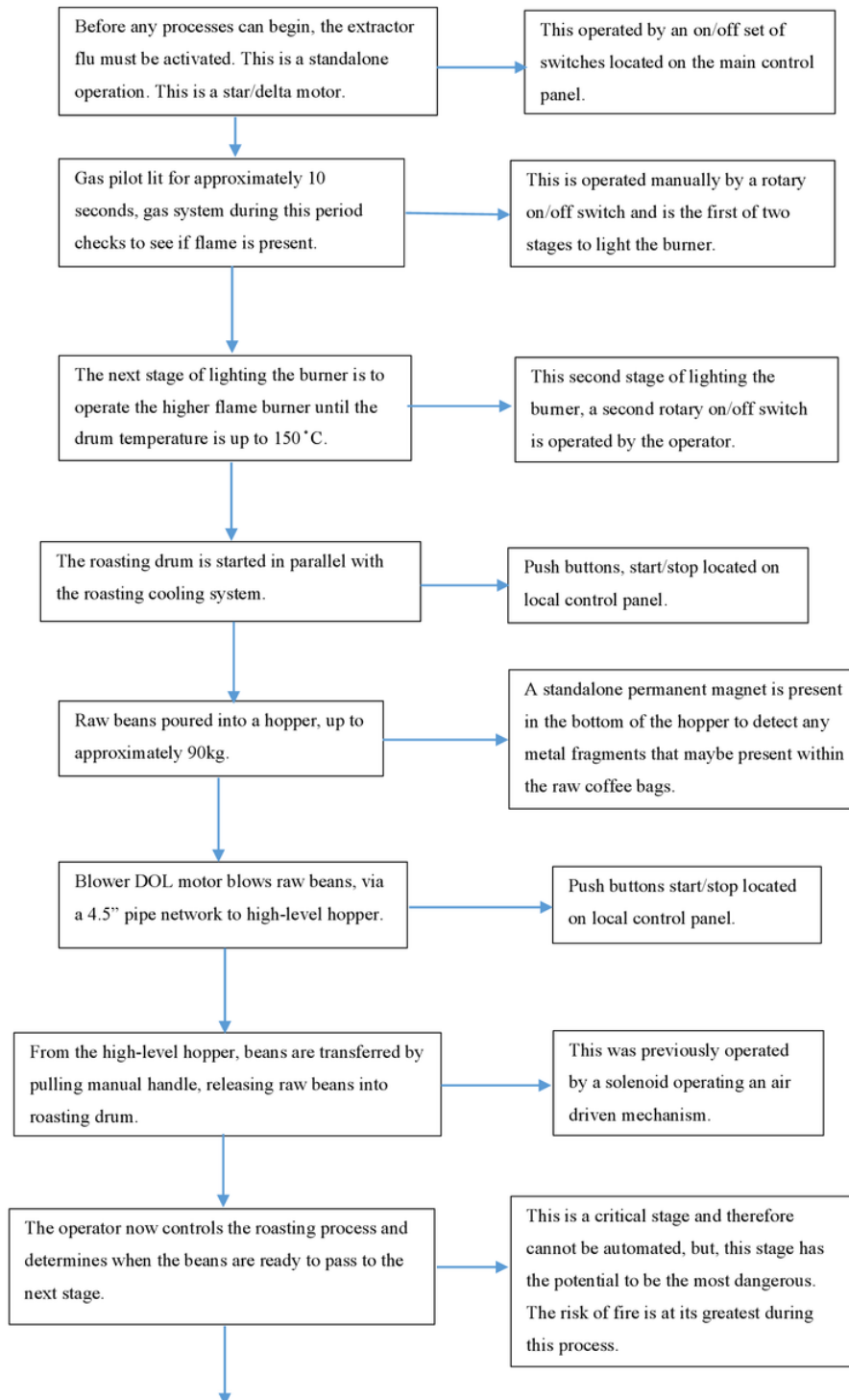
*Very detailed general specification  
given*

