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by Jordan Gough

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Good Structure

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Finally, I would like to show my appreciation to the lecturers for providing support throughout the completion of the project.

A good set of acknowledgements

1. Executive Summary

The requirement for dual carbon monoxide and methane analyser became apparent through a series of heater audits, which identified instances of combustion difficulty multiple times over the audit period. The Yokogawa TDLS8100 was seen as the ideal sensor to incorporate into the design.

The design process consisted mainly of producing all of the necessary documents required to carry out the installation work and incorporate it into the already existing heater shutdown system. Upon reviewing the documents from the manufacturer, improvements to the project became apparent and temperature compensation was incorporated into the design to increase accuracy. This meant additional materials were added to the costing spreadsheet, which still came in £61,599.30 under-budget. However, it also meant an increase to installation time and was reflected in the project plan.

A series of delays meant the delivery date for the analyser was heavily prolonged and the plan needed to be reworked to ensure that progress didn't halt entirely. This allowed for earlier development of the PLC and DCS changes that were required but restricted the testing of the changes to simulation-based tests. Although these tests prove functionality to an extent, they are limited in and cannot be deemed a suitable testing measure prior to commissioning.

The original completion date was estimated for April 7th but after considering the delays and the additional steps required that were originally not included, the estimated completion date changed to June 20th.

2. Introduction

The aim of this report is to develop the previously devised system for carbon monoxide and methane analysis within an oil refinery's fired heater. The solution being applied is that of a tuneable diode laser spectrometer, which will measure the gas concentration in the heater's convection section and initiate a safe shutdown of the heater, should a high carbon monoxide PPM be detected.

The development of the solution will be completed through a series of drawings and documents. Upon delivery of the materials, the installation works will be carried out as per the documentation and the necessary changes to the PLC and DCS systems will be made to achieve full implementation. Extensive testing will be carried out to prove operability of the whole system following completion and will be recorded for comparison between expected and actual results – allowing for discrepancies in both the testing procedure and functional design specification to be identified and remedial actions to be determined.

3. Design

3.1 Functional Design Specification Changes

An initial list of materials had been previously created to identify all of the components that will be required to complete the installation works, but also for tracking the cost of the materials against the budget on the costing spreadsheet.

To further the develop of the outlined solution, tha sensor's manual was studied to esnure that all of the necessary information had been captured. However, this increased the design's requirements after identifying that it accomodates temperature compensation from an external temperature sensor. This will increase the accuracy of the readings and can be achieved by modiying an existing temperautre measurement loop to make it compatible. It also requires an update to the functional design specification, work breakdown structure and GANTT chart to ensure the steps for the modification have been captured and time has been alloted to them.

Other FDS updates include the addition of the carbon monoxide PPM value that will activate the shutdown function – which was originally excluded because a value had not been decided on. There is no industry standard for a high carbon monoxide trip, so working with a process engineer it was decided that the a trip point of 1500PPM would be applied. This is substantially lower than a typical lower explosive limit. However, little information is available to apply to heater fireboxes, so setting the trip point at 1500PPM provides confidence that there are no unmeasured areas which would reach the lower exploive limit and allows for uncertainty regarding varying process conditions.

Additionally, the need to install a digital input Delta V CHARM was missed from the FDS initially. This is required for the fault alarm and are readily available, with all of the wiring to the empty slots done. The main work requirement is putting the CHARM into the empty slot and configuring it. The updated FDS can be found in Appendix Table 1.

The first assignment was an opportunity to plan and consider these things. I hope that you now appreciate the importance of better preparation of FDS documentation and that this will assist you in your next project.

3.2 Drawings and Documents

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Prior to the commencement of any insatllation works, the solution must be further developed to identify the exact nature of what is required – including where the installations will be made and how the installation will be configured. To achieve this, a series of documents need to be created or modified, and verified. The documents produced can be shown in the table below, which details the document description, the appendix location and whether the document is completely new, or if it is an existing document that has been modified. The new documents listed in this table were created specifically for the newly installed components within the project, whereas the modified documents are applied to the Alkylation plant as a whole – so many already exist.

Document Description	New Document or Modification?	Appendix Figure
Block Diagram	New	Appendix Figure 1
P&ID	Mod	Appendix Figure 2 Appendix Figure 3
04-AT-2394 Loop Diagram 04-TT-0070 Loop Diagram 04-FSL-2346A/B Loop Diagram	New	Appendix Figure 4 Appendix Figure 5
04-US-2435 Loop Diagram	New	Appendix Figure 5
04-BPS-2394 Loop Diagram	New	Appendix Figure 6
04-AN-10 Junction Box Drawing	Mod	Appendix Figure 7
04-ES-01 Junction Box Drawing	Mod	Appendix Figure 8
04-X-45 Junction Box Drawing	Mod	Appendix Figure 9
C00-EIN-ICD-ES729 Cable Interconnection Diagram	New	Appendix Figure 10
C00-ES-723 Cable Interconnection Diagram	New	Appendix Figure 11
Manufacturer's Power Junction Box Drawing	New	Appendix Figure 12
Manufacturer's Signal Junction Box Drawing	New	Appendix Figure 13
Manufacturer's Hook-up Drawing	New	Appendix Figure 14
Pneumatic Hook-up Drawing	New	Appendix Figure 15
04-AT-2394 Data Sheet	New	Appendix Figure 16
04-TT-0070 Data Sheet	New	Appendix Figure 17
Cause and Effect Diagrams	Mod	Appendix Figure 18
Cable Schedule	New	Appendix Figure 19

CHARM Schedule	Mod	Appendix Figure 20
Triconex Schedule	Mod	Appendix Figure 21
Range, Alarm and Trip Schedule	New	Appendix Figure 22
PLC Flowchart	New	Appendix Figure 23
Logic Solver Change Request Form	New	Appendix Figure 24 Appendix Figure 25 Appendix Figure 26
Safety Integrity Level Calculations	New	Appendix Figure 27
Location Plan	New	Appendix Figure 28 Appendix Figure 29 Appendix Figure 30

Table 1 – New and Modified Documents

To maintain anonymity and conform to data protection, the names of personnel, and company names and logos have been covered up throughout the documents in the appendix.

The block diagram gives an overview of the system as a whole and shows each component and how they connect to each other, whether it's an electrical connection, a serial link, or a process or pneumatic connection. This is an extremely useful tool, not only for determining where in the system a component belongs, but also because it helps in identifying what documents need to be produced or modified.

The existing Piping and Instrumentation Diagram, or P&ID, for the 'Depropanizer Reboiler' has been modified to include all of the new or changed loops that are being installed on the heater. These have been drawn using red lines and surrounded with a bubble to indicate what has been added. This shows the new analyser with its process connections to the heater. It also shows the electrical connections it makes to the temperature indication for compensation and the PLC, the serial connections the PLC makes to the Delta V DCS for the alarms and indications, and the pneumatic connections made with the purge panel. This P&ID does not show the purge panel in full, hence the need for the hook-up drawings.

There were three total sheets created for the analyser's electrical loop drawing. Typically, this could have been achieved across two sheets but the loop is too large. The first sheet showed the field side of the loop diagram and contained the analyser, flow switch, temperature transmitter and the signal junction box. The second sheet showed the PLC and DCS side of the loop and included the junction boxes, cabinets, fuses, barriers and the DCS charm. The PLC side is for shutdown function and the process values, which are transmitted via serial link.

Whereas, the DCS side is for the digital fault alarm. The third sheet showed the entirety of the shutdown loop's bypass switch and light back to the PLC. This loop is used to prevent the shutdown function from initiating and to allow for scheduled maintenance and testing to be carried out while the heater is online.

The junction box and cable interconnection drawings break down the loop drawings and focus on the junction boxes and enclosures. They identify the specific cable cores that will be used for the electrical loops and where they will be connected up in each enclosure. These drawings will ensure that the loops are fully connected end-to-end and polarities are correct throughout. As per the block diagram, the junction boxes, including the two provided by the manufacturer – Yokogawa – are in the field, and the cabinets on the interconnection diagrams are within the 'Inverter Room', found in the 'Cracking & Olefins' Operations Control Room.

The hook-up drawing provided by the manufacturer provides a layout of the connections made on the purge panel that they are supplying. This drawing contains a key, which describes what each connection is used for. However, these connections are only those within the boundaries of the panel. The other hook-up drawing is not provided by the manufacturer, but is crucial in showing where the connections will be made to the panel's tubing, from the calibration gas bottles or the utility instrument air supply for the purge.

The data sheets are used to ensure th Spelling he transmitter configurations are correct, once the installation works are completed. Alongise technical information, such as the calibration *don't instruct your reader*
figures, it is also important to capture device information which can be utilised in the future for carrying out maintenance research or ordering spare parts, without having to visit the sensor.

The cause and effect diagram is used to ensure that the PLC functions are executed correctly. This diagram will show the valves which need to be closed when the safety shutdown function is activated by the sensor – ensuring that the correct function activates and both personal and process safety is maintained. The cause and effect diagrams are generally made for the entire unit, not a specific piece of equipment, so the existing diagram for the Alkylation unit required modification to include the new sensor.
Two schedules have been modified for the installation, whilst another two have been created. The modifications were made to the DCS CHARM and Triconex PLC schedules, due to them covering the whole unit. The CHARM schedule shows the CHARM type and location, the electrical connections and the cable identification number. Similarly, the Triconex PLC schedule shows the electrical connections, the fuse number and the cable identification number. The two new schedules are the cable schedule and the range, alarm and trip

schedule. The cable schedule was created specifically for this installation, due to the number of cables being installed. This schedule identifies the type of cable to be used, the type of gland to be used and the beginning and ending locations.

The range, alarm and trip schedule is useful for configuring the DCS faceplates as it shows key information – including the range and units of the sensor, the values at which the alarms activate and the function of each DCS point. The faceplates are already designed by Emerson and saved as templates to maintain consistency, so they generate themselves once the information is entered. However, there is further work to do when configuring. Additionally, the graphic displaying the heater overview will be amended to include both the methane and carbon monoxide process values and the editing process is not restricted by templates.

Although creating the drawings and other documents sets up the installation in theory, the physical locations of all of the components need to be confirmed against the paperwork to ensure the designs are feasible. Due to two of the junction boxes already existing, suitable cable tray was identified for running the cables to and from these enclosures. There was also cable tray on the heater which could be used for housing the cables and valdation pipework for calibration – so, no new cable tray wouild be required. Finally, the mounting flange for the analyser was identified for the purpose of marking it on a drawing in anticipation of installation. The platform on top of the heater where the analyser will be installed is quite large and has plenty of open space, so there will be plenty of options for where the utility panel can be installed. A dedicated area for the validation cylinders will be on the floor, rather than on top of the heater near the panel, and outside the unit boundaries. This will make gas cylinder replacement safer and easier.

Using the ‘plot plan’ drawing for the Alkylation unit, a location plan was created to visually demonstrate, from above, roughly where the cables and validation gas pipework will be run and where the instruments and enclosures will be installed. This drawing covered a large area and had to be divided up across three sheets to fully display the installation, similarly to the loop drawing. Determining the physical locations of the cables, sensors and panel covers totally covers one FDS item, item 11, and partly covers two more, items 4 and 17. The remaining information on items 4 and 17 will be covered during installation.

3.3 PLC Changes

Prior to the commencement of any PLC changes, a flowchart was created to aid in determining what the changes to the program will entail. Determining the changes beforehand are crucial for achieving approval to make any changes. The desired changes to the SIS – Safety Instrumented System – PLC must be submitted as a request using the 'Logic Solver Change Request Form'. This form details the problem description, the necessary changes to the inputs and outputs and any other additional information that is deemed important. This form needs to be approved by a designated Instrumentation and Control or SIS Engineer. Additionally, working alogside the SIS Engineer, the overall SIL – Safety Integrity Level – rating of the system must be calculated.

Don't instruct your reader, they are not carrying out this project so you don't need to tell how they should do it.

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The Triconex saftey PLCs are heavily protected to ensure that they are not tampered with. There are no local PC stations connected to any of the PLCs and they have to be accessed using a laptop. The laptops are kept with a restricted area of the Admin building to prevent access to unauthorized individuals. Even if the laptop is obtained, they can only be logged into if the user has a specified login, approved by a member of the leadership team. The PLCs are all mounted inside locked cabinets and the keys are only distributed to approved individuals. To obtain a login and key to the cabinets, the individual's must complete a background check to ensure they are who they say they are and will not be susceptible to bribery, they have received formal training in the use of the PLCs and they have been deemed competent by their manager or director. Due to restrictions with authorisation and the unavailability of the Instrument Engineers, the PLC changes could not be made on the laptop. To make the changes, a copy of the TriStation 1131 software had to be obtained and installed onto a PC which is not connected to any corporate networks. This would prevent any corruption or problematic changes of the files stored on the system. Once installed to a PC, a PDF copy of the Alky unit program had to be obtained and the heater specific logic had to be recreated.

TriStation 1131 is the software used for programming the Triconex PLCs. Although it has access to SCL and ladder logic, all of the programs are built using function blocks. The logic can be separated up across different programs to make it more easily navigateble.

When recreating the logic, many of the blocks were readily available from the software's library. However, there were some blocks which aren't apart of the library but are crucial to the development, so had to be built using what was available. They can be built on the sheets and then contained into a single function block to minimise the amount on one sheet. These include:

- Analogue Input – This block uses a millaimp output from a transmitter as an analogue input and scales it. It also allows for range values to be specified.
- Analogue Scaling – The analogue input block was put into a larger block for analogue scaling that allowed for alarm points, trip values and maintenance bypass data to be specified.
- Line Fault Detection – This block uses analogue inputs to determine the state of a switch using the counts from a milliamp input conversion.
- 2-out-of-3 Voting – This block allowed 3 analogue inputs to be simplified into a voting block when this trip system is in place. It encompasses three 2-input AND gates and one 3-input OR gate.
- DVC – DVCs are a model of valve Spelling er produced by Fisher, which has HART compatability. This block uses the poitioner's milliamp output as an analog input to determine the valve's position, any faults present and if it is currently being calibrated.

The programs and function blocks recreated can be seen in full in Appendix Figure 37.

The logic that was recreated, along with the function blocks mentioned above and the new logic added can be found in the table below. There are some other miscellaneous sheets which don't fall under those in the table, but can still be found in the appendix.

Logic	Function	Appendix Figure
Depropaniser High Pressure	2-out-of-3 Shutdown	Appendix Figure 38 Appendix Figure 39
Depropaniser Low Bottoms Level	Shutdown	Appendix Figure 40
Heater Low Pass Flow	Shutdown	Appendix Figure 41 Appendix Figure 42 Appendix Figure 43 Appendix Figure 44 Appendix Figure 45 Appendix Figure 46 Appendix Figure 47 Appendix Figure 48
Heater Low Fuel Gas Pressure	Shutdown	Appendix Figure 49 Appendix Figure 50 Appendix Figure 51
Heater Low Combustion Air Flow	2-out-of-3 Shutdown	Appendix Figure 52 Appendix Figure 53 Appendix Figure 54

Heater High Outlet Temperature	Shutdown	Appendix Figure 55
Heater Local ESD Button	Shutdown	Appendix Figure 56
Heater High Carbon Monoxide PPM	Shutdown	Appendix Figure 57
Heater High Methane %	Indication	Appendix Figure 58
Heater Fuel Gas XV Operation	Shutdown	Appendix Figure 59 Appendix Figure 60 Appendix Figure 61 Appendix Figure 62 Appendix Figure 63
Heater Purge	Start-up	Appendix Figure 64 Appendix Figure 65 Appendix Figure 66 Appendix Figure 67 Appendix Figure 68
Analogue Input	Function Block	Appendix Figure 71
Analogue Scaling	Function Block	Appendix Figure 72
Line Fault Detection	Function Block	Appendix Figure 73
2-out-of-3 Voting	Function Block	Appendix Figure 70

Table 2 – PLC Logic

The combustion difficulty analyser has two inputs into the PLC – one for the carbon monoxide measurement shutdown input (A) and one for the methane measurement (B). The analyser produces two separate outputs for each measurement, so there are two hardwired inputs into the PLC. However, only the A scaling block produces a trip output.

All of the shutdown logic, apart from the ESD switch and the fuel gas XVs, use the analogue scaling blocks to convert from milliamps to 0-4095 counts, or 12-bit, to represent the analogue input as digital. The field transmitters are all hardwired into the PLC, as per the example in in Appendix Figure 5. The range values, reset percentage, fault alarm currents, and trip point are all assigned to the scaling block as REAL data points. The scaled value is outputted by the function block twice – once as the raw counts, which is the data sent to Delta V via serial link, and as the process value in its engineering units, which are displayed on the PLC when it's running. The transmitter fail alarm, trip, trip alarm and pre-alarm all become true when the input value reaches any of the defined set-points. There is also an input, which comes from the maintenance bypass switch logic. When the bypass switch is active, the scaled values will

change and the alarms will activate, but it will prevent the trip output from becoming true – thus preventing a shutdown of the heater.

past tense here if you have done this work

The 2-out-of-3 systems will have three separate analogue inputs going to three separate analogue scaling blocks. The 2-out-of-3 installation is used to prevent trips if one transmitter reaches the trip value, unlike the 1-out-of-1 systems. Therefore, the function block takes inputs from the scaling blocks' trip outputs and will only produce an output of its own if at least two trip outputs are active. These systems typically don't have maintenance bypasses, so the bypass input on the scaling block is constantly set to FALSE.

Using line fault detection (LFD) for the emergency shutdown switch allows for four possible options – switch open at 8.9mA, switch closed at 9.1mA, short circuit at 16.4mA and open circuit at 4.2mA. This is beneficial to fault finding and preferred to a digital input which doesn't have the short or open circuit detection. Then there are two outputs from the LFD, the switch output which activates the heater trip, and the fault output, which only produces a fault alarm.

If any of the trip functions activate when the heater is running under normal operation, the fuel gas XVs close to extinguish the flame and prevent any more gas entering the heater. This is achieved through the use of solenoid valves, which energise with a signal from the PLC and vent off the air that is holding the valves open, allowing them to fail closed using the internal spring. The smart positioners on the valves allow for accurate position monitoring which can be used to prevent heater firing if they aren't opening fully. There is also a timing function built into the logic to ensure they are closing fast enough to be deemed safe.
Although the fuel gas valves are closed, the combustion air valves remain open. This is to maintain an air flow through the heater, removing any gas from the top of the heater and into the stack.

To ensure the air flow is carried out for long enough, there is a purge sequence which the heater must go through before it starts. This Operator will only be allowed to start the purge sequence if all of the trip inputs are healthy. Then to ensure the purge sequence is running, one of the combustion air flow transmitters will monitor the air flow and will fail the purge if the flowrate drops below a trip point. The combustion air flow trip point under normal operation is 17.5km^3/hr falling, but under purge conditions it is 20km^3/hr. This ensures that the flow remains over roughly 25% of its range. This air flow will have to be maintained for the 900 second purge timer. If the purge completes successfully, the pilot flames will light. If the pilot flame lights successfully, the fuel gas XVs will open and the Field Operator can start introducing burners into the heater, which light the main flames using fuel gas.

4 Implementation and Management

4.1 Costing, Delays and Plan Changes

The addition of the temperature transmitter modification and the Delta V CHARM installation meant that the Gantt chart and the work breakdown structure had to be amended to include the increased workload – along with the costing spreadsheet, due to the need for more materials. Fortunately, the transmitter – along with an enclosure - are deemed 'store-stock' items and are therefore readily available in the refinery's warehouse – assuming the stock levels have been maintained. However, they still need to be taken from the warehouse against a department's budget, so will be reflected in the costing spreadsheet and counted towards the project's budgetary costs.

The updated costing for the spreadsheet is £188,495.50. This leaves £61,504.50 remaining, should any further expenditure become apparent. The original costing spreadsheet can be found in Appendix Figure 31 and the final costing spreadsheet can be found in Appendix Figure 32.

The temperature transmitter an Spelling ure head were the final components added to the costing spreadsheet and, thus, the las items to be ordered. Many of the items were ordered from local suppliers that are often used and are on the refinery's 'approved vendors list'. This meant that the lead time on some items, such as cable reels, glands and bolts, was relatively short. The lead time for the mechanical components – such as tubing, fittings and mounting clips – required for the validation pipework was slightly longer, due to the stainless-steel requirements. The delivery took roughly three weeks longer. As stated previously, the temperature transmitter and enclosure were stocked items within the refinery's warehouse and, therefore, had no lead time and could be withdrawn immediately and put aside safely until required.

The biggest issue encountered with lead times was from Yokogawa, the manufacturer of the analyser. Due to the product being relatively new to the market and the extra requirements – the utility purge panel, the HMI, a calibration cell and a factory acceptance test – the lead time was extremely long and fell in to March. However, this date was pushed back to May due to unforeseen issues – including industrial strike action and both planned and unplanned unit shutdown maintenance events - causing a priority shift and a business need to refocus resources. The refocusing of resources included the engineers who would assist with the PLC and Delta V DCS modifications, meaning that there were also delays with these changes. The delays to the project plan were reflected in the Gantt chart. The original Gannt chart can be

found in Appendix Figure 33 and the updated Gantt chart can be found in Appendix Figure 34. Also, the original and updated WBS can be found in Appendix Figure 35 and Appendix Figure 36 respectively.

The updated Gantt chart shows that the design phase was extended to accommodate the large number of documents that required production. However, these drawings and documents could be created in-line with some of the installation works, so the overlap wasn't problematic. The delays to the factory acceptance test, and consequently, the analyser delivery meant that the implementation phase's end date was moved from March 17th to May 26th. Two extra days were added to the sensor installation to accommodate the need for the temperature measurement modification. An extra step was added to the implementation phase that allocated time to update documents as required. The PLC and DCS changes were also extended due to the need for software familiarisation not being originally considered. Given that the installation cannot be practically tested, a new step was added to allow for time to carry out simulation testing.

4.2 Installation and DCS Changes

The delivery and factory testing delay for the analyser caused a knock-on effect to other parts of the installation, including:

- Temperature Loop Modifications
- Validation Pipework Installation
- Full Loop Connection Termination

The cable installation work could begin following the completion of the cable schedule and the location plans, and could run alongside the creation of the loop, junction box and interconnection drawings. The cable installation was carried out by an on-site electrical contractor, who provided a quote for the amount of work required. The cable installation was originally scheduled to complete after 5 weeks, as per the Gantt chart, but completed after 7 weeks due to the contractors being involved in the industrial strike action. The cables were run as per the cable schedule, but no terminations were completed initially and will remain disconnected until the full installation is completed. However, the cable glands were fitted with the assistance of the electrical contractors. Any cables that had a destination in place were fitted into the enclosure entries to protect them and any that were awaiting installation of enclosures were covered in plastic bags, to prevent weather damage, and cable-tied away from any possible impact. There will still be some cables to install when the analyser and enclosures are delivered, but they will be very short runs and won't consume a large amount of time.

