1809797

by Lourens Brits

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Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
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Good Structure

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Finally, to my subject academic tutors, your guidance and drive for excellence betters us as students, thank you.

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1. Executive Summary

A simulation system was designed and built to enable a select number of the main ARU/SRU project FDS to be tested.

During the design phase, specifications had to be identified that would be practical for the simulation system and benefit the main project. Once the FDS items were identified, the system was designed, which included identifying the required hardware, designing the PLC logic and creating wiring diagrams to be utilised during construction.

The original project work breakdown structure was amended to include the simulation, from which a simulation Gantt chart was created to ensure the project was executed in a timely manner, keeping within the academic timeline.

Legislative and sustainability constraints applicable to the simulation project were elaborated upon and shown to be implemented.

A comparison was carried out showing the differences in quotations received from the primary component supplier, with a full costing breakdown of the main project and simulated project provided, as well as what measures were taken to stay within the budget and reduce overall expenditure.

The simulation system was constructed and systematically energised, where individual components were confirmed to operate correctly before fully-assembled power-up. The PLC program was downloaded, after which the system was configured and function tested, with all results documented.

Finally, the project execution was elaborated upon, followed by a thorough evaluation of the outcomes.

2. Introduction

This report aims to accurately document the design, implementation and execution of a gas detection upgrade project being executed on a complex oil refinery.

An alternative solution will be selected due to the main project stagnation, which will enable the simulation system to be designed and documented in line with the main project functional design specifications and constraints, where applicable.

The system will be designed using industry standard methods, where wiring loop drawings, flow charts and test tables will be created.

Once suitable components are selected and the simulation hardware and software is built, the system will be created and function tested, with all results recorded accurately for further evaluation.

Project outcomes will be compared and elaborated upon to enable a deeper understanding of the wider project management techniques that was implemented.

3. Design

Following the project disruption and delay due to budget re-approval, the decision was made to create a simulation rig, in line with the FDS, to enable system testing to be carried utilising the test table. Some testing will not be applicable due to the system being simulated, this will be elaborated upon in the testing and results section.

3.1 FDS Items Applicable to Simulation

The following FDS items have been highlighted as necessary to ensure the simulation system functions correctly and in a manner which accurately portrays the original field project. Due to the nature of the workshop-based simulation, not all FDS items are applicable.

2	**Maintenance Activities**	
2.2	Maintenance Overrides and Inhibits	Alarm inhibits must be available to enable maintenance activities. Inhibits must be captured using established site procedures
2.3 c	Loss of Power Recovery	The 24v power supply must have an N+1 redundancy configuration, where N is the number of supplies for the calculated load.
3	**Environmental Requirements**	
3.2	Electromagnetic Compatibility	Separation of signal and power cables and galvanic isolation
4	**Performance Requirements**	
4.2 a	System Response Time	The gas detection system must alert an operator through the DCS system of any gas release within 30 seconds,
4.4	Major Accident Survivability	The system must be able to produce an alarm signal in the event of a significant accident, i.e., signal cables open circuit
5	**System Interfaces**	
5.1 d	Operator Interface	In addition to the DCS alarms, hardwired fault loops must indicate: System Fault (0mA) & Detector Fault (3.6mA)
5.2	Alarm Levels	Gas detection alarm levels must be set to 5ppm (low) & 10ppm (high)
6	**Power Supplies**	
6.1 b	Electrical	Manufacturer-supplied 24v power supplies must be able to seamlessly switch to standby supply in the event of a failure.
7	**Trip and Reset Philosophy**	
7.1	Alarm Acknowledge	The gas-detected alarm output shall be latching. Acknowledge (AKN) switch must silence audible alarms with visual alarms staying active.
7.2	Alarm Reset	The system must only allow a full reset once all detectors are below 5ppm
7.3	Alarm Outputs (Audio / Visual)	Alarm outputs shall energise to trip (ETT) for audio/visual alarms

Table 1 - FDS Items Applicable to Simulation

3.2 Simulation System Design

The simulation block diagram was created as a visual aid to show the overview of the system and indicate the various components that will be utilised.

The Regard Classic controller can accommodate 16 analogue cards, where three cards will be utilised for the simulation. Three Draeger Polytron 7000 H2S detectors will be wired to the analogue cards, and MTL 5541 galvanic isolators will be utilised for safe and hazardous area separation.

A dual 24v power supply unit will provide a stable 24v DC supply through a diode switch to ensure power supply redundancy. Each power supply will have a fault output.

The hard-wired normally open 5ppm and 10ppm alarm signals will provide DCS low and high alarms, and normally closed fault signal will provide DCS fault indication in the event a detector is faulty, or power is lost to the controller.

The PLC available for the simulation was an Allen Bradley ControlLogix 1756 which was used in the site electronics workshop for testing programs before uploading to live process control systems.

The PLC input signals will be in the form of 4-20mA analogue hard-wired signals

The Regard Classic controller will be used for the audio / visual alarm activation, achieved by utilising the common 5ppm low alarm relay contact to provide a 24v DC signal to the combined audio / visual beacon in the event H2S gas has been sensed. The beacon will have its own dedicated 24v supply. It was not practical to utilise a battery backup supply (UPS) for the simulation.

The block diagram shows a solid-state relay (SSR) supplying the audible/visual alarms intended to simulate the field installation. This SSR was not implemented to ensure costs were kept to a minimum. The Regard Classic controller has common relay outputs which were utilised.

The PSUs will be supplied by a stable 110v AC supply in the workshop for testing and commissioning purposes. A seamless switchover during a power supply failure will be simulated, including a PSU failure alarm.

Audio and visual alarm reset will be carried out utilising the reset pushbutton incorporated into the front face of the control cards as well as a dedicated pushbutton to energise the reset contact in the PLC ladder logic through a 24v DC input card.

DCS graphic construction could not be carried out on site due to the unavailability of the DCS-group simulator; therefore, the Allen Bradley graphic design suite and associated HMI will be utilised accordingly.

Once the main project commences in May 2023, the DCS graphics creation will be scheduled into the refinery maintenance schedule and completed in line with the graphic created for the simulation.

Due to the simulation being executed in a workshop location, the armoured cable will not be utilised to keep costs and waste to a minimum. The cables used will meet the minimum core thickness criteria stipulated by the manufacturer of 1.5mm^2.

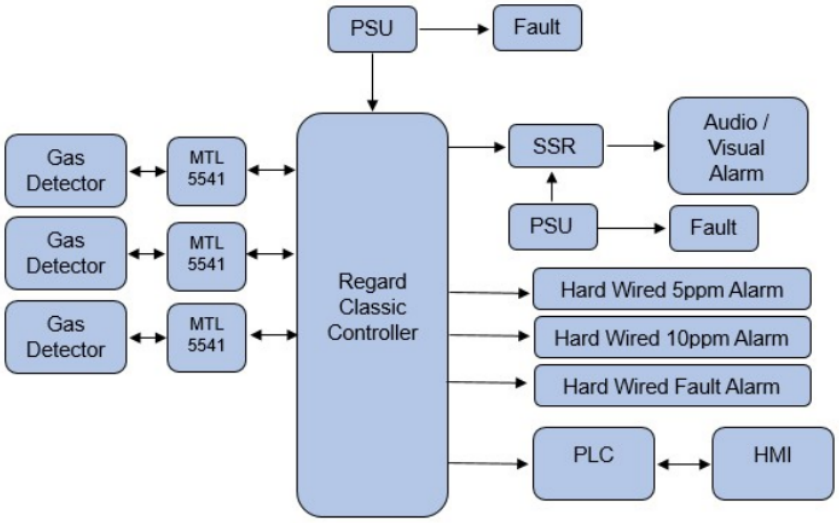


Figure 1 - Simulation Block Diagram

It is not clear as to why are you writing in the future tense, you should be writing in the present or past tense explaining what you have produced.

3.3 Simulation Drawings and Settings

The simulation drawings shown in Appendix figure 1, 2 and 3 were created by using the block diagram to ensure all components are recorded. Once the drawings were reviewed, a day was spent in the drawing office to gain familiarity with the software utilised to create site standard drawings, during which the final drawings were created.

This is the standard of drawings that will be created for the main project. The Regard 7000 cabinet wiring diagrams will be created by the manufacturer and sent to the site drawing office, where the drawings will be standardised to site specification and issued for SME review. Once

A story is unnecessary as this should be recorded in the log book.

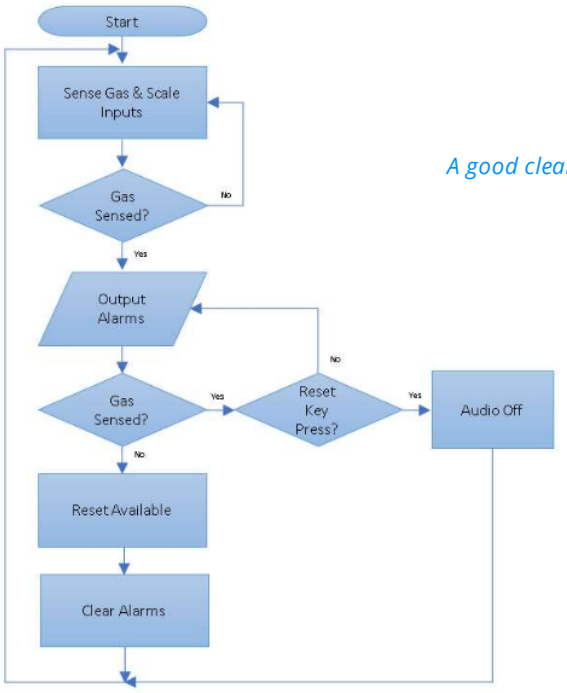
the drawings are approved, they will be uploaded to the online drawing library, with hard copies held.

3.4 PLC Logic

The PLC logic design flow chart shown in figure 2 was created as a design-aid for creating the PLC ladder logic. Once the process starts it immediately looks for values of gas sensed. If gas is sensed the alarm output will energise, if not it continues to sense gas.

During the alarm output function, the system will continue to confirm whether gas has been sensed. A decision will be made whether gas is still being sensed, if yes, another decision will be made regarding the reset key-press input; if yes, the audio output will be silenced and the sequence will return to the start. If no reset key-press is active the alarms will continue to output.

If no gas is sensed in the second "gas sensed" decision block, the "reset available process will be available, followed by the "clear Alarms" process, after which the process returns to sense gas and scale outputs.



A good clear design

Figure 2 - PLC Logic Design Flow Chart

The PLC analogue input (AI) card (1756-IF16) scales the 4-20mA input signal to assigned engineering units, reducing processor loading whist running the program, thereby increasing response time.

Appendix table 4 show the function blocks required to enable the operations defined in the flow diagram to be executed.

The scaled AI values would serve as the trigger to energise the audio and visual alarm contacts and would require a dead-band to ensure spurious alarming is avoided. Furthermore *unfinished*

4. Implementation and Management

4.1 Constraints Applicable to Simulation

4.1.1 Legislative Constraints

The simulation system construction adhered to the legislative constraints, shown in table 2, detailed in the planning phase to ensure an accurate representation of the main project as well as to gain a further understanding of the practices required, to be applied during the implementation phase.

The components used comply with BS EN 45544-1:2015 & BS EN 60079:2014. The detectors are CE marked and comply with ATEX hazardous area requirements.

The installation complies with BS EN 7671:2008 where electrical and signal wiring is appropriately separated and the minimum manufacturers recommended cable thicknesses are adhered to.

The System operation complies with Shell DEP 32.30.10.11-Gen, which is also outlined in the FDS to ensure rapid response to gas releases in addition to the required methods of raising awareness of gas releases to operators and the general workforce.

The certified H2S gas utilised during the simulation system commissioning and testing in the workshop has been limited to 10ppm, which will ensure the high alarm is triggered without using higher concentrations than are necessary. Further safety precautions include ensuring adequate ventilation to ensure rapid gas dispersion as well as an overhead extractor activated during testing. This shows adherence to HSE COSHH reg 6(1), Reg 7 (1), which states; "*Regulation 6(1)(a) requires that employers should not carry out work that is liable to expose employees to substances hazardous to health until all risks have been evaluated and minimised*" (2002) *page number needed for direct quotations*

Document Number	Title
British Standards	
BS EN 45544-1:2015	Workplace atmospheres - Electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours
BS EN 60079:2014	Explosive Atmospheres and Explosive Atmosphere equipment
BS EN 7671:2008	Requirements for electrical installations. IET wiring regulations. 17th edition
Shell DEPs - Valero Overlay	
DEP 32.30.10.11 - Gen	Valero - Fire, Gas and Smoke Detection Systems
HSE	
COSHH Reg 6(1), Reg 7 (1)	The Control of Substances Hazardous to Health (COSHH) regulations

Table 2 - Simulation Legislative Constraints

The above table is too generally, it should contain more specific information from these sources with Havard references.

4.1.2 Sustainability Constraints

Although the simulation system is relatively small with few parts required for correct operation, there is scope to build the system in a sustainable manner.

Table 3 shows the original sustainability constraints elaborated upon during the design phase of the main project.

The simulation project was constructed within these constraints. All parts will either be re-purposed in the main project or kept as spares for future projects.

Spelling

- Readily available resources were used were possible
- The minimum amount of 4-20mA control cards were used to achieve the required results, thereby reducing energy usage
- Although the PSUs have significantly larger than the required capacity for the simulation, reapplication in the main project ensures sustainable engineering.
- The Polytron 7000 detectors, docking stations and sensors will be used in the main project
- Less precious metals like stainless steel and aluminium were used
- The absolute minimum of parts was used for construction
- Any parts that are not re-purposed will either be held in stores, re-used or recycled

Sustainable Engineering Considerations	
Energy	Utilising renewable and readily available resources
	Reduce pollution
	Reducing energy usage
Product design	Maximum component energy, temporal and mass efficiency
	Consideration complexity and entropy for end-of-cycle disposal
	Material diversity reduction
	Reduction in non-essential capacities and capacities
Disposal	Prioritise waste reduction over waste management
	Design for re-application
	Design for recycling if re-application is not feasible

Table 3 - Sustainable Engineering Considerations

4.2 Simulation Component Selection

Appendix table 1 show the components that will be used to construct the simulation system. The components have been selected to ensure the simulation operates in a manner which will closely mimic the main project, as well as be incorporated therein where applicable.

4.3 Costing Spreadsheet

4.3.1 Draeger Order

The Draeger order was placed, Appendix table 2 show an exported Excel table from SAP of the purchase order in itemised view. The total net expenditure on components for the original project totalled £82 742.69. The total is a slightly lower amount than the original quoted price, which is attributable to a decrease in cost of some components due to the world-wide semiconductor shortages alleviating slightly.

A comparison of the original and procured quote can be seen in Appendix table 3.

4.3.2 Simulation Component Cost

Table 4 shows the simulation component cost table. In an attempt to keep additional expenditure to a minimum as many free-issue parts were used for the simulation. The Draeger Regard Classic chassis and 4-20mA cards were held on site as spares and originate from the Alkylation unit gas detection system which was recently upgraded. The Polytron 7000 gas detectors, docking stations and H2S sensors were booked out from stores on the main project budget and will be installed in the field once commissioning commences, with the three new detectors credited to stores to be held as spares.

An PSUs and diode switch *were* will be utilised during the implementation/construction stage as they are site standard and the current rating is sufficient for the main project.

The Unistrut and associated fixings will be held in the department mechanical fitters' stores as spares to be repurposed as needed.

Simulation Component Costing			
Part	Qty	List Price	Actual Cost
Regard Classic Chassis	1	£8,000	Free Issue
Regard 4-20mA Card	3	£450	Free Issue
Polytron 7000 4-20mA Tx	3	£957.21	£2,871.63
Polytron 7000 Docking Station	3	£43.50	£130.50
H2S Sensor	3	£281.60	£844.80
PSU	2	£705.19	£1,410.38
Diode	1	£148.38	£148.38
Unistrut 1m	3	£12.40	£37.20
Bolts	20	£0.56	£11.20
Channel Nut	20	£0.74	£14.80
Washer	20	£0.54	£10.80
1.5mm single core 1m	20	£0.59	£11.80
Allen Bradley PLC	1	£2,663.91	Free Issue
Total Project Attributable cost			£5,491.49

Table 4 - simulation Component Cost

4.4 WBS & Gantt Compliance

The overall project allowed for 150 days for planning, design and execution. The planning and design phase were executed on schedule, with the remaining 67 days allocated for execution being significantly overdue due to company-wide policy changes on project budget approvals.

The project budget was approved in late 2022, where all necessary steps were followed to ensure parts procurement could commence as planned in early 2023. Due to significant maintenance event overspending, the company required all expenditures to be re-evaluated in an attempt to limit Capex overspend.

Due to many projects being executed in 2023, the re-approval for the SRU / ARU project was significantly delayed, and finally, full funding was granted in late March.

The main project stagnation occurred at 17% completion in line with the original WBS, shown in Appendix figure 4. Once the project resumes the WBS and updated Gantt Chart will be utilised to ensure the project is executed as planned.

Appendix figure 5 shows revised WBS which structures the design, simulation, implementation and commissioning phases of the project as well as the allocated percentage of time for each phase, where 1% represents 1.5 days. This revised WBS enabled an updated Gantt chart to be produced as shown in Appendix figure 6 to allocate a specific timeline to each aspect of the simulation and revised timeline for the main project. Appendix figure 7 shows the simulation project expanded timeline.

The simulation phase illustrated in the WBS has 20% of the revised project time allocated to it, which equates to 30 working days.

4.5 Simulation Construction

4.5.1 Simulation Hardware Setup

Appendix figure 9 shows the simulation system during construction. The Regard Classic controller was mounted on a Unistrut frame at a comfortable height to reduce the potential for injuries during setup and commissioning. The wiring interconnection blocks were in a central position and laid out in a manner which provides maximum separation of power and signal wiring, with the 110v AC supply at the far left of the DIN rail and the 24v DC signal isolation barriers to the far right.

The dual redundant 24v DC power supplies and redundancy diode were DIN mounted at the lowest point, to aid in stability due to their combined weight.

Cable ducting was used to aid in cable separation and to maintain neatness of the installation.

The Polytron7000 gas detectors were mounted on a purpose-built Unistrut frame as shown in Appendix figure 12.

The 4-20mA control cards required setting up to ensure correct operation, the following steps were carried out utilising the manual as guidance – see Appendix figure 10.

- Enter Config mode by pressing reset for 5 seconds and entering the password CC**
- Set measurement units to ppm
- Set target gas to H2S
- Set upper range value to 25ppm
- Set low alarm to 5ppm
- Set high alarm to 10ppm
- Set alarm action to rising
- Set analogue output range to 4-20mA
- Set analogue card zero value
- Ensure drift band is set to 0.0%

Appendix figure 11 show the 4-20mA control cards' configuration.