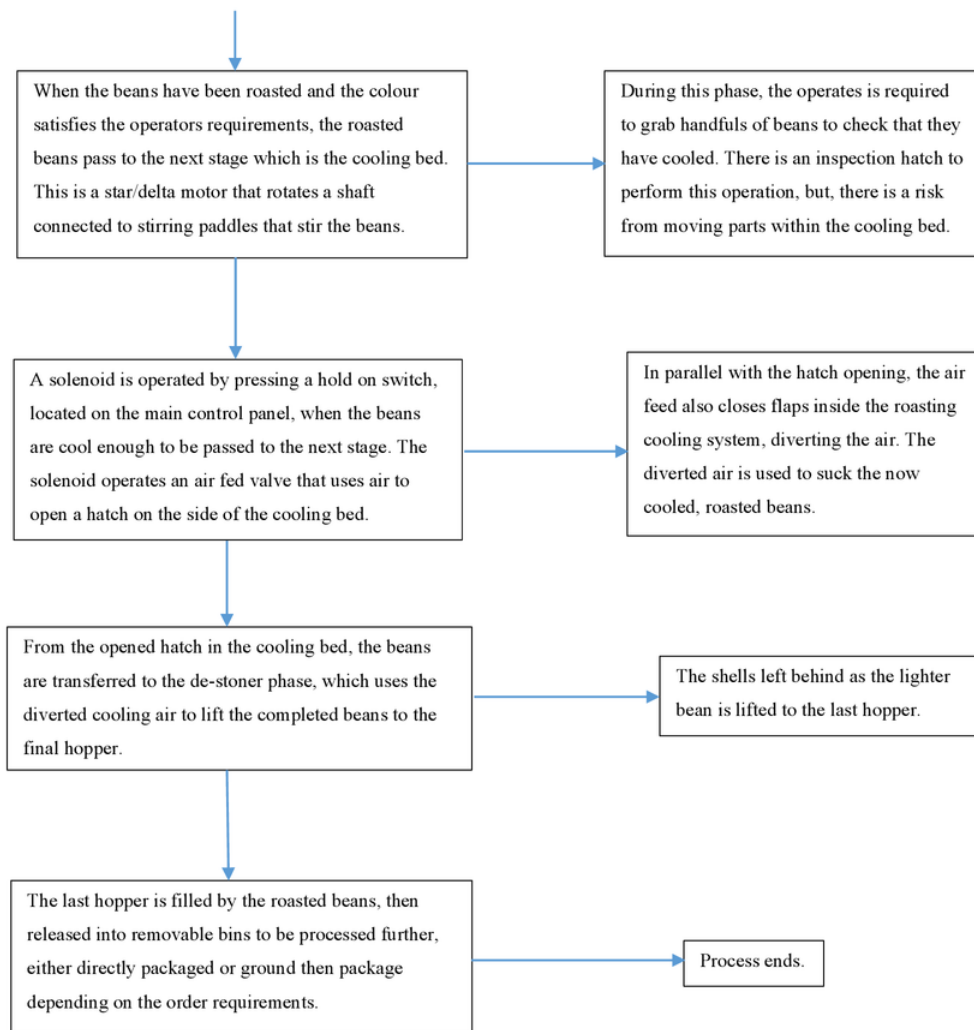
According to (Robinson, 2016), hardware selection and verification for machine design safety and machine control systems safety has for many years been dealt with by the body responsible for harmonised European standards. Publications such as the then EN ISO 13849-1 (Safety of machinery, Safety related 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.

*Non-standard line spacing.*

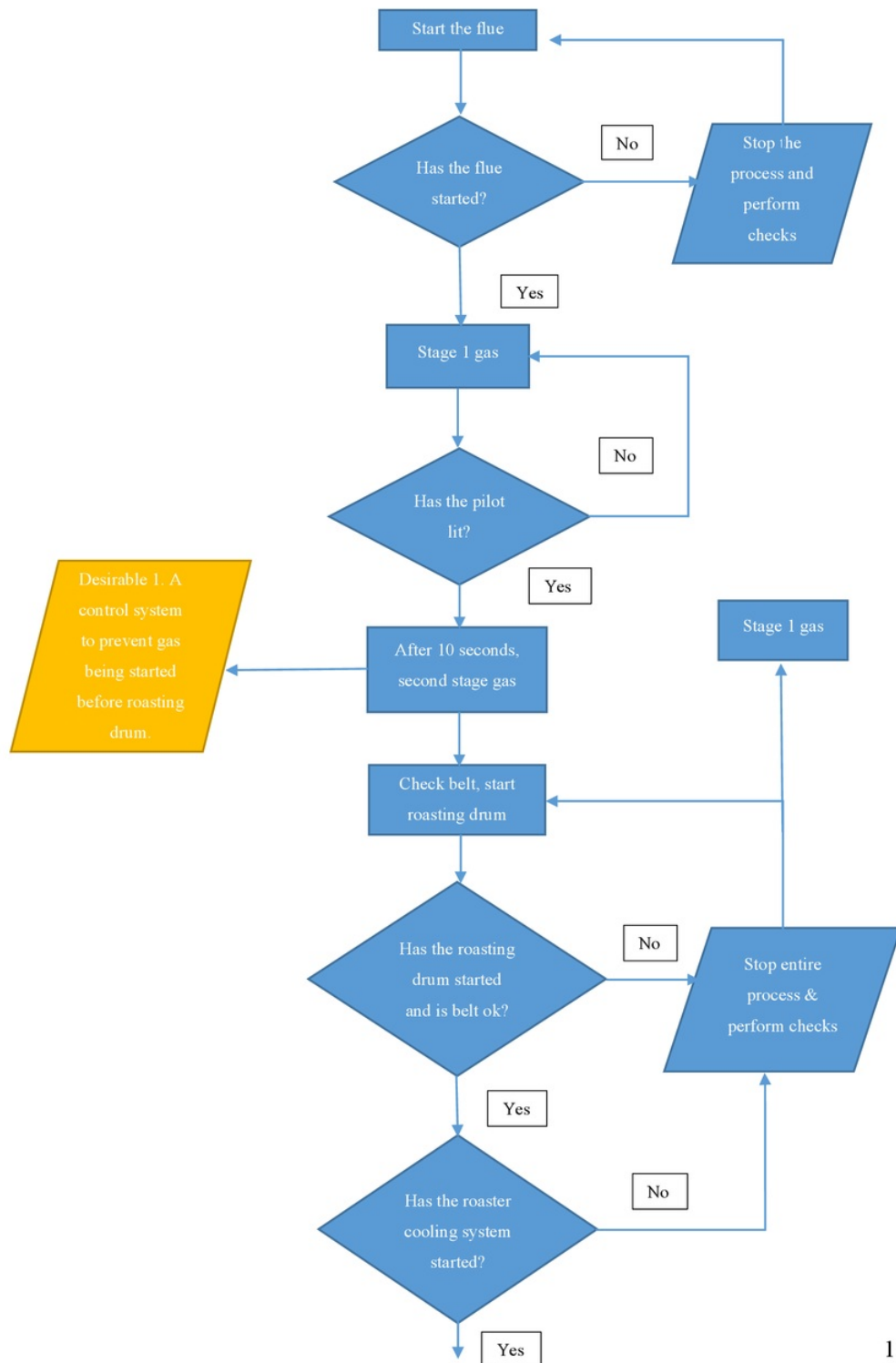
### 5.1 Flow diagrams of the current process.