With the delays to the analyser delivery, the focus had to be move to other parts of the implementation. The Delta V points could be created but could not be downloaded to the live Operations control panel because the hardware is missing, and they will not work. This would lead to module alarms being present because the circuit is open-loop. A total of four faceplates need to be created – two alarm faceplates and two process variable faceplates – and the graphic screen for the Alky Depropaniser Reboiler requires modification. The tags for the faceplates can be found in the table below.

Faceplate Tag / Graphic	Function	Appendix Figure
04AI2394A	CO Indication	Appendix Figure 75
04AI2394B	CH_4 Indication	Appendix Figure 76
04AXH2394A	High CO Shutdown Alarm	Appendix Figure 77
04UA2435	Fault Alarm	Appendix Figure 78
04H101 Depropaniser Reboiler	Overview	Appendix Figure 79

Table 3 – Delta V Faceplates

The Delta V points are known as ‘control modules’ and are found in an application called ‘Delta V environment’. Inside the control modules are function blocks, which can be found inside ‘Delta V control studio’. These function blocks are generally input blocks for analogue, discrete / digital or pulses. When a block is placed into the control module that has been created, the parameters for the block can be assigned. The parameters focus mainly on alarms but can also be used for scaling when an analogue input is used. Once the parameters have been added, they can be edited to include the necessary information – such as the range values, the engineering units, the alarm points and the alarm priorities. The alarm priorities are used to determine where the alarm sits in the list when it activates, the colour of the alarm and how immediate the response by the Control Operator needs to be. There is also a feature within Delta V which provides the Operators with information about the possible process causes that would initiate the alarms and the steps they should take to make it safe again before the equipment trips or is restarted. However, this is a new feature and hasn’t been implemented yet.

Once finalised, the modules can be assigned an address, be saved and downloaded to a set. This will allow them to appear on the Delta V control panel through the automatically generated faceplates from the templates.

The two indication faceplates are analogue blocks, and the shutdown alarm is a discrete block which take their inputs from the PLC loop via serial link. The data type of the input or output can be assigned when they are added to the function blocks. These types include BOOL, REAL and floating points. Due to the PLC being used, there’s no requirement for any CHARMs and the serial link is connected to a controller. However, the fault alarm is hardwired into a digital input CHARM. This means that the base configuration is the same but, instead of assigning it an address, it is assigned a CHARM installed onto the I/O rack.

Although the individual faceplates show ‘normal’, or are reading zero PPM or percent, the Alky depropaniser reboiler graphic is showing faults on all of the indications, except the ones added. This is because the graphics have been built on a computer which is typically run offline, so not all of the indications will work until it is switched online, and the changes are made to the live panel. The newly created faceplates would work because they were downloaded to the test rig and had their data types set to ‘floating point’ for the purpose of proving functionality.

5 Testing and Results

The delays to the acquisition of the analyser and its associated components have limited the testing of the installation – as per the previously devised test plan. Despite this, the test plan was still updated to include the new temperature transmitter, trip point and digital input CHARM – as seen in Appendix Table 2.

Many of the items in both the testing and conformance tables cannot be checked until all of the materials have been delivered and the further installation work is underway or completed. In some cases, there is potential for alternative testing to be carried out. This mainly includes simulation testing, where it can be applied. As for the compliance table, some items may be confirmed through the use of documents provided by manufacturers – but no simulation can be applied. The testing table has been further updated to reflect the alternative means of proving as many FDS items as possible. The compliance table and the further updated testing table can be found in Appendix Table 3 and Appendix Table 4.

These tables will be updated alongside the test to ensure that the results are accurately recorded, and no key information is missed. As these tests are going to be simulations, the results will need to be proven with practical testing results once the final installation is complete.

An official working maintenance procedure has also been produced. This system will also be tested using this procedure to ensure that it is fully complete, contains no errors that could potentially impact the process and no changes are required. Then it can be used for testing at regular intervals.

5.1 Simulation Testing Table

The table below shows the results of any tests that could be carried out.

Item Number(s)	Functional Test	Simulation Test	Expected Result	Actual Result	Success / Failure	Evidence
3	Complete analyser validation checks using validation gas cylinders and measure the output mA	Unable to simulate	Analyser produces 4mA output when no validation gases are applied. Analyser produces 20mA when 10000ppm of Carbon Monoxide is applied and when 5% methane is applied.	No testing completed until installation finished	Pending	N/A
5, 13	Verify loop connections and apply power to the loop	Unable to simulate	110VAC measured at UPS input and 24VDC measured at UPS output, using calibrated multimeter. Analyser powers up when 24V is applied to the power terminals.	No testing completed until installation finished	Pending	N/A
6	Manually generate a fault in the loop and measure the output mA	Unable to simulate	Analyser produces below 3.6mA or above 21mA when a fault is generated in the loop.	No testing completed until installation finished	Pending	N/A
7	Connect to analyser and change configuration, using either Emerson 475 or Emerson TREX HART communicators.	Unable to simulate	Analyser configuration can be completed through HART communication protocol	No testing completed until installation finished	Pending	N/A
8, 11, 16	Change through HMI display screens and note the parameters and alarms which are present.	Unable to simulate	Analyser HMI display shows real time diagnostic and monitoring information. Fault alarms generated on HMI when power supply or purge air is lost.	No testing completed until installation finished	Pending	N/A
9	Connect the utility air or nitrogen to the panel and open valve. Verify that a flow increase is seen on the indicator and adjust as required. Connect validation cylinders to the installed fittings.	Unable to simulate	Panel allows for air or nitrogen flow from a utility point through the tubing and fittings. Flow rate can be adjusted using restriction valve on flow indicator. Gas cylinders successfully connect to the panel.	No testing completed until installation finished	Pending	N/A

<table>
<tr><td>15</td><td>Isolate the UPS using the safety switch outside the Ex d enclosure. Measure the voltages at the input and output of the UPS.</td><td>Unable to simulate</td><td>No voltage measured when power supplies in Ex d enclosure are isolated using safety switch.</td><td>No testing completed until installation finished</td><td>Pending</td><td>N/A</td></tr>
<tr><td>20, 21</td><td>View the program using a laptop connected to the PLC and verify all the changes have been made. Have a second technician or engineer simulate milliamps on the loop and monitor inputs and outputs on the screen.</td><td>Simulate PLC logic using the TriStation emulator by forcing the inputs and ensuring the outputs change state when viewing.</td><td>Practical - Analogue inputs and outputs, and digital outputs are noticed in PLC program. Analogue inputs respond to change in mA, using calibrated mA source. Digital outputs trigger when mA trip point is reached, using calibrated mA source. Trip point is at 1500ppm, or 6.4mA.

Simulation - Inputs are forced and heater shutdown is initiated to prove the output changes to the fuel gas XVs.</td><td>Shutdown instruments were forced healthy to allow for heater to be shown as healthy and fuel gas XVs to show their open states. The 04AT2394A_TRIP point was forced to initiate the shutdown, which made the fuel gas XV trip TRUE and tripped the fuel gas XVs' solenoid valves and closed them.</td><td>Simulations successful

Practical testing required</td><td>Appendix Figure 80
Appendix Figure 81
Appendix Figure 82
Appendix Figure 83
Appendix Figure 84
Appendix Figure 85
Appendix Figure 86
Appendix Figure 87</td></tr>
<tr><td>22, 23</td><td>View the DCS graphics in the control room. Have a second technician or engineer simulate milliamps on the loop and</td><td>Simulate inputs into the Delta V DCS Test Rig and ensure changes are noted on the built faceplates prior to downloading to the live control panel.</td><td>Practical - Process readings are noticed on Delta V DCS graphics. Live process values respond to change in mA, using calibrated mA source. DCS alarms activate when alarm conditions are met.

Simulation – Force values onto the DCS faceplates to ensure they are displaying the correct information and responding to the changes. Carry out practical test of digital input by downloading to test rig and functioning at CHARM.</td><td>DCS faceplates responding when the simulations were applied. Alarms were initiating on the alarm list, faceplates and graphics.

Fault alarm activated when practically tested at the digital input CHARM on the test rack.</td><td>Simulations successful

Practical testing required</td><td>Appendix Figure 88
Appendix Figure 89
Appendix Figure 90
Appendix Figure 91
Appendix Figure 92
Appendix Figure 93
Appendix Figure 94
Appendix Figure 95</td></tr>
<tr><td>24, 25</td><td>Connect a thermocouple calibrator to the temperature transmitter and inject a millivoltage.</td><td>Configure Rosemount 644 transmitter in workshop and function check using thermocouple calibrator.</td><td>Practical - Change in mA output is noticed on the connected HART communicator. Change in temperature indication noticed on the HMI.

Simulation - Change in mA output is noticed on the connected HART communicator.</td><td>Testing results as follows:<table><tr><td>Input (°C)</td><td>Output (mA)</td></tr><tr><td>0</td><td>4</td></tr><tr><td>650</td><td>12</td></tr><tr><td>1300</td><td>20</td></tr></table></td><td>Workshop testing successful

Testing required when HMI has been installed</td><td>Appendix Figure 96
Appendix Figure 97
Appendix Figure 98</td></tr>
</table>

Table 4 – Completed Testing Table

5.2 Simulation Testing Breakdown

5.2.1 PLC Testing

A test PLC was not available, so the PLC changes had to be tested using TriStation's built in emulator. Due to this being a recreation of the live program, it has been assumed that the existing trip functions work to reduce testing time. The testing was carried out by forcing all of the trip functions to be TRUE, which made the output from the gate to be FALSE – due to it being inverted. Due to the program containing all of the heater trips, they had to be forced healthy to make the simulation work. The trip form the analyser was set to FALSE, which changed the state of the AND gate to true. This initiated the shutdown function and changed the fuel gas XV trips from FALSE to TRUE. This then carried over to the sheets for both of the fuel gas XVs and triggered the SOV output which would cause the air applied to the valve actuators in the field to vent off and close the valves. The analogue input for the analyser could not be tested, so practical testing will still be required.

5.2.2 DCS Testing

Testing the analogue DCS faceplates would require a PLC to be connected to the DCS test rig and inputs applied to the PLC to produce the serial link outputs. However, the DCS test rig doesn't have a PLC connected to it and the Triconex PLCs are rack mounted, so there was no possibility of making the connection.

The Delta V Explorer software allows for built-in simulation testing, which can be used to test some features of the Delta V faceplates. Simulating inputs will prove the displayed process readings change on both the faceplates and the heater graphics, the alarms come in when they should on both the faceplates and the alarm lists, and the alarm priorities are set correctly.

When testing the faceplates '04AI2394A' and '04AI2394B', the inputs were set slightly higher than the alarm points to initiate the 'high' alarm and the 'high-high' alarm. These alarms are triggered within the DCS by the faceplate value, rather than the PLC trip output. The inputs were then set at 50% and 100% of the ranges to ensure the bar chart on the faceplate changes proportionally to the reading. Both of the 'high' alarms are set at HIGH priority, and the 'high-high' alarm's priority was set as EMERGENCY. When the changes were being made to the values, the Alky heater graphic was being monitored to ensure the process values were changing and the alarms were initiating without having the faceplates open.

Testing the '04AXH2394A' faceplate was completed differently to the other two. It was also an alarm point, so had to be simulated. This was done by setting the faceplate to true and ensuring it changed state to read 'shutdown' and initiate the EMERGENCY alarm.

The fault alarm '04UA2435' is not a PLC point and is instead assigned to a CHARM. The control module could be downloaded to the CHARM rack connected to the test rig and a practical function check could be completed. Although there isn't a physical switch connected, the alarm can be generated by disconnecting a wire and opening the loop. This initiated the 'fault' state change on the faceplate.

5.2.3 Temperature Transmitter Testing

Using Emerson's TREX hart communicator to provide 24VDC, the Rosemount 644 Temperature Transmitter can be powered up, configured and tested. The transmitter was configured as per the FDS requirements and the data sheet.

To complete the testing of the transmitter, a thermocouple calibrator was connected to it using K-type thermocouple compensating cable. This ensures the wires are the same material as those used in a K-type thermocouple, reducing the possibility of inaccuracies. The only possible tests to carry out on the transmitter was to measure the output mA current and ensure it ties in with the 0-1300°C range.

5.3 Compliance Checking Table

This table below shows the compliance checks carried out.

Item Number(s)	Compliance Check	Expected Result	Actual Result	Success / Failure	Evidence
1	Compare total cost to budget	Total cost falls below £250,000.	Total cost came under budget	Success	Appendix Figure 32
2	Compare project end date to project plan	Project was completed on or before deadline.	Project yet to be completed	Failure	Appendix Figure 34
4	Ensure the installation complies with ASME B16.5	Correct nuts and bolts are used for the flange on the analyser, and they have been torqued to correct ft·lb value.	Analyser not yet installed; flange standard stated on data sheet	Pending	Appendix Figure 101
17	Ensure the installation complies with BS 7671	Correct cable types are used, run and terminated correctly inside any enclosures used.	Cables correct, awaiting terminations	Pending	Appendix Figure 107
18	Complete ATEX inspection form for any installed electronics or enclosures and confirm BS EN 60079 compliance	Electronics and enclosures meet all of the criteria on the company's 'ATEX Initial Inspection' forms and are deemed appropriate for the area, as per hazardous area drawings.	Awaiting installation to complete ATEX inspections ATEX inspection completed for temperature transmitter	Pending	Appendix Figure 108 Appendix Figure 109
19	Review the documentation provided by the manufacturer and confirm the sensor's SIL rating, as per BS EN 61508	Sensor is SIL 2 rated.	Sensor is SIL 2 rated	Success	Appendix Figure 99 Appendix Figure 100

5.4 Compliance Checking Breakdown

To meet some of the compliance table's criteria, data sheets and manuals were used to identify the requirements. Using the documents, the SIL rating for the analyser and the standard of flange for mounting were identified. There is no practical way of proving these and it must be done from the documents provided by the manufacturer, so they can be deemed successful. However, 'item 4' cannot be fully completed until the analyser is mounted to ensure that the nuts and bolts are torqued to the correct value.

Every new electronic component or enclosure within the loop will need an ATEX inspection completed to ensure it complies with BS EN 60079. Currently, only the temperature transmitter is available for inspection. It is also assumed that existing components and enclosures have already been inspected and added to the database.

6 Evaluation and Project Outcomes

Shown below is the FDS completed as per the project's progress thus far.

Item Number	Description	Specification	Criteria Met	Explanation	Next Step
1	Cost	Cost must be within £250,000 budget.	Yes	Total cost came under budget	N/A
2	Completion Date	Project must be completed by the end of Q3 2023.	No	Delays caused project to fall behind on GANTT chart timings	Continue with project installation
3	Analyser Measurement and Output	Sensor must be able to measure CH_4 and CO. CO measurement range: 0-10000 PPM. CH_4 measurement range: 0-5%. 4mA output indicates 0PPM / 0%. 20mA output indicates 10000PPM / 5%. Analyser's response must be linear.	Pending	Measurement and output current information displayed within manual and data sheet	Functionality test to be carried out on analyser following installation
4	Analyser Mounting and Location	Sensor must be flange mounted on the heater's convection section. Flanges and bolting must comply with ASME B16.5.	Pending	Flange standard stated in manual and data sheet	Mount analyser on convection section to ASME B16.5
5	Analyser Power Requirement	Sensor must be 24VDC.	Pending	Power supply information displayed within manual and data sheet	Confirm analyser powers up when connected to 24VDC
6	Analyser Output Standard	The 4-20mA output must comply with NAMUR NE43, i.e., sensor fault when mA is below 3.6mA or above 21mA for more than 4 seconds.	Pending	Output current information displayed within manual and data sheet	Confirm analyser fault current limits when configuring and carry out function test
7	Analyser Capabilities	Sensor must be HART capable.	Pending	HART capability displayed within manual and data sheet	Confirm HART communicator connects to analyser
8	Analyser Interfacing	Sensor must have a local HMI to display diagnostic information.	Pending	HMI option undertaken when ordering	Confirm HMI displays diagnostic information
9	Utility Panel Compatibility	Panel must be installed and have the capability to switch between an air purge and validation gas. The purge air will be used to keep any possible lenses or reflectors inside the sensor clean. Validation gas will be used to prove operability of the sensor. Panel must have correct fittings to allow for gas cylinder connection.	Pending	Utility panel ordered and hook-up drawing provided by manufacturer	Functionality test to be carried out on panel following installation
10	Utility Panel Construction	Panel must use Swagelok tubing, fittings, pressure gauges and flow indicators with low flow switches.	Pending	Swagelok requested as per site standard for instrument and analyser pipework	Verify Swagelok branding upon receipt of utility panel
11	Utility Panel Interfacing	Low flow switches must be connected to the sensor, via an interface box, and generate a low flow alarm on the HMI.	Pending	Low flow switches ordered as part of utility panel	Functionality checks to be carried out following installation
12	Utility Panel Location	Panel must be located on heater platform, with validation pipework running down to grade to allow for safe gas cylinder replacement.	Pending	Installation areas for panel and cylinders, and path for validation pipework identified	Install panel and run validation pipework to cylinder storage location

13	Power Supply Requirements	110VAC to 24VDC power supply must be installed.	Pending	Power supplies ordered as part of utility panel. Data sheet shows 110VAC to 24VDC.	Verify power supply type following installation
14	Power Supply Location	Power supplies must be installed within Ex d enclosure in the field.	Pending	Ex d enclosures ordered as part of utility panel	Complete ATEX form to prove Ex d certification
15	Power Supply Isolation	Ex d enclosure will have external isolator.	Pending	Isolator switch ordered as part of utility panel	Functionality test to be carried out on isolator following installation
16	Power Supply Failure	Second power supply to be installed in enclosure to allow for dual redundancy. Power supply failure to generate failure alarm on local HMI.	Pending	Power supplies ordered as part of utility panel	Functionality test to be carried out on fault alarm following installation
17	Cable Installation	Steel wire armour cables must be installed in cable tray above ground. Wiring inside enclosures must conform to BS 7671. (The Institution of Engineering and Technology, 2018)	Pending	Cables installed in above ground cable tray	Complete terminations to BS 7671
28	ATEX Rating	Components must have a minimum ATEX rating of Zone 2, Gas Group IIC and Temperature Class T3 - as indicated on hazardous area drawing and as per BS EN 60079. Any enclosures must have a minimum IP rating of 65, as per BS EN 60529. (The British Standards Institution, 2014)	Pending	Analyser and temperature transmitter per manuals and data sheets	Complete ATEX forms to prove remaining components' certifications
19	Sensor SIL Rating	Sensor must be SIL 2 rated, as per BS EN 61508. (International Electrotechnical Commission , 2017)	Yes	Analyser SIL 2 rating confirmed by data sheet and manual	N/A
20	PLC Modifications	PLC program must be modified to introduce analogue inputs and digital outputs. Process readings and alarms will be communicated to Delta V Distributed Control System (DCS) via serial link (RS 232).	Yes	Changes made to PLC program on TriStation software	Download software to PLC and confirm Delta V communications
21	PLC Output Operability	PLC must close both fuel gas XVs upon detection of high CO. Trip Value is 1500PPM	Pending	Changes made to PLC program on TriStation software	Monitor PLC program's outputs during functionality testing
22	DCS Display Modifications	DCS screens must be modified to include real-time process readings, on the heater screen, and alarms.	Yes	DCS faceplates created, and graphics modified	Download to live operator panel
23	DCS Alarm Configuration	Common fault alarm generated on Delta V when any alarm is activated on the HMI. Transmitter fault alarm generated on Delta V when output mA is outside of the 4-20mA range.	Pending	Fault alarms tested through simulation	Monitor Delta V alarms during functionality testing
24	Temperature Measurement	04-TI-0070 temperature loop must be modified to allow compensation in the analyser head through the installation of a Rosemount 644 temperature transmitter and necessary cabling in the loop, rather than the thermocouple connecting to a DCS multiplexer. Transmitter must be mounted separately from the thermocouple, with K-type compensating cable between the transmitter and the thermocouple.	Pending	Rosemount 644 transmitter and enclosure head acquired from site stores	Install transmitter and head following analyser installation

25	Temperature Transmitter Configuration	Temperature transmitter's probe type must be set to a K-type thermocouple. Temperature transmitter's configured range must be 0-1300°C. Temperature transmitter's response must be linear. Temperature transmitter must be 24V.	Yes	Transmitter configured using HART communicator	N/A
26	DCS CHARM	Delta V CHARM installed for fault alarm must be a digital input type. Delta V CHARM must be connected for loop powering, not external powering.	Pending	Delta V CHARM acquired	Install charm following analyser installation

Table 5 – Completed FDS

Of the twenty-six items on the FDS, only five of them can be deemed successful. This is due to the majority of the items requiring the completion of the installation and, therefore, the criteria could not be proven.

The costing for the project comfortably came in under budget. The sensor SIL rating was declared as SIL 2 by the manufacturer. This is proven by the data sheet supplied by the manufacturer and cannot be proven another way. Therefore, this information is sufficient for meeting the criteria. Although the testing wasn't fully completed, the PLC program was modified to incorporate the new field inputs that join the heater shutdown logic and the outputs to DCS. Until full testing is completed, it can be assumed that the program is functional, and no changes will need to be made. Similarly, the DCS faceplates were created, and the graphics were modified. Practical testing was only carried out on the digital input for the alarm. However, this is identical to a typical function check, so any failures in testing post-installation will be external to the DCS. The remaining faceplates were only tested via simulation. Finally, the temperature transmitter could be configured immediately and put to one side for safekeeping until it was time to install. The testing was carried out for this but will need further testing alongside the HMI.

Many of the FDS items have been marked up as pending because they have partially met criteria or they unable to be proven yet, so cannot be deemed a success or failure. Regarding the items specific to the analyser, most of the information can be gathered from the data sheet, as per the referenced figures above, but they should still be proven upon delivery to ensure the product is as specified. A similar approach can be made towards the utility panel and junction boxes. Until delivery, the details cannot be finalised – however, the product should conform to the FDS if the manufacturer produces as requested. The remaining points focus on the system's function which, as mentioned above, require practical testing.

Only one item on the list, which is the targeted completion date, can be confirmed as unsuccessful and is proven by the delayed delivery date of the analyser. However, this was caused by additional factors delaying the factory acceptance test. These included industrial strike action, planned and unplanned unit shutdown maintenance events and mass Christmas annual leave being taken.