The Polytron 7000 gas detectors were setup by using the manual as guidance. Firstly, the target gas (H2S) was selected, followed by setting the analogue output parameters and date and time for internal datalogging accuracy. Lastly the fault logs were checked to ensure there are no standing alarms (Draeger, 2021). A collage of this setup sequence is shown in Appendix figure 13.

4.5.2 Simulation Logic

The simulation logic was created using Rockwell RS Logix5000 software. A new project was created and the L61 controller and 13 slot chassis selected (Appendix figure 14). The PLC required three IO cards to be installed for the system to operate correctly, these were; IF16 Analogue input (AI) card, IB32/A DC input card and OW16I DC isolated relay card. The cards were each allocated a slot in the PLC chassis.

The analogue input card was configured to carry out appropriate scaling of the 4-20mA input current to the required engineering units of 0-25 (ppm) (Appendix figure 15).

The main program routine consisted of three parallel pairs of “greater than or equal to” (GEQ) function blocks which compared each scaled analogue input value to 4ppm and 5ppm respectively to function as a dead-band to reduce spurious alarms. Each rung would energise the corresponding “gas sensed” output contact. Finally, a “jump to subroutine” (JSR) function was added to ensure the alarm logic subroutine is executed (Appendix figure 16).

An alarm ladder logic program was created, which consisted of three non-latched input contacts in parallel and one output contact for the unit audio alarm on the first ladder rung. A fourth contact was added in parallel as a rung latching contact which was energised by the unit audio alarm (Appendix figure 17).

A reset input latched contact was added after the input contacts to reset the unit audio alarms, but was found to only instantaneously silence the audio alarms. Once the reset was pressed and released the audio alarm would activate again in the event gas is still being sensed. This also highlighted a potential for a dangerous situation occurring in the event the reset switch is stuck on (Appendix figure 17).

To overcome these two issues a “count-up” counter (CTU) was added in series with an “equal to comparator”, once the counter has counted to 1, the equal to comparison will be true and allow the reset to be executed resulting in the audio output to be de-energised. Any further reset inputs would have no effect on this rung (Appendix figure 17).

The second rung was created by inserting three “less than” (LES) comparators in series with the reset input. The LES function blocks compared source A, tagged to the three scaled mA inputs, to source B set to engineering unit 5 (5ppm), resulting in the CTU reset only being available once the gas sensed value falls below 5ppm (Appendix figure 17).

The third rung consisted of the same three “gas sensed” input contacts as mentioned above, with the output contact being the unit visual alarm contact. A “unit visual alarm” rung latching contact was added in parallel with the three gas sensed contacts to latch the unit visual alarms. The reset input contact was added in series with the rung latching visual alarm contact, which

would only allow a full reset once all three “gas sensed” contacts were de-energised (Appendix figure 17).

The fourth rung consisted of the reset input contact and reset output contact.

Appendix table 4 show the function blocks’ operation as integrated into the simulation system logic

5.4.3 HMI Creation

The planned simulation design, implementation and testing could not be fully carried out due licensing issues with the Rockwell factory view software. Multiple attempts were made to enable the software to no avail. This issue is still with the refinery IT department to be resolved.

The graphic face plate shown in figure 3 was built whilst the software was still functioning correctly, with the intent to tag the three simulation-system analogue signals to the graphic for operational testing. Appendix figure 20 show the HMI build within the software,

The locations were referenced from the refinery plot plan and are an accurate representation of detector locations on the units. One of the major drivers for this project was to conform to Shell DEP 32.30.10.10 which requires the operator interface to show the exact locations of the gas release, the concentration of the release and which detector alarmed first to aid in leak isolation and emergency response.

The analogue gauges at each detector location will provide the measured gas concentration fulfilling two of the three requirements. The third requirement being indication of which detector alarmed first will be addressed by adding a latching red glow animation to the analogue gauges, triggered by a pre-determined setpoint.

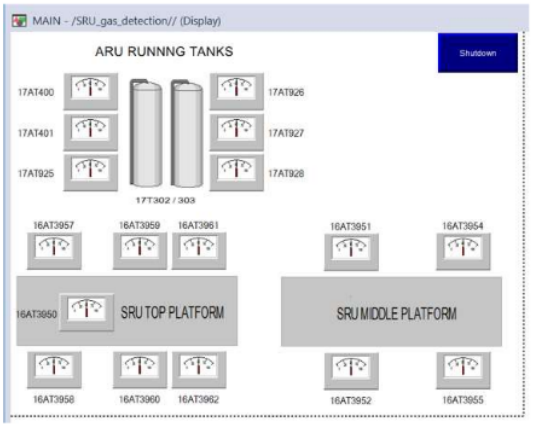


Figure 3 - HMI Operator Interface

4.6 Project Management - Plan Adherence / Deviations

As stated previously, the execution phase of the main project had stagnated. The Gantt chart shown in Appendix figure 7 was created to ensure the simulation was carried out in a timely manner and completed by the stated deadline.

It is clear to see that all aspects of the simulation project had been completed on time, depicted by the green highlighted progress bars. Due to work commitments, a small number of deadlines were missed by half a day at most, these lost time incidents were recuperated in a prompt manner which did not affect the timeline and had therefore not been shown.

Microsoft project allows for projects to be incorporated into existing project timelines, which was done in this instance. The simulation project was placed at the stagnation point in the main project, which will conveniently continue two weeks after the simulation has been completed.

The simulation project is preceded by a significant delay attributable to the aforementioned budget delays. An additional delay in continuation of the main project is apparent after the simulation, due to the projected factory acceptance test being scheduled for early June and the ground work start date scheduled for the second week of June when the refinery schedule allows.

The delays in the project have enabled a further understanding of project management in large corporations to be gained. Most notably is the need to be able to adapt to delays and to ensure a degree of fluidity is maintained, especially where budget approvals and delivery lead times are concerned.

In hindsight, the placement of the order for the Draeger parts should have been placed as soon as the budget was initially approved, with the Gantt chart updated to reflect the timeline change. *That is the reason for planning*

5. Testing and Results

Testing was carried out in line with the simulation FDS testing table created. The tests were carried out on the simulation system in a controlled manner, with the area barriered off whilst H2S gas was being utilised for PLC logic testing. Initial setup and calibration of the gas detectors were executed with 25ppm H2S to set the high range accurately. Further tests were conducted with a lower concentration of 10 ppm for safety reasons.

The completed FDS and PLC logic test tables are shown in Appendix 5 and 6, respectively, with the corresponding Appendix image number referenced in the evidence tab.

The FDS testing was mostly successful, with one failure and three tests not carried out due to the aforementioned HMI software issue and will need to be carried out during the main project testing phase.

The one failure was due to the incoming 110v AC supply being outside the allowable tolerance of 5% at 117 volts, although the frequency was correct at 50Hz. The transformer was encased in a metal structure with no data labels to ascertain the cause of the increased voltage, which could be due to the reasonably small load applied. Although this is an FDS failure, the system operated correctly.

The power supply redundancy functioned correctly, with uninterrupted supply maintained whilst alternating between the two PSUs.

Individual control cards were proven to be able to be inhibited for testing and maintenance to ensure no unnecessary alarms were activated. The control cards also displayed the inhibit mode code (60-0) as a further visual aid to ensure the card is not left inhibited once maintenance activities are finished.

The trip and reset tests proved that the audio alarms can be silenced whilst visual alarms are still active during a gas release event, a Shell DEP 32.30.10.11 – Gen fire and gas detection constraint requirement.

All PLC tests passed, with no issues arising. This is due to the nature of PLC programming, where the development of the logic includes continual testing and analysis to ensure the logic operates as intended.

An overall conclusion can be made that the gas detection system simulation functioned as intended, proven by the testing results, and will aid in ensuring the main project execution is carried out more efficiently.

6. Evaluation of Project Outcomes

The main project outcomes cannot be elaborated upon as the implementation phase is due to commence in June 2023. The original FDS table will be utilised to ascertain whether the project was successful.

Once the main project component procurement was carried out, the lead times slipped significantly. A previous agreement with the manufacturer guaranteed reduced lead times down to 5 weeks; this agreement could no longer be upheld due to the delay in procurement and various other orders being submitted from other companies earlier in the year, causing lead times to slip to around 25 weeks.

The order was subsequently placed, and all other aspects of the execution phase are on hold until May when the maintenance schedule would allow for work to commence.

The decision was made to simulate the system to gain further underpinning knowledge and to enable pre-commissioning testing of some of the components that will be utilised in the system.

Various parts were utilised from spare parts held on-site to build the simulation system in an environmentally friendly and sustainable manner. Any parts purchased would be selected to function within the main project, either directly or as spare parts held in-store stock.

Due to the cost and lead time of the Regard 7000 controller, it was deemed that a Draeger Regard Classic gas detection system controller would be most suitable for the simulation, with the additional benefit that a running spare was held and would not impact the main project budget.

The Allen Bradley PLC used for the simulation system is used in the electronics workshop for PLC program creation and testing and was free to use.

The simulation project was mostly successful. The gas detection controller, gas detectors and PLC program functioned as specified by the simulation FDS.

The HMI could not be fully function-tested due to software issues. The HMI graphics were built to FDS criteria, and there are no foreseeable issues relating to enabling the graphics to function correctly once the software issues are addressed.

The simulation WBS and Gantt chart timelines were adhered to, with no significant hindrances experienced.

The budget will be comfortably met as, to date, £99291.22 has been spent out of a budget of £145 000. The payment to Draeger includes all hardware as stated on the quote and two

engineers installing and commissioning the system on-site, the factory acceptance and site acceptance testing. This will reduce the overall spending on on-site contractors.

Further outstanding costs are shown on the revised labour costing spreadsheet in Appendix Table 7, which reflects a reduction in total spending to £7382.50. this reduction is to the removal of the controller cabinet installation and wiring costs, amounting to £2905.00.

In addition to the labour costs, the temporary gas detector hire amounts to £4162.25 to rent 25 area detectors for a week, and the drawing office costs, which amount to £12200 for standardising drawings. The drawing office worksheet estimates 220 hours charged at £55.45 per hour, as shown in Appendix 8.

The total predicted cost will amount to £123035.97, leaving a contingency fund of £21964.03, therefore, the project should be implemented below budget.

7. Conclusions and Recommendations

The delays experienced in the budget re-approval were disappointing because they seemed unnecessary. The delays did, however, enable insight and better understanding to be gained into the real-world issues project managers encounter, resulting in future preparedness for such occurrences. Additionally, it highlights the need to remember that each project is part of a bigger picture, with multiple influences that affect decisions.

The simulation system functioned as intended, which provided a better understanding of the underpinning technology that will be incorporated into the main project systems, which will undoubtedly aid the implementation and commissioning phases.

The simulation system could have been significantly improved if the HMI software had operated correctly and the RS485 communications card was not in use elsewhere on site. The creation of the Modbus map would have been very beneficial to the main project implementation.

The need to amend the WBS and Gantt chart to include the simulation project enabled further managerial skills to be gained, which will prove helpful in potential future managerial roles.

A further improvement to the simulation would have been achieved if the DCS graphics were created and simulated, it is understandable though that all departments are under pressure and cannot always accommodate all non-scheduled requests.

You appear to be blaming others for your failure to achieve all parts of your project

Correct method of listing.

8. Works Cited

This is a small range of sources compared to what is expected at level 6

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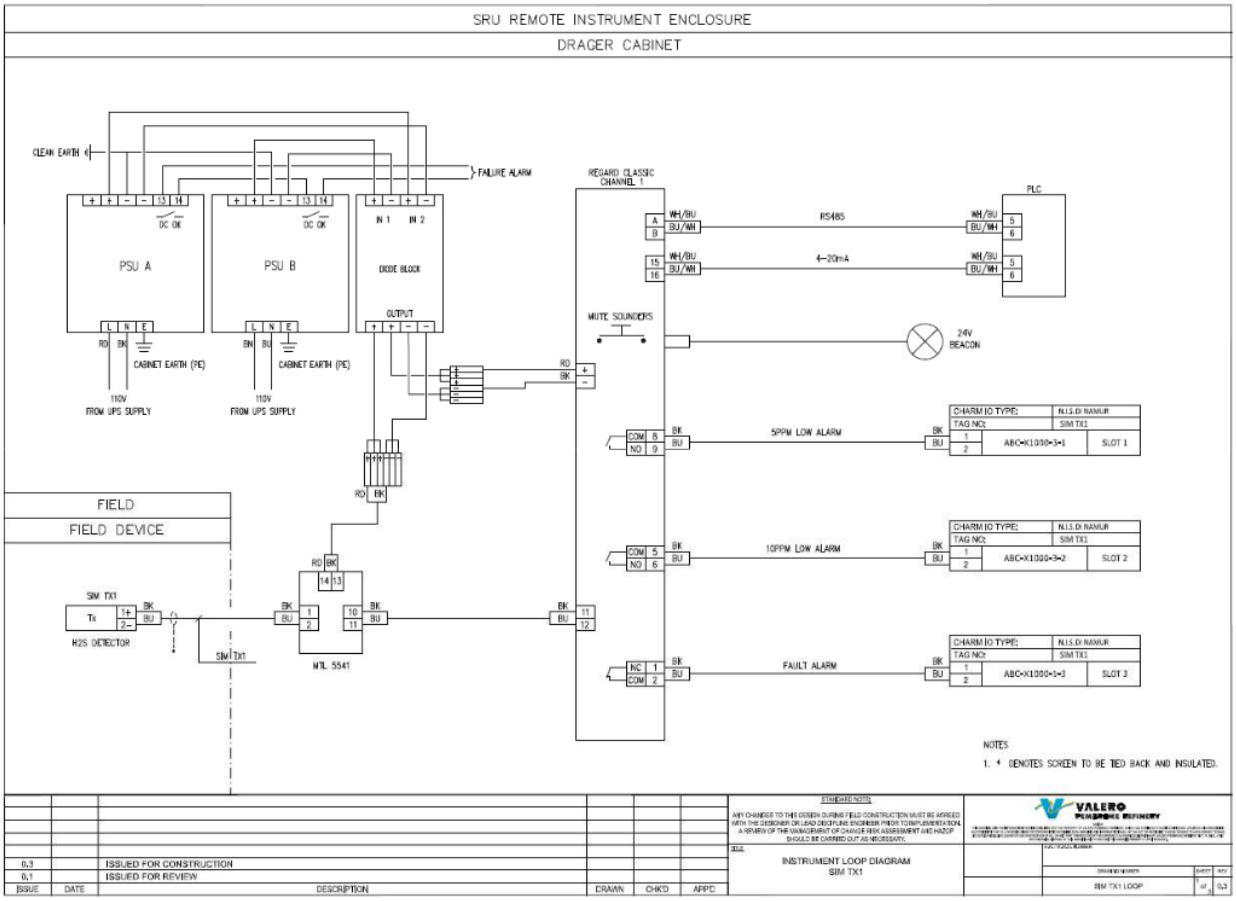
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9. Appendix