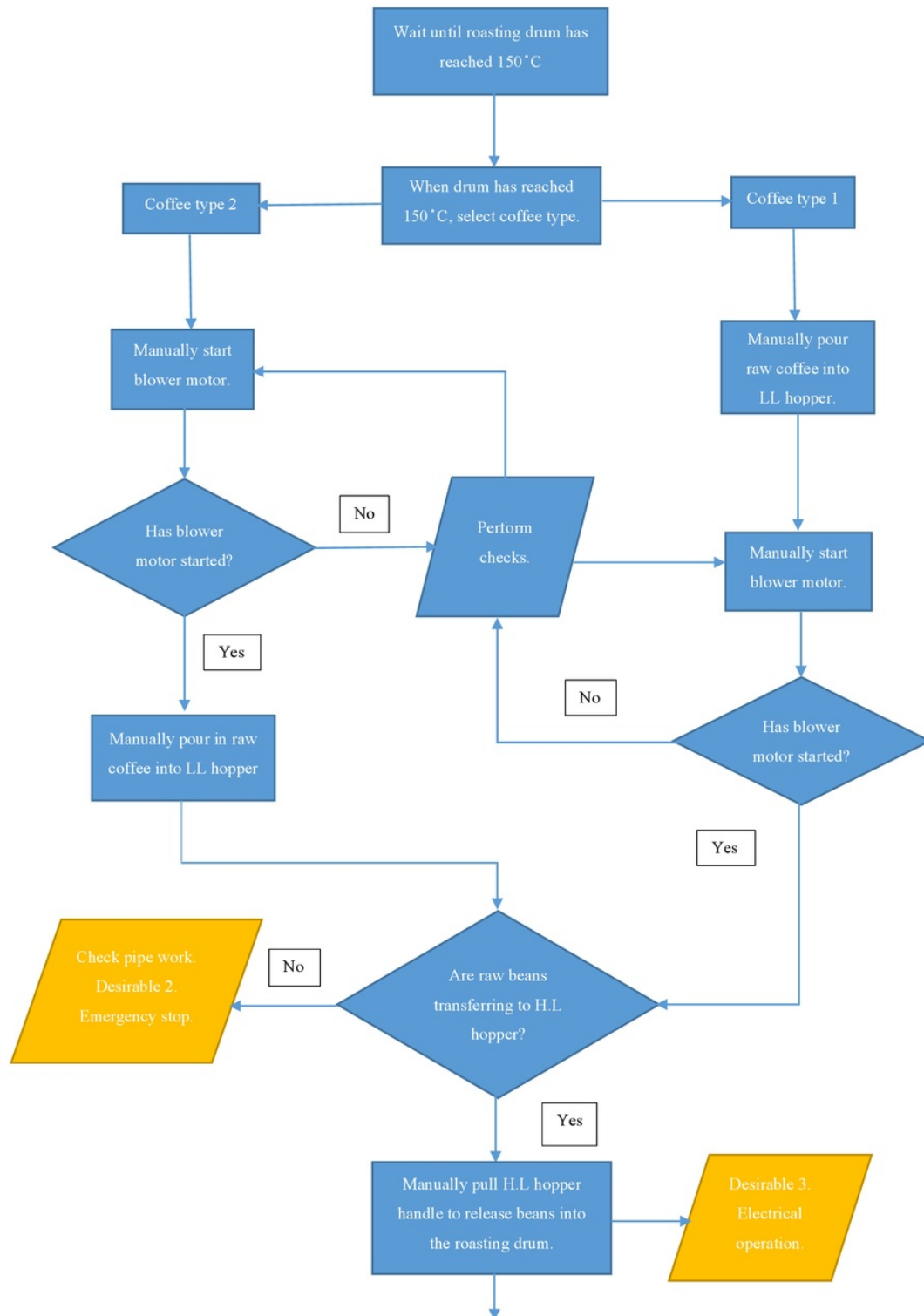




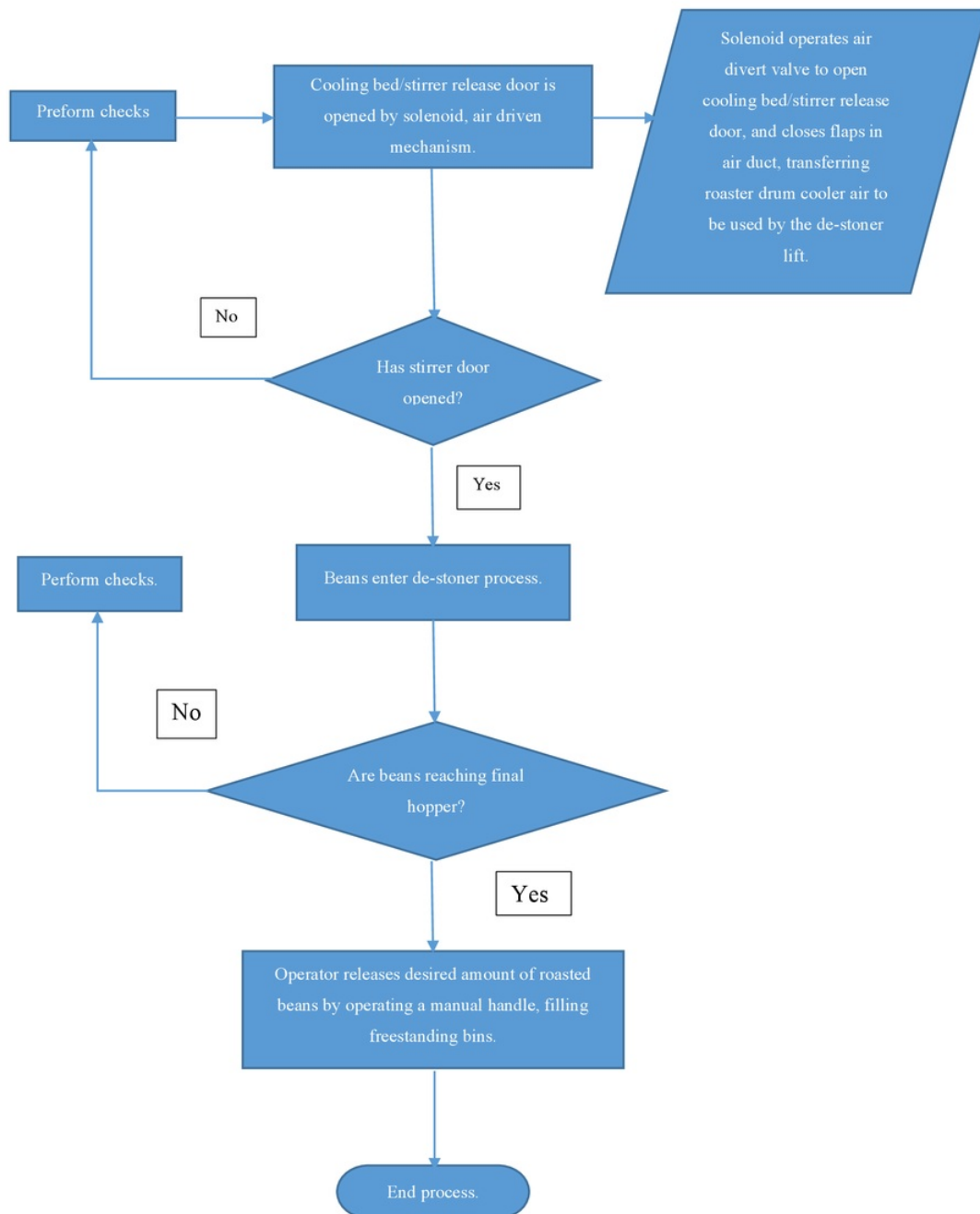
*Very good detail shown which clearly shows the full process*

## 5.2 Flow chart of process









*Very good analysis of the sequence of events required to produce the roasted coffee beans.*

Excellent block diagram of the process, maybe should be in the background section.