Alongside the FDS, a series of additional constraints were identified during the design phase which were more generalised. A series of safety-driven constraints were identified, such as using a crane to lift the goods, applying the work-permit system and wearing the specified PPE. No lifting has taken place yet, but any work carried out was done under an approved

permit, as per the HSE, and any field work carried out – such as cable installation – was done using the correct PPE, as per API751. Another constraint which applies to the entire site is the need for minimum IP66 ratings on sensors. Per the data sheet, the analyser is IP66 rated.

7 Conclusions and Recommendations

The safety shutdown system utilising the TDLS analyser was sufficiently designed following the selection of Yokogawa's model. The design and development of the system was completed through the production of a series of drawings, schedules and data sheets which detailed the physical installation and configuration information. Along with the documents, the modifications to the PLC and DCS control system needed to be detailed and requested for approval. Additionally, using the manufacturer provided documents, the over safety integrity level of the system needed to be calculated. Although the sensor itself was SIL 2 rated, which conformed to the FDS, the overall system was calculated to be a SIL 1 system – a lower protection level. This wasn't cause for concern, but the ideal rating would be SIL 2. To improve the SIL rating, the installation would need to be expanded to include at least one more sensor, making the system a 2-out-of-2 voting system. This would also increase the accuracy of measurement and prevent any spurious heater shutdowns. If accuracy-based issues did occur and persist, pressure compensation could be added alongside the temperature compensation. However, there are no nearby loops to modify, as there was for the temperature compensation, so a new install would be required.

A series of unforeseen events caused delays to the design and installation phases, which ultimately means that the installation is yet to be completed. Some materials had a shorter lead time and could be installed, focusing mainly on the cabling installed by an electrical contracting company, whereas the desired temperature transmitter was readily available. Following receipt of the remaining materials, it is crucial to maintain the progress being made to ensure the installation is completed in the shortest time possible and the system can be commissioned to improve the safe running of the heater. The delays and changes have been reflected in the Gantt chart to allow a new completion data to be selected. The completion percentage of the project is calculated at 62%.

Both the PLC and DCS modifications could be made following approval of the requested changes. The DCS modifications were made on the designated PC within the Control Engineering department and the PLC modifications were made on a home desktop PC, due to access restrictions. Due to the incomplete nature of the project, the testing could be carried out via simulation, but this is not a substitute for extensive practical testing. Therefore, the testing table will still be required. Additionally, the preventative maintenance testing procedure will be followed during the scheduled tests at a regular interval.

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This is a very small range of sources for a level 6 project that has informed your design process

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9 Appendix

9.1 Updated Functional Design Specification, Costing Spreadsheet and Plan

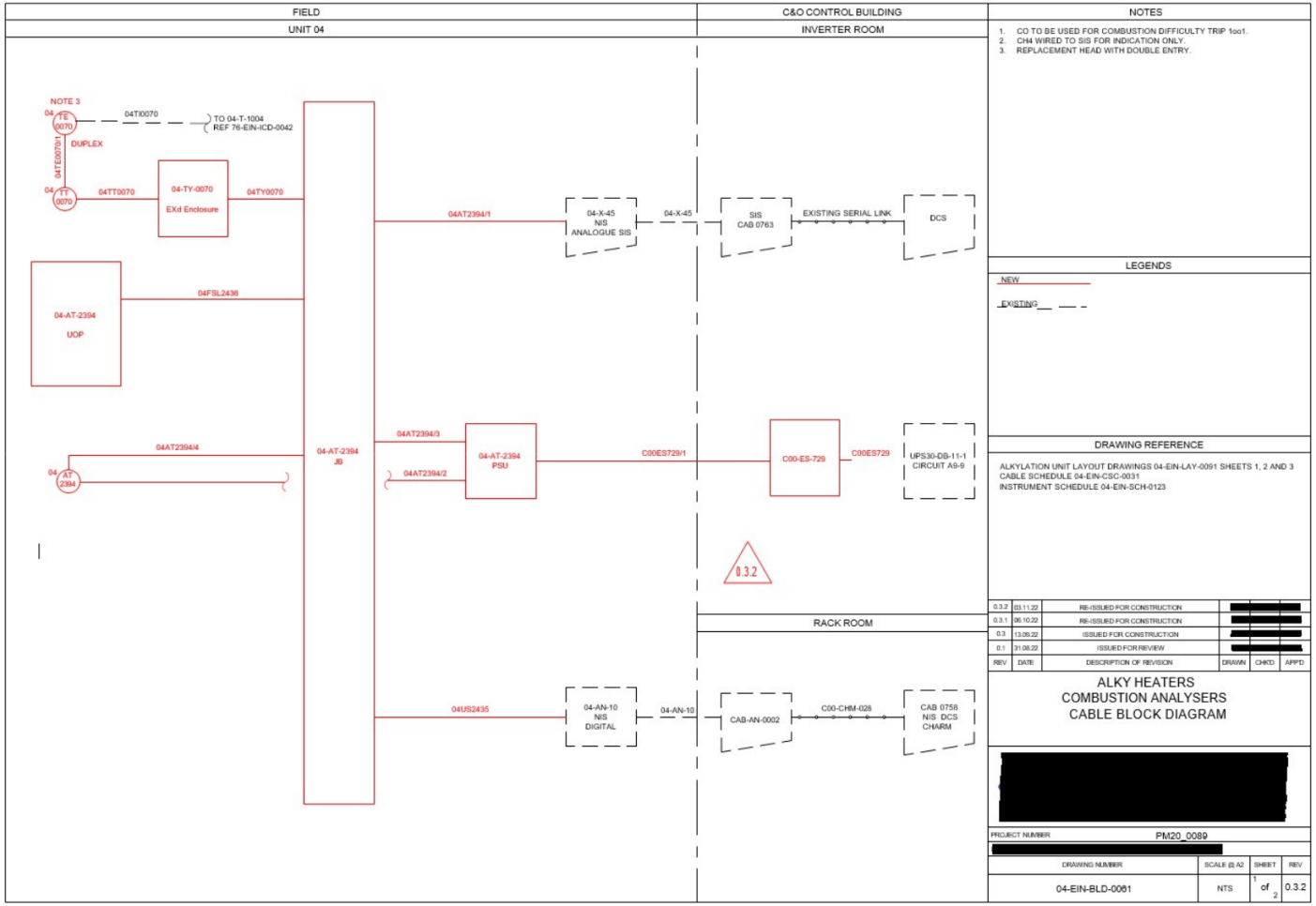
Item Number	Description	Specification
1	Cost	Cost must be within £250,000 budget.
2	Completion Date	Project must be completed by the end of Q3 2023.
3	Analyser Measurement and Output	Sensor must be able to measure CH_4 and CO. CO measurement range: 0-10000 PPM. CH_4 measurement range: 0-5%. 4mA output indicates 0PPM / 0%. 20mA output indicates 10000PPM / 5%. Analyser's response must be linear.
4	Analyser Mounting and Location	Sensor must be flange mounted on the heater's convection section. Flanges and bolting must comply with ASME B16.5.
5	Analyser Power Requirement	Sensor must be 24VDC.
6	Analyser Output Standard	The 4-20mA output must comply with NAMUR NE43, i.e., sensor fault when mA is below 3.6mA or above 21mA for more than 4 seconds.
7	Analyser Capabilities	Sensor must be HART capable.
8	Analyser Interfacing	Sensor must have a local HMI to display diagnostic information.
9	Utility Panel Compatibility	Panel must be installed and have the capability to switch between an air purge, and validation gas. The purge air will be used to keep any possible lenses or reflectors inside the sensor clean. Validation gas will be used to prove operability of the sensor. Panel must have correct fittings to allow for gas cylinder connection.
10	Utility Panel Construction	Panel must use Swagelok tubing, fittings, pressure gauges and flow indicators with low flow switches.
11	Utility Panel Interfacing	Low flow switches must be connected to the sensor, via an interface box, and generate a low flow alarm on the HMI.
12	Utility Panel Location	Panel must be located on heater platform, with validation pipework running down to grade to allow for safe gas cylinder replacement.
13	Power Supply Requirements	110VAC to 24VDC power supply must be installed.
14	Power Supply Location	Power supplies must be installed within Ex d enclosure in the field.
15	Power Supply Isolation	Ex d enclosure will have external isolator.
16	Power Supply Failure	Second power supply to be installed in enclosure to allow for dual redundancy. Power supply failure to generate failure alarm on local HMI.
17	Cable Installation	Steel wire armour cables must be installed in cable tray above ground. Wiring inside enclosures must conform to BS 7671.

28	ATEX Rating	Components must have a minimum ATEX rating of Zone 2, Gas Group IIC and Temperature Class T3 - as indicated on hazardous area drawing and as per BS EN 60079. Any enclosures must have a minimum IP rating of 65, as per BS EN 60529
19	Sensor SIL Rating	Sensor must be SIL 2 rated, as per BS EN 61508.
20	PLC Modifications	PLC program must be modified to introduce analogue inputs and digital outputs. Process readings and alarms will be communicated to Delta V Distributed Control System (DCS) via serial link (RS 232).
21 *	PLC Output Operability	PLC must close both fuel gas XVs upon detection of high CO. Trip Value is 1500PPM
22	DCS Display Modifications	DCS screens must be modified to include real-time process readings, on the heater screen, and alarms.
23	DCS Alarm Configuration	Common fault alarm generated on Delta V when any alarm is activated on the HMI. Transmitter fault alarm generated on Delta V when output mA is outside of the 4-20mA range.
24 **	Temperature Measurement	04-TI-0070 temperature loop must be modified to allow compensation in the analyser head through the installation of a Rosemount 644 temperature transmitter and necessary cabling in the loop, rather than the thermocouple connecting to a DCS multiplexer. Transmitter must be mounted separately from the thermocouple, with K-type compensating cable between the transmitter and the thermocouple.
25 **	Temperature Transmitter Configuration	Temperature transmitter's probe type must be set to a K-type thermocouple. Temperature transmitter's configured range must be 0-1300°C. Temperature transmitter's response must be linear. Temperature transmitter must be 24V.
26 **	DCS CHARM	Delta V CHARM installed for fault alarm must be a digital input type. Delta V CHARM must be connected for loop powering, not external powering.