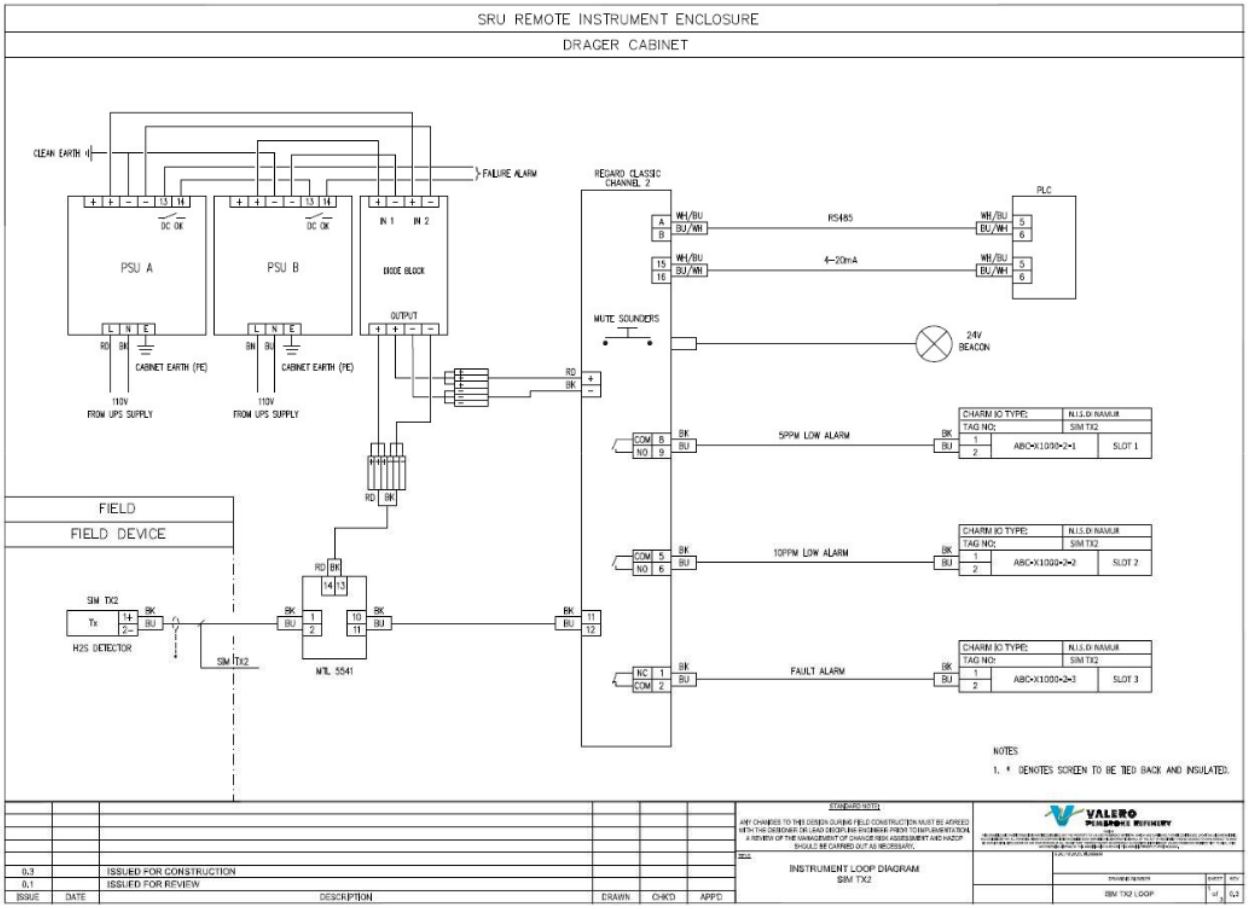
9.1 Design

Simulation Wiring Diagrams -Transmitter 1



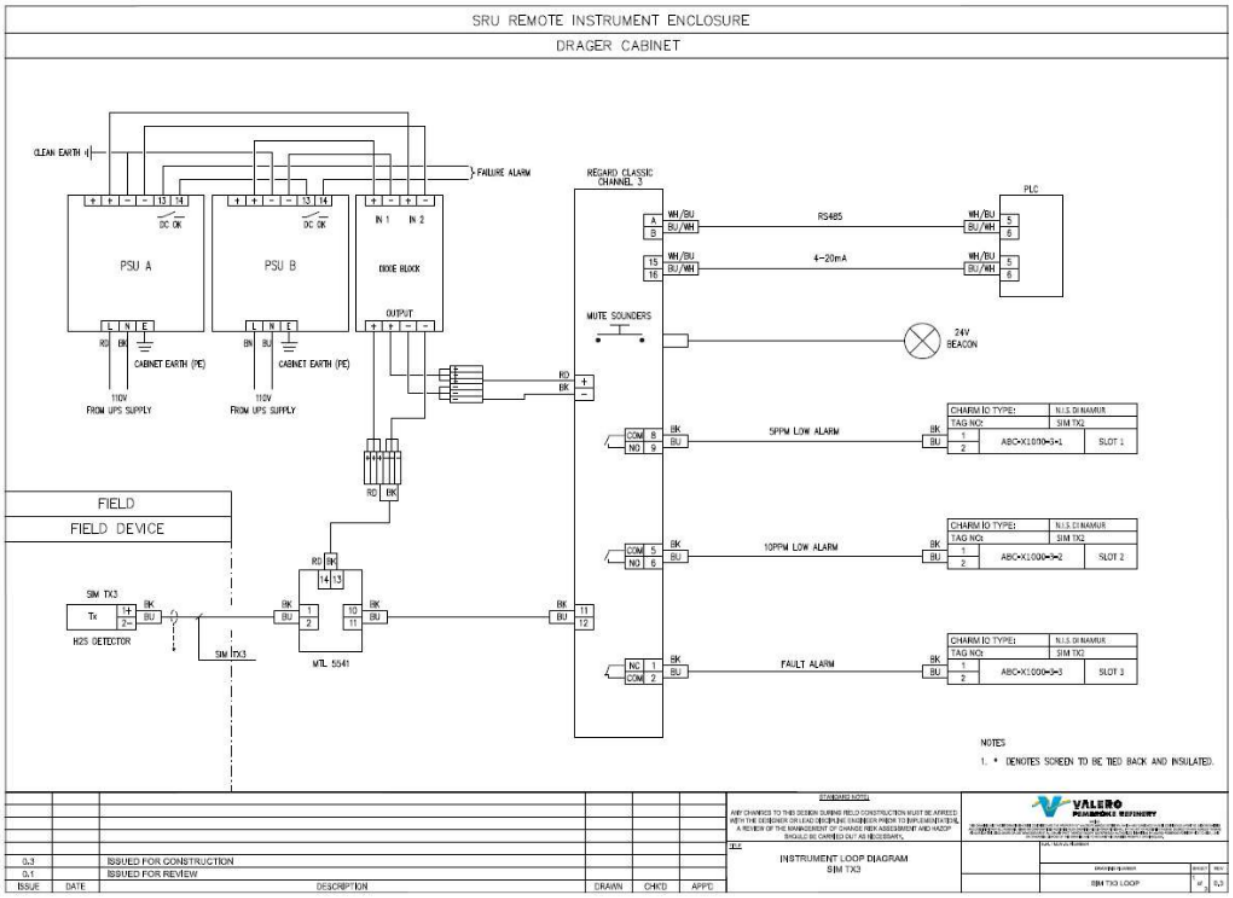
Appendix Figure 1 -Simulation Wiring Diagrams -Transmitter 1

Simulation Wiring Diagrams -Transmitter 2



Appendix Figure 2 - Simulation Wiring Diagrams -Transmitter 2

Simulation Wiring Diagrams -Transmitter 3



Appendix Figure 3 - Simulation Wiring Diagrams -Transmitter 3

9.2 Implementation

Simulation Component Selection Table

Image	Discription	Part Number	Mounting	Input Voltage	Output Voltage	Output Current
	PSU	Quint-PS/1AC/24DC/40	DIN Rail	110v AC	24v DC	40A
	Redundancy Diode	Quint-Diode/12-24DC-/2x24DC/2x40	DIN Rail	2x 24v DC	2x 24v DC	2 x 40A
	Polytron 7000	8317710 PEC7000 4-20mA HART D	Field	24V DC	n/a	4-20mA
	H2S Sensor	6810435	Polytron 7000	24v DC	n/a	n/a
	Regard Classic Chassis	Discontinued	Rack	24v DC	24v DC	4-20mA
	Regard 4-20mA Control Card	Discontinued	Chassis	24v DC	24v DC	4-20mA
	Allen Bradley PLC	1756-IB	Rack	240v AC	Output card dependant	Output card dependant
	Allen Bradley Analogue Input Card	1756-IF16	Chassis	n/a	24v DC	4-20mA
	Allen Bradley DC Output Card	1756-OV16E	Chassis	n/a	24v DC	n/a
	Allen Bradley DC Input Card	1756-OB32	Chassis	24V DC	n/a	n/a

Appendix Table 1 - Simulation Component Selection Table

SAP Purchase export

Item of Requisition	Short Text	Quantity Requested	Unit of Measure	Valuation Price	Line Total	Delivery Date	Desired Vendor	Requisitioner
10	9209378 Regard 7000 Control Panel	1.000	EA	19,914.75	19,914.75	24.05.2023	Draeger	BRITSL
20	9209378 Compact Housing for Dashboard	1.000	EA	4,950.18	4,950.18	24.05.2024	Draeger	BRITSL
30	9209378 Regard 7000 Parts	1.000	EA	17,740.28	17,740.28	24.05.2025	Draeger	BRITSL
40	8317710 PEC7000 4-20mA HART D	17.000	EA	957.21	16,272.57	24.05.2026	Draeger	BRITSL
50	8317990 Polytron 3000/7000 Docking Station	17.000	EA	43.50	739.50	24.05.2027	Draeger	BRITSL
60	8317860 Sensor Diagnostic Dongle Polytron	17.000	EA	198.20	3,369.40	24.05.2028	Draeger	BRITSL
70	6810435 DrägerSensor H2S	17.000	EA	281.60	4,787.20	24.05.2029	Draeger	BRITSL
80	9209222 EXE Junction Box	1.000	EA	780.87	780.87	24.05.2030	Draeger	BRITSL
90	9209222 EXD Junction Box	1.000	EA	2,732.94	2,732.94	24.05.2031	Draeger	BRITSL
100	1965206 Installation - See Attached Scope	1.000	PU	6,375.00	6,375.00	06.04.2023	Draeger	BRITSL
110	1965205 Commissioning	1.000	PU	1,830.00	1,830.00	06.04.2023	Draeger	BRITSL
120	1965205 FAT	1.000	PU	750.00	750.00	06.04.2023	Draeger	BRITSL
130	1965205 SAT	1.000	PU	1,000.00	1,000.00	06.04.2023	Draeger	BRITSL
140	1940430 Crating and Shipping	1.000	EA	1,500.00	1,500.00	06.04.2023	Draeger	BRITSL
Requisitioner Approval:		Total Net (GBP)			82,742.69	Procurement Approval:		

Appendix Table 2 - SAP Purchase export

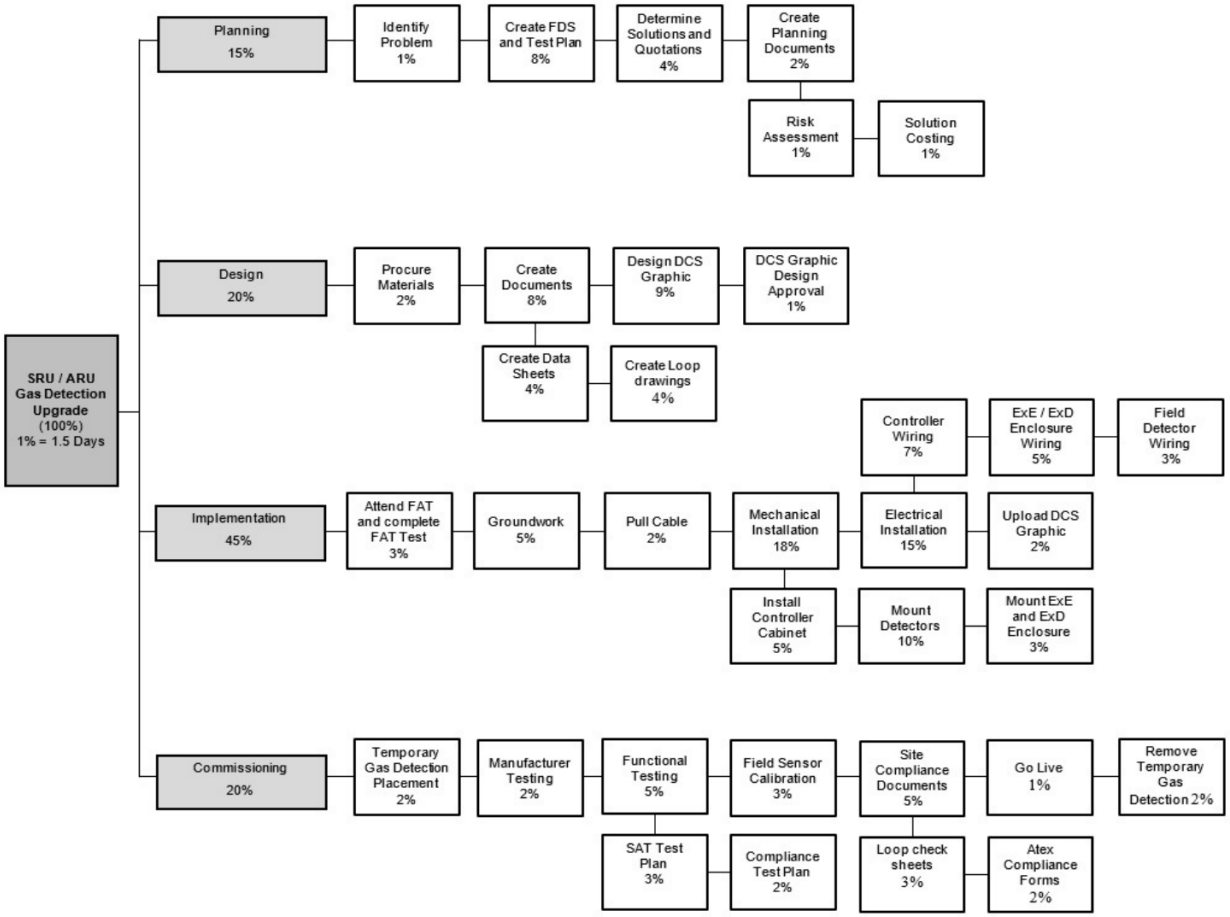
Quote Comparison

	Procured Quote			Original quote	
	Quantity	Component Cost	Total	Component Cost	Total
9209378 Regard 7000 Control Panel	1.000	£19,914.75	£19,914.75	£21,258.63	£21,258.63
9209378 Compact Housing for Dashboard	1.000	£4,950.18	£4,950.18	£4,085.10	£4,085.10
9209378 Regard 7000 Parts	1.000	£17,740.28	£17,740.28	£18,849.05	£18,849.05
8317710 PEC7000 4-20mA HART D	17.000	£957.21	£16,272.57	£889.01	£15,113.17
8317990 Polytron 3000/7000 Docking Station	17.000	£43.50	£739.50	£40.41	£686.97
8317860 Sensor Diagnostic Dongle Polytron	17.000	£198.20	£3,369.40	£184.08	£3,129.36
6810435 DrägerSensor H2S	17.000	£281.60	£4,787.20	£379.40	£6,449.80
9209222 EXE Junction Box	1.000	£780.87	£780.87	£829.68	£829.68
9209222 EXD Junction Box	1.000	£2,732.94	£2,732.94	£3,416.18	£3,416.18
1965206 Installation - See Attached Scope	1.000	£6,375.00	£6,375.00	£6,375.00	£6,375.00
1965205 Commissioning	1.000	£1,830.00	£1,830.00	£850.00	£850.00
1965205 FAT	1.000	£750.00	£750.00	£750.00	£750.00
1965205 SAT	1.000	£1,000.00	£1,000.00	£1,000.00	£1,000.00
1940430 Crating and Shipping	1.000	£1,500.00	£1,500.00	£1,500.00	£1,500.00
	Total Net Cost		**£82,742.69**	**Total Net Cost**	**£84,292.94**

Appendix Table 3 - Quote Comparison

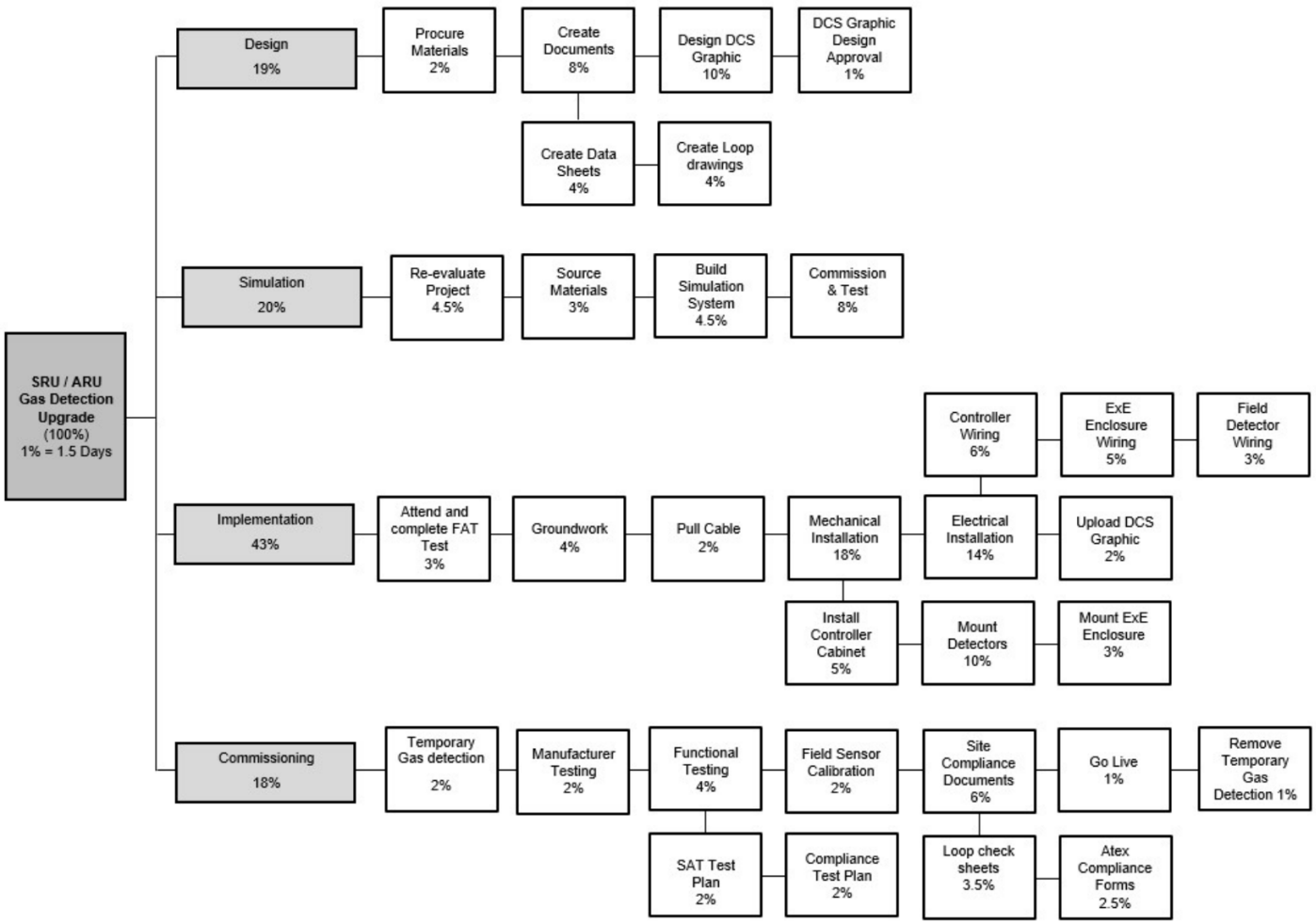
9.3 Project / Simulation WBS and Gantt Chart