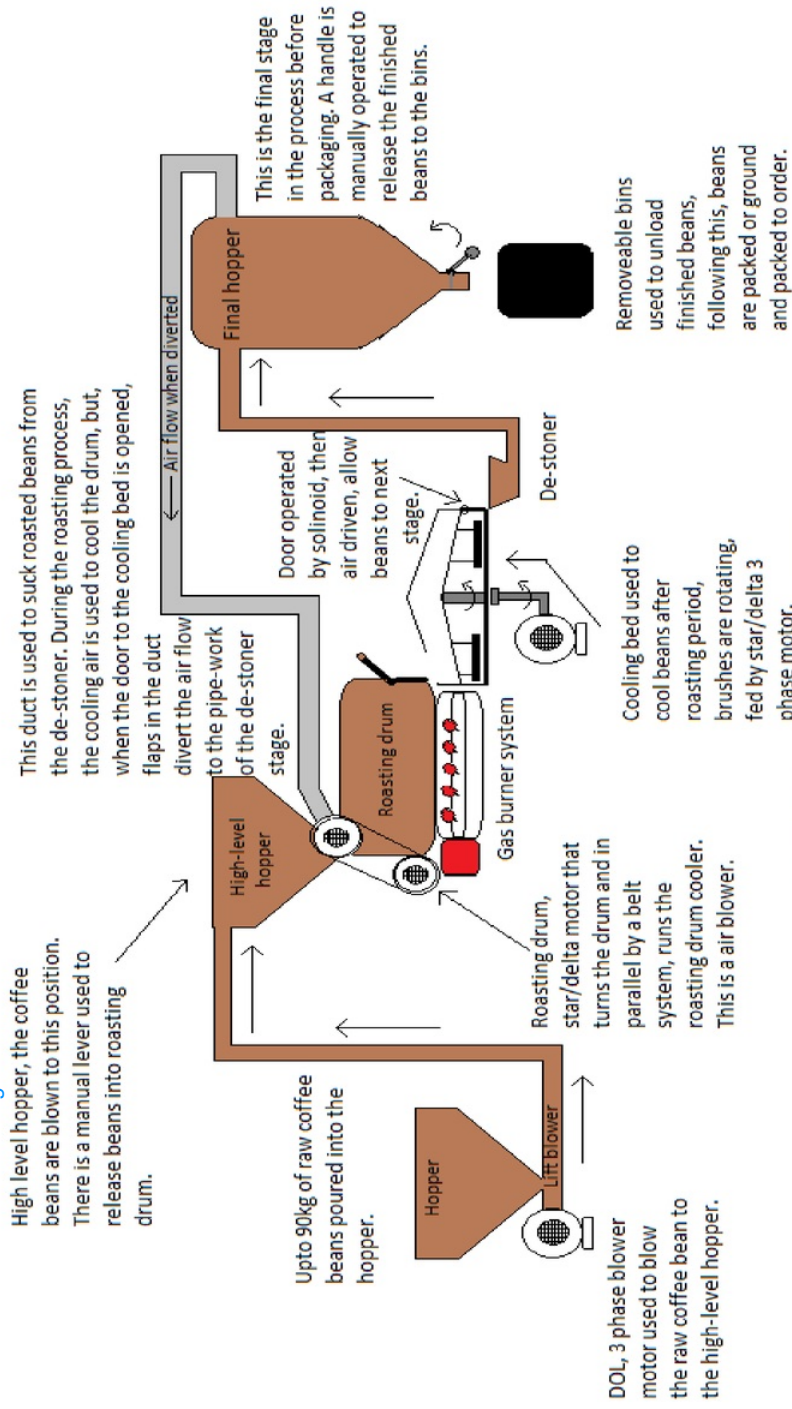


Figure 12: The current process and descriptions.

## 6. Literature review including potential solutions

### 6.1 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.*

## 6.2 Solution 2 PLC

Following on from the relay design is a method of control that has naturally evolved from relay logic and who's 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.*

### 6.3 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                           |
|----------------------------------------------|-------------------------------------------------|
| <b>High performance parallel processing.</b> | Loss of memory when power lost.                 |
| <b>Custom hardware flexibility.</b>          | Require more specialist experience.             |
| <b>Hardware logic reliability.</b>           | Less robust.                                    |
| <b>Adaptable software.</b>                   | Harder to interlace in industrial environments. |

*Table 3: Advantages and disadvantages of FPGA's.*

*Good information shown related to 3 choices researched as solutions to the project problem*

## 7. Comparison of solutions

### 7.1 Comparison matrix

|                  | 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

Where do these numbers come from and

### 7.2 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.

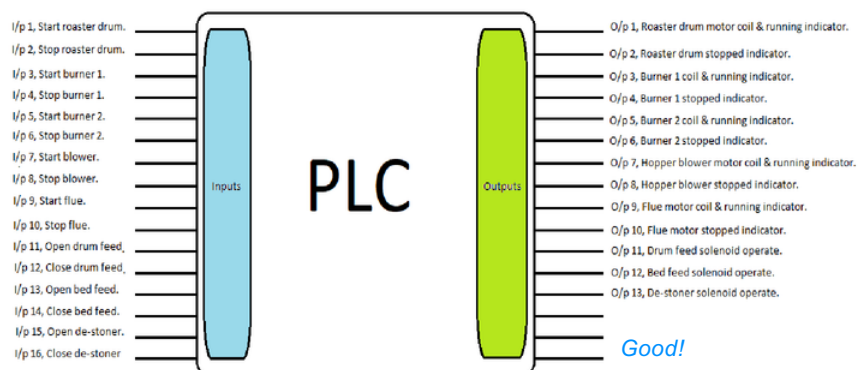


Figure 13: Possible input and outputs of the PLC.

## 8. Chosen solution specification

### 8.1 Standards

- ❖ BS 7671:2008 (Requirements for Electrical Installations IET Wiring Regulations 17<sup>th</sup> 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

### 8.2 Objectives

#### 8.2.1 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.

#### 8.2.2 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 deenergise 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 deenergise 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 deenergise 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 deenergise 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.

#### 8.2.3 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 deenergised 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 panels trunking, to the doors of the main and remote panels.
  - c. Provide 0.75mm<sup>2</sup> 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.

*Very detailed specification shown for the solution taken forward.*

## 9 Work Breakdown Structure / Action plan

Campbell states that “*Project managers use a tool called a work breakdown structure, or WBS, to break larger activities into smaller, more manageable components. Only after you’ve established the basic milestones for a project can the real work begin*”. (2011, p. 105)

According to Campbell (2011), using a tree diagram or an outline, a WBS is a hierarchical chart used to organise project activities into manageable elements. Levels one & two are commonly known as the “*root node*” & “*level two*” and define set outcomes of the project that collectively & completely signify 100% of the project scope. The following levels, “*the children of a parent node*”, collectively & completely signify 100% of the project scope of their parent node.