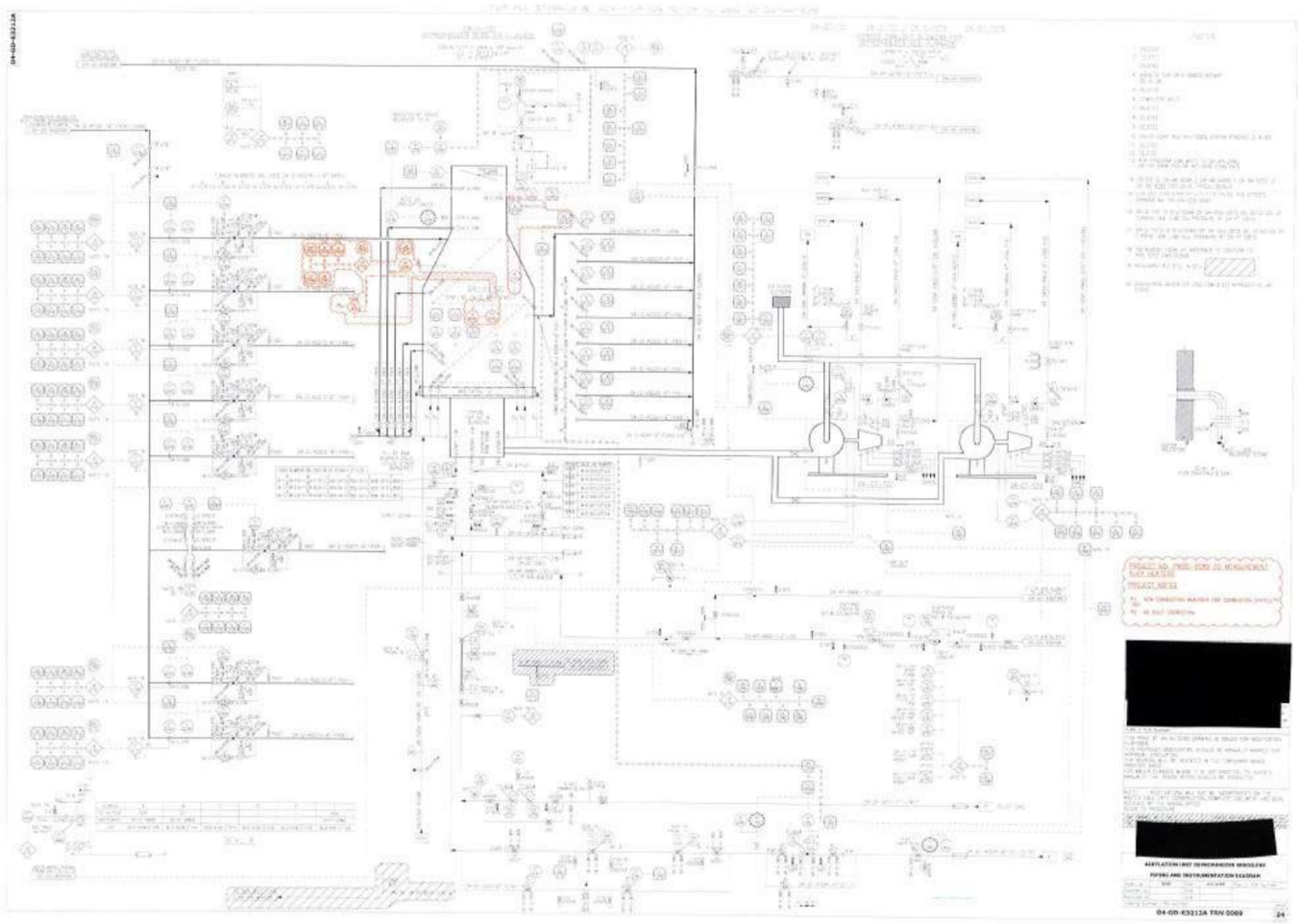
Appendix Table 1 – Updated FDS

- * - Updated item
- ** - New item

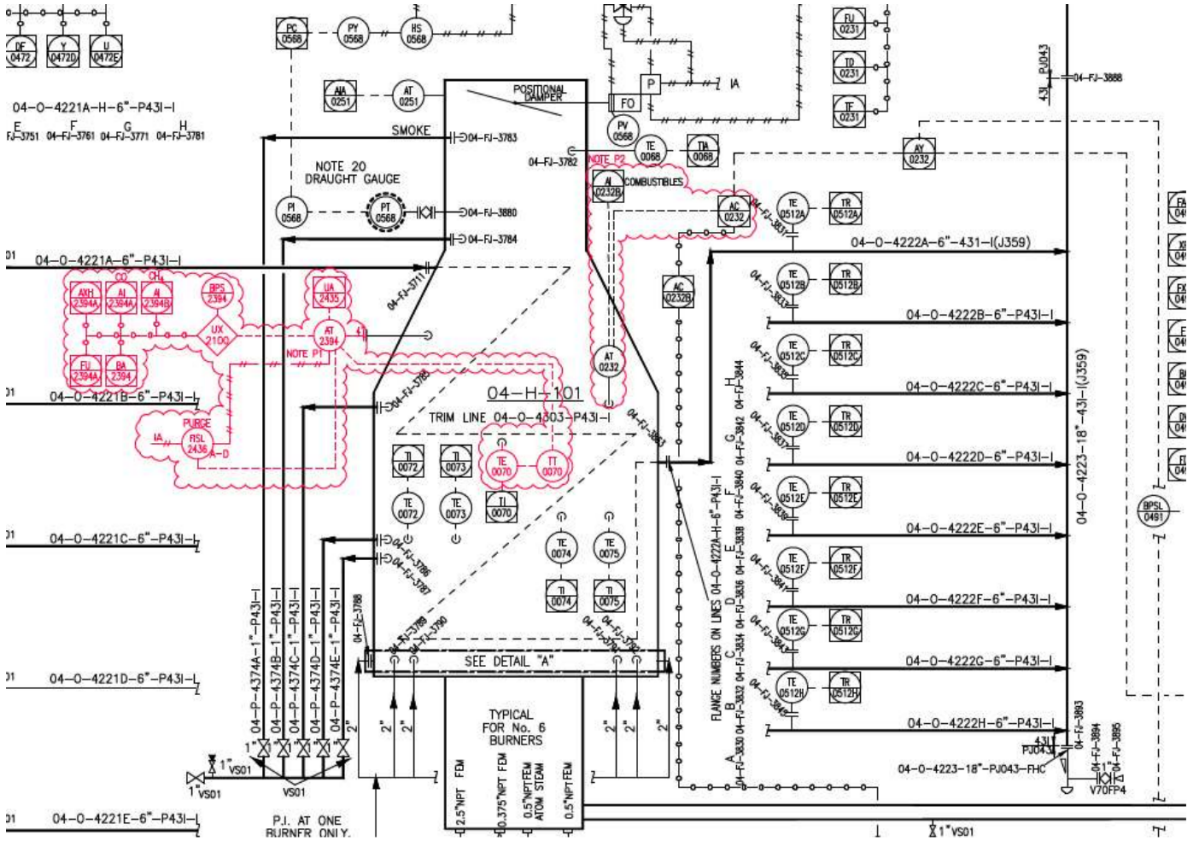
9.2 Drawings, Data Sheets and Schedules



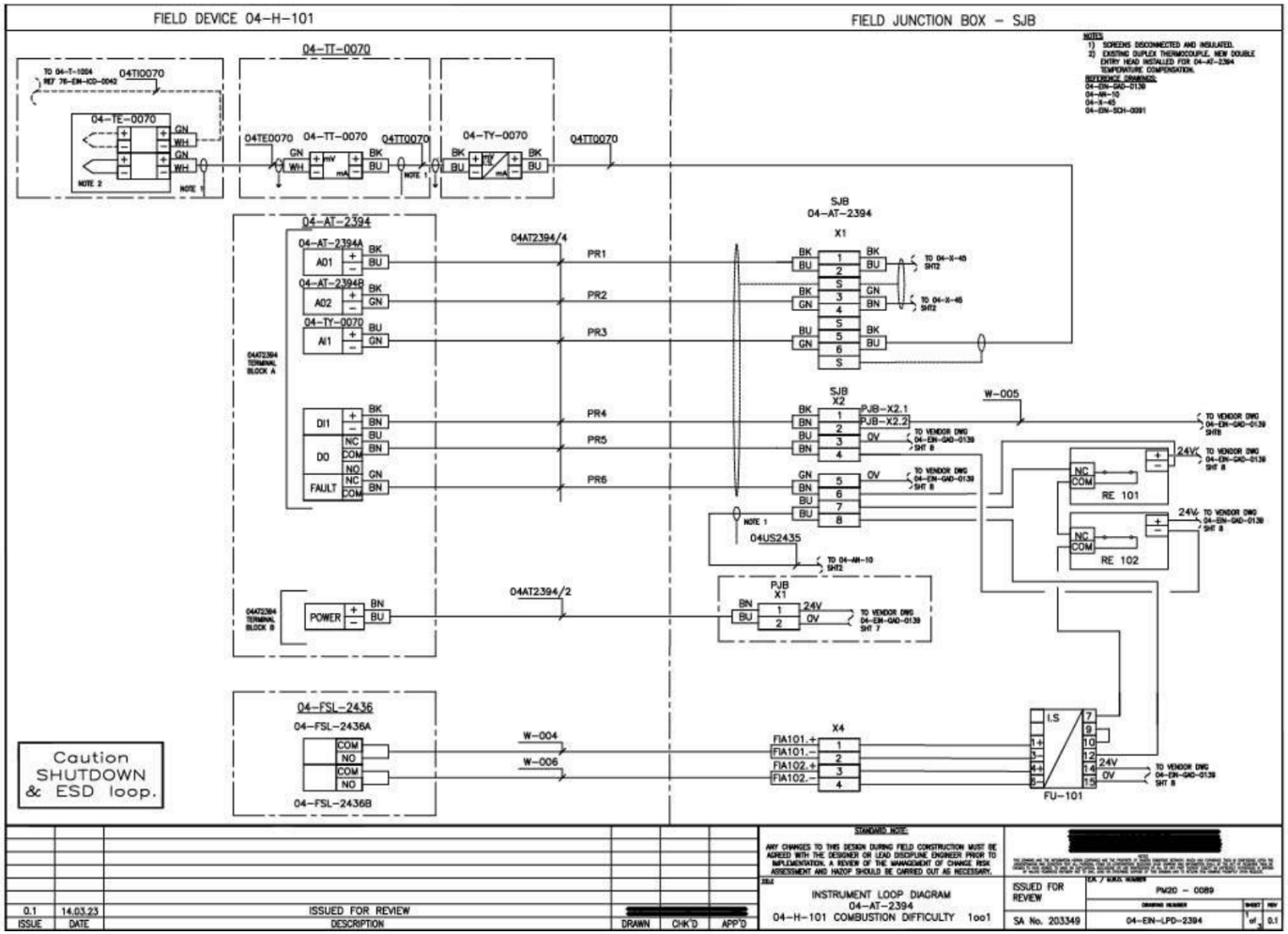
Appendix Figure 1 – Block Diagram



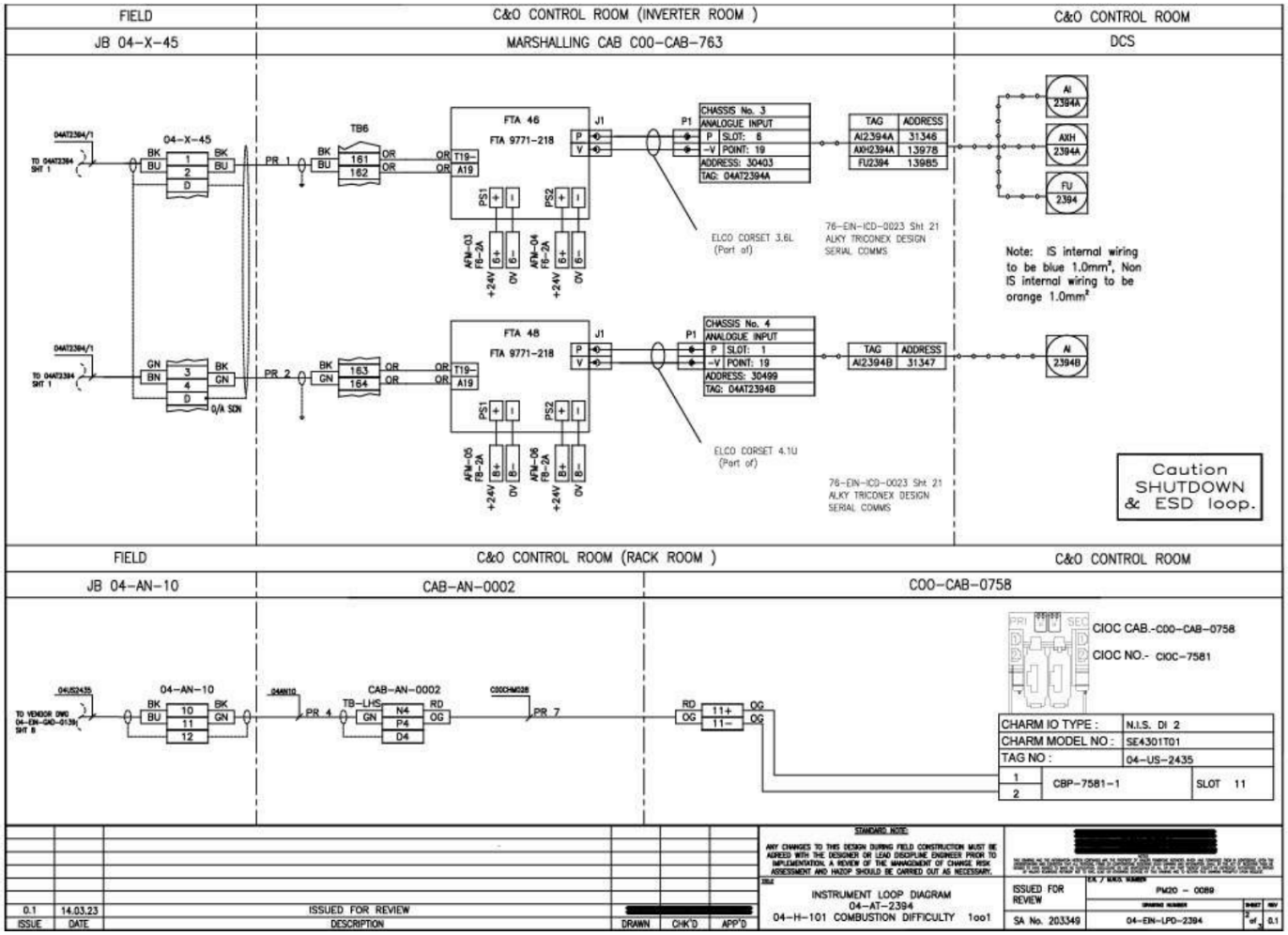
Appendix Figure 2 – P&ID



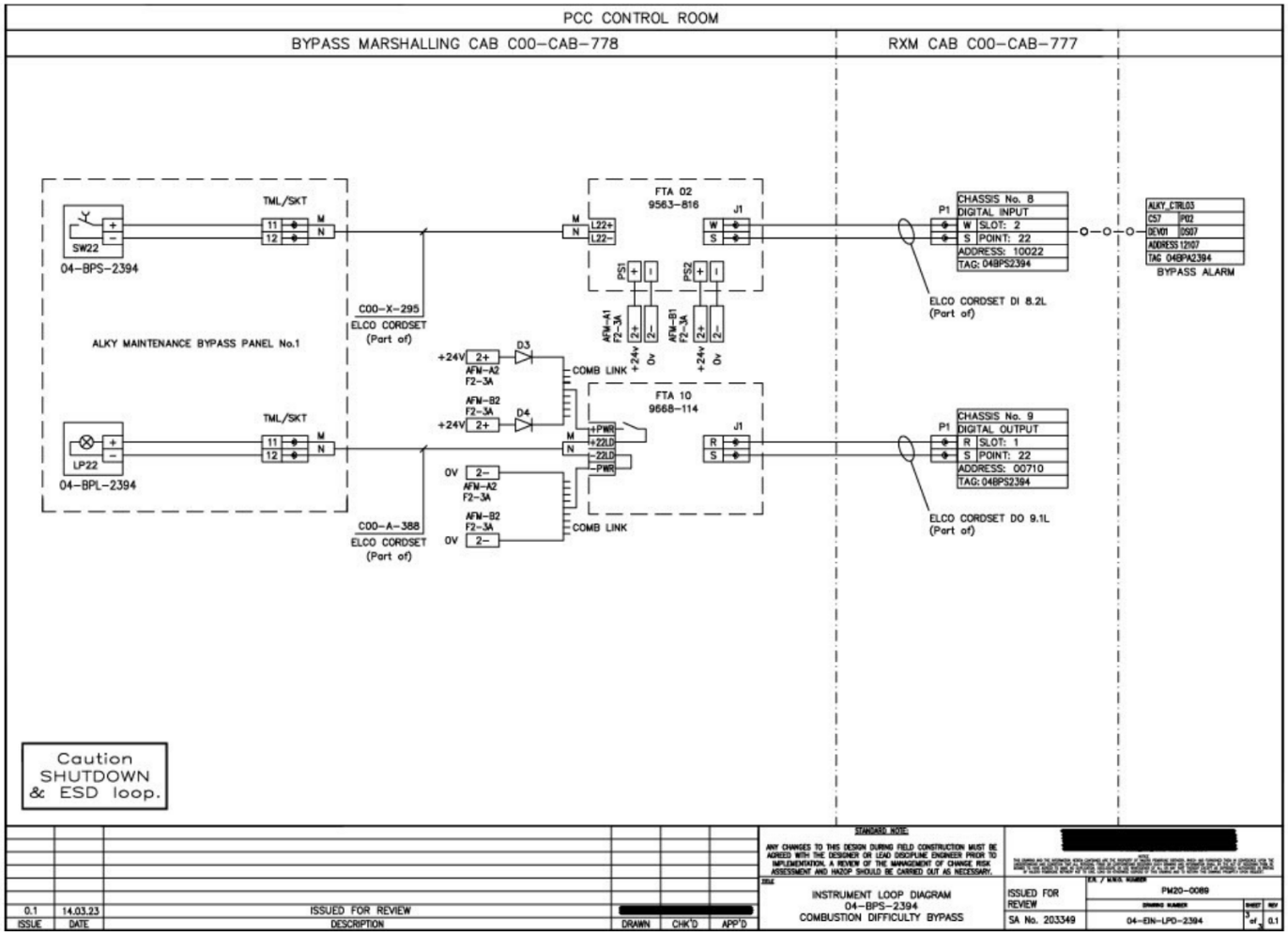
Appendix Figure 3 – P&ID Close-up



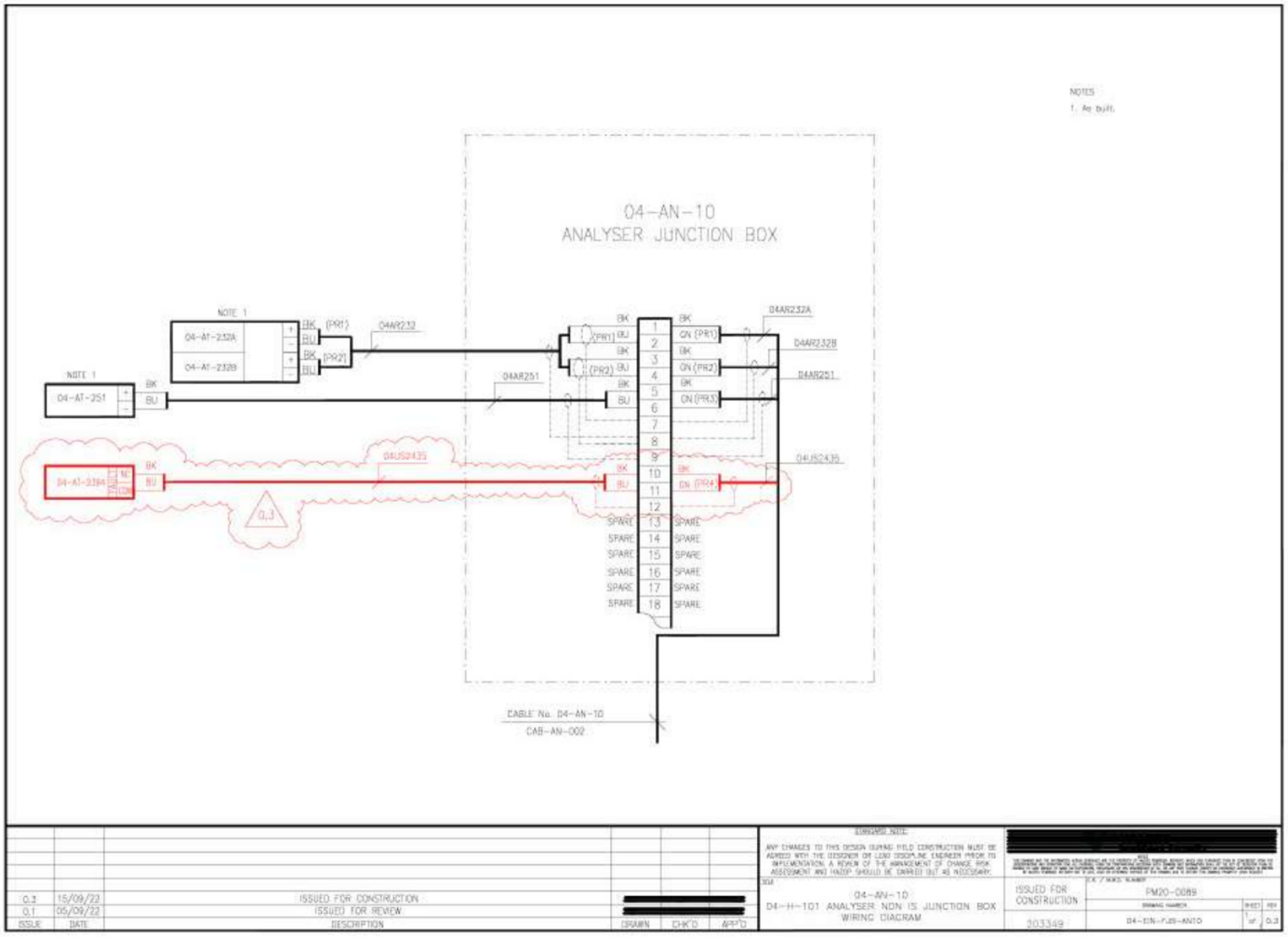
Appendix Figure 4 – Analyser Loop Diagram, Field Side



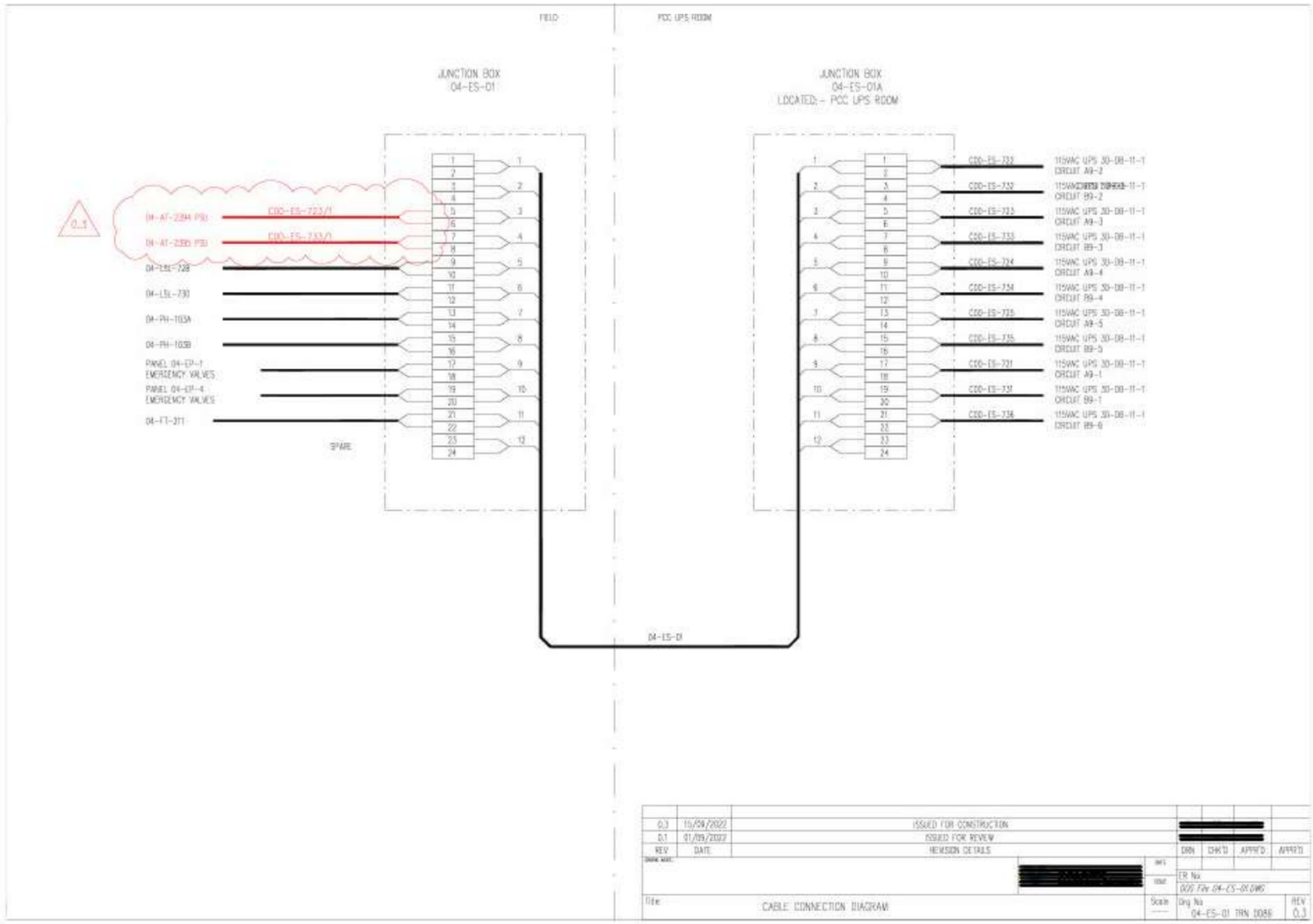
Appendix Figure 5 – Analyser Loop Diagram, PLC & DCS Side



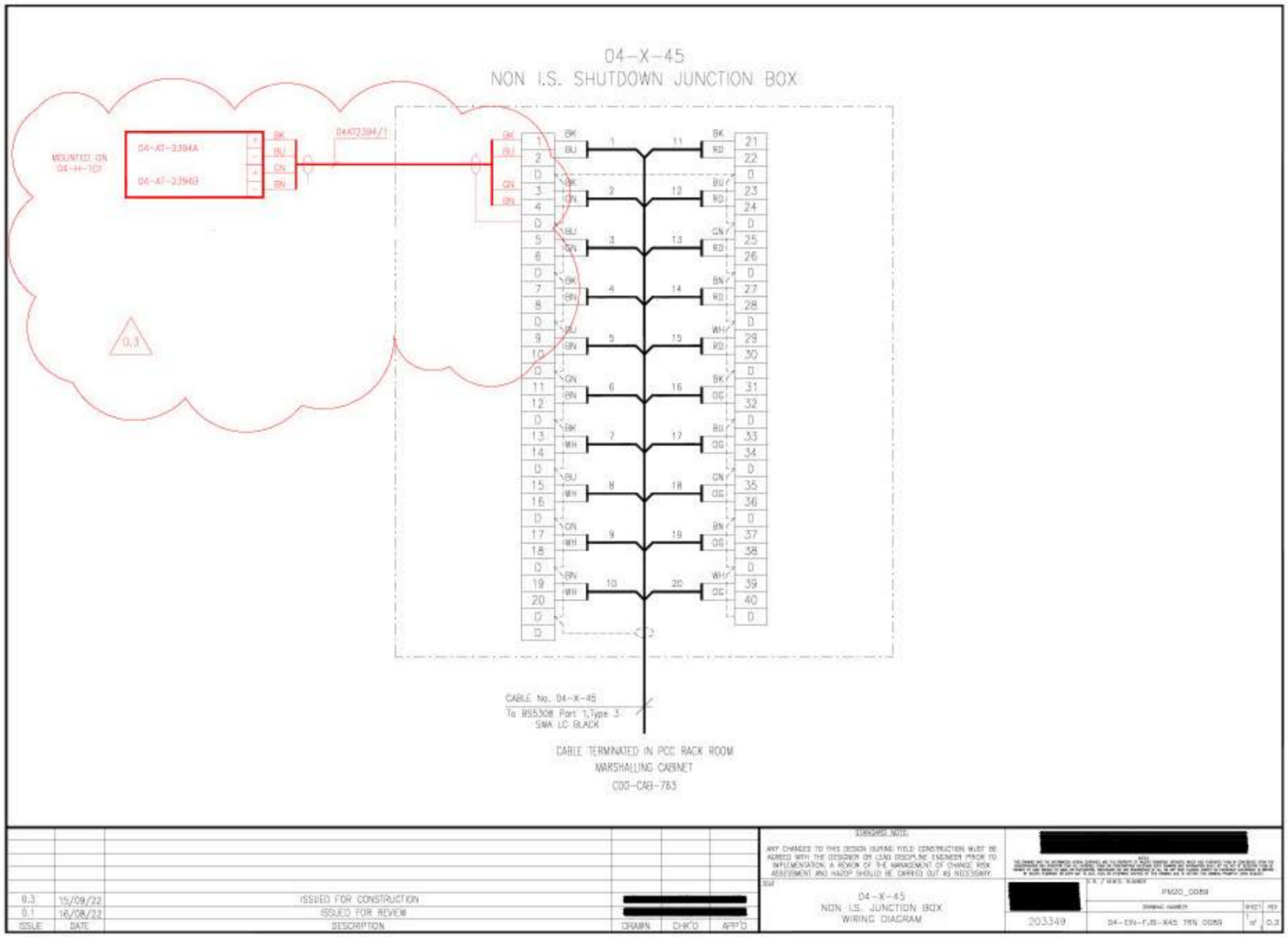
Appendix Figure 6 – Bypass Switch Loop Diagram



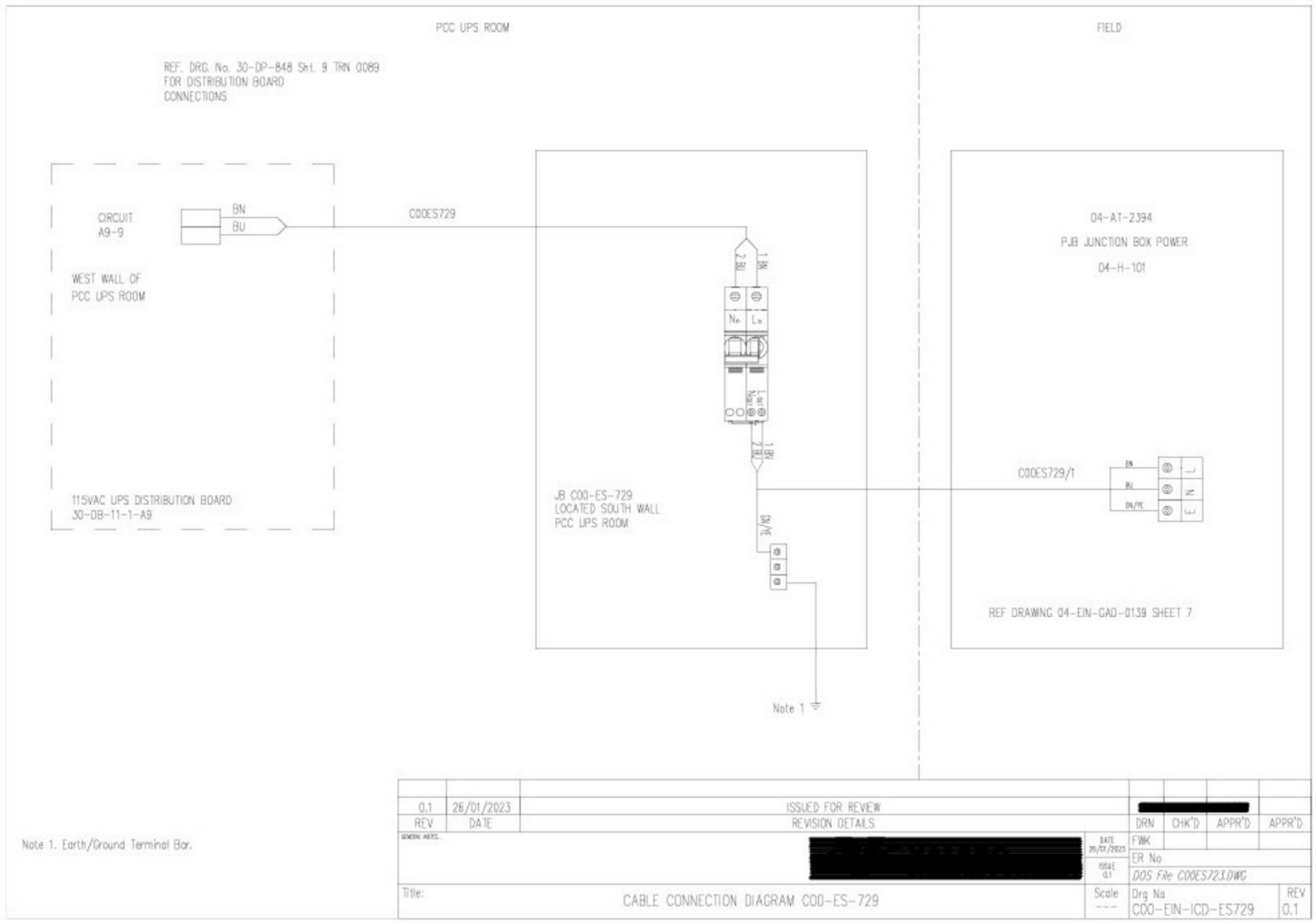
Appendix Figure 7 – 04-AN-10 Junction Box Drawing