Original WBS



Appendix Figure 4 -Original WBS

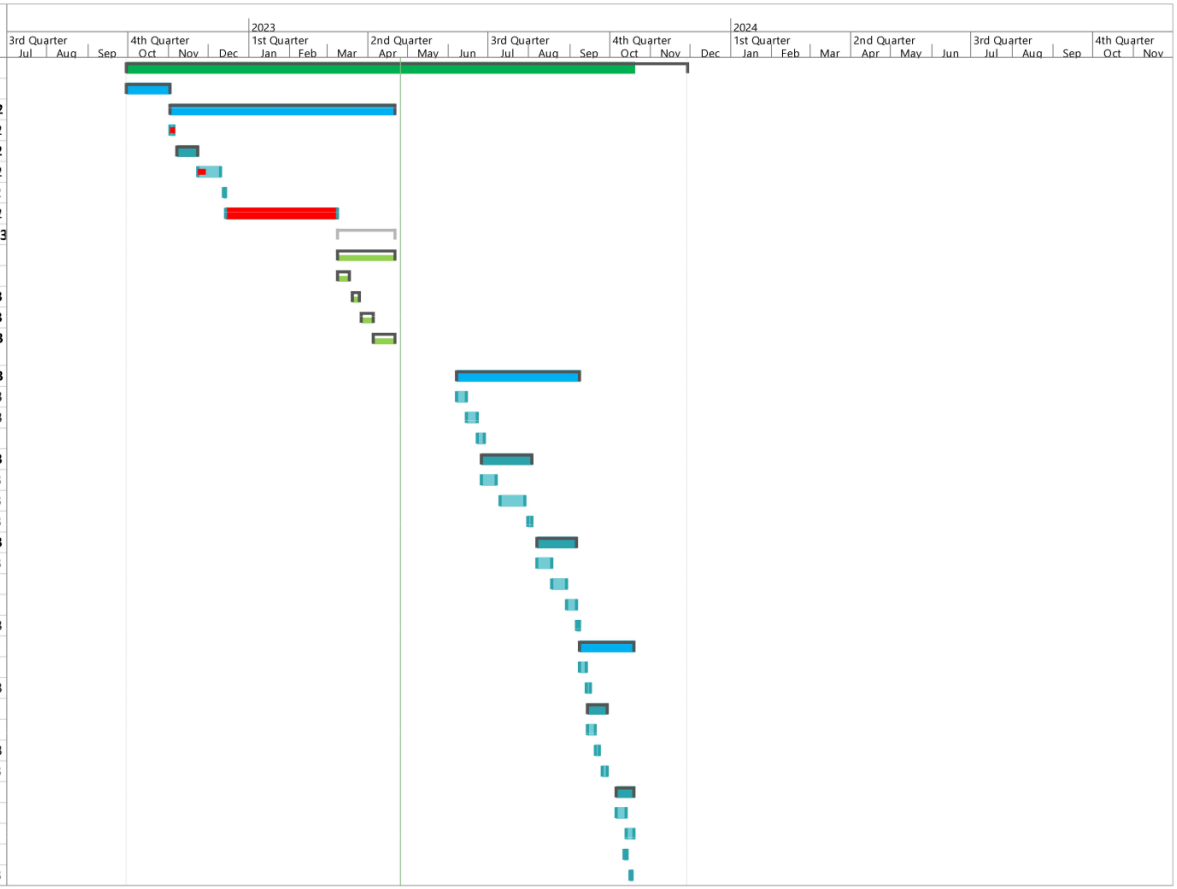
Revised WBS



Appendix Figure 5 - Revised WBS

Revised Gantt Chart showing Simulation within the main project

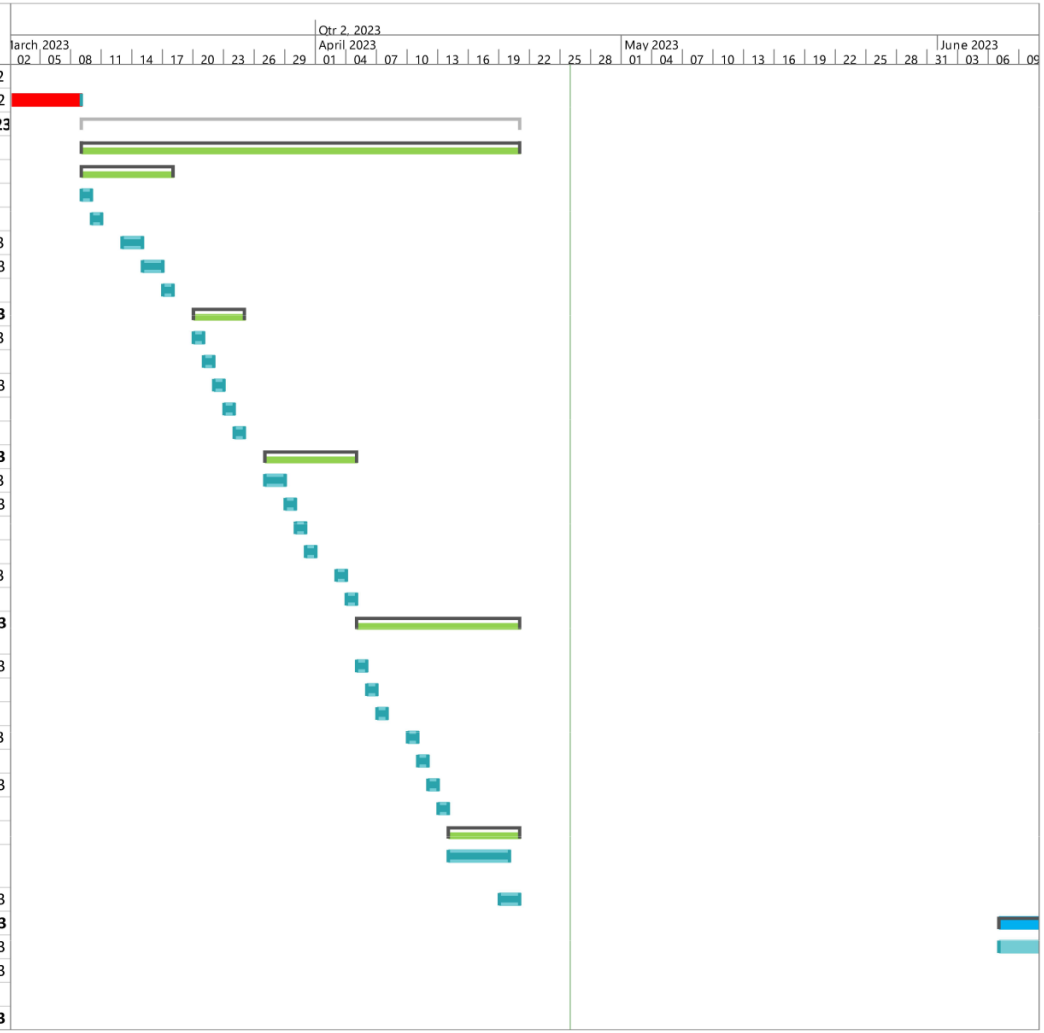
ID	Task Mode	Task Name	Duration	Start
1		**SRU / ARU Gas Detection Upgrade**	**303 days**	**Fri 30/09/22**
2		**Planning Phase**	**23 days**	**Fri 30/09/22**
9		**Design Phase**	**122 days**	**Wed 02/11/22**
10		Procure Materials	3 days	Wed 02/11/22
11		**Create Documents**	**12 days**	**Mon 07/11/22**
14		Design DCS Graphic	13 days	Wed 23/11/22
15		DCS Graphic Testing	2 days	Mon 12/12/22
16		Budget Delay Lag	61 days	Wed 14/12/22
17		**Project1 24042023**	**31 days**	**Thu 09/03/23**
1		**System Simulation**	**31 days**	**Thu 09/03/23**
2		**Re-Evaluate Project**	**7 days**	**Thu 09/03/23**
8		**Source Materials**	**5 days**	**Mon 20/03/23**
14		**Build Simulation System**	**7 days**	**Mon 27/03/23**
21		**Commission & Test Simulation System**	**12 days**	**Wed 05/04/23**
18		**Implementation**	**67 days**	**Wed 07/06/23**
19		Attend FAT and complete FAT Test	5 days	Wed 07/06/23
20		Groundwork	7 days	Wed 14/06/23
21		Pull Cable	3 days	Fri 23/06/23
22		**Mechanical Installation**	**28 days**	**Mon 26/06/23**
23		Install Controller Cabinet	9 days	Mon 26/06/23
24		Mount Detectors	15 days	Mon 10/07/23
25		Mount ExE and ExD Enclosure	3 days	Mon 31/07/23
26		**Electrical Installation**	**22 days**	**Mon 07/08/23**
27		Controller Wiring	9 days	Mon 07/08/23
28		ExE / ExD Enclosure Wiring	7 days	Fri 18/08/23
29		Field Detector Wiring	6 days	Tue 29/08/23
30		Upload DCS Graphic	2 days	Wed 06/09/23
31		**Commissioning**	**29 days**	**Fri 08/09/23**
32		Temporary Gas Detection Placement	3 days	Fri 08/09/23
33		Manufacturer Testing	3 days	Wed 13/09/23
34		**Functional Testing**	**11 days**	**Thu 14/09/23**
35		SAT Test Plan	4 days	Thu 14/09/23
36		Compliance Test Plan	3 days	Wed 20/09/23
37		Field Sensor Calibration	4 days	Mon 25/09/23
38		**Site Compliance Documents**	**9 days**	**Fri 06/10/23**
39		Loop check sheets	5 days	Fri 06/10/23
40		Atex Compliance Forms	4 days	Fri 13/10/23
41		Go Live	2 days	Thu 12/10/23
42		Remove Temporary Gas Detection	2 days	Mon 16/10/23



Appendix Figure 6 - Revised Gantt Chart showing Simulation within the main project

Revised Gantt Chart showing expanded simulation timeline

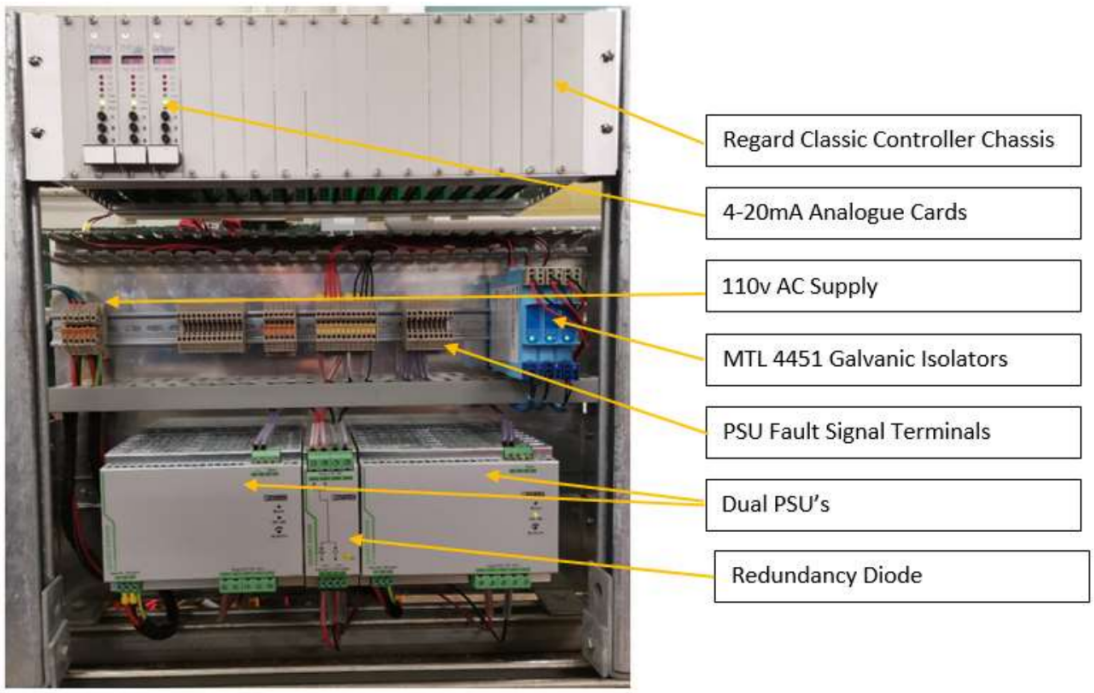
ID	Task Mode	Task Name	Duration	Start
15		DCS Graphic Testing	2 days	Mon 12/12/22
16		Budget Delay Lag	61 days	Wed 14/12/22
17		**Project1 24042023**	**31 days**	**Thu 09/03/23**
1		**System Simulation**	**31 days**	**Thu 09/03/23**
2		**Re-Evaluate Project**	**7 days**	**Thu 09/03/23**
3		Ammend FDS	1 day	Thu 09/03/23
4		Ammend Gantt Chart	1 day	Fri 10/03/23
5		Create New Test Table	2 days	Mon 13/03/23
6		Design Simulation system	2 days	Wed 15/03/23
7		Create Wiring Diagrams	1 day	Fri 17/03/23
8		**Source Materials**	**5 days**	**Mon 20/03/23**
9		Source Power supplies	1 day	Mon 20/03/23
10		Source Field Detector Controller	1 day	Tue 21/03/23
11		Source Field Detectors	1 day	Wed 22/03/23
12		Source MTL5541 Barriers	1 day	Thu 23/03/23
13		Source PLC and HMI	1 day	Fri 24/03/23
14		**Build Simulation System**	**7 days**	**Mon 27/03/23**
15		Build Support Frames	2 days	Mon 27/03/23
16		Mount Controller	1 day	Wed 29/03/23
17		Controller Wiring	1 day	Thu 30/03/23
18		Barrier Wiring	1 day	Fri 31/03/23
19		Field Detector Wiring	1 day	Mon 03/04/23
20		PLC Wiring	1 day	Tue 04/04/23
21		**Commission & Test Simulation System**	**12 days**	**Wed 05/04/23**
22		Carry out Pre-energise Checks	1 day	Wed 05/04/23
23		Energise System	1 day	Thu 06/04/23
24		Set up Draeger Controller	1 day	Fri 07/04/23
25		Calibrate Gas Detectors	1 day	Mon 10/04/23
26		Function Test Analogue Loops	1 day	Tue 11/04/23
27		Load PLC Program	1 day	Wed 12/04/23
28		Function Test PLC	1 day	Thu 13/04/23
29		**Simulation System Testing**	**5 days**	**Fri 14/04/23**
30		Carry Out Testing as stated in testing table	4 days	Fri 14/04/23
31		Contingency Allocation	2 days	Wed 19/04/23
18		**Implementation**	**67 days**	**Wed 07/06/23**
19		Attend FAT and complete FAT Test	5 days	Wed 07/06/23
20		Groundwork	7 days	Wed 14/06/23
21		Pull Cable	3 days	Fri 23/06/23
22		**Mechanical Installation**	**28 days**	**Mon 26/06/23**



Appendix Figure 7 - Revised Gantt Chart showing expanded simulation timeline

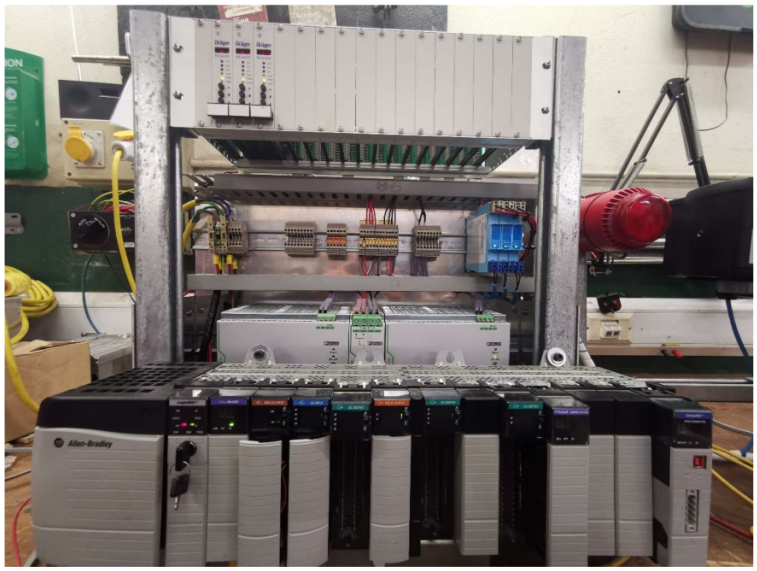
9.4 Simulation hardware Construction

Initial Build



Appendix Figure 8 - Simulation System Initial Build

Final Build



Appendix Figure 9 - Simulation System Final Build

00–1 P.WD Enter password

1. Select 00–1 and press Reset.
2. The display will show "????".
3. Press ⇧ or ⇩ to select the first letter of the password.
4. Press Reset to enter the first letter. The second letter will then flash.
5. Use ⇧ and ⇩ to select the second letter and press Reset again.
6. Enter the third and fourth letters in the same way.
7. When the Reset button is pressed after the fourth letter has been set, the display will show MNT if the maintenance password was entered, CFG if the configuration password was entered, or BAD if an invalid password was entered.
8. The display returns to 00–1.

If an invalid password is entered, the card will remain at read level. Press Reset again to enter another password.

00–2 SAVE Save configuration settings

Writes the configuration settings to EEPROM.

1. Select 00–2 and press Reset.
2. The display will show SAVE and then show NO.
3. Use ⇧ or ⇩ to change the display to YES and press Reset.
4. The display will show WAIT while the settings are saved, then OK, confirming that the settings have been saved.

If there are no new configuration settings to save, the display will show NO! at step 2. Pressing ⇧ or ⇩ will have no effect. Press Reset to return to 00–2.

04–0 GAS Set gas name

1. Select 04–0 and press Reset.
2. The display will show the current gas name.
3. Press ⇧ or ⇩ to select a new gas.
4. Press Reset.

04–1 UNIT Set measurement unit

1. Select 04–1 and press Reset.
2. The display will show the current measurement unit.
3. Press ⇧ or ⇩ to select a new unit.
4. Press Reset.

04–2 FSD Set range

1. Select 04–2 and press Reset.
2. The display will show the current range.
3. Press ⇧ or ⇩ to select a new range.
4. Press Reset.
5. The display will show NEW to indicate that a new range has been selected.

04–4 A1 R Set A1 relay normally energised or energised on alarm

1. Select 04–4 and press Reset.
2. The display will show ENER for energised on alarm or NORM for normally energised.
3. Press ⇧ or ⇩ to change the setting.
4. Press Reset.

04–5 A2 R Set A2 relay normally energised or energised on alarm

1. Select 04–5 and press Reset.
2. The display will show ENER for energised on alarm or NORM for normally energised.
3. Press ⇧ or ⇩ to change the setting.
4. Press Reset.

04–9 AOUT Set analogue output range

1. Select 04–9 and press Reset.
2. The display will show 4–20 or 0–20.
3. Press ⇧ or ⇩ to change the setting.
4. Press Reset.

If the analogue output is set to a voltage output, the 0–20 setting will give a 0–5V output, and the 4–20 setting a 1–5V output.

WARNING: When the output is set to 0-20 it is not possible to distinguish between zero gas and a loop fault. Use the 4-20 setting if possible.

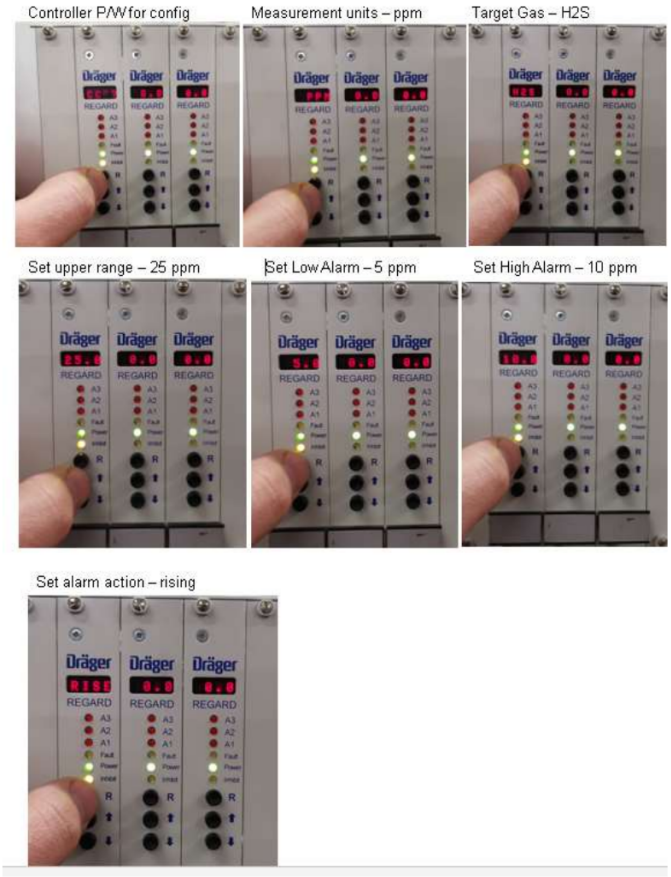
10–0 ZERO Set zero (4–20 cards)

1. Select 10–0 and press Reset.
2. The display will show the current gas reading.
3. Press ⇧ or ⇩ until the display shows 0.
4. Press Reset.

Note: The zero point can only be adjusted by ±1mA. If you are unable to zero the display then the transmitter may need re-calibrating.