Compliant legislation

*Good detail.*

9.1 WBS chart

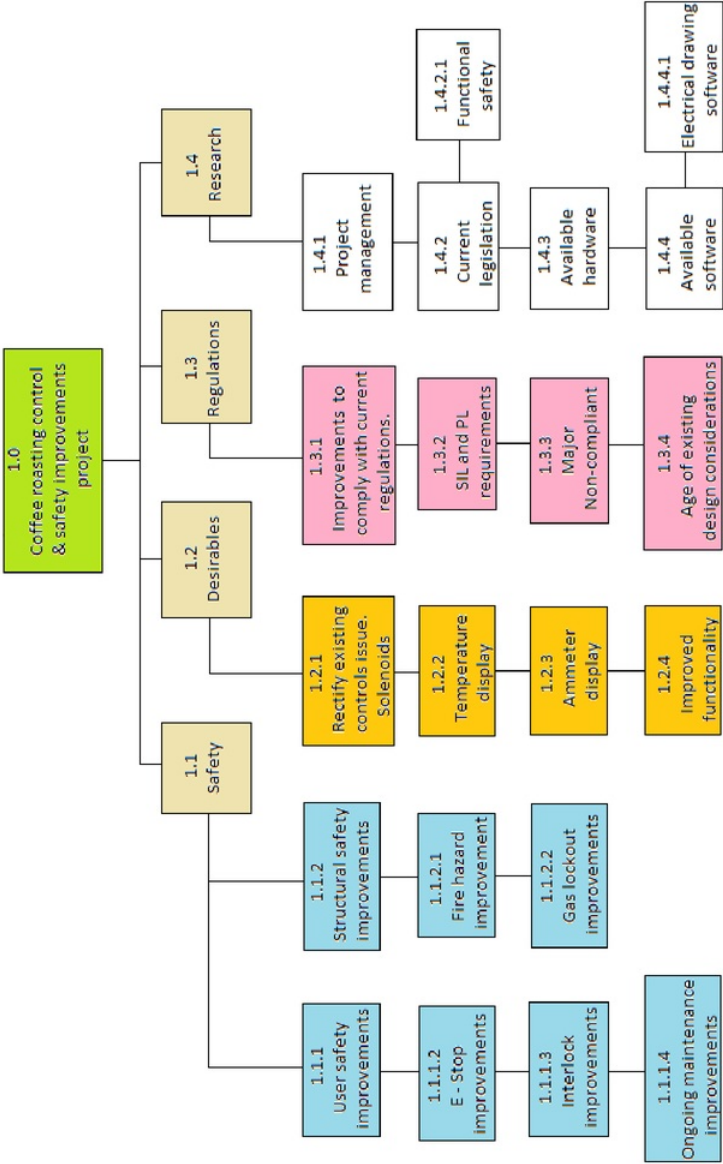


Figure 1.4: The work breakdown structure chart.

Very good detail  
shown in WBS

## 9.2 Gantt chart

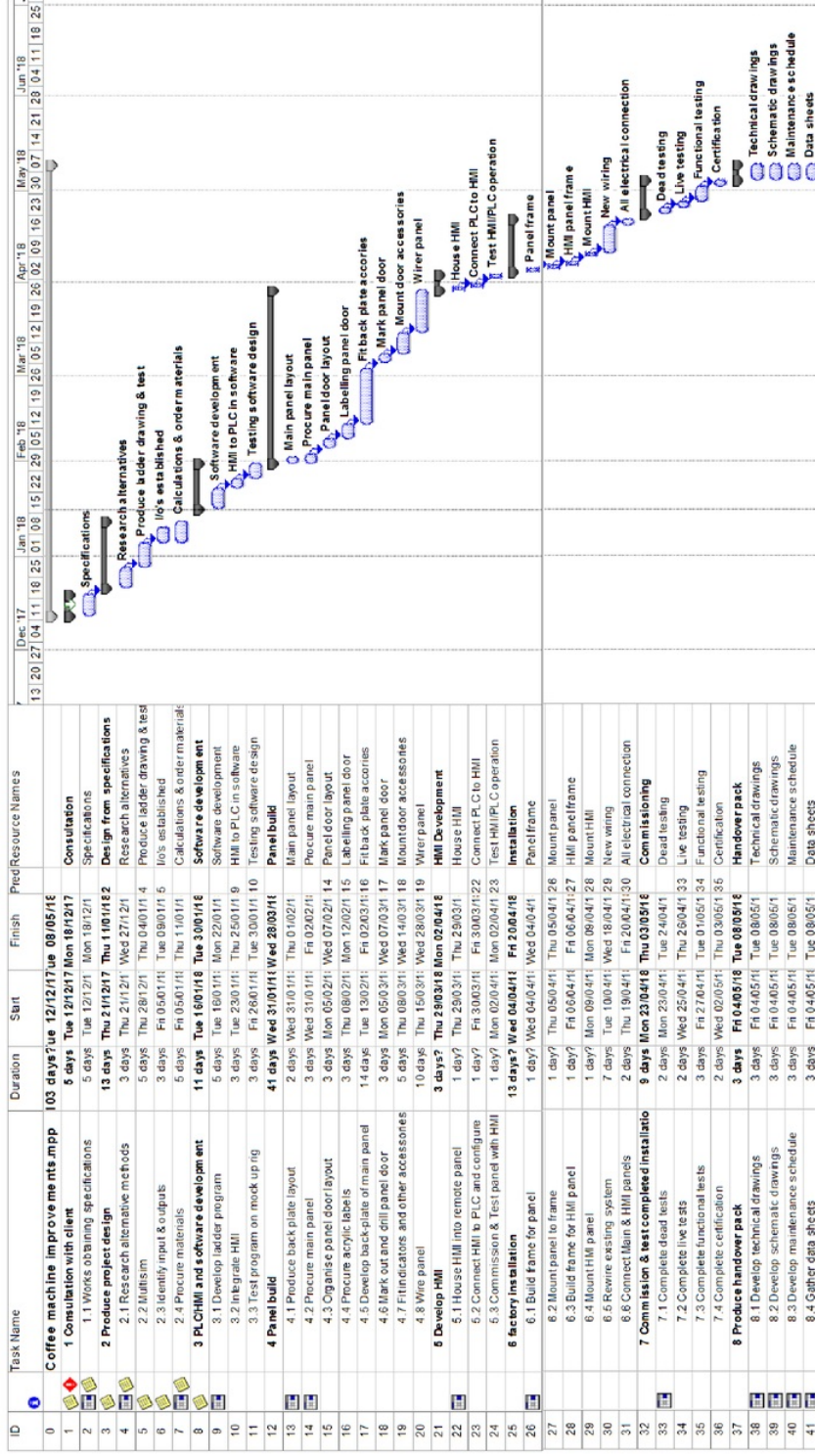


Figure 15: The Gantt chart of the ongoing project.