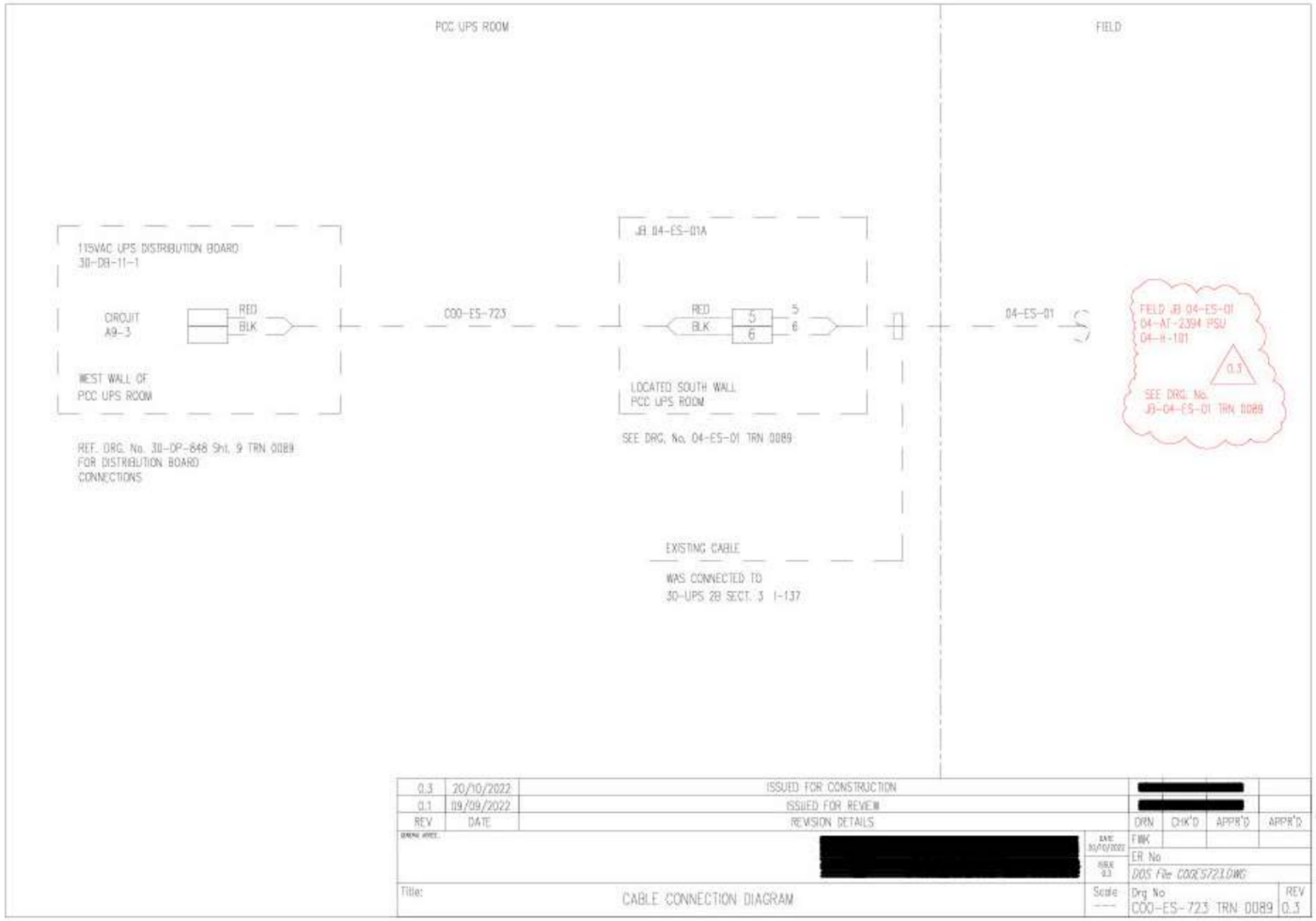
Appendix Figure 8 – 04-ES-01 Junction Box Drawing



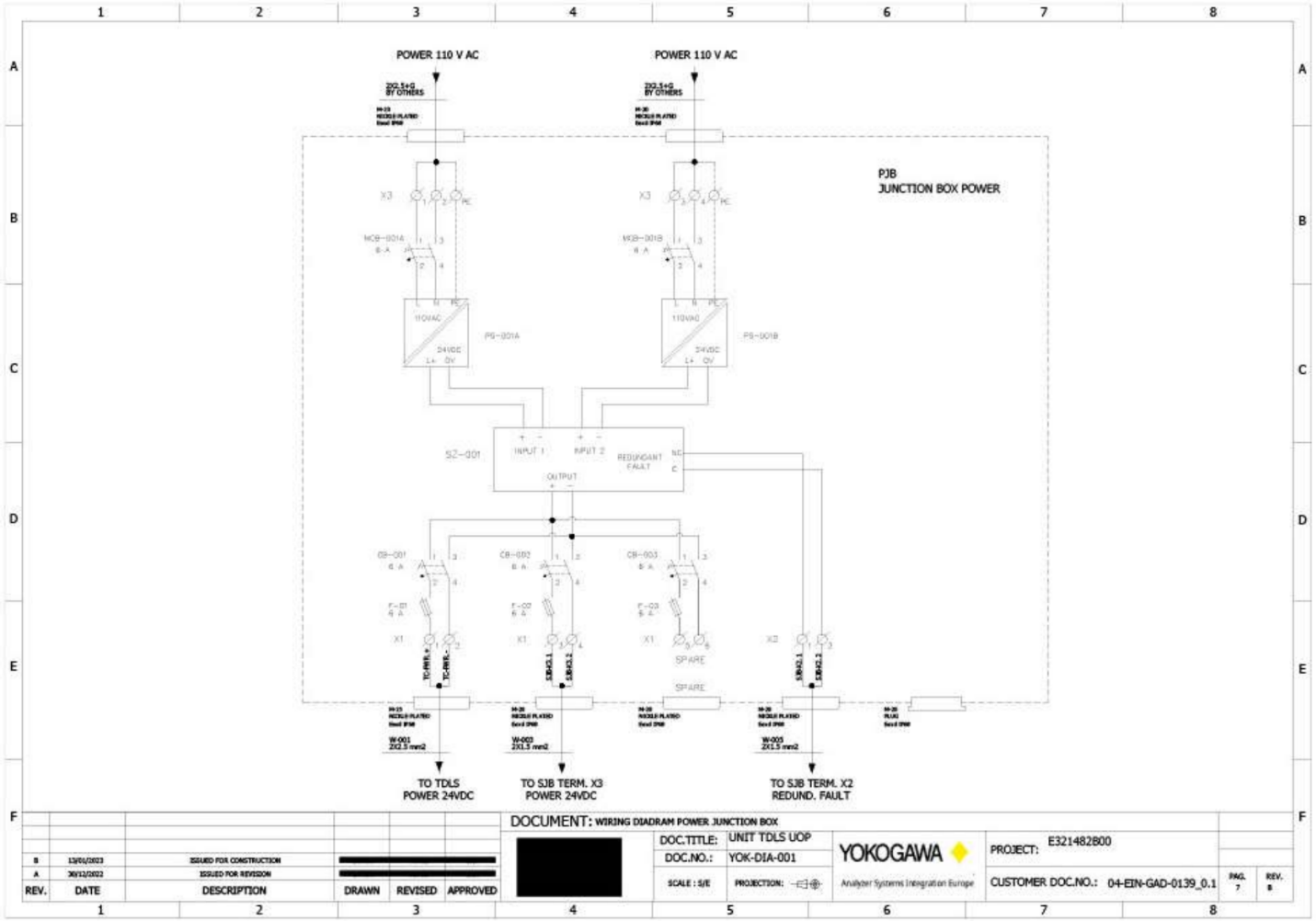
Appendix Figure 9 – 04-X-45 Junction Box Drawing



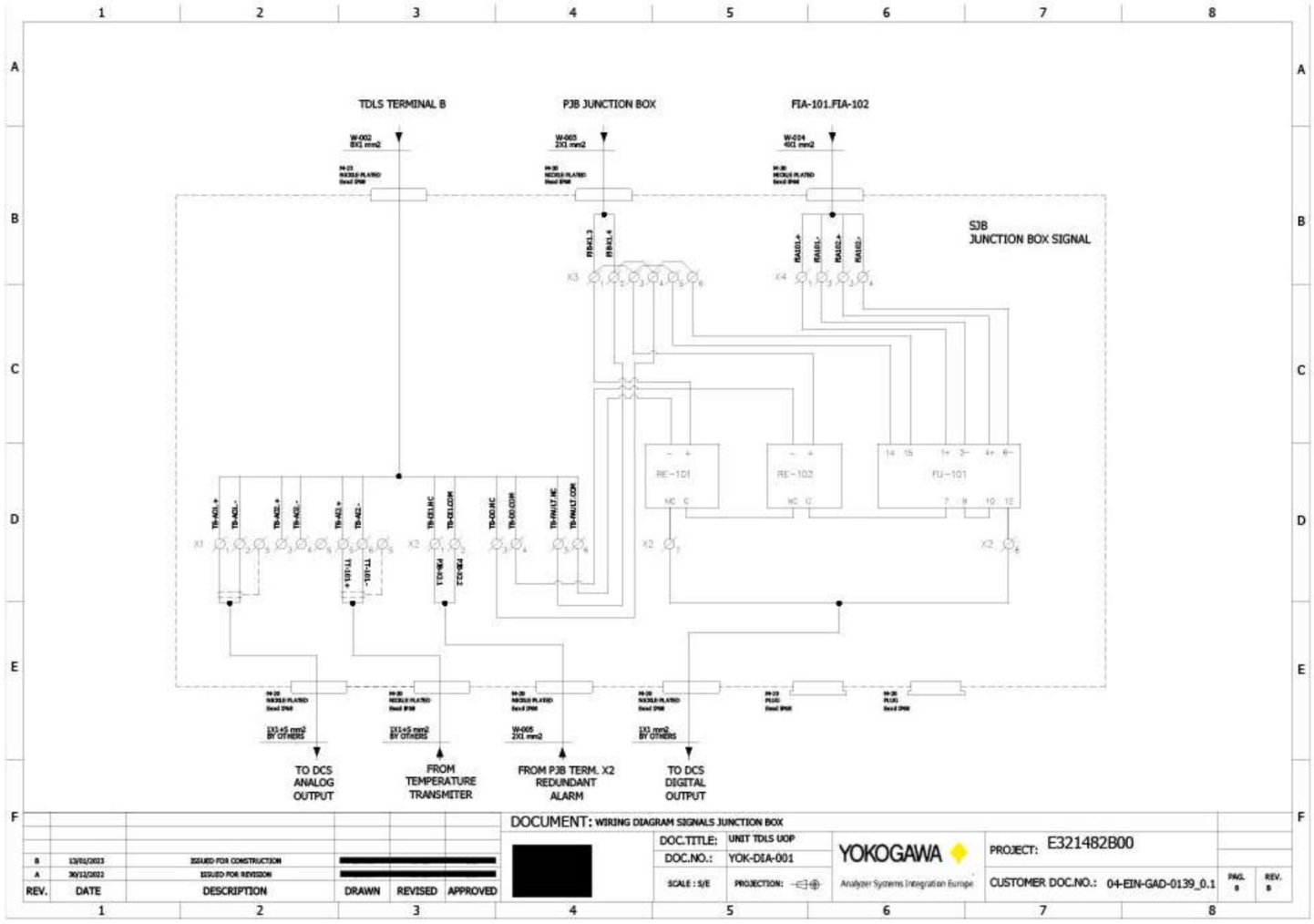
Appendix Figure 10 – C00-ES-729 Connection Diagram



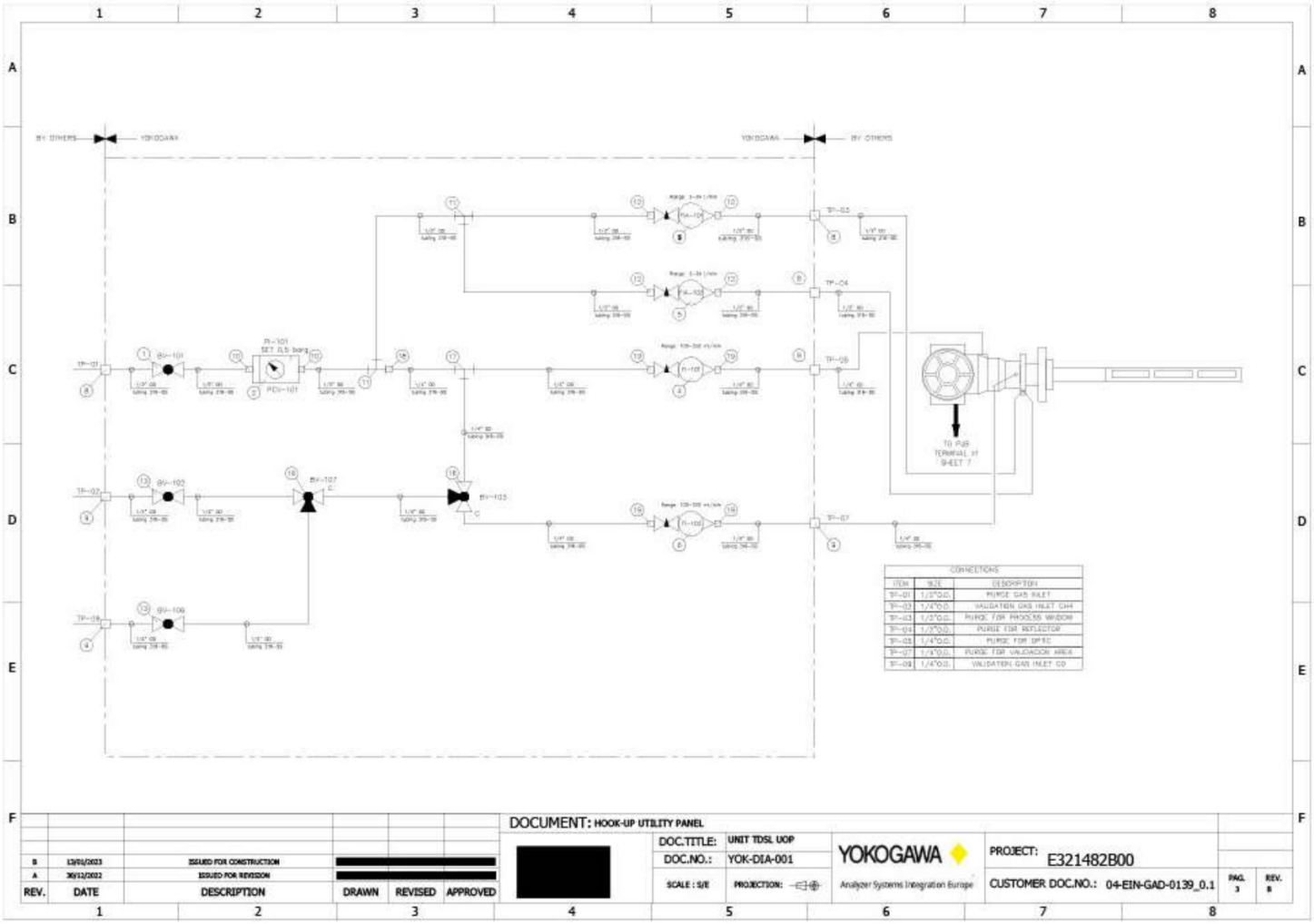
Appendix Figure 11 – C00-ES-723 Connection Diagram



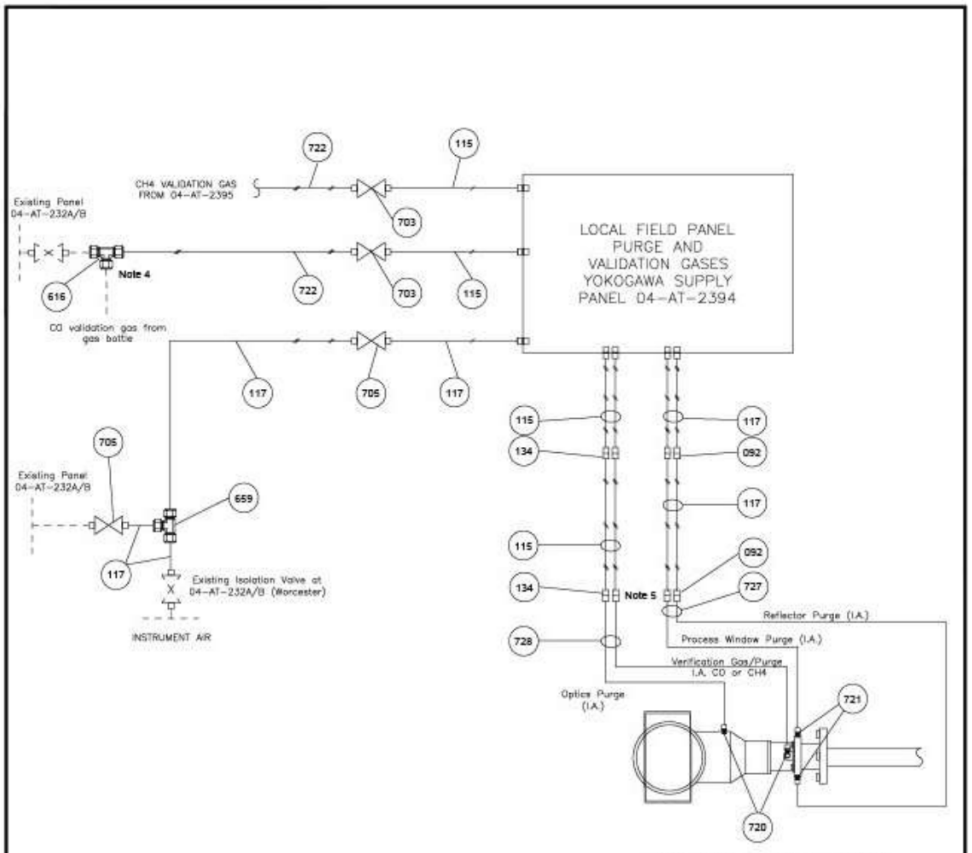
Appendix Figure 12 – Manufacturer Power Junction Box Drawing



Appendix Figure 13 – Manufacturer Signal Junction Box Drawing



Appendix Figure 14 – Manufacturer Hook-up Drawing



NOTES:

1. DASHED ITEMS ARE EXISTING EQUIPMENT
2. MAXIMUM LENGTHS OF TUBE TO BE USED TO MINIMISE THE USE OF UNIONS
3. BULKHEAD FITTINGS ARE SUPPLIED WITH THE PANEL
4. NEW ¼" O.D. EQUAL TEE COMPRESSION FITTING TO BE FITTED BEFORE EXISTING ISOLATION VALVE FOR CO AT PANEL 04-AT-232A/B
5. UNION CONNECTIONS TO LAND <100mm FROM 04-AT-2394, ENSURING PURGE IS APPLIED DURING INSTALLATION.

ITEM	QTY	PART No.	DESCRIPTION
727	2		1/2"O/D x 1/2"O/D FLEXIBLE HOSE 74" LONG SWAGELOK
728	2		1/4"O/D x 1/4"O/D FLEXIBLE HOSE 74" LONG SWAGELOK
722	COIL	ON 0139	1/4"O/D x 0.035" WT PVC/316-SS SWAGELOK SS-JT-4-S-035-250
721	2		1/2"O/D x 1/4"BSPT(M) STUD COUPLING SWAGELOC SS-810-1-4RT
720	2		1/4"O/D x 1/4"BSPT(M) STUD COUPLING SWAGELOC SS-400-1-4RT
705	2		BALL VALVE SWAGELOK TYPE SS-63TS8 1/2" OD CONNECTIONS
703	2		BALL VALVE SWAGELOK TYPE SS-62TS4 1/4" OD CONNECTIONS
659	1		1/2"O/D EQUAL TEE COMPRESSION FTG. 316-SS SWAGELOK SS-810-3
616	1		1/4"O/D EQUAL TEE COMPRESSION FTG. 316-SS SWAGELOK SS-400-3
134	4		UNION STRAIGHT COUPLING 1/4" OD - 316-SS
117	24		TUBE 1/2" OD x 0.062 WT - 316 SS
115	24		TUBE 1/4" OD x 0.035 WT - 316 SS
092	4		UNION STRAIGHT COUPLING 1/2" OD - 316-SS

BILL OF MATERIALS

1	04-AT-2394	
2		
3		

INSTRUMENT TAG NUMBERS

REV	DATE	DESCRIPTION	DRAWN	CHKD	APPD
0.3	11/11/02	ISSUED FOR CONSTRUCTION	[redacted]		
0.1	12/10/02	ISSUED FOR REVIEW	[redacted]		

TITLE: PNEUMATIC HOOK UP LOCAL PANEL 04-AT-2394

[redacted]

B.A. No. 203349

UNIT	DISCIPLINE	DOCUMENT	SEQUENTIAL	SHEET	REV
04	EIN	HUD	0138	1 of 1	0.3

Appendix Figure 15 – Pneumatic Hook-up Drawing

Process data					
Location	04-H-101				
Process	Depropaniser Reboiler Combustion Box				
Parameter	**Units**	**Minimum**	**Normal**	**Maximum**	**Design**
Flowrate	Am³/h		635 (L) / 5244 (V)	762 (L) / 6293 (V)	
Process pressure	Kg/cm² g		19	19	29
Process temperature	°C		180	180	205
Operating density	kg/m³		498 (L) / 49.5 (V)	498 (L) / 49.5 (V)	
Fluid velocity	m/s		1.2 (L) / 9.8 (V)	1.4 (L) / 11.8 (V)	
Fluid viscosity	cP		0.098(L) / 0.012 (V)	0.098 (L) / 0.012 (V)	
Mol Weight	gm/mol		76		
Corrosive Properties	HF Acid				
Field instruments					
Tag number	04-AT-2394	04-TT-0070	04-TE-0070		
Instrument type	TDLS	Temperature Transmitter	Thermocouple		
Function	Indication / ESD	Indication	Indication		
Location	04-H-101 Top Platform		04-H-101 Skin Point		
Type	Electronic (HART)		Type K		
Diameter / Length	1500mm	-	6mm / 437mm		
Sheath material	Alloy 800	-	316SS		
Process connections	4" 150 ANSI	-	Welded		
Instrument Range		-	-270 to 1372°C		
Calibrated range	0 – 10,000 PPM (CO) 0 – 5 % (CH_4)	4 to 20mA (HART)	0 - 1300°C		
Signal	mA	mA	mV		
Manufacturer	Yokogowa	Emerson	Wika		
Model / part number	TDLS8100-S1-L-C4-NN-150-Z-U4-A1-N-N/RC/AP3/Z	644SAI1WR5A1Q4QT DCHR7	TC12-B		
Certification	Ex d	Dual Certified Ex d / Ex ia			
ATEX certificate		Baseefa12ATEX101X	TUV10ATEX555973X		

Input / outputs					
System	04-UX-2100				
I/O type	Analogue input				
Chassis	13				
Slot	19				
Sub slot	18				
Address	311010				
Interface					
Type	I.S barrier				
Location	C00-CAB-763				
Position	FTA-1302L / 02				
Manufacturer	MTL				
Model	4541				
Certification	Ex ia IIC				
ATEX certificate	Baseefa 06ATEX0156				
Delta V Module					
Tag name	04AI2394A	04AI2394B	04AXH2394A	04UA2345	
Controller	ALKY_CTRL03				
Address	31084	13480	13482	13483	

Notes

Refer to 76-CSE-SPC-0008 Sht 21 & 76-EIN-ICD-0023 Sht 21 for Serial Link Data.