Appendix Figure 10 - Draeger 4-20mA Controller Card Configuration Guide

Draeger 4-20ma Control card configuration



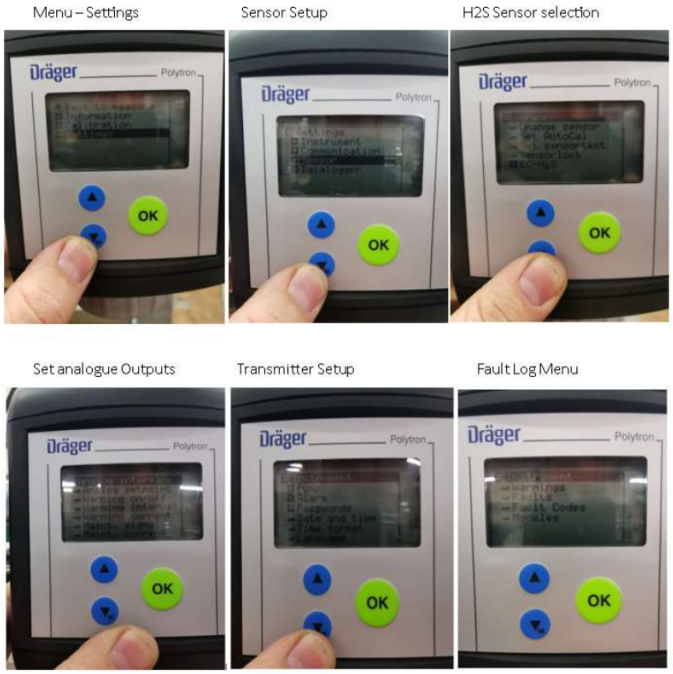
Appendix Figure 11 - Draeger 4-20ma Control Card configuration

Polytron 7000 Detectors & Mounting Frame



Appendix Figure 12 - Polytron 7000 Detectors & Mounting Frame

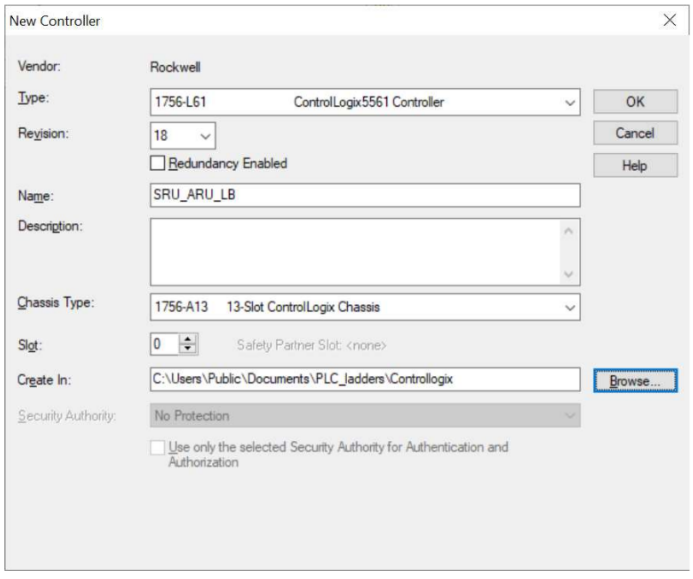
Polytron 7000 H2S Detector Configuration



Appendix Figure 13 - Polytron 7000 H2S Detector Configuration

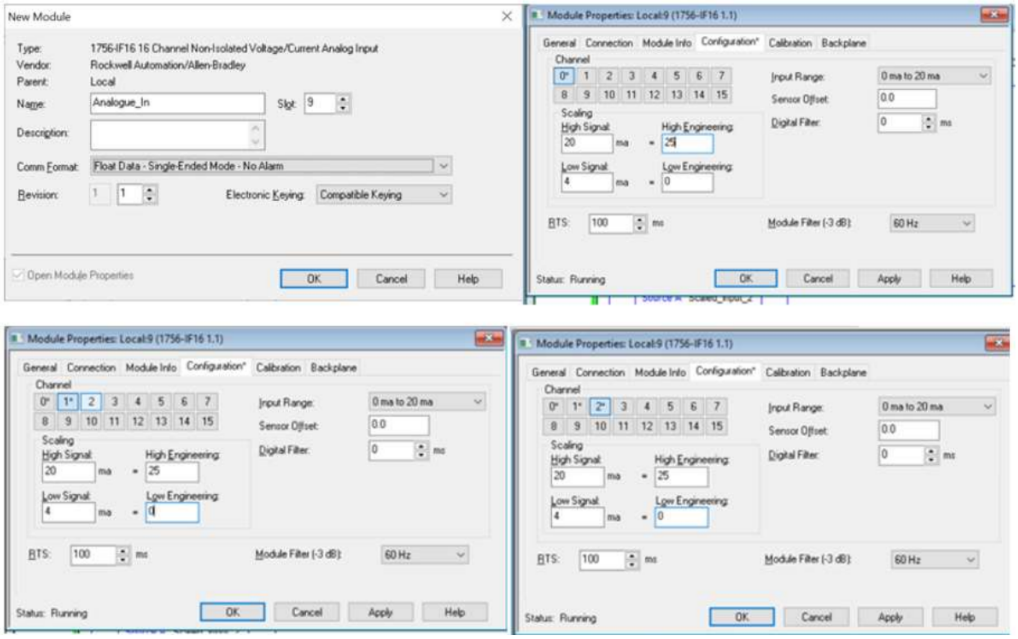
9.5 Simulation Logic

New PLC Project Created



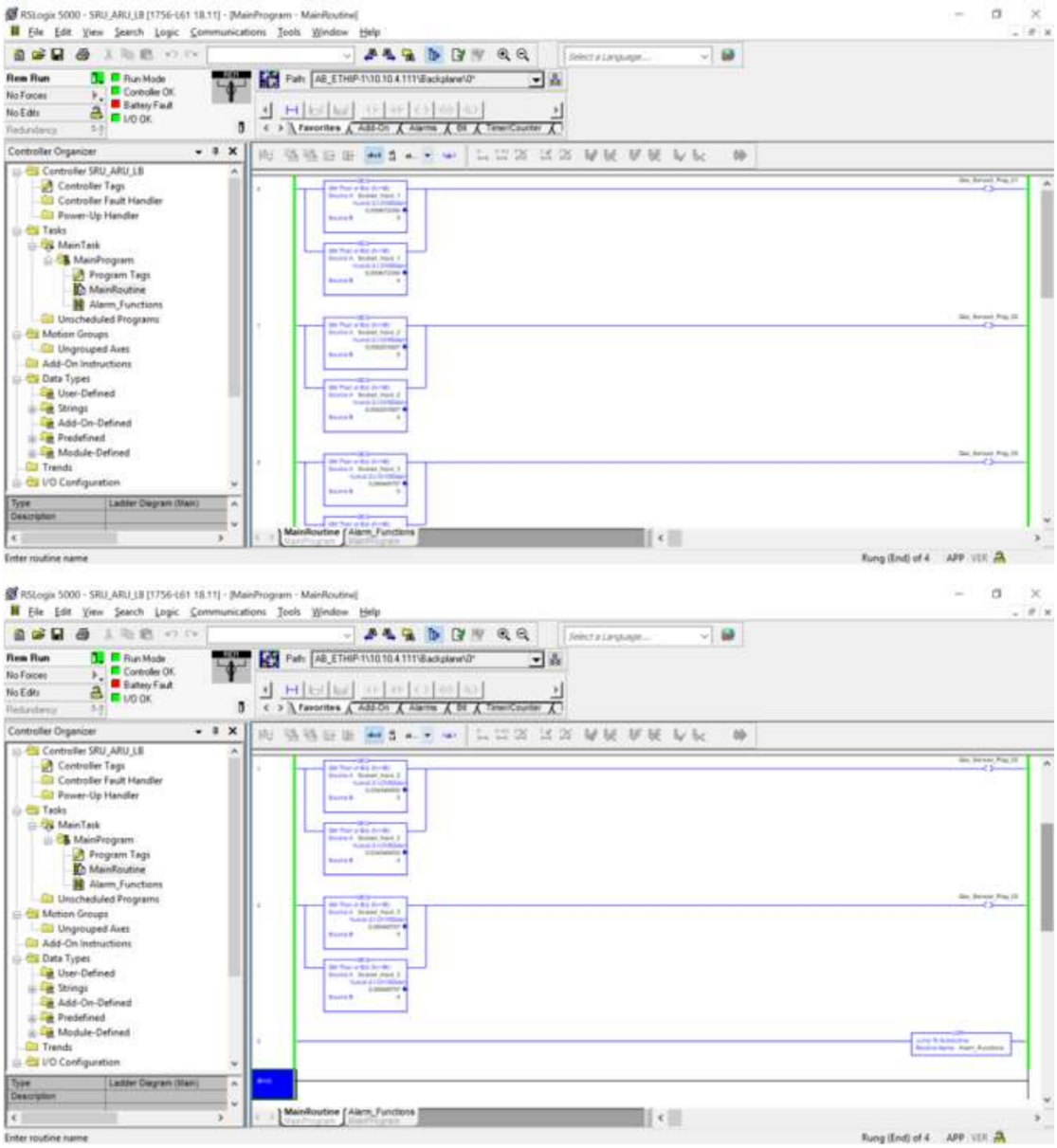
Appendix Figure 14 - PLC Project Created

AI cards Configuration



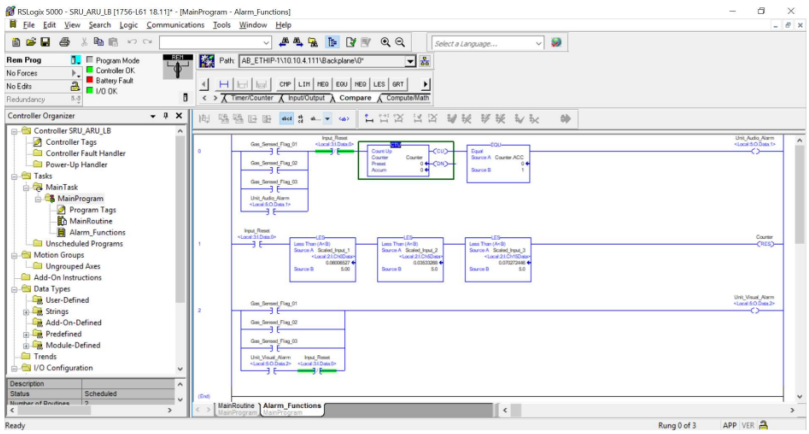
Appendix Figure 15 - AI cards Configuration

Main Logic Routine



Appendix Figure 16 - Main Logic Routine

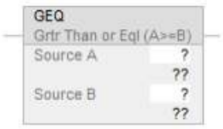
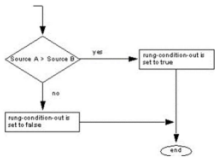
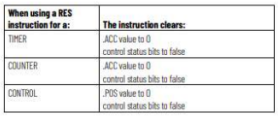
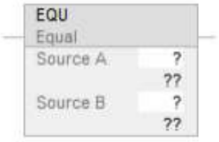
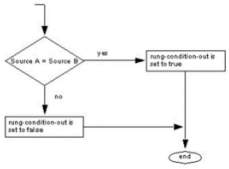
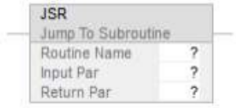
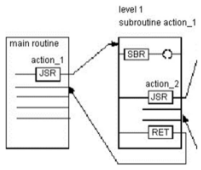
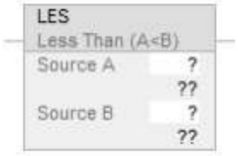
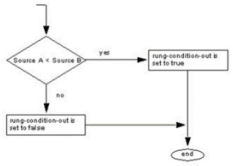
Alarm Logic Routine



Appendix Figure 17 - Alarm Logic Routine

Ladder Logic Function Block Summary Table

There is no good reason to include this information

Ladder Logic Function Blocks			
Function Block	**Description**	**Flow Chart**	**Purpose**
	To test whether source A is greater than source B using the ≥ operator		Tests whether the three 0-20mA analogue inputs scaled to 0 - 25 are greater than 5 to energise the audio and visual unit alarm outputs
	The instruction counts up each time the condition switches to true	See appendix ***	Counts up to 1 in the event either "Gas_Sensed_flag" is true.
	The instruction resets the CTU counter		Resets the CTU counter and is preceded by three LES functions
	The instruction tests whether source A is equal to source B using the = operator		The EQU function tests whether the CTU output is equal to 1 and energises the "Unit_Audio_alarm" if source A is equal to 1
	The instruction invokes a subroutine		The JSR function is used to jump to the alarm functions routine, thereby enabling the alarm logic
	The instruction tests whether source A is less than source B using the < operator		LES functions are to ensure the CTU is only reset once the measured value falls below 5

Appendix Table 4 - Ladder Logic Function Block Summary Table

9.6 Testing and Results

Simulation FDS Test table

FDS Item	Description	Expected Outcome	Actual Outcome	Pass / Fail	Evidence / Reference
4.2.2	Maintenance Overrides / Inhibits	Individual control cards can be inhibited for maintenance	Correct	Pass	Appendix Figure 18
4.2.3 c	Loss of Power Recovery	24v Power supplies have N+1 redundancy configuration	Correct	Pass	Appendix Figure 19
4.4.2	System Response Time	DCS alert generated within 30seconds of a gas release	Unable to Test	n/a	n/a
4.5.1 b	Operator Interface	DCS graphic indicates exact location and concentration of gas release	Unable to Test	n/a	n/a
4.5.1 c	Operator Interface	DCS graphic indicates which detector alarmed first	Unable to Test	n/a	n/a
4.5.1 d	Operator Interface	System Fault, Gas detector fault and both power supplies failures initiate an alarm on DCS	Unable to Test	n/a	n/a
4.5.1 e	Operator Interface	System fault (0mA) and detector fault (3.6mA) loops are hardwired to DCS	Unable to Test	n/a	n/a
4.5.2 a	Alarm Levels - H2S	Alarm levels set to 5ppm - low and 10ppm - high for H2S	Correct	Pass	Appendix Figure 21
4.6.1 c	Electrical Requirements	Voltage and frequency requirements are met within tolerance - 110v (5%) @ 60 Hz (2%)	117.2v	Fail	Appendix Figure 22
4.6.1 d	Electrical Requirements	Power supplies seamlessly switch to standby supply in the event of a failure	Correct	Pass	Appendix Figure 23
4.7.1 a	Trip and Reset Philosophy	The gas detected alarm output is latching	Correct	Pass	Appendix Figure 25
4.7. b	Trip and Reset Philosophy	Audible alarms are silenced by the AKN switch with visual alarms still energised	Correct	Pass	Appendix Figure 26
4.7. c	Trip and Reset Philosophy	Full reset is only allowed once all detectors are below 5 ppm	Correct	Pass	Appendix Figure 27
4.7. d	Trip and Reset Philosophy	Alarm outputs energise to trip (ETT) for audio/visual alarms	Correct	Pass	Appendix Figure 28

Appendix Table 5 – Simulation FDS Test table

Simulation PLC Logic Test Table			
Test Description	Expected Outcome	Pass / Fail	Evidence / Reference
Analogue Scaling blocks correctly scale the 4-20mA signal to 0-25ppm	4-20mA signal is scaled to 0-25ppm	Pass	Appendix Figure 29
Gas sensed outputs energise when scaled value is >5ppm	Gas sensed outputs energise above 5ppm	Pass	Appendix Figure 30
Gas sensed Inputs energise when 5ppm gas is sensed	Gas sensed inputs energise when gas sensed value is above 5ppm	Pass	Appendix Figure 31
Unit audio alarm activates at 5ppm	Unit audio alarm activates at 5ppm	Pass	Appendix Figure 32
Unit visual alarm activates at 5ppm	Unit visual alarm activates at 5ppm	Pass	Appendix Figure 32
Reset input contact deactivates the unit audio alarm	Unit audio alarm deactivates upon reset input contact energising	Pass	Appendix Figure 33
The unit visual alarm remains active once unit audio alarm is deactivated	The unit visual alarm remains active once unit audio alarm is deactivated	Pass	Appendix Figure 34
The unit visual alarm remains active whilst gas sensed is above 5ppm and the reset input is energised	The unit visual alarm remains active whilst gas sensed is above 5ppm and the reset input is energised	Pass	Appendix Figure 34
Alarm condition reset once gas sensed value is below 5ppm	Alarm condition reset once gas sensed value is below 5ppm	Pass	Appendix Figure 35

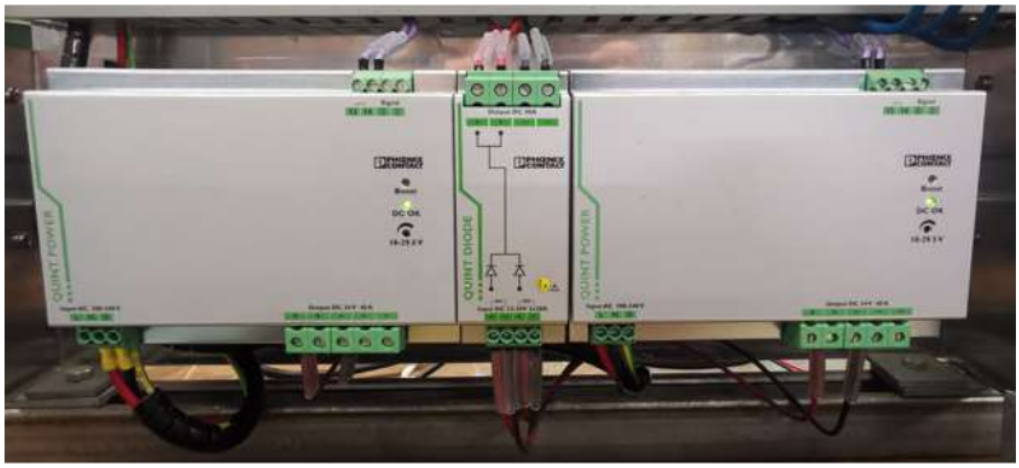
Appendix Table 6 - Simulation PLC Logic Test Table