Excellent breakdown of work to be carried out in  
Gantt Chart but no contingencies noted

## 10. Progress and testing to date

Currently, the testing has been undertaken using National Instruments software package, Multisim. Information taken from the specifications has been used to produce the following ladder drawings. The exact final program has not been established as more tests need to be undertaken. The introduction of timers will need to be performed for the starting conditions of the star/delta motors and a way of reducing the I/O's to the minimum will be investigated, hence the final costs will be established when the final designing and testing has been completed.

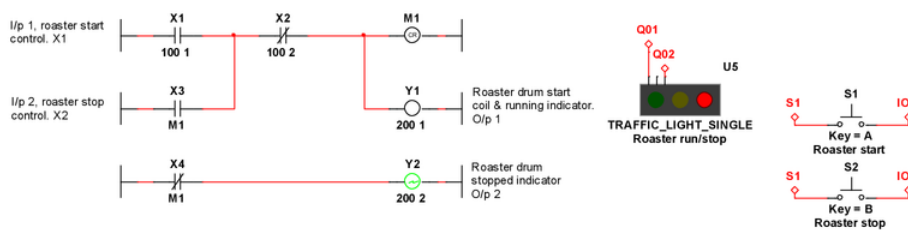
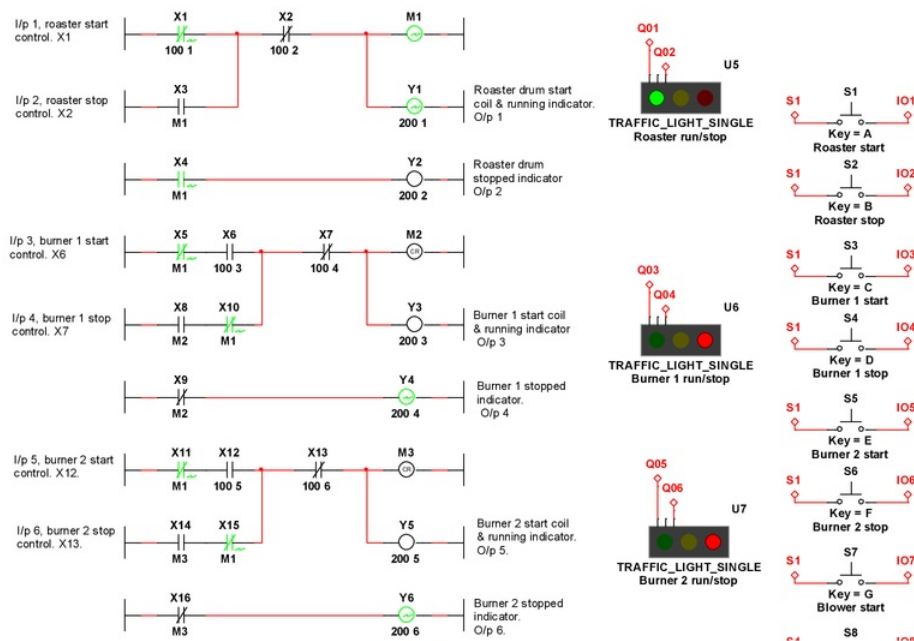


Figure 16: Test circuit 1.

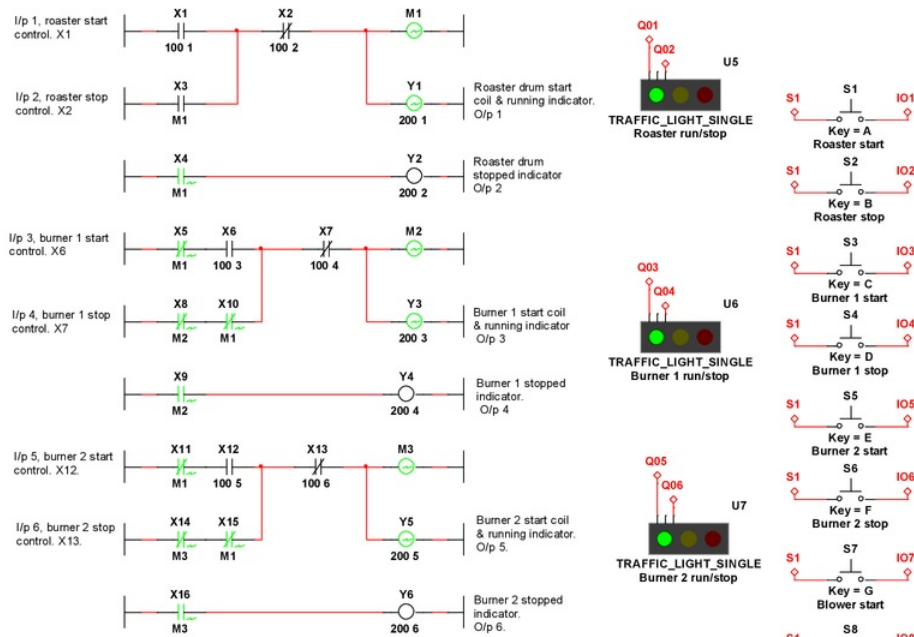
Shown in the previous figure is the draft design, without timer circuitry, to prove the starting and stopping of the first motor coil. It can be seen that the stopped indicator is illuminated as the first coil is holding closed contact X4.