Rev 3.0 –As Built to PM18-0288

Loop Components: 04-AT-2394, 04-TE-0070, 04-TT-0070, 04AI02394A, 04AI02394B, 04AXH2394, 04UA2345, 04-BPSL-02394, 04BPA2394			
Service:	Depropaniser Reboiler Combustion Box		Rev: 3.0
Process Data:	Comp'd By: [redacted]	App'd By: [redacted]	04-EIN-DTS-2394
Instrument Data:	Comp'd By:	App'd By:	
P&ID No.: 04-GD-83212A	Date: 15.11.2022	Page 1 of 2	

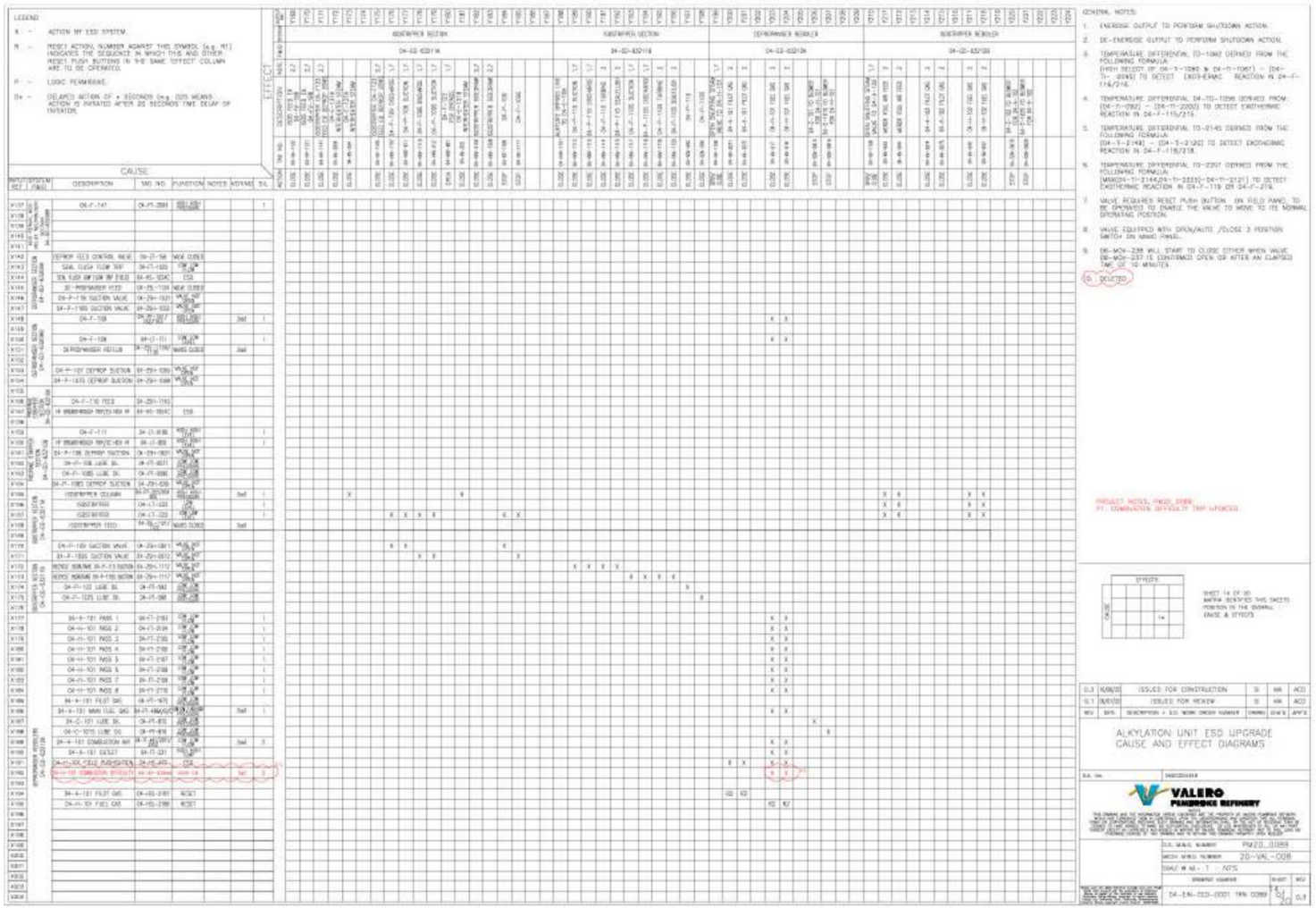
Appendix Figure 16 – Data Sheet, Sheet 1

Field instruments					
Tag number	04-BPSL-0231				
Instrument type	Illuminated Changeover Switch				
Function	Bypass Switch	Bypass Indication			
Location	BPS Panel Section 1				
Type	2-position	White LED			
Body material	--	--			
Head material	--	--			
Diameter	--	--			
Sheath material	--	--			
Process connections	--	--			
U length	--	--			
Measurement range	--	--			
Calibrated range	--	--			
Signal	--	--			
Grounded/ ungrounded	--	--			
Failure action	Maintained Stayput				
Manufacturer	Allen-Bradley				
Model / part number	800FP-LSM2*				
Certification	--	--			
ATEX certificate	--	--			
Input / outputs					
System	04-UX-2100				
Tag name	04BPS2394	04BPL2394			
LCN node	--	--			
Process network	--	--			
I/O type	Digital input	Digital output			
Chassis	8	9			
Slot	2	1			
Point	13	13			
Address	10013	00701			
Interface					
Type	FTA	FTA			
Location	C00-CAB-778	C00-CAB-778			
Position	13	13			
Manufacturer	Honeywell	Honeywell			
Model	9563-816	9668-114			
ATEX certificate	n/a	n/a			

Delta V Module					
Tag name	04BPA2394				
Controller	ALKY_CTRL03				
Address	12080				

Loop Components: 04-AT-2394, 04-TE-0070, 04-TT-0070, 04AI02394A, 04AI02394B, 04AXH2394, 04UA2345, 04-BPSL-02394, 04BPA2394			
Service:	Depropaniser Reboiler Combustion Box		Rev: 3.0
Process Data:	Comp'd By: [redacted]	App'd By: [redacted]	04-EIN-DTS-2394
Instrument Data:	Comp'd By: [redacted]	App'd By: [redacted]	
P&ID No.: 04-GO-83212A	Date: 15.11.2022	Page 2 of 2	

Appendix Figure 17 – Data Sheet, Sheet 2



Appendix Figure 18 – Cause & Effect Diagram

Cable Details		
Cable Number	Cable Specification	Length (m)
04AT2394/1	2 pair x 1.5mm² SWA with black PVC outer sheathInstrument Cable non IS toBS5308 Part 1 Type 2	100
04AT2394/2	2 core x 2.5mm² SWA with black PVC outer sheath PowerCable to BS5467	20
04AT2394/3	2 core x 2.5mm² SWA with black PVC outer sheath PowerCable to BS5467	10
04AT2394/4	5 pair x 0.75mm² SWA with black PVC outer sheathInstrument Cable non IS toBS5308 Part 1 Type 2	20
04FSL2436	2 pair x 1.5mm² SWA withBLUE PVC outer sheathInstrument Cable IS to BS5308Part 1 Type 2 O/ALL SCR	10
04TE0070/1	1 pair x 1.3mm² SWA withgreen PVC outer sheath Type KThermocouple CompensatingCable	10
04TT0070	1 pair x 1.5mm² SWA withBLUE PVC outer sheathInstrument Cable IS to BS5308Part 1 Type 2	20
04TY0070	1 pair x 1.5mm² SWA withblack PVC outer sheathInstrument Cable non IS toBS5308 Part 1 Type 2	10
04US2435	1 pair x 1.5mm² SWA withblack PVC outer sheathInstrument Cable non IS toBS5308 Part 1 Type 2	20
C00-ES-729	3C x 4mm XPLE/LSZH/SWABlack PVC outer Sheath PowerCable BS6724	10
C00-ES-729/1	3C x 4mm XPLE/LSZH/SWABlack PVC outer Sheath PowerCable BS6724	350

Cable Source			
Location	Gland	Gland Size	Gland Description
04-AT-2394 Signal JB	ICG653/UNI/O-M20	M20	EEx d/e barrier cablegland for SWA cable
04-AT-2394 PSU JB	ICG653/UNI/O-M20	M20	EEx d/e barrier cablegland for SWA cable
04-AT-2394 PSU JB	ICG653/UNI/O-M20	M20	EEx d/e barrier cablegland for SWA cable
04-AT-2394	ICG653/UNI/O-M25	M25	EEx d/e barrier cablegland for SWA cable
04-AT-2394 UOP	ICG653/UNI/O-M20	M20	EEx d/e barrier cablegland for SWA cable
04-TE-0070	ICG653/UNI/O-M20	M20	EEx d/e barrier cablegland for SWA cable
04-TT-0070	ICG653/UNI/O-M20	M20	EEx d/e barrier cablegland for SWA cable
04-TY-0070	ICG653/UNI/O-M20	M20	EEx d/e barrier cablegland for SWA cable
04-AT-2394 Signal JB	ICG653/UNI/O-M20	M20	EEx d/e barrier cablegland for SWA cable
UPS30-DB-11-1-A9-3	501/453/UNI/A-M20	M20	EEx d/e cable gland forSWA cable
C00-ES-729	501/453/UNI/A-M20	M20	EEx d/e cable gland forSWA cable

Cable Destination			
Location	Gland	Gland Size	Gland Description
04-X-45	ICG653/UNI/O-M20	M20	EEx d/e barrier cablegland for SWA cable
04-AT-2394	ICG653/UNI/O-M20	M20	EEx d/e barrier cablegland for SWA cable
04-AT-2394 Signal JB	ICG653/UNI/O-M20	M20	EEx d/e barrier cablegland for SWA cable
04-AT-2394 Signal JB	ICG653/UNI/O-M25	M25	EEx d/e barrier cablegland for SWA cable
04-AT-2394 Signal JB	ICG653/UNI/O-M20	M20	EEx d/e barrier cablegland for SWA cable
04-TT-0070	ICG653/UNI/O-M20	M20	EEx d/e barrier cablegland for SWA cable
04-TY-0070	ICG653/UNI/O-M20	M20	EEx d/e barrier cablegland for SWA cable
04-AT-2394 Signal JB	ICG653/UNI/O-M20	M20	EEx d/e barrier cablegland for SWA cable
04-AN-10	ICG653/UNI/O-M20	M20	EEx d/e barrier cablegland for SWA cable
C00-ES-729	501/453/UNI/A-M20	M20	EEx d/e cable gland forSWA cable
04-AT-2394 PSU JB	501/453/UNI/A-M20	M20	EEx d/e cable gland forSWA cable

ISSUE	DATE	DESCRIPTION	DRAWN	CHK'D	APP'D
0.1.2	04/11/2022	ISSUED FOR CONSTRUCTION	[redacted]	[redacted]	[redacted]
0.1.1	07/10/2022	ISSUED FOR CONSTRUCTION	[redacted]	[redacted]	[redacted]
0.1	16/09/2022	ISSUED FOR CONSTRUCTION	[redacted]	[redacted]	[redacted]

STANDARD NOTE:
ANY CHANGES TO THIS DESIGN DURING FIELD CONSTRUCTION MUST BE AGREED WITH THE DESIGNER OR LEAD DISCIPLINE ENGINEER PRIOR TO IMPLEMENTATION. A REVIEW OF THE MANAGEMENT OF CHANGE RISK ASSESMENT AND HAZOP

[redacted]

CO MEASUREMENT, ALKY HEATER CABLE SCHEDULE

04-AT-2394

ISSUED FOR REVIEW

PM20-0089

DRAWING NUMBER	REV
04-EIN-CSC-0031	0.1.2

Appendix Figure 19 – Cable Schedule

ID	Field Tag Existing	Field Tag New (DST)	Signal Type	Field Cable No.	Field Cable Pair	Cabinet Reference	Inter Cab Cable No	Inter Cab Cable Pair	TB Rail	CIOC No.	CHARMS Backplane No.	CHARMS Slot No.	Charm Positive Connection	Charm Negative Connection	Comments	Revision	Checked
2201	08-AT-221	08-AT-0221	N.I.S. AI 4 wire	08-AN-221	PR1	C00-AN-002	C00-CHM-028	PR13	TBD	CIOC7581	CBP7581-1	1	2	4	Added field cable details.	B3	
2331	04-AR-1982	04-AR-1982	N.I.S. AI 4 wire	00-AN-1982	PR1	C00-AN-002	C00-CHM-028	PR11	06-AN-3 18/19	CIOC7581	CBP7581-1	2	2	4	Added field cable details.	B3	
2332	04-AR-1983	04-AR-1983	N.I.S. AI 4 wire	00-AN-1983	PR1	C00-AN-002	C00-CHM-028	PR12	06-AN-3 42/43	CIOC7581	CBP7581-1	3	2	4	Added field cable details.	B3	
2431	04-AT-251	04-AT-0251	N.I.S. AI 4 wire	04-AN-10	PR3	C00-AN-002	C00-CHM-028	PR9	Above TB2 (RHS) P3/N3	CIOC7581	CBP7581-1	4	2	4		B2	
1654	04-AT-253	04-AT-0253	N.I.S. AI 4 wire	04-AN-11	PR3	C00-AN-002	C00-CHM-028	PR10	Above TB2 (RHS) P8/N8	CIOC7581	CBP7581-1	5	2	4		B2	
1009	02-PT-4041	02-PT-4041	N.I.S. AI 4 wire	02-EX-10	PR3	C00-CAB-782	C00-CHM-019	PR3	TBD	CIOC7581	CBP7581-1	6	2	4	Added inter cab cable details.	B3	
1990	02-AT-1271	02-AT-1271	N.I.S. AI 4 wire	07-E-9	PR7	C00-AN-001	C00-CHM-025	PR1	TB-D (RHS)	CIOC7581	CBP7581-1	7	2	4	ILS-1012 moved from CBP220R1-4-8	B3	
999	02-AT-2614	02-AT-2614	N.I.S. AI 4 wire	C00-E-46	PR2	C00-AN-001	C00-CHM-025	PR2	Next to MTL-2442	CIOC7581	CBP7581-1	8	2	4	ILS-1012 and ILS-2069 moved from CBP103F1-3-9	B3	
N/A	SPARE	SPARE								CIOC7581	CBP7581-1	9	2	4		B2	
2236	16-AT-430	16-AT-0430	N.I.S. AI 4 wire	16-AN-430	PR1	C00-AN-001	C00-CHM-025	PR5	TBD	CIOC7581	CBP7581-1	10	2	4	ILS-2094 added inter cab cable details.	B3	
	04-US-2435	04-US-2435	N.I.S. DI 2 Wire	04-AN-10	PR4	C00-AN-002	C00-CHM-028	PR7	TB1 (RHS) P11/N11	CIOC7581	CBP7581-1	11	1	2	04-AT-2394 Fault and Purge Flow Alarms	0.3	
	04-US-2437	04-US-2437	N.I.S. DI 2 Wire	04-AN-11	PR4	C00-AN-002	C00-CHM-028	PR8	TB1 (RHS) P12/N12	CIOC7581	CBP7581-1	12	1	2	04-AT-2395 Fault and Purge Flow Alarms	0.3	
2099	02-AT-546	02-AT-0546	N.I.S. AI 4 wire	TBD	TBD	C00-AN-001	C00-CHM-025	PR3	TB-D (RHS) 1/2	CIOC7581	CBP7581-2	1	2	4		B2	
2215	06-AT-044	06-AT-0044	N.I.S. AI 2 wire			C00-AN-002	C00-CHM-030	PR1	Above 06AN3 P38/N38	CIOC7581	CBP7581-2	2	1	2	Moved from CBP7582-6-3	B3	
2212	06-AT-140	06-AT-0140	N.I.S. AI 4 wire	06-AN-3	PR2	C00-AN-002	C00-CHM-028	PR1	06-AN-3 (LHS) 4/5	CIOC7581	CBP7581-2	3	2	4	Added field cable details.	B3	
2336	06-AR-0946	06-AR-0946	N.I.S. AI 2 wire			C00-AN-002	C00-CHM-030	PR2	TB2 P48/N48	CIOC7581	CBP7581-2	4	1	2	Change in revision B2 reverted.	B3	
2337	06-AR-0947	06-AR-0947	N.I.S. AI 2 wire			C00-AN-002	C00-CHM-030	PR3	TB2 P51/N51	CIOC7581	CBP7581-2	5	1	2	Change in revision B2 reverted.	B3	
2138	04-AT-277	04-AT-0277	N.I.S. AI 4 wire	TBD	TBD	C00-AN-002	C00-CHM-028	PR2	Above 06AN3 LHS P33/N33	CIOC7581	CBP7581-2	6	2	4		B2	
2220	04-AT-232	04-AT-0232	N.I.S. AI 4 wire	04-AN-10	PR1	C00-AN-002	C00-CHM-028	PR3	Above TB2 (RHS) P1/N1	CIOC7581	CBP7581-2	7	2	4		B2	
2230	04-AT-237	04-AT-0237	N.I.S. AI 4 wire	04-AN-11	PR1	C00-AN-002	C00-CHM-028	PR4	Above TB2 (RHS) P6/N6	CIOC7581	CBP7581-2	8	2	4		B3	
2514	06-AA-0140	06-AA-0140	N.I.S. DI NAMUR	06-AN-2	PR2	C00-AN-002	C00-CHM-029	PR1	TB2 (RHS) 5/6	CIOC7581	CBP7581-2	9	1	2		B3	
2515	06-AS-0387	06-AS-0387	N.I.S. DI NAMUR	06-AN-3		C00-AN-002	C00-CHM-029	PR2	TB2 (RHS) 9/10	CIOC7581	CBP7581-2	10	1	2		B3	
2516	06-ASH-0387	06-ASH-0387	N.I.S. DI NAMUR	06-AN-3		C00-AN-002	C00-CHM-029	PR3	TB2 (RHS) 7/8	CIOC7581	CBP7581-2	11	1	2		B3	
1856	02-TSH-3817	02-TSH-3817	N.I.S. DI NAMUR	02-TSH-3817	PR1	C00-CAB-758			TBD	CIOC7581	CBP7581-2	12	2	4		B3	
1857	02-TSH-3818	02-TSH-3818	N.I.S. DI NAMUR	02-TSH-3818	PR1	C00-CAB-758			TBD	CIOC7581	CBP7581-3	1	2	4		B3	
1858	02-TSH-3819	02-TSH-3819	N.I.S. DI NAMUR	02-TSH-3819	PR1	C00-CAB-758			TBD	CIOC7581	CBP7581-3	2	2	4		B3	
N/A	SPARE	SPARE								CIOC7581	CBP7581-3	3	1	2	ILS-1012 deleted by Analyser Dept.	B3	
1011	04-AT-167	04-AT-0167	N.I.S. AI 4 wire	C00-E-16	PR1	C00-AN-002	C00-CHM-028	PR5	Above 06AN3 LHS P29/N29	CIOC7581	CBP7581-3	4	2	4	Added inter cab cable details.	B3	
2153	04-AT-268	04-AT-0268	N.I.S. AI 4 wire	C00-E-15	PR3	C00-AN-002	C00-CHM-028	PR6	TB2 5/6	CIOC7581	CBP7581-3	5	2	4	Added inter cab cable details.	B3	
N/A	SPARE	SPARE								CIOC7581	CBP7581-3	6	2	4	ILS-1012 deleted by Analyser Dept.	B3	
2200	08-AT-311	08-AT-0311	N.I.S. AI 2 wire	08-AN-0311	PR1	C00-CAB-758	C00-CHM-028	PR14	TB2 20/21	CIOC7581	CBP7581-3	7	1	2	ILS-1012 added inter cab cable details.	B3	
2216	06-AT-177	06-AT-0177	N.I.S. AI 2 wire	TBD	TBD	C00-CAB-758	C00-CHM-030	PR4	TBD	CIOC7581	CBP7581-3	8	1	2	ILS-1012 changed to 2-wire.	B3	
escripti	02-FT-4070	Orig	N.I.S. AI 4 wire	Chkd	PR6	Appr	C00-CHM-019	PR1	9	CIOC7581	CBP7581-3	9	2	4		B2	
N/A	SPARE	SPARE								CIOC7581	CBP7581-3	11	2	4	ILS-1012 Move from CBP220R1-3-5 reverted.	B3	
N/A	SPARE	SPARE								CIOC7581	CBP7581-3	12	2	4	ILS-1012 Move from CBP220R1-3-6 reverted.	B3	
1757	02-SP-3665	02-SP-3665	I.S. AI 2 wire	02-E-81	PR2	C00-CAB-758			TBD	CIOC7582	CBP7582-1	1	3	4		A1	
1758	02-SP-3668	02-SP-3668	I.S. AI 2 wire	02-E-81	PR3	C00-CAB-758			TBD	CIOC7582	CBP7582-1	2	3	4		A1	
1759	02-FT-3718	02-FT-3718	I.S. AI 2 wire	02-E-81	PR4	C00-CAB-758			TBD	CIOC7582	CBP7582-1	3	3	4		A1	
1760	02-FT-3719	02-FT-3719	I.S. AI 2 wire	02-E-81	PR5	C00-CAB-758			TBD	CIOC7582	CBP7582-1	4	3	4		A1	
1761	02-FT-3728	02-FT-3728	I.S. AI 2 wire	02-E-81	Date	C00-CAB-758			TBD	CIOC7582	CBP7582-1	5	3	4		A1	
1763	02-FT-3731	02-FT-3731	I.S. AI 2 wire	0.1	15/09/2022	C00-CAB-758			TBD	CIOC7582	CBP7582-1	6	3	4		A1	