Individual control cards can be inhibited for maintenance



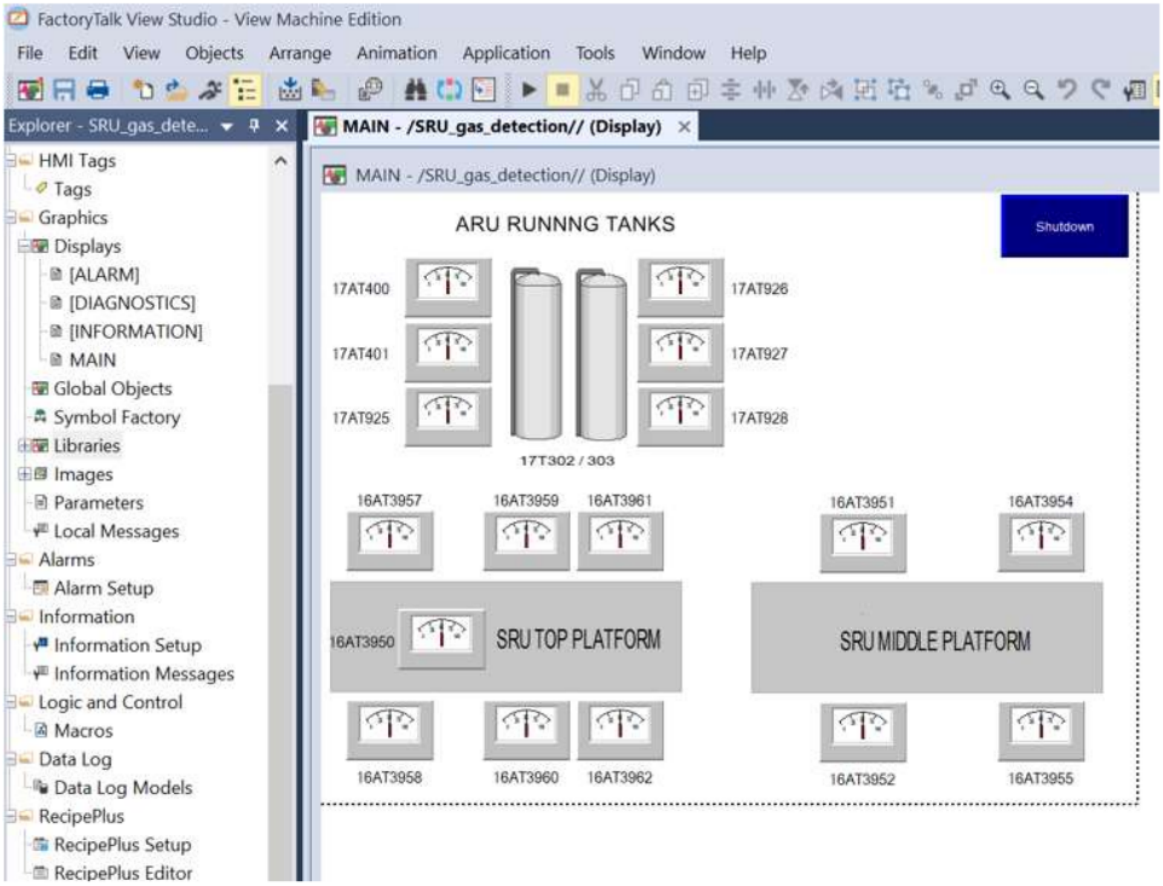
Appendix Figure 18 - Control Card Inhibited

24v Power supplies have N+1 redundancy configuration



Appendix Figure 19 - Dual Redundancy PSU's

DCS (HMI) graphic indicates exact location and concentration of gas release



Appendix Figure 20 - DCS (HMI) Graphic Construction

Alarm levels set to 5ppm - low and 10ppm - high for H2S

Regard 4-20mA controller alarm setpoints 5.0ppm (low) and 10.0ppm (high)



Appendix Figure 21 - Regard 4-20mA Controller Alarm Setpoints

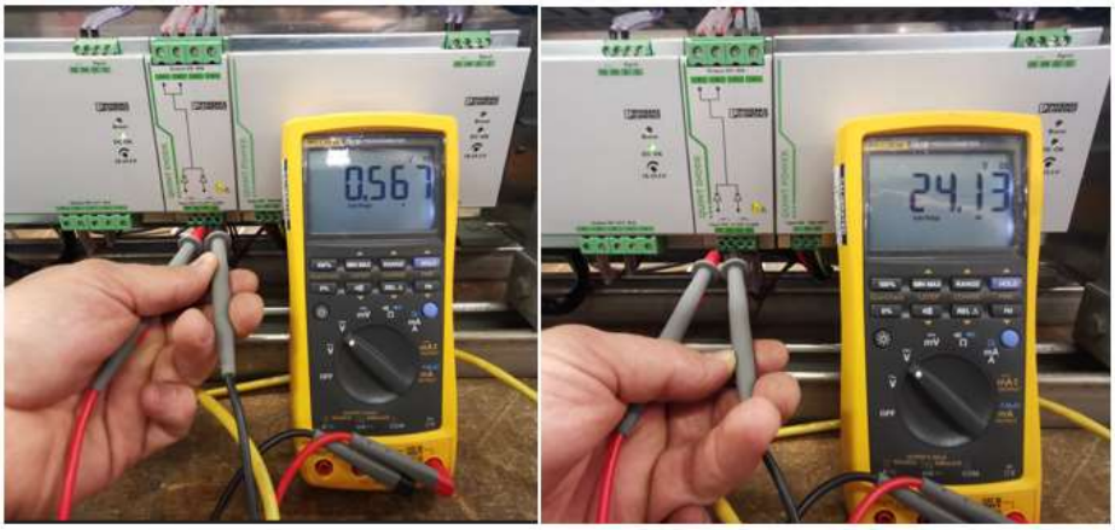
Supply Voltage and Frequency Tests - 110v (5%) @ 50 Hz (2%)



Appendix Figure 22 - Supply Voltage and Frequency Tests - 110v (5%) @ 50 Hz (2%)

Power supplies seamlessly switch to standby supply in the event of PSU failure and initiates PSU fault alarm

PSU 1 (left) online and PSU 2 (right) offline – Diode supply maintained

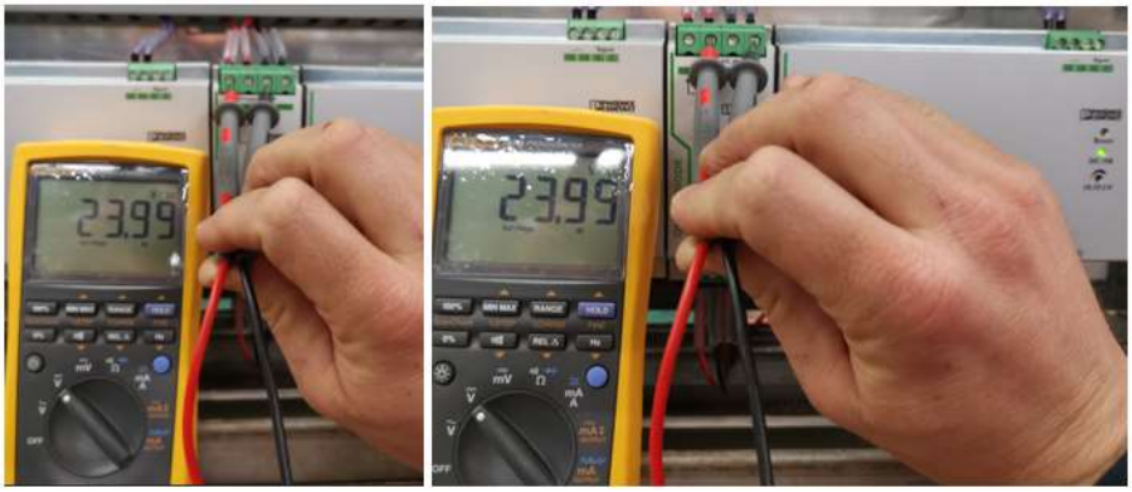


PSU 1 fault contact closed (healthy) and PSU 2 fault contact open circuit (closed)



Appendix Figure 23 - PSU Switchover Test

Redundancy Diode maintaining 24v DC output during a PSU failure event



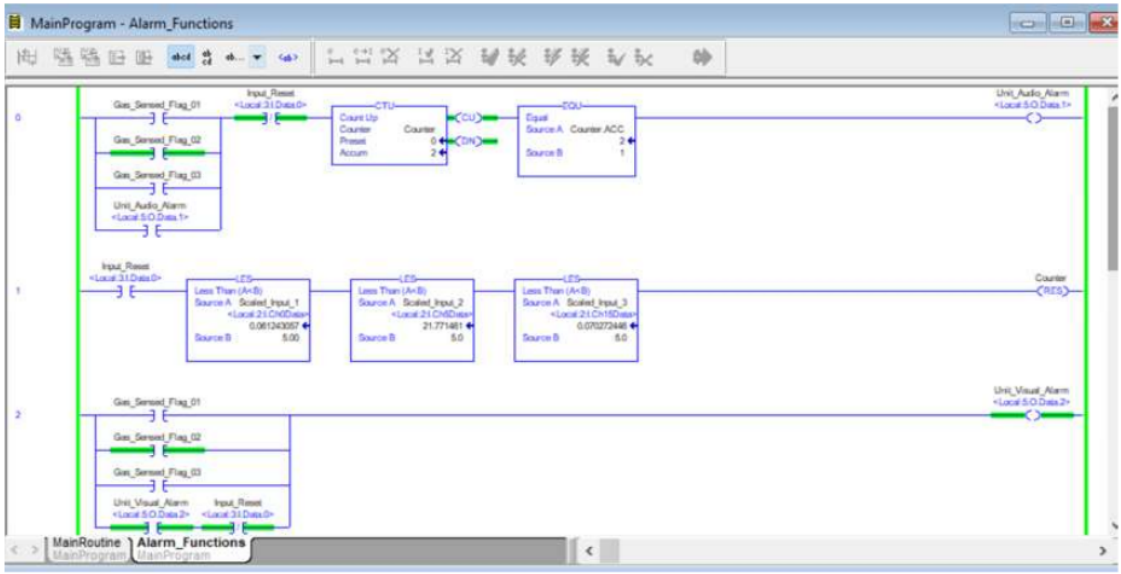
Appendix Figure 24 - Redundancy Diode Output

The gas detected alarm output is latching



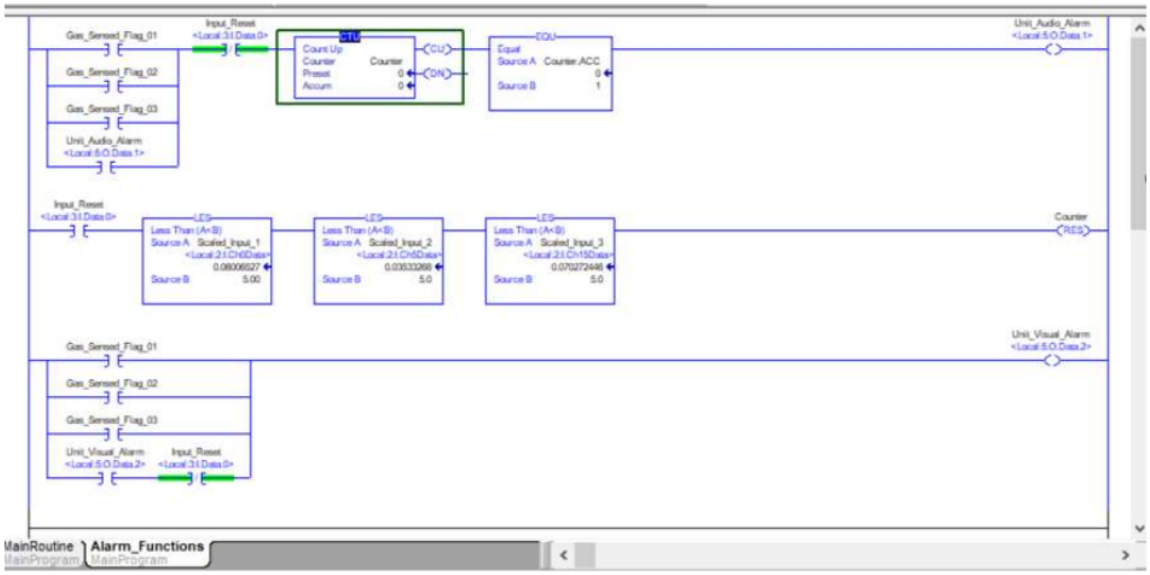
Appendix Figure 25 - Analogue Control Cards Latching Alarms

Audible alarms are silenced by the AKN switch with visual alarms still energised whilst gas is still sensed



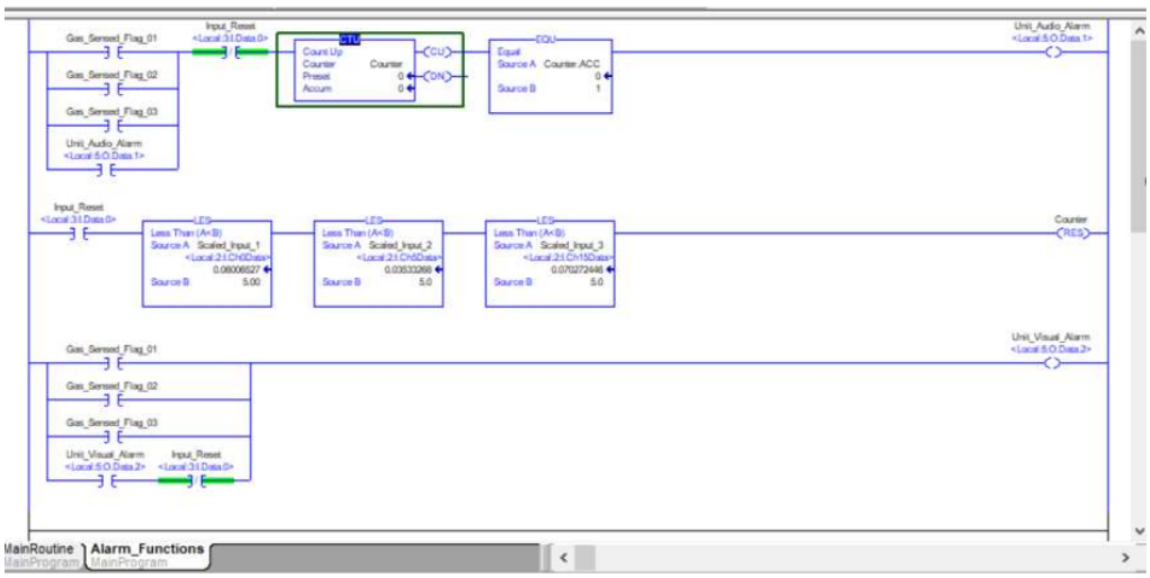
Appendix Figure 26 - PLC Logic - Audio Alarm

Full reset is only allowed once all detectors are below 5 ppm



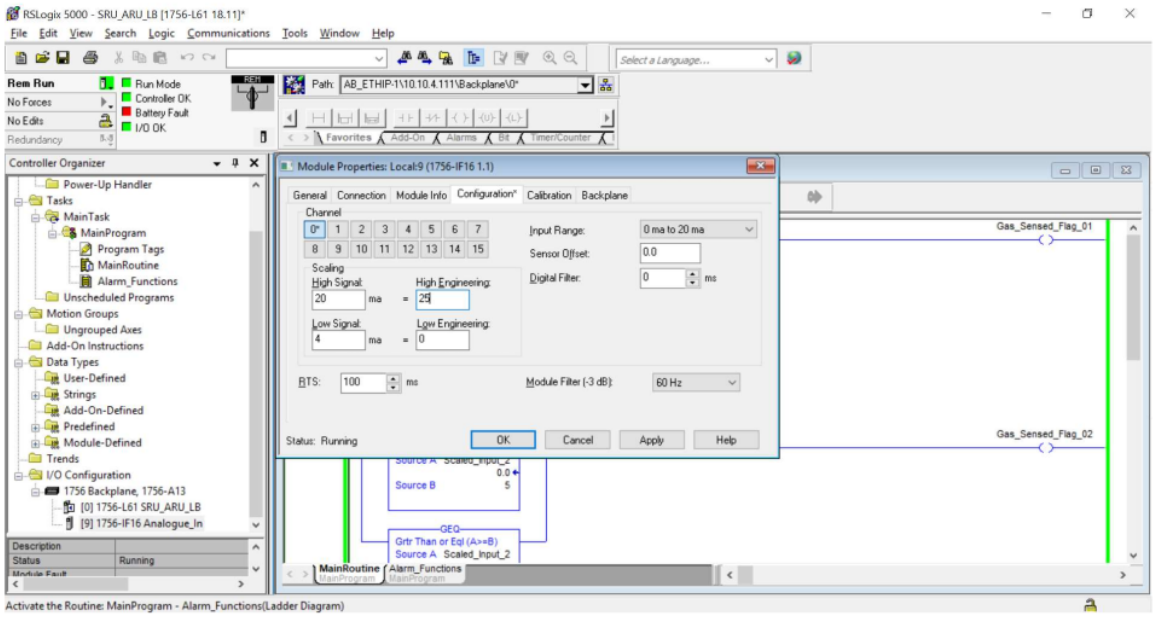
Appendix Figure 27 - PLC Logic - Full Reset

Alarm outputs energise to trip (ETT) for audio/visual alarms



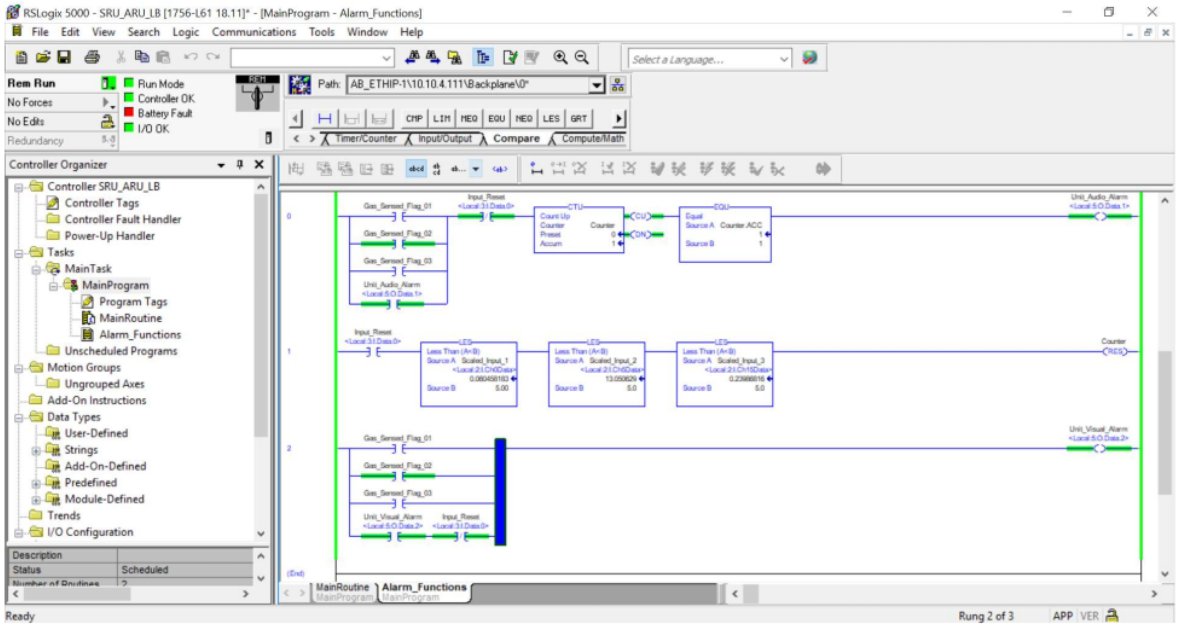
Appendix Figure 28 - PLC Logic - Alarm Outputs ETT