The next figure will show how, when the start button is pressed, the stopped indicator will extinguish and the first motor coil, M1, will energise. This, shown in the figure, demonstrates, not only the starting of the first motor, but, also the provision of allowing the burners circuits to be energised when ready. As the specifications, the burners should not be able to energise until the roaster drum, motor coil M1, has first been energised.

*Excellent use made of MultiSim in PLC  
mode to predict the PLC program required  
for control of the coffee roasting system*



The next figure shows the burner circuits energised as their relative start buttons have been activated. The stopped indicators have been extinguished and the running indicators have been illuminated.



## 11. Works Cited

Campbell, G. M., 2011. *The complete idiots guide to project management*. 5 ed. New York: Alpha Books.

G Verma, M. W., 2015. *Autocad Electrical 2016 Black Box*. 1 ed. Georgia: CAD/CAM/CAE Works.

Robinson, S., 2016. *SIL or PL? What is the difference?*, Cleveland: TUV-SUD.

*Works cited could have been a lot more  
detailed.  
Why no conclusion and recommendations? Really  
spoiled a good detailed project report!*

# B Jones Interim report

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## GRADEMARK REPORT

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FINAL GRADE

GENERAL COMMENTS

52/100

**Instructor**

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PAGE 1

**Text Comment.** Incomplete!

**Text Comment.** Coffee Machine System Upgrade?

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PAGE 2

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PAGE 3

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PAGE 4

**Text Comment.** Project!

**Text Comment.** Excellent project introduction, but should have concentrated on the project outcomes rather than the project process

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PAGE 5

**Text Comment.** Good detail

**Text Comment.** Very clear indication as to the operation of the current system

**Text Comment.** As seen in Figure 1

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PAGE 6

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PAGE 7

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PAGE 8

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PAGE 9

**Text Comment.** Each figure should be labelled and explained seperately

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PAGE 10

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**Text Comment.** Good use made of pictorial evidence in showing how the system functions at present.

**Text Comment.** This should be an addition and not part of the specification

**Text Comment.** Very detailed general specification given

**Text Comment.** Non-standard line spacing.

**Text Comment.** Very good detail shown which clearly shows the full process

**Text Comment.** Very good analysis of the sequence of events required to produce the roasted coffee beans.

**Text Comment.** Excellent block diagram of the process, maybe should be in the background section.

**Text Comment.** Good information shown related to 3 choices researched as solutions to the project problem

**Text Comment.** Where do these numbers come from and what do they mean?

**Text Comment.** Good!

PAGE 25

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PAGE 26

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PAGE 27

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PAGE 28

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PAGE 29

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PAGE 30

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PAGE 31

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**Text Comment.** Very detailed specification shown for the solution taken forward.

PAGE 32

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**Text Comment.** Good detail.

PAGE 33

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**Text Comment.** Very good detail shown in WBS

PAGE 34

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**Text Comment.** Excellent breakdown of work to be carried out in Gantt Chart but no contingencies noted

PAGE 35

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**Text Comment.** Excellent use made of MultiSim in PLC mode to predict the PLC program required for control of the coffee roasting system

PAGE 36

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PAGE 37

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**Text Comment.** Works cited could have been a lot more detailed.

**Text Comment.** Why no conclusion and recommendations? Really spoiled a good detailed project report!

GRADING FORM: CSG-RUBIC

## RESEARCH-INFORMED LITERATURE



Introduction (4/5): Good, written in an interesting way. However, you should focus on the aims and objectives of the actual project rather than the process of executing it. Background Research (3/4): Good descriptions and explanations supported by photos. Figure 12 belongs to this section. Harvard Referencing: (1/4): Small range of sources listed and cited. Literature Review (4/7): Three methods considered and choice made.

## 12

## KNOWLEDGE AND UNDERSTANDING



WBS (7/10): Good, detailed WBS shown in the report. Specification (8/10): Very good, plenty of detail. Watch your scope. Flow charts probably belong in another section but do show the design requirements well. Additional specification provided in the solution section. Gantt Chart (7/10): Very detailed but no contingencies noted.

## 22

## ANALYSIS



Analysis of test results (6/10): Good use made of MultiSim in PLC mode to predict the PLC program required for control of the coffee roasting system. Conclusions (0/10): No conclusions shown in the report.

## 6

## **PRACTICAL APPLICATION AND DEP.**

|                                                                                   |                                                                                                                                                                                          |          |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
|  | Progress to date (3/5): Good progress to date.<br>Simulation carried out on proposed PLC program.<br>Presentation of test results (2/5): Results of<br>simulation given as light states. | <b>5</b> |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|

## **SKILLS FOR PROFESSIONAL PRAC.**

|                                                                                   |                                                                                                          |          |
|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------|
|  | Recommendations (0/10): None offered. Quality of<br>report (7/10): Good, clear diagrams, well presented. | <b>7</b> |
|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------|