4-20mA signal is scaled to 0-25ppm



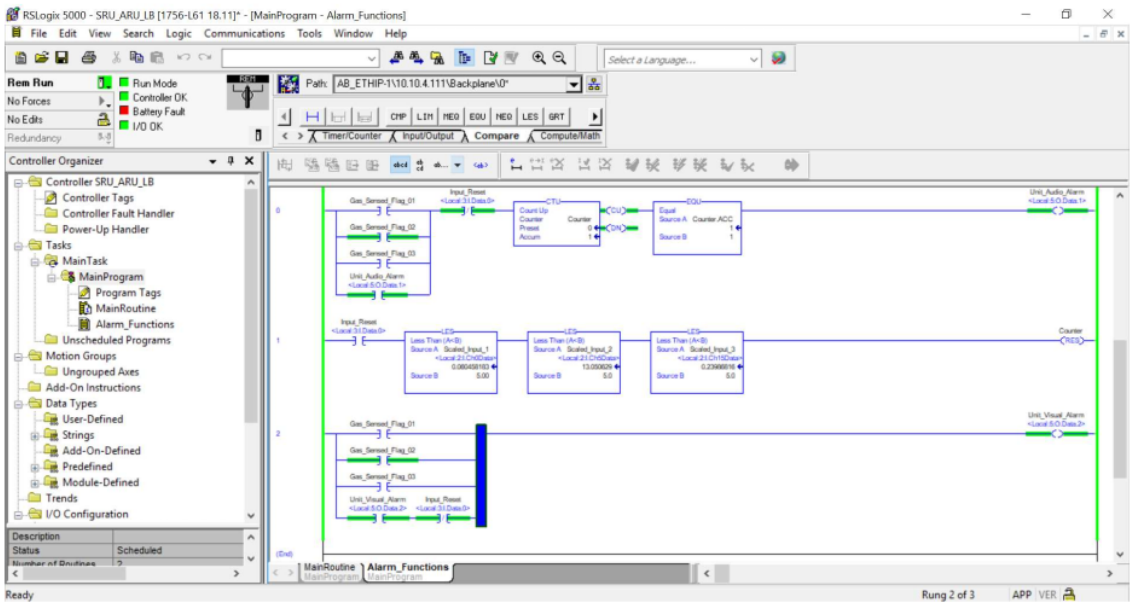
Appendix Figure 29 - PLC Logic - Input Signal Scaling

Gas sensed outputs energise above 5ppm



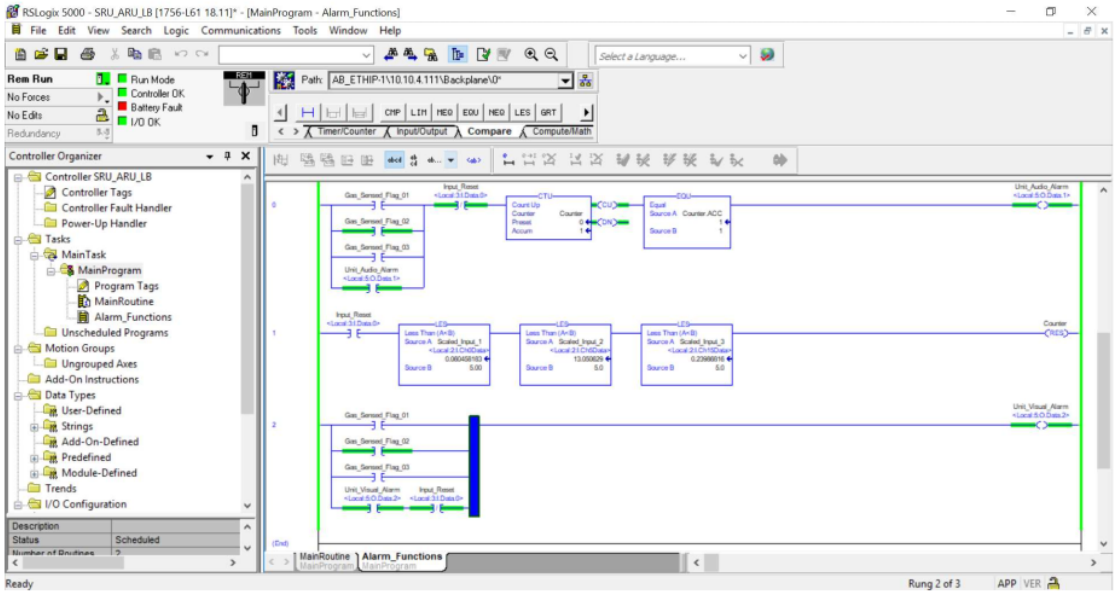
Appendix Figure 30 - PLC Logic – Alarm Output Contacts

Gas sensed inputs energise when gas sensed value is above 5ppm



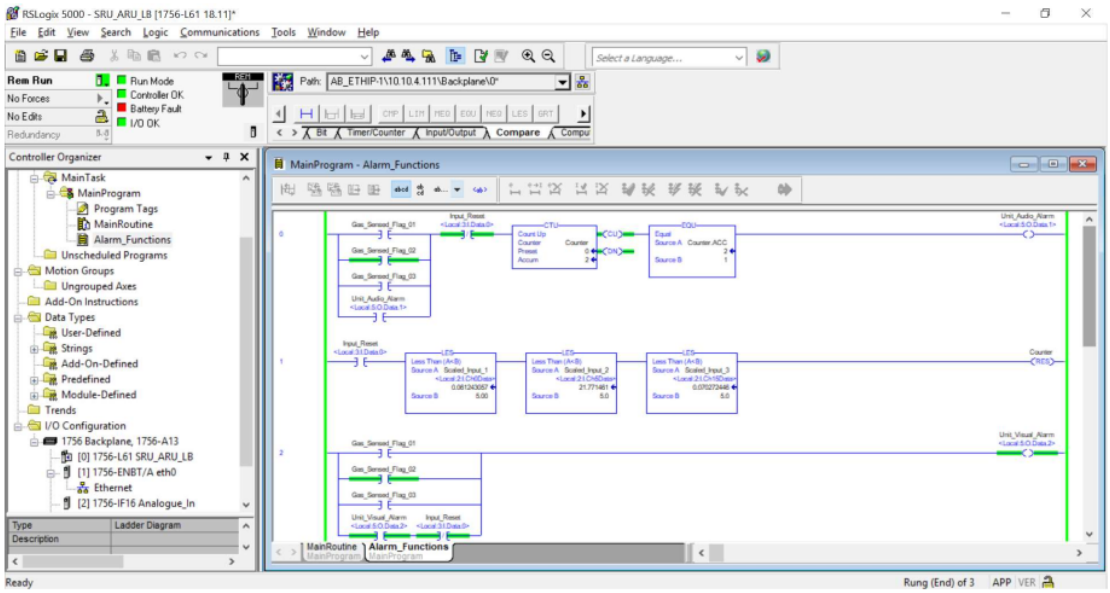
Appendix Figure 31 - PLC Logic - Gas Sensed Input Contacts

Unit audio & visual alarm activates at 5ppm



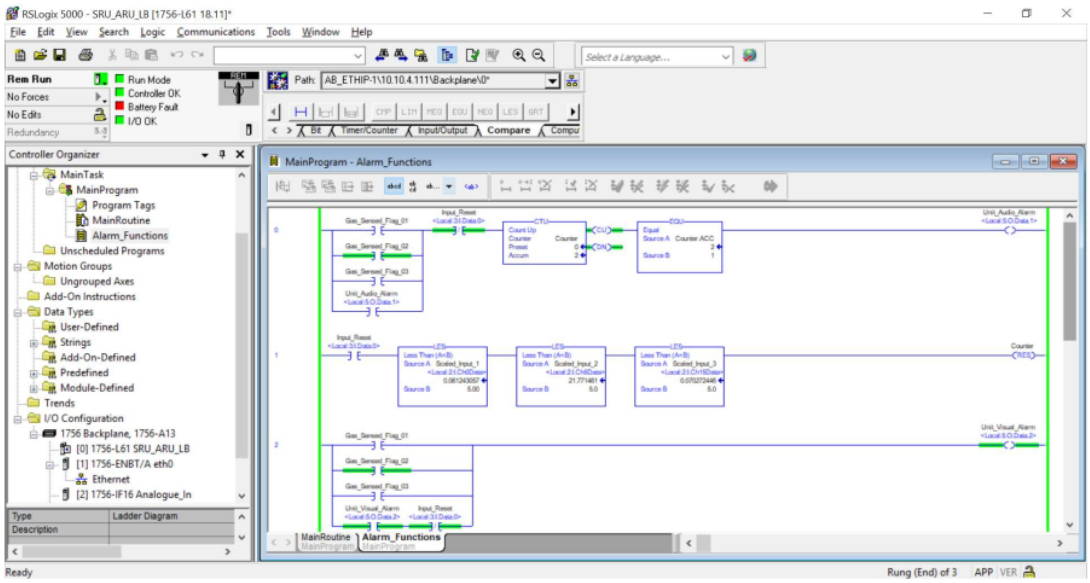
Appendix Figure 32 - PLC Logic - Unit Audio and Visual Alarms Activating

Unit audio alarm deactivates upon reset input contact energising



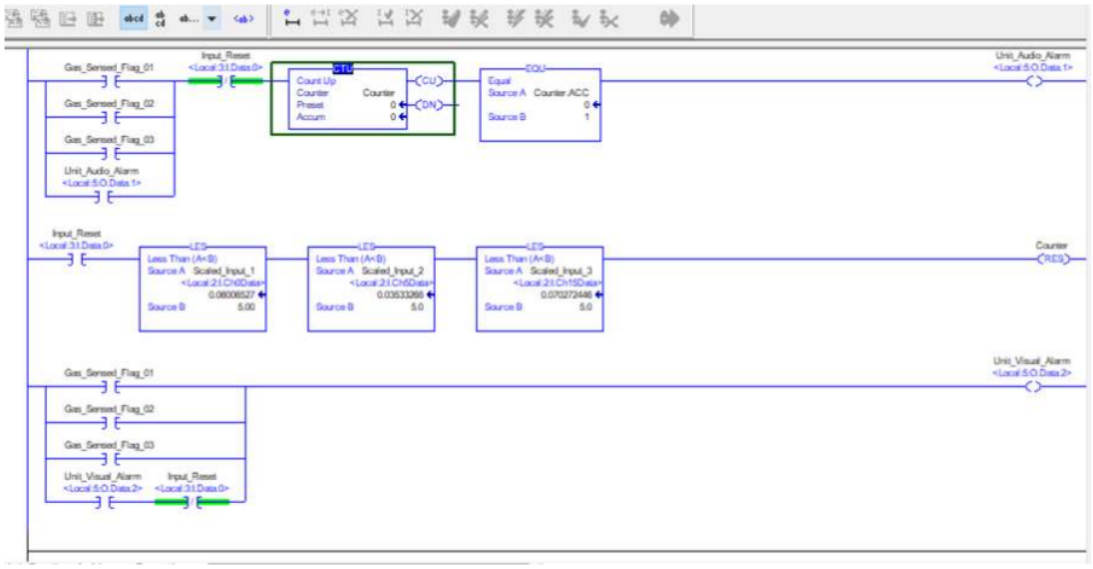
Appendix Figure 33 - PLC Logic - Audio Alarm Reset

The unit visual alarm remains active whilst gas sensed is above 5ppm and the reset input is energised



Appendix Figure 34 - PLC Logic - Reset Philosophy – Audio off / Visual On

Alarm condition reset once gas sensed value is below 5ppm



Appendix Figure 35 - PLC Logic - Reset Philosophy - All Contacts De-Energised

E&I Integrity Job Sheet					
1. Outline Scope of Work			Originator		L. Brits
MWO Number	6908098		Originator Extension		2745
Service Order No.			Originator Contact		
Task Priority	High		Unit		SRU / ARU
Date of Notification					
Task to Commence on			Task Completion Date		
Description of Work	SRA/ARU Gas Detection Labour				
2. Detailed Scope of Work			Contractor Reference		
Provide Detailed Scope of Work	Dig trench 20m @ 1m deep - pull 20 pair cable - close trench - install and wire controller cabinet - install / wire 2 x enclosures - mount / wire detectors				
Labour Plan		**Total Hours**		**Hourly Cost**	**Total Cost**
Excavations for 20 pair cable	Excavator + Driver hire	8		£100.00	£800.00
	Dig trench 20m @ 1m deep	8		£20.00	£160.00
	Close Trench	8		£20.00	£160.00
20 Pair Cable	Pull Cable	32		£17.50	£560.00
Controller Cabinet	Install New Controller Cabinet	0		£17.50	£0.00
	Wire Controller Cabinet	0		£17.50	£0.00
ExD Enclosure	Install ExD enclosure	8		£17.50	£140.00
ExE Enclosure	Install ExE enclosure	8		£17.50	£140.00
	Electrical / wiring works	24		£17.50	£420.00
Gas Detectors	Fabricate Mounts	16		£17.50	£280.00
	Fit Detectors	24		£17.50	£420.00
	Electrical works	16		£17.50	£280.00
	Total Hours	152		**Planned Labour Cost**	£3,360.00
3. Materials					
Item	**Description**	**Qty**		**Cost**	**Total Cost**
20 Pair Cable	Supply Cable to specifiaction	1		£3,249.00	£3,249.00
Consumables	Unistrut - Galvanised 6m	3		£25.00	£75.00
	Zebs - Galvanised 6mm	100		£0.40	£40.00
	Bolts - Galvanised M10 x 25mm	100		£0.35	£35.00
	Washers - Galvanised 6mm	100		£0.04	£4.00
	M20 Inst. Glands	45		£10.00	£450.00
	M40 Inst. Gland	1		£19.50	£19.50
	M20 Potted Gland	10		£15.00	£150.00
Quote approval	**Signature**	**Date**			
Project Owner				**Planned Materials Cost**	£4,022.50
Valero Budget Holder					
Contract Manager			**Total cost - Labour / Materials**		£7,382.50

Appendix Table 7 - Revised Labour Costing

	400	Step Number	OPEX Hours (Designer)	OPEX Hours (Engineer)	Number of Deliverables	Design Changes as detailed below	Engineer Admin / Miscellaneous	Total Hours Designer	Total Hours Engineer	Total Hours per Drg Type
	Surveys	400	4	4	1			4	4	8
	Development & Preparation	410	10	40	1	-10	-20		20	20
	P & I D's, Layout & GA's	420	124			-110		14		14
	Detail Drawings	430	512			-420		92		92
	Schedules	440	1		1			1		1
	Calculations	450		30			-15		15	15
	As Builts	470	Individual WO						60	60
	Procurement	480	44	4		-38		6	4	10
	Miscellaneous	490	SEE BELOW							
	TOTAL s				**3**	**-578**	**-35**	**117**	**103**	**220**

	Miscellaneous (Hrs to be added to yellow cells above +)	Designer	Engineer	Total
1	TQ / As Builds			
2	Design Discussions - meetings			
3				
4				
5				
6				
7				
8				
9				
10				
	Sub total hours for development / Miscellaneous - 490			
	Total hours for job	**117**	**103**	**220**

	Notes/Qualifications
1	Hourly rate £55.45
2	
3	
4	
5	

Rev	Description	Date	By	Checked	Approved
0.3					
0.2					
0.1	PM09-6606946	10.01.23	JD		

Filename :-

Appendix Table 8 - Drawing Office Costs

SGEL6000

Independent Project

Log Book

Lourens Brits

1809797

ARU/SRU Gas Detection Upgrade

2022 - 2023

Summary of Entries

Log Entry	Date	Brief Description of Activity	Duration (hrs)	Accumulated time (hrs)
1	29/09/22	Project objectives discussion	8	8
2	06/10/2022	Project Proposal creation	4	12
3	13/10/2022	Unit walk around – familiarisation	4	16
4	20/10/2022	Research SRU/ARU operation	16	32
5	27/10/2022	Research constraints	10	42
6	03/11/2022	Create FDS	12	54
7	10/11/2022	Create FDS test tables	12	66
8	17/11/2022	Research possible solutions	16	82
9	24/11/2022	Research sensor technology	12	94
10	01/12/2022	Creating costing spreadsheet	10	104
11	08/12/2022	Create solution scoring matrix and radar chart	10	114
12	15/12/2022	Research project management techniques	12	126
13	22/12/2022	Create work breakdown structure	14	140
14	29/12/2022	Create Gantt chart	6	146
15	05/01/2023	Complete risk assessment and conclusions	8	154
16	09/01/2023	Review report and submit	2	156
17	17/01/2023	Create project presentation	8	164
18	27/01/2023	Present presentation and document feedback	6	170
19	24/01/2023	Budget delays – alternative solutions	8	178
20	02/02/2023	Project execution meeting	8	186
21	03/03/2023	Budget re-approval & Order placed	10	196
22	09/03/2023	FDS, Gantt & test table amendment	36	232
23	15/03/2023	System Design	25	257
24	20/03/2023	Parts list and parts Order	40	297
25	27/03/2023	Simulation System Construction	40	337
26	05/04/2023	System power-up and set up	24	361
27	10/04/2023	Calibrations and PLC programming	30	391

28	14/04/2023	System testing	24	415
29	17/04/2023	Write report	80	495
30				

Only log entries for the implementation phase were required

Log Entry Sheet

Log Number	1
Date	29/09/2022
Duration (hrs)	8
Accumulated time (hrs)	8

Record of activities and achievements

A meeting was arranged with the budget holder to discuss the project objectives and issues relating to the current system. The following topics were discussed;

- Project objectives

Replace obsolete gas detectors.

Replace obsolete controller and combine individual subsystems into one controller.

Install Serial link to DCS system to enable a live graphic of detectors in field to be created

Overall cost shall not exceed £145 000

- Obsolete monitor identification

I referred to a preventative maintenance report documenting all the monitors which are maintained at a 3-monthly interval. From this document I identified the 15 detectors manufactured by General Monitors, which need to be replaced and created the table below. The manufacturer will need to know how many units are on the existing system to ensure the replacement controller infrastructure can accommodate the total amount of detectors required.

General Monitor		Dreager	
SRU	ARU	SRU	ARU
16-AN-580	17-AN-400	16-AT-3950	17-AT-3063
16-AN-581	17-AN-401	16-AT-3951	17-AT-3064
16-AN-582	17-AN-925	16-AT-3952	17-AT-3065
16-AN-583	17-AN-926	16-AT-3953	17-AT-3066
16-AN-584	17-AN-927	16-AT-3954	17-AT-3067
16-AN-585	17-AN-928	16-AT-3955	17-AT-3068
16-AN-586	17-AN-929	16-AT-3956	17-AT-3069
16-AN-587		16-AT-3957	17-AT-3070
		16-AT-3958	17-AT-3071
		16-AT-3959	17-AT-3072
		16-AT-3960	17-AT-3073
		16-AT-3961	17-AT-3074
		16-AT-3962	17-AT-3075

The possibility of incorporating 20% extra capacity in the new controller has to be discussed with the manufacturer, to enable future expansion if the need arises.

Plans for next week
• Create project proposal and ensure it is signed by budget holder

Signed _____L. Brits_____ Signed _____

Log Entry Sheet

Log Number	2
Date	06/10/2022
Duration (hrs)	4
Accumulated time (hrs)	12

Record of activities and achievements
The project proposal has been created, reviewed and approved by the budget holder and handed in to Rob for review. Amendments were made and returned for sign-off. This will be held in assignment 1 appendix.

Plans for next week
• Process unit familiarisation. • Field equipment familiarisation • Controller familiarisation

Signed _____L. Brits_____ Signed _____

Log Entry Sheet

Log Number	3
Date	13/10/22
Duration (hrs)	4
Accumulated time (hrs)	16

Record of activities and achievements
The unit field gas detection was scoped to ensure published location, material and equipment data is accurate in relation to field installations. No irregularities were noted. Notes were made on system integration as well as locations and the condition of junction boxes illustrated in the existing loops.

Plans for next week
Carry out research into SRU/ARU operation: • How is H2S produced by refining oil? • Effects on humans? • Effect on site infrastructure?

Signed _____L. Brits_____ Signed _____

Log Entry Sheet

Log Number	4
Date	20/10/2022
Duration (hrs)	16
Accumulated time (hrs)	32

Record of activities and achievements
Thorough research was carried out into the process that take place to remove sulphur from refining process streams, how it is transported to the ARU and recovered / processed in the SRU. This is a complex process and required research utilising various credible sources. H2S was found to not only be extremely toxic to humans but also adversely affect infrastructure

Plans for next week
Carry out research into project / engineering constraints

Signed _____L. Brits_____ Signed _____

Log Entry Sheet

Log Number	5
Date	27/10/2022
Duration (hrs)	10
Accumulated time (hrs)	42

Record of activities and achievements
Research was carried out into the constraints that has to be considered for the project which included ethical, legal and sustainability.

Plans for next week
Create FDS

Signed _____L. Brits_____ Signed _____

Log Entry Sheet

Log Number	6
Date	03/11/2022
Duration (hrs)	12
Accumulated time (hrs)	54

Record of activities and achievements
Functional design specifications were identified. These specifications will be used to measure whether the project was success full through the use of test tables that directly relate to the FDS. Careful consideration was given to each individual function that the system has to deliver. The FDS was reviewed by the process unit lead, process safety engineer, site electrical engineer and process control specialist, whom were all in agreement that the FDS is suitable and attainable.

Plans for next week
Create test tables for FDS. The test tables must be separated into factory acceptance testing, site acceptance testing and compliance assurance tables.

Signed _____L. Brits_____ Signed _____

Log Entry Sheet

Log Number	7
Date	10/11/2022
Duration (hrs)	12
Accumulated time (hrs)	66

Record of activities and achievements
The FDS items were utilised to create accurate test tables, which will be completed during the FAT, SAT and site commissioning phase.

Plans for next week
Review relevant literature in relation to manufacturers and the solutions that can be implemented to achieve the design specifications. Create a system overview of to gain a better understanding of variables to aid in decision making

Signed _____L. Brits_____ Signed _____

Log Entry Sheet

Log Number	8
Date	17/11/2022
Duration (hrs)	16
Accumulated time (hrs)	82

Record of activities and achievements

Research was carried out into various H2S gas detection manufacturers in the market. The company's approved manufacturer list was reviewed to ascertain which manufacturers are suitable. From the AML three viable manufactures were selected;

- Draeger
- Honeywell
- GazDetect
- Groveley
- General Monitors
- Crowcon

Draeger, Honeywell, GM, Crowcon and Groveley are currently utilised by the company for hydrocarbon (fixed and LOS), H2S, Oxygen and sonic leak detection.

GazDetect was found to have no significant installations on this particular refinery, apart from two locations which have very hot ambient temperatures.

Plans for next week

Carry out further research into H2S sensing technologies – elaborate on efficiency, cost and suitability for this application

Signed _____L. Brits_____ Signed _____

Log Entry Sheet

Log Number	9
Date	24/11/2022
Duration (hrs)	12
Accumulated time (hrs)	94

Record of activities and achievements

Research was carried out into the sensing technologies utilised to detect H2S gas. The three technologies were;

- Electrochemical
- Semiconductor
- Tuneable Laser Diode – Line of sight detection

The operating principles were elaborated upon as well as the advantages and limitations.

Electrochemical cells were found to be the most suitable technology.

Consideration was given to the companies that supply the various sensing technologies which found Draeger, Groveley and GazDetect the most suitable manufacturers.

Plans for next week

Create a costing spreadsheet to aid in solution selection.

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Log Entry Sheet

Log Number	10
Date	01/12/2022
Duration (hrs)	10
Accumulated time (hrs)	104

Record of activities and achievements
A costing spreadsheet was created for each manufacturer. This included all components required for sensing H2S and the controller utilised for data acquisition, alarm activation / reset and reporting to DCS. Draeger – Electrochemical : £105 000 GazDetect – Semiconductor: £ 112 000 Groveley – Line of sight : £ 100 000

Plans for next week
Created a scoring matrix that includes manufacturer data, sensor technology and cost as well as other significant parameters found during research.

Signed _____L. Brits_____ Signed _____

Log Entry Sheet

Log Number	11
Date	08/12/2022
Duration (hrs)	10
Accumulated time (hrs)	114

Record of activities and achievements

A scoring matrix was created utilising the following parameters;

- Overall material costs
- Complexity
- Energy Consumption
- Availability
- Technical support
- Maintenance
- Sustainability

The resulting scores were illustrated using a radar graph.

Draeger was found to be the most suitable manufacturer following a thorough evaluation of the resulting scores.

Plans for next week

Carry out research into project management techniques.

Liaise with site E&I contract service provider for an estimated labour cost for the installation phase of the project.

Signed _____L. Brits_____ Signed _____

Log Entry Sheet

Log Number	12
Date	15/12/2022
Duration (hrs)	12
Accumulated time (hrs)	126

Record of activities and achievements

Various project management techniques were evaluated with particular emphasis on work breakdown structures, Gantt charts, QA/QC management and continuous improvement techniques.

An estimated labour cost of £10287.50 for the project was calculated through consultation with the company's E&I contract service provider manager.

The overall cost of the materials and labour was calculated to be £11143.03, which is within the budget and leaves scope for absorbing additional unexpected costs.

Plans for next week

Create a work break down structure

Carry out research into the companies Risk assessment standards

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Log Entry Sheet

Log Number	13
Date	22/12/2022
Duration (hrs)	14
Accumulated time (hrs)	140

Record of activities and achievements

A WBS was created but breaking the project down into four quantifiable phases;

- Planning
- Design
- Implementation
- Commissioning

These phases were further reduced to create milestones within the phase.

A meeting was held with the company's process safety engineer to review risk assessment criteria and processes including management of change processes. Intellectual property rights and GDPR restrictions were also discussed.

Plans for next week

Create a detailed Gantt Chart.

Signed _____L. Brits_____ Signed _____

Log Entry Sheet

Log Number	14
Date	29/12/2022
Duration (hrs)	6
Accumulated time (hrs)	146

Record of activities and achievements
A detailed Gantt chart was created, where each phase was allocated a time frame. This will aid in project management and continual improvement.

Plans for next week
Conduct a Risk assessment relating to the changes that will be implemented during the project.

Signed _____L. Brits_____ Signed _____

Log Entry Sheet

Log Number	15
Date	05/01/2023
Duration (hrs)	8
Accumulated time (hrs)	154

Record of activities and achievements
A risk assessment for the implementation phase was conducted. Report conclusions and recommendations were written.

Plans for next week
Review report and submit.

Signed _____L. Brits_____ Signed _____

Log Entry Sheet

Log Number	16
Date	09/01/2023
Duration (hrs)	2
Accumulated time (hrs)	156

Record of activities and achievements
The report was reviewed and submitted

Plans for next week
Create project presentation

Signed _____L. Brits_____ Signed _____

Log Entry Sheet

Log Number	17
Date	17/01/2023
Duration (hrs)	8
Accumulated time (hrs)	164

Record of activities and achievements
Create and present project presentation.

Plans for next week
• Submit presentation on 27/01/2023 • Initiate contractor on-boarding – discuss scope of work, time frame and objectives. • Check Draeger order progression

Signed _____ Signed _____

Log Entry Sheet

Log Number	18
Date	27/01/2023
Duration (hrs)	6
Accumulated time (hrs)	170

Record of activities and achievements

Presentation completed and presented -feedback:

- Include Gantt Chart
- More detail on solutions and costings
- Include radar
- Include FDS & highlight most important topics
- Be more precise – too vague….

Make changes and keep for next presentation

Plans for next week

- Initiate contractor on-boarding – discuss scope of work, time frame and objectives.
- Check Draeger order progression

Signed _____ Signed _____

Log Entry Sheet

Log Number	19
Date	24/01/2023
Duration (hrs)	8
Accumulated time (hrs)	178

Record of activities and achievements
Drawing office meeting conducted to review progress on loop diagrams, cable runs and datasheets *Further delay in procurement* Corporate policy change on capex expenditure – Current order on hold pending further justification of project, including Refinery, Operations and maintenance manager presentation on solution, costings and benefits. Conclusion reached that £50k should be spent on this project – if any more funds are needed, other project funds should be utilised. Potential solution two replacement gas chromatographs can be rescheduled to 2024 to release funds for this project. Civils and Electrical contractor onboarding meeting held. Both parties are clear on expectations and tighter time frame for excavations & mechanical installations. Excavations to commence 31/01.23 with cable pull 06/02.23.

Plans for next week
Review timeline progression Can the deadline be met with budget delays? Create backup plan

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Log Entry Sheet

Log Number	20
Date	02/02/2023
Duration (hrs)	8
Accumulated time (hrs)	186

Record of activities and achievements

Project execution meeting held to re-evaluate realistic goal following 65% reduction in budget.

Proposed solutions 1:

- The General Monitors ExP field controller will need to be replaced in any considered solutions.
- Not replacing the Regard classic controller and utilising any spare inputs on the obsolete 4-20mA analogue cards
- Utilising spare relay card slots on obsolete system
- Drawing last remaining controller from stores stock to accommodate 15 additional 4-20mA signals.
- Installing Regard 7000 controller to control the 15 analogue signals and integrate into existing DCS communications – This will require both controllers to operate simultaneously

Proposed solutions 2:

- Wait for final decision on budget - this will result in project completion significantly surpassing deadline.
- Contingency simulation of the PLC program / logic, enabling safety features t be tested on purpose-built gas detection rig which will incorporate as many of the final project components as possible

Trench Excavation put on hold due to higher priority work on VBU / HTU1 slowdown events.

Plans for next week

Create plan for simulation solution, include;

- Frame
- Components
- Wiring
- PLC program
- Test plan (in line with original test plan)
- Timeline

Carry out comparison of projected project progress vs current progress

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Log Entry Sheet

Log Number	21
Date	03/03/2023
Duration (hrs)	8
Accumulated time (hrs)	198

Record of activities and achievements
The budget has been re-approved for the full amount of £145 000 The Draeger order was promptly placed and confirmation requested upon receipt. Delivery lead times were confirmed to have slipped to The decision has been made that the simulation of the gas detection system will be the most suitable solution.

Plans for next week
• Amend FDS • Amend Gantt Chart • Create new test table • Design simulation system • Create wiring diagrams

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Log Entry Sheet

Log Number	22
Date	09/03/23
Duration (hrs)	34
Accumulated time (hrs)	232

Record of activities and achievements
An amended FDS, Gantt chart and test table has been created to for the simulation system. The required parts were located and gathered to the workshop and a list of parts that needed to be bought compiled.

Plans for next week
• Design the simulation system • Create wiring diagrams

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Log Entry Sheet

Log Number	23
Date	15/03/23
Duration (hrs)	25
Accumulated time (hrs)	257.5

Record of activities and achievements
The simulation system has been designed. The design was used to ascertain if any additional parts were required for the construction of the system. Preliminary wiring diagrams were created.

Plans for next week
• Finalise required parts list • Source all components required • Create the PLC logic

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Log Entry Sheet

Log Number	24
Date	20/03/23
Duration (hrs)	40
Accumulated time (hrs)	297.5

Record of activities and achievements

The required parts list was finalised and enabled parts to be ordered that were not held on site.

A costing spreadsheet was created to document costs which could be attributed to the main project.

Parts were ordered with the aim of utilising them for the main project in an attempt to keep within the budget.

The power supplies, diode and MTL5541 barriers were ordered from RS components who provide next day delivery.

The PLC logic was built and tested during the building phase. Simulation indicate the logic should function correctly.

Plans for next week

- Build simulation system

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Log Entry Sheet

Log Number	25
Date	27/03/23
Duration (hrs)	40
Accumulated time (hrs)	337.5

Record of activities and achievements
The simulation hardware mounting frame was built out of Unistrut and the components fitted to it. Wiring of components commenced and no issues arose.

Plans for next week
• Commission and test the simulation system

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Log Entry Sheet

Log Number	26
Date	05/04/23
Duration (hrs)	24
Accumulated time (hrs)	361.5

Record of activities and achievements

Pre-commissioning checks were carried out by energising the power supplies firstly to ensure the correct voltage is being supplied. Each further section was energised in systematically to ensure no components were damaged.

Once the system was powered, the setup of the controller cards and detectors were carried out.

Plans for next week

- Calibrate gas detectors
- Function test analogue loops
- Load PLC program
- Function test PLC program

Signed _____ Signed _____

Log Entry Sheet

Log Number	27
Date	10/04/23
Duration (hrs)	30
Accumulated time (hrs)	391.5

Record of activities and achievements
Field detectors were calibrated which enabled analogue loops to be tested. The PLC program was downloaded to the Allen Bradley controller which enabled the program to be function tested with physical analogue inputs. A problem was found with the analogue input card, which took some time to resolve. The issue was due to an instruction in the manual that was missed, where the 0v signals were required to be linked to a common return terminal on the AI card

Plans for next week
• Carry out testing as per the FDS and PLC testing table

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Log Entry Sheet

Log Number	28
Date	14/04/23
Duration (hrs)	24
Accumulated time (hrs)	415.5

Record of activities and achievements
The system was tested using the testing table created. Most tests were successful.

Plans for next week
• Write report

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Log Entry Sheet

Log Number	29
Date	17/04/23
Duration (hrs)	80
Accumulated time (hrs)	495

Record of activities and achievements
Report was written

Plans for next week
Submit completed report by 23:59 on 28/04/2023

Signed _____ Signed _____

1809797

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

67 /100

PAGE 1

PAGE 2

QM

Good Structure

Report is structured exactly as stated in the assignment brief.

PAGE 3

PAGE 4

PAGE 5

QM

Good formatting of paragraph through full justification and 1.5 line spacing

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

Text Comment. It is not clear as to why are you writing in the future tense, you should be writing in the present or past tense explaining what you have produced.

Text Comment. A story is unnecessary as this should be recorded in the log book.

PAGE 11

Text Comment. A good clear design

PAGE 12

Text Comment. unfinished

Text Comment. page number needed for direct quotations

PAGE 13

Text Comment. The above table is too generally, it should contain more specific information from these sources with Havard references.

QM

Spelling

Spelling error

PAGE 14

Text Comment. were

PAGE 15

Text Comment. were

PAGE 16

PAGE 17

PAGE 18

PAGE 19

PAGE 20

Text Comment. That is the reason for planning

PAGE 21

PAGE 22

PAGE 23

Text Comment. You appear to be blaming others for your failure to achieve all parts of your project

PAGE 24

QM

Correct method of listing.

You have listed your sources correctly according to the Harvard method.

Text Comment. This is a small range of sources compared to what is expected at level 6

PAGE 25

PAGE 26

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PAGE 36

Text Comment. better to explain the set up and cite this as a source

PAGE 37

PAGE 38

PAGE 39

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PAGE 42

Text Comment. There is no good reason to include this information

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PAGE 60

Text Comment. Only log entries for the implementation phase were required

PAGE 61

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GRADING FORM: NEW CSG-RUBRIC

LOURENS BRITS

67

1. ENGAGEMENT WITH LITERATURE

Section 3: Judicial use and critical evaluation of technical literature in the design of the project.
There is good evidence of judicial use of sources with reference to constraints, regulations and design information. (4/5)
Section 8: Extent of reading, range of credible sources and use of Harvard method
There is a small range of sources, much less than expected at this level. (2/5)

6/10

6

2. KNOWLEDGE AND UNDERSTANDING

Sections 3 and 4: Advanced knowledge and critical understanding demonstrated in the design and implementation of the project
There is clear evidence of these skills in the report where you have had to learn how to program the PLC and the HMI. It is a shame you did not manage to get them to communicate. (6/10)

6

3. COGNITIVE AND INTELLECTUAL

Section 5: Testing and analysis of results
There is good evidence of testing parts of the project and of testing the simulation with an explanation related to the tables in the appendix with good photographic evidence of results. (7/10)
Section 5: Critical evaluation of the project outcomes
An honest and full evaluation of the outcomes acknowledging the changes that were needed due to issues outside your control. (7/10)
Section 6: Conclusions and recommendations
Some good conclusions and recommendations. However, you seem to be blaming your circumstances and other people for your failure to implement even your simulation fully. (5/10)

19

19/30

4. PRACTICAL APPLICATION

Section 4: Deployment method, use of material, tools, equipment and techniques in the construction of the project.
Good evidence of correct method of construction and good programming of PLC and HMI. (7/10)
Section 4: Quality of the final product or system.
Software and HMI screen are good for simulation only. System should have been housed in a panel. (6/10)
Sections 5, 6 and appendix: Management of the design process including use of plans, costing spreadsheet and log book.
Good use of management methods, revision of plans, costs and work breakdown with complete

20

logbook (though entries are brief). However, your initial plans should have allowed for the changes that were needed.
(7/10)

20/30

5. TRANSFERABLE SKILLS

Section 1: Acknowledgements, executive summary and introduction.
Good sections that fully explain your project. (4/5)
All Sections: Presentation quality of the report, diagrams, charts, tables, figure numbering, page and section numbering etc.
A well presented report. However, your appendix is too large (guides and datasheets were not needed) (4/5)
All Sections: Quality of the writing style, use of punctuation and grammar.
Generally well written but the tense is sometimes wrong and you seem to be telling a story rather than explaining the end product. (3/5)
Word count limit not exceeded (5/5)

16/20

16