Appendix Figure 20 – CHARM Schedule

REV	TAG NO.	CABLE No.	Pr.	COLOUR	RAIL	TMLs	BARRIER	DEVICE	TMLs	FTA	SLOT	FUSE	FTA/MODEL No.	REMARKS
0.1	04AT2394A	04-X-45	01	BK	T6	161	N/A	N/A	T19-	46	19	AFM 03/04	9771-218	
				BU		162			A19			F6 2.0A		
0.1	04AT2394B	04-X-45	02	BK	T6	163	N/A	N/A	T19-	48	19	AFM 05/06	9771-218	
				GN		164			A19			F8 2.0A		
2.0	Spare	04-X-45	03	BU	T6	165	N/A	N/A						SEE NOTE 2
				GN		166								
2.0	Spare	04-X-45	04	BK	T6	167	N/A	N/A						SEE NOTE 2
				BN		168								
2.0	Spare	04-X-45	05	BU	T6	169	N/A	N/A						SEE NOTE 2
				BN		170								
2.0	Spare	04-X-45	06	GN	T6	171	N/A	N/A						SEE NOTE 2
				BN		172								
2.0	Spare	04-X-45	07	BK	T6	173	N/A	N/A						SEE NOTE 2
				WH		174								
2.0	Spare	04-X-45	08	BU	T6	175	N/A	N/A						SEE NOTE 2
				WH		176								
2.0	Spare	04-X-45	09	GN	T6	177	N/A	N/A						SEE NOTE 2
				WH		178								
2.0	Spare	04-X-45	10	BN	T6	179	N/A	N/A						SEE NOTE 2
				WH		180								
	SPARE	04-X-45	11	BK	T6	181	N/A	N/A						SEE NOTE 2
				RD		182								
	SPARE	04-X-45	12	BU	T6	183	N/A	N/A						SEE NOTE 2
				RD		184								
	SPARE	04-X-45	13	GN	T6	185	N/A	N/A						SEE NOTE 2
				RD		186								
	SPARE	04-X-45	14	BN	T6	187	N/A	N/A						SEE NOTE 2
				RD		188								
	SPARE	04-X-45	15	WH	T6	189	N/A	N/A						SEE NOTE 2
				RD		190								
	SPARE	04-X-45	16	BK	T6	191	N/A	N/A						SEE NOTE 2
				OG		192								
	SPARE	04-X-45	17	BU	T6	193	N/A	N/A						SEE NOTE 2
				OG		194								
	SPARE	04-X-45	18	GN	T6	195	N/A	N/A						SEE NOTE 2
				OG		196								
	SPARE	04-X-45	19	BN	T6	197	N/A	N/A						SEE NOTE 2
				OG		198								
	SPARE	04-X-45	20	WH	T6	199	N/A	N/A						SEE NOTE 2
				OG		200								

REV	DESCRIPTION	DATE	DRN	CHK'D	APP'D	APP'D
0.3	ISSUED FOR CONSTRUCTION	15/09/2022	[redacted]			
0.1	ISSUED FOR REVIEW	16/08/2022	[redacted]			

ALKY UNIT
TRICONEX ESD
MARSH SCHEDULE
C00-CAB-763

NOTE 1. End of Line resistors to be fitted in Field Instruments.
NOTE 2. All unused pairs to be terminated to earth.
PROJECT No.
DRG No. 04-EIN-SCH-0009 TRN 0089 sht 16 of 21

Appendix Figure 21 – Tricon Schedule

P&ID	P&ID Tag	DCS Tag	Service Descriptor	Function	Analogue															Digital			Additional Notes / Additional Alarms required / Existing or New Instrument, etc.
					Engineering Units	Min Range (4 mA)	Max Range (20 mA)	Input Cond. (Linear/SQR)	Normal PV/SP	HiHi Alarm (TRIP)	HiHi Alarm Priority	High Alarm	High Alarm Priority	Low Alarm	Low Alarm Priority	LoLo Alarm (TRIP)	LoLo Alarm Priority	Composite Alarm Priority	Open / De-energised State Descriptor	Closed / Energised State Descriptor	Off Normal/Alarm Priority	
04-GD-63212A TRN 0089	04AT2394	04AI2394A	04H101 Flue gas CO	Safety	PPM	0	10000	linear	20-30			500	NOTE 1										
04-GD-63212A TRN 0089	04AT2394	04AXH2394A	04H101 Flue gas CO, Combustion Difficulty	Safety						1500	NOTE 1												
04-GD-63212A TRN 0089	04AT2394	04AI2394B	04H101 Flue gas, CH4	Indication	%	0	5	linear															
04-GD-63212A TRN 0089	04UA2435	04UA2435	04AT2394 Fault	Alarm																Fault	Normal	NOTE 1	
04-GD-63212A TRN 0089	04FISL2394A		Optic Purge Flow Alarm 04AT2394	Alarm	l/min									15						Fault	Normal		NOTE 2
04-GD-63212A TRN 0089	04FISL2394B		Optic Purge Flow Alarm 04AT2394	Alarm	l/min									15						Fault	Normal		
04-GD-63212A TRN 0090	04TT070		04AT2394 Temperature Compensation	Alarm	Deg C	0	1300	linear															

NOTES

1. PRIORITIES TO BE CONFIRMED ON COMPLETION OF ADA.
2. PURGE FLOW SWITCH TO INITIATE ANALYSER 04AT2394 COMMON ALARM 04UA2435
3. 24VDC PSU FAILURE CONTACT TO PROVIDE INPUT TO COMMON FAULT ALARM.

Revisions

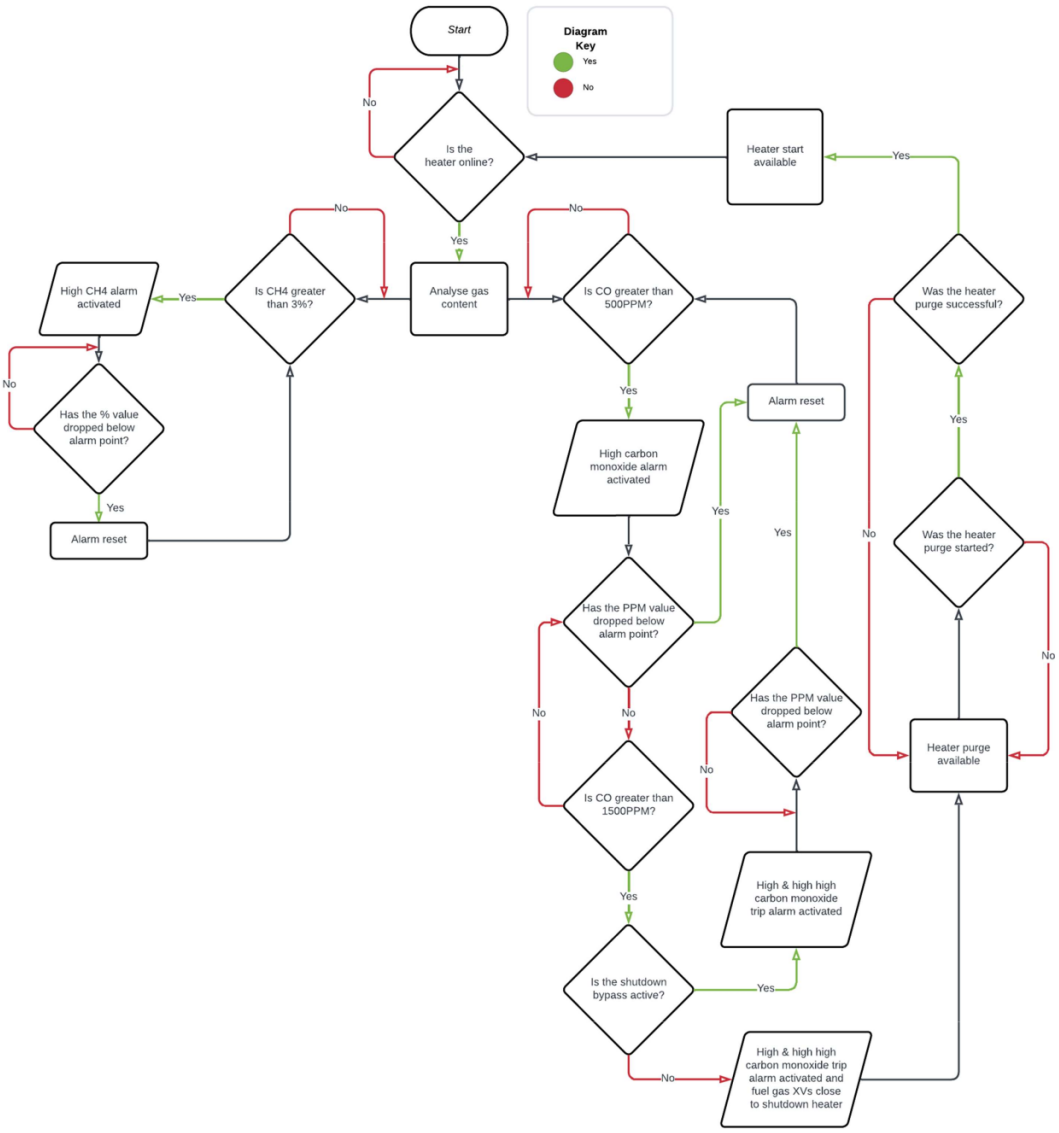
Rev	Date	Description	By	Checked	Approved
0.1	16/08/2022	Issued for Review	[redacted]	[redacted]	[redacted]
0.2	09/11/2022	Issued for Approval	[redacted]	[redacted]	[redacted]
0.3	29/11/2022	Issued for Construction	[redacted]	[redacted]	[redacted]

[redacted]

Range, Alarm and Trip Schedule

Client:	[redacted]
Location:	[redacted]
Project:	CO Measurement, Alky Heaters.
Project Number:	PM20_0089
	SHEET 1 OF 1
	04-EIN-SCH-0124

Appendix Figure 22 – Range, Alarm & Trip Schedule



Appendix Figure 23 – PLC Flowchart

1	**Logic Solver Change** Change Identification	
1.1	Describe the reason for the change:	**04-H-101** Detection of high combustibles on Depropanizer Reboiler, 04-H-101 will be achieved by sensing Carbon Monoxide saturation in the convection section of the heater via a new SIL 2 Tunable Diode Laser Spectrum Analyser, TDLS, 04-AT-2394, providing an ESD trip via the existing Alkylation SIS PLC, closing the existing main Fuel Gas feed valves. The new SIL 2 trip will provide protection against the following scenarios. • An increase in fuel gas flowrate of burners without a corresponding increase in combustion air flow rate to the burners (as indicated by increase of CO). • Changes in fuel gas composition. • Burner tip plugging in one or more burners. • Non uniform adjusting of burner fuel block valves or air registers. • A reduction in flame burn zone temperature. • Changes in ambient conditions. • Allow hydrogen and/or hydrocarbon tube leak into the firebox.
1.2	Identify the affected equipment:	
	A Input Functions (Measurements)	**B** PLC / Logic Solver Hardware **C** Output Functions (Valves, Motors, etc.)
1.3	04-AT-2394A 04-AT-2394B	04-UX-2100 2 New NIS AI 04-XV-0617 04-XV-0618

1.4	Describe the required changes to each section of equipment:		
	04-AT-2394A 04-AT-2394B	Application code to be changed to include 2 new analogue input signals and isolation of the main fuel gas in the event of high combustibles.	Existing Main Fuel Gas valves 04-XV-0617 & 04-XV-0618 to provide main fuel gas isolation on combustion difficulty tip from 04-AT-2394A.
1.5	Provide any further relevant information for the change:	Update software to Tri station latest version. Sequence of Events, SOE, to be configured with all ESD inputs and internal valve open/ closed limits.	

Appendix Figure 24 – Logic Solver Change Request Form, Page 1

2	Logic Solver Change Change Specification	
2.1.1	Summarise the general requirements of the Instrumented Function being modified, highlighting in bold the changes:	**04-H-101 Combustion Difficulty Trip.** Install new TDLS Analyser 04-AT-2394 to measure CO and CH4. When CO reaches 1500PPM, the programable logic solver 04-UX-2100 commands 04-SOV-0617 and 04-SOV-0618 to de-energise and closes main fuel gas valves 04-XV-0617 and 04-SOV-618, isolating the main fuel gas to the heater. The maximum response time is 27 seconds. CH4 will provide indication only, to DCS. The logic solver, 04-UX-2100 application code will be updated to include two new Analogue signals, providing a trip to the close the XV's. **04-BPS-2394** will provide bypass of the trip function for essential maintenance and proof testing to be carried out online.
2.2	For each bold change above, document the wording before and after the change (add additional rows as required):	
2.2.1	Wording prior to/ after 1st Change in Section 1.4:	**04-H-101 Combustion Difficulty Trip.** 04-AT-2394A shall close 04-XV-0617 and 04-XV-0618 in the event, CO measurement is greater than 1500ppm in the convection section of 04-H-101, providing isolation of main fuel gas to the heater.

Appendix Figure 25 – Logic Solver Change Request Form, Page 2

2.2.2	Wording prior to/ after 2nd Change in Section 1.4:	**Ref 2.1.1.** **04-BPS-2394** shall provide a Maintenance Bypass of the SIF to allow essential maintenance and proof testing to be carried out.
2.3	Identify any functions interconnected to the functions being changed in the SIS logic solver that are defined as SIL1 or higher:	The following functions share final elements with combustion difficulty trip on the Alky heaters. 04-H-101 Main Fuel Gas Low Low/ High High pressure trip. 04-PT-486A/B/C 2oo3. (SIL1). 04-H-101 Combustion Air, Low Low pressure trip. 04-FT-491/2251 & 2252. (SIL2) 04-F-109, 04-LT-171, Low Low Level. (SIL1) 04-F-109, High pressure trip. 04-PT-161/162/163. 2oo3. (SIL1) 04-F-124, 04-LT-1192 Fuel Gas KO Drum high level. (SIL1) 04-H-101 PASS 1 04-FT-2103 Low Low Flow. (SIL1) 04-H-101 PASS 2 04-FT-2104 Low Low Flow. (SIL1) 04-H-101 PASS 3 04-FT-2105 Low Low Flow. (SIL1) 04-H-101 PASS 4 04-FT-2106 Low Low Flow. (SIL1) 04-H-101 PASS 5 04-FT-2107 Low Low Flow. (SIL1) 04-H-101 PASS 6 04-FT-2108 Low Low Flow. (SIL1) 04-H-101 PASS 7 04-FT-2109 Low Low Flow. (SIL1) 04-H-101 PASS 8 04-FT-2110 Low Low Flow. (SIL1) 04-F-107 04-LT-0142A/B/C, Acid Settler high high high level. (SIL2) 04-F-123, 04-PT—0203, 204, 205. (SIL 1).

Appendix Figure 26 – Logic Solver Change Request Form, Page 3

2 04H101 Combustion difficulty 1oo1 Heater 04H101, Combustion Difficulty

This chapter details the SIL Verification results, selections, and assumptions for the 04H101 Combustion difficulty 1oo1 Heater 04H101, Combustion Difficulty Safety Instrumented Function.

2.1 General SIF Information

The following characterizes the Safety Instrumented Function.

SIF Name:	1oo1 Heater 04H101, Combustion Difficulty
SIF Tag	04H101 Combustion difficulty
SIF Description:	1oo1 TDLS AT CO, closes main fuel to 04H101.

2.2 Safety Integrity Levels

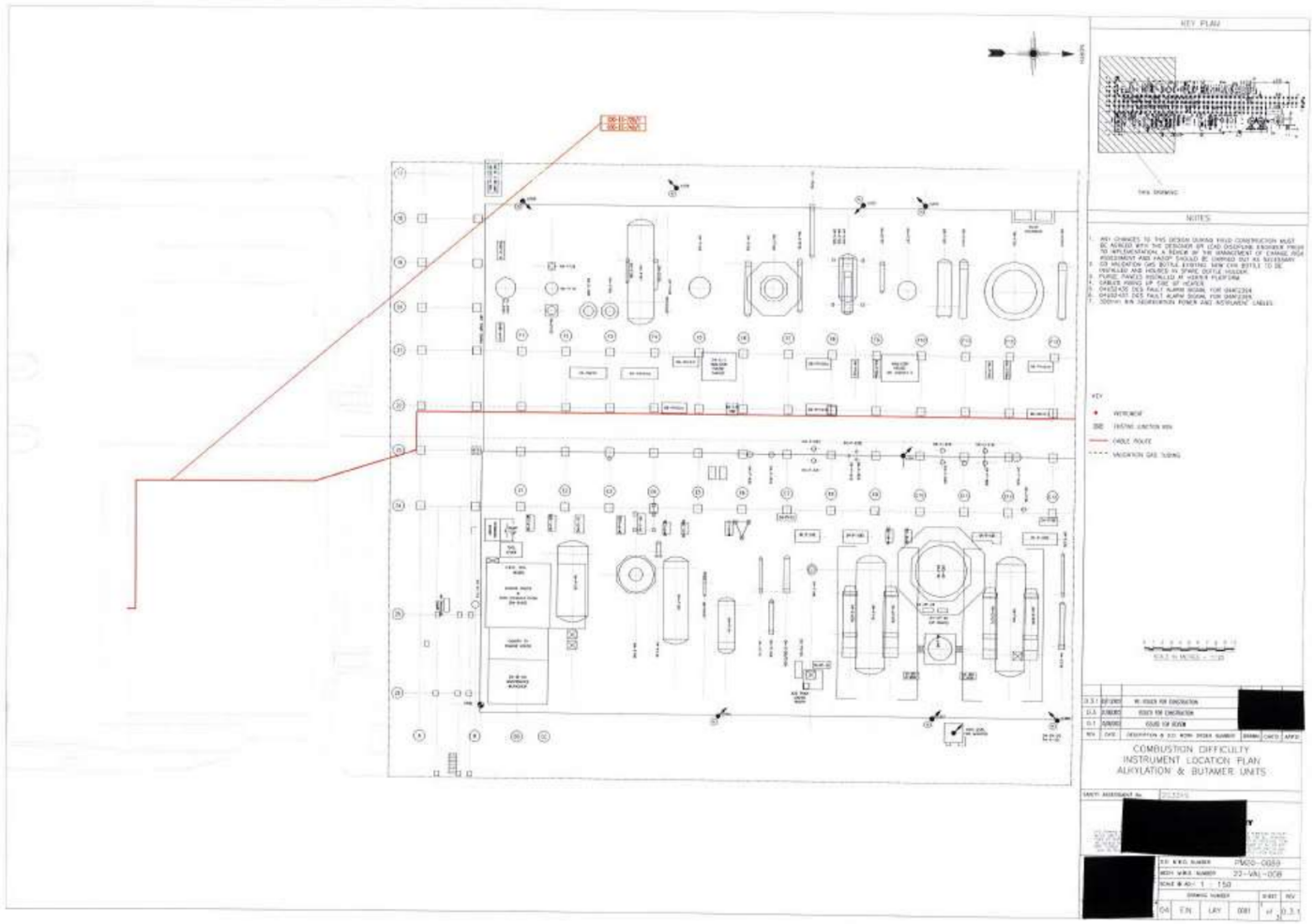
The target Safety Integrity Level determined for this Safety Instrumented Function is:

SIL 2 with RRF ≥ 207.6

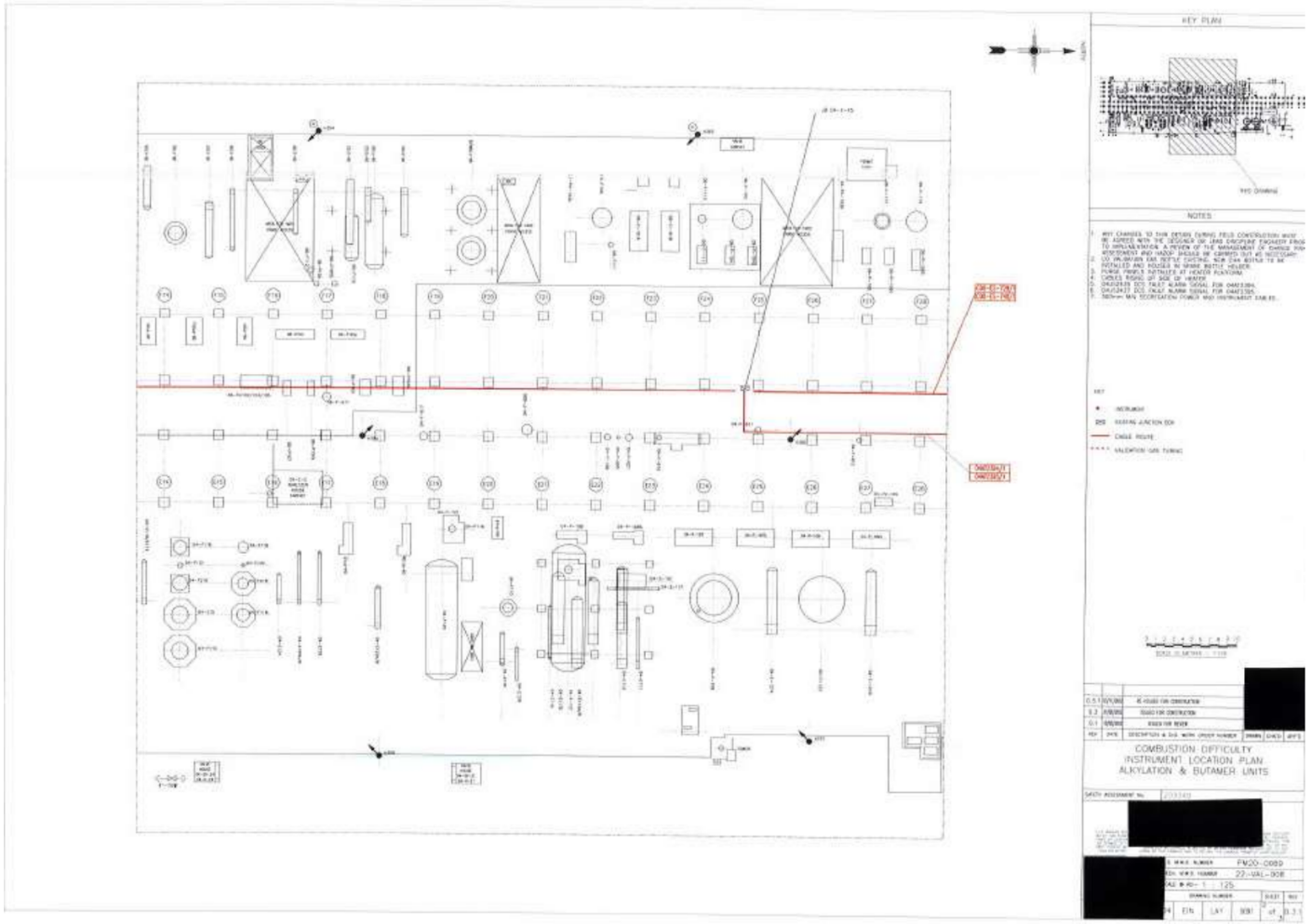
The calculated achieved Safety Integrity Level for this Safety Instrumented Function is:

SIL 1 with RRF = 57.4

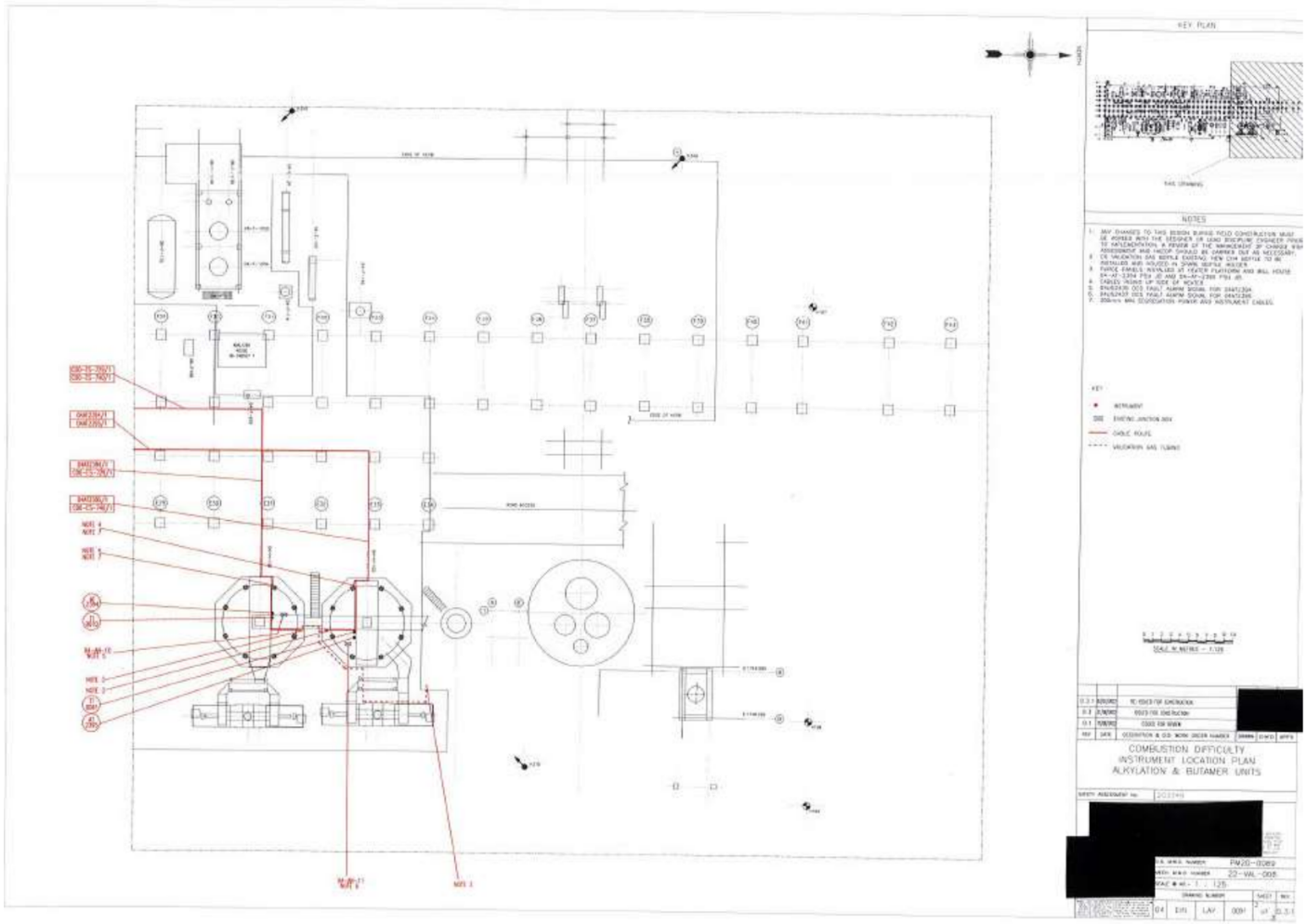
Appendix Figure 27 – Overall SIL Rating



Appendix Figure 28 – Location Plan, Sheet 1



Appendix Figure 29 – Location Plan, Sheet 2



Appendix Figure 30 – Location Plan, Sheet 3

9.3 Costing and Project Plan

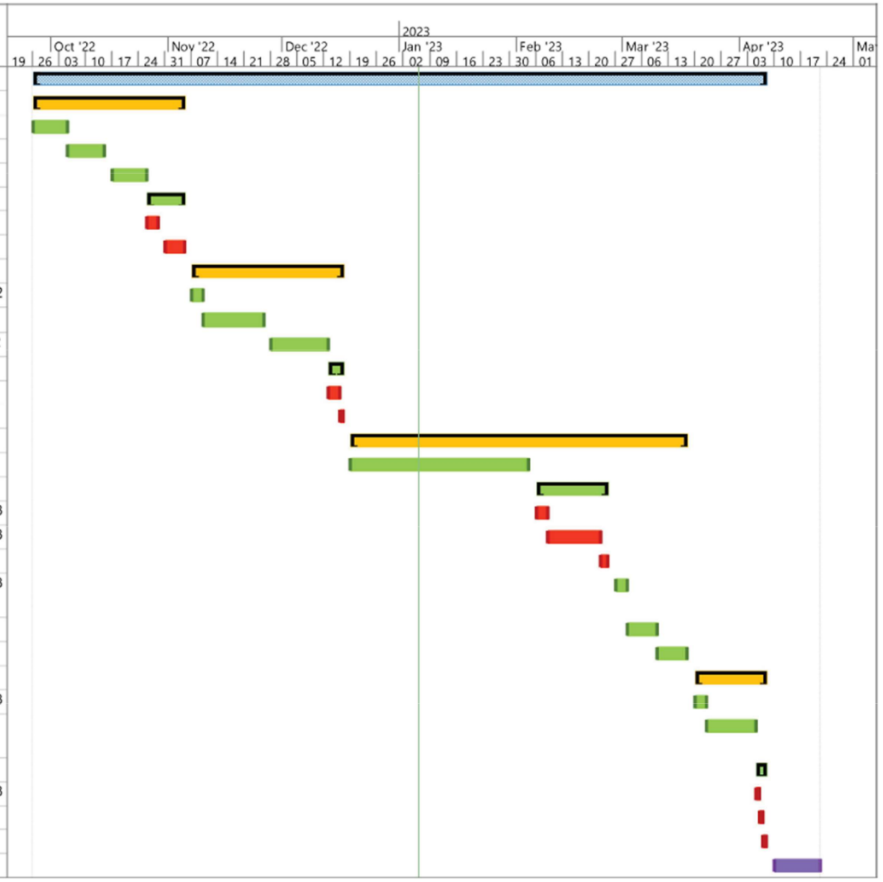
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Probe Type Tunable Diode Laser Spectrome	1.00	EA	37,532.65	37,532.65	7,506.53	45,039.18
HMI Interface Unit H8000-S2-E-N/M/C/SCT	1.00	EA	3,845.44	3,845.44	769.09	4,614.53
Calibration Cell K9777ZA	1.00	EA	3,728.39	3,728.39	745.68	4,474.07
Utility Panel BOP107227	1.00	EA	21,686.32	21,686.32	4,337.26	26,023.58
Project Management & Engineering	1.00	EA	6,853.56	6,853.56	1,370.71	8,224.27
Packing BOP 107227	1.00	EA	606.37	606.37	121.27	727.64
SAT - 1 day at site	1.00	EA	1,500.00	1,500.00	300.00	1,800.00
Document Control	1.00	EA	3,990.00	3,990.00	798.00	4,788.00
PMI BOP107227	1.00	EA	670.00	670.00	134.00	804.00
Witnessing of Factory Acceptance Test (FAT)	1.00	EA	1,500.00	1,500.00	300.00	1,800.00
Delivery	1.00	EA	1,500.00	1,500.00	300.00	1,800.00
1x2x1.3mm Type KX PVC Cam PVC - Green	20.00	EA	8.00	160.00	32.00	192.00
1pr 1.5 Pas5308 Pt1 Tp2 Pe Overall Scree	60.00	EA	2.90	174.00	34.80	208.80
1pr 1.5 Pas5308 Pt1 Tp2 Pe Overall Scree	40.00	EA	2.90	116.00	23.20	139.20
2x2.5mm² Xlpe Swa PVC 1kv Black Bs5467	60.00	EA	1.15	69.00	13.80	82.80
2pr 1.5 Pas5308 Pt1 Tp2 Pe Ind & Overall	200.00	EA	3.30	660.00	132.00	792.00
2pr (Quad) 1.5 Pas5308 Pt1 Tp2 Pe Overall	20.00	EA	2.50	50.00	10.00	60.00
5pr 0.75 Pas5308 Pt1 Tp2 Pe Overall Scre	40.00	EA	2.95	118.00	23.60	141.60
Hawke 501 453 Universal A-Gland Kit M20	8.00	EA	11.48	91.84	18.37	110.21
Hawke ICG 653 Universal Brass Gland, O, M20	26.00	EA	22.53	585.78	117.16	702.94
Hawke ICG 653 Universal Brass Gland, B, M25	4.00	EA	31.25	125.00	25.00	150.00
Mg221020-3 Weidmuller Ktb Mh 303020	2.00	EA	701.08	1,402.16	280.43	1,682.59
3x4mm² Xlpe Swa Pvc 1kv Black Bs5467	720.00	EA	2.10	1,512.00	302.40	1,814.40
Hawke Icg653 Universal Os Gland	6.00	EA	21.78	130.68	26.14	156.82
402133177 4 Way Metal Easy9 Consumer Uni	2.00	EA	47.38	94.76	18.95	113.71
Easy9 Blank 402134312	8.00	EA	2.00	16.00	3.20	19.20
Ic60h2 Rcbo 10a 30ma	2.00	EA	147.31	294.62	58.92	353.54
½" OD Union Straight 316stst Ss-810-6	8.00	EA	25.08	200.64	40.13	240.77
¼" OD X 0.035" Wall Thickness 316stst	48.00	EA	6.39	306.72	61.34	368.06
½" OD X 0.035" Wall Thickness 316stst	48.00	EA	15.68	752.64	150.53	903.17
¼" OD Union Straight 316stst Ss-400-6	8.00	EA	11.88	95.04	19.01	114.05
¼" OD Union Tee Ss-400-3 Swagelok ~ M	3.00	EA	24.11	72.33	14.47	86.80
½" OD Union Tee Ss-810-3 Swagelok ~ M	2.00	EA	47.92	95.84	19.17	115.01
¼" OD x ¼" Bspt Male Straight Connection	8.00	EA	7.69	61.52	12.30	73.82
½" OD x ¼" Bspt Male Straight Connection	8.00	EA	15.27	122.16	24.43	146.59
¼" x 0.035" Avg Wall 316/316ss Seamles	250.00	EA	8.93	2,232.50	446.50	2,679.00
Double End Shut Off Quick Disconnect 1/2	1.00	EA	58.09	58.09	11.62	69.71
Double End Shut Off Quick Disconnect 1/2	1.00	EA	58.09	58.09	11.62	69.71
¼" OD x ½" OD Tube Adaptor Reducer 3	1.00	EA	11.58	11.58	2.32	13.90
¼" OD Ss-62ts4 60 series Ball Valve, Rei	5.00	EA	190.84	954.20	190.84	1,145.04
½" OD Ss-63ts8 60 series Ball Valve, Rei	4.00	EA	230.83	923.32	184.66	1,107.98
Ss-Th8ta8ta8-62 T Series Ptfe Hose, 316	1.00	EA	346.09	346.09	69.22	415.31
29-EIN-SOW-0061	1,237.00	HOURS	46.57	57,607.09	11,521.42	69,128.51
Drilling out Junction Boxes	34.00	HOURS	46.57	1,583.38	316.68	1,900.06
Materials				2,000.00	400.00	2,400.00
Total Cost				156,493.80	31,298.76	187,792.56

Appendix Figure 31 – Original Costing Spreadsheet

	Quantity	Unit Type	Unit Price	Net Cost £	VAT £	Total Cost £
Probe Type Tunable Diode Laser Spectrome	1.00	EA	37,532.65	37,532.65	7,506.53	45,039.18
HMI Interface Unit H8000-S2-E-N/M/C/SCT	1.00	EA	3,845.44	3,845.44	769.09	4,614.53
Calibration Cell K9777ZA	1.00	EA	3,728.39	3,728.39	745.68	4,474.07
Utility Panel BOP107227	1.00	EA	21,686.32	21,686.32	4,337.26	26,023.58
Project Management & Engineering	1.00	EA	6,853.56	6,853.56	1,370.71	8,224.27
Packing BOP 107227	1.00	EA	606.37	606.37	121.27	727.64
SAT - 1 day at site	1.00	EA	1,500.00	1,500.00	300.00	1,800.00
Document Control	1.00	EA	3,990.00	3,990.00	798.00	4,788.00
PMI BOP107227	1.00	EA	670.00	670.00	134.00	804.00
Witnessing of Factory Acceptance Test (FAT)	1.00	EA	1,500.00	1,500.00	300.00	1,800.00
Delivery	1.00	EA	1,500.00	1,500.00	300.00	1,800.00
1x2x1.3mm Type KX PVC Cam PVC - Green	20.00	EA	8.00	160.00	32.00	192.00
1pr 1.5 Pas5308 Pt1 Tp2 Pe Overall Scree	60.00	EA	2.90	174.00	34.80	208.80
1pr 1.5 Pas5308 Pt1 Tp2 Pe Overall Scree	40.00	EA	2.90	116.00	23.20	139.20
2x2.5mm² Xlpe Swa PVC 1kv Black Bs5467	60.00	EA	1.15	69.00	13.80	82.80
2pr 1.5 Pas5308 Pt1 Tp2 Pe Ind & Overall	200.00	EA	3.30	660.00	132.00	792.00
2pr (Quad) 1.5 Pas5308 Pt1 Tp2 Pe Overall	20.00	EA	2.50	50.00	10.00	60.00
5pr 0.75 Pas5308 Pt1 Tp2 Pe Overall Scre	40.00	EA	2.95	118.00	23.60	141.60
Hawke 501 453 Universal A-Gland Kit M20	8.00	EA	11.48	91.84	18.37	110.21
Hawke ICG 653 Universal Brass Gland, O, M20	26.00	EA	22.53	585.78	117.16	702.94
Hawke ICG 653 Universal Brass Gland, B, M25	4.00	EA	31.25	125.00	25.00	150.00
Mg221020-3 Weidmuller Ktb Mh 303020	2.00	EA	701.08	1,402.16	280.43	1,682.59
3x4mm² Xlpe Swa Pvc 1kv Black Bs5467	720.00	EA	2.10	1,512.00	302.40	1,814.40
Hawke Icg653 Universal Os Gland	6.00	EA	21.78	130.68	26.14	156.82
402133177 4 Way Metal Easy9 Consumer Uni	2.00	EA	47.38	94.76	18.95	113.71
Easy9 Blank 402134312	8.00	EA	2.00	16.00	3.20	19.20
Ic60h2 Rcbo 10a 30ma	2.00	EA	147.31	294.62	58.92	353.54
½" OD Union Straight 316stst Ss-810-6	8.00	EA	25.08	200.64	40.13	240.77
¼" OD X 0.035" Wall Thickness 316stst	48.00	EA	6.39	306.72	61.34	368.06
½" OD X 0.035" Wall Thickness 316stst	48.00	EA	15.68	752.64	150.53	903.17
¼" OD Union Straight 316stst Ss-400-6	8.00	EA	11.88	95.04	19.01	114.05
¼" OD Union Tee Ss-400-3 Swagelok ~ M	3.00	EA	24.11	72.33	14.47	86.80
½" OD Union Tee Ss-810-3 Swagelok ~ M	2.00	EA	47.92	95.84	19.17	115.01
¼" OD x ¼" Bspt Male Straight Connection	8.00	EA	7.69	61.52	12.30	73.82
½" OD x ¼" Bspt Male Straight Connection	8.00	EA	15.27	122.16	24.43	146.59
¼" x 0.035" Avg Wall 316/316ss Seamles	250.00	EA	8.93	2,232.50	446.50	2,679.00
Double End Shut Off Quick Disconnect 1/2	1.00	EA	58.09	58.09	11.62	69.71
Double End Shut Off Quick Disconnect 1/2	1.00	EA	58.09	58.09	11.62	69.71
¼" OD x ½" OD Tube Adaptor Reducer 3	1.00	EA	11.58	11.58	2.32	13.90
¼" OD Ss-62ts4 60 series Ball Valve, Rei	5.00	EA	190.84	954.20	190.84	1,145.04
½" OD Ss-63ts8 60 series Ball Valve, Rei	4.00	EA	230.83	923.32	184.66	1,107.98
Ss-Th8ta8ta8-62 T Series Ptfe Hose, 316	1.00	EA	346.09	346.09	69.22	415.31
29-EIN-SOW-0061	1,237.00	HOURS	46.57	57,607.09	11,521.42	69,128.51
Drilling out Junction Boxes	34.00	HOURS	46.57	1,583.38	316.68	1,900.06
Materials				2,000.00	400.00	2,400.00
Rosemount 644 Temperature Transmitter	1	EA	498.25	498.25	99.65	597.90
Temperature Transmitter Head	1	EA	8.53	8.53	1.71	10.24
Delta V Digital Input Charm	1	EA	79.00	79.00	15.8	94.80
Total Cost				157,079.58	31,415.92	188,400.70

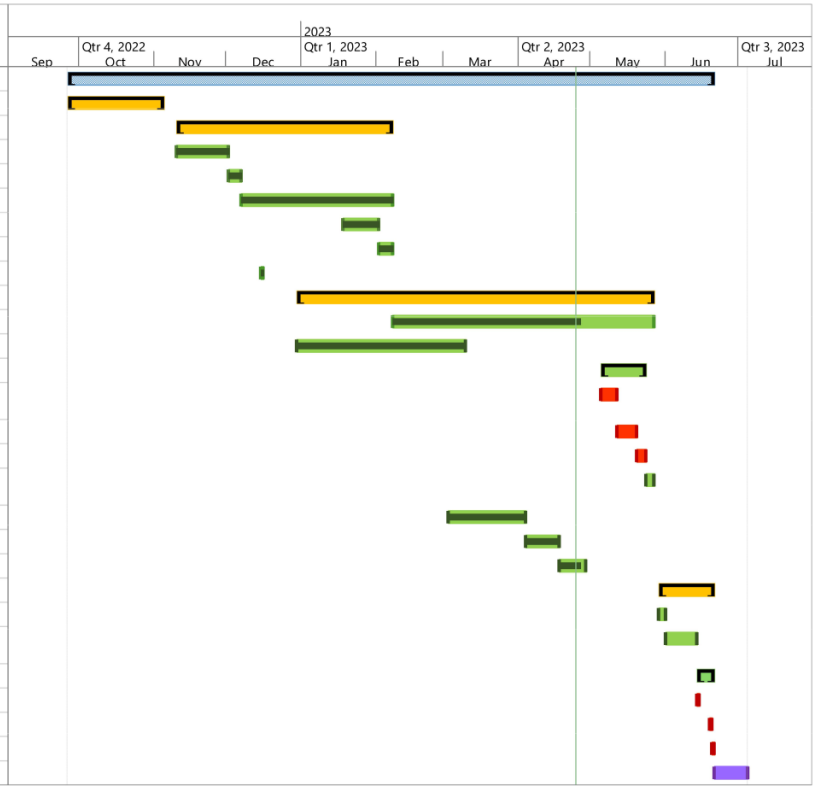
Appendix Figure 32 – Final Costing Spreadsheet

ID	Task Mode	Task Name	Duration	Start	Finish
1		**Heater Combustion Difficulty Project**	**140 days**	**Mon 26/09/22**	**Fri 07/04/23**
2		**Planning Phase**	**30 days**	**Mon 26/09/22**	**Fri 04/11/22**
3		Identify Problem	7 days	Mon 26/09/22	Tue 04/10/22
4		Develop FDS and Test Plan	8 days	Wed 05/10/22	Fri 14/10/22
5		Determine Solution and Obtain Quotes	7 days	Mon 17/10/22	Tue 25/10/22
6		Produce Planning Documents	**8 days**	**Wed 26/10/22**	**Fri 04/11/22**
7		*Costing Spreadsheet*	3 days	Wed 26/10/22	Fri 28/10/22
8		*Risk Assessment*	5 days	Mon 31/10/22	Fri 04/11/22
9		**Design Phase**	**30 days**	**Mon 07/11/22**	**Fri 16/12/22**
10		Order Materials	3 days	Mon 07/11/22	Wed 09/11/22
11		Create Drawings and Data Sheets	12 days	Thu 10/11/22	Fri 25/11/22
12		Determine PLC and DCS Ammendments	11 days	Mon 28/11/22	Mon 12/12/22
13		Complete Pre-implementation Paperwork	**4 days**	**Tue 13/12/22**	**Fri 16/12/22**
14		*SIS Change Request Form*	3 days	Tue 13/12/22	Thu 15/12/22
15		*Work Permits*	1 day	Fri 16/12/22	Fri 16/12/22
16		**Implementation Phase**	**65 days**	**Mon 19/12/22**	**Fri 17/03/23**
17		Install Cables	35 days	Mon 19/12/22	Fri 03/02/23
18		Complete Mechanical Installation	**15 days**	**Mon 06/02/23**	**Fri 24/02/23**
19		*Mount Sensor*	3 days	Mon 06/02/23	Wed 08/02/23
20		*Mount Enclosures*	10 days	Thu 09/02/23	Wed 22/02/23
21		*Mount Utility Panel*	2 days	Thu 23/02/23	Fri 24/02/23
22		Make Pneumatic and Electrical Connections	3 days	Mon 27/02/23	Wed 01/03/23
23		Complete PLC Ammendments	6 days	Thu 02/03/23	Thu 09/03/23
24		Complete DCS Ammendments	6 days	Fri 10/03/23	Fri 17/03/23
25		**Commissioning Phase**	**15 days**	**Mon 20/03/23**	**Fri 07/04/23**
26		Verify Documents Produced	3 days	Mon 20/03/23	Wed 22/03/23
27		Complete Funcional and Compliance Tests	9 days	Thu 23/03/23	Tue 04/04/23
28		Complete Paperwork and Sign Off	**3 days**	**Wed 05/04/23**	**Fri 07/04/23**
29		*Loop Check Forms*	1 day	Wed 05/04/23	Wed 05/04/23
30		*ATEX Forms*	1 day	Thu 06/04/23	Thu 06/04/23
31		*QA/QC Documents*	1 day	Fri 07/04/23	Fri 07/04/23
32		**Contingency**	10 days	Mon 10/04/23	Fri 21/04/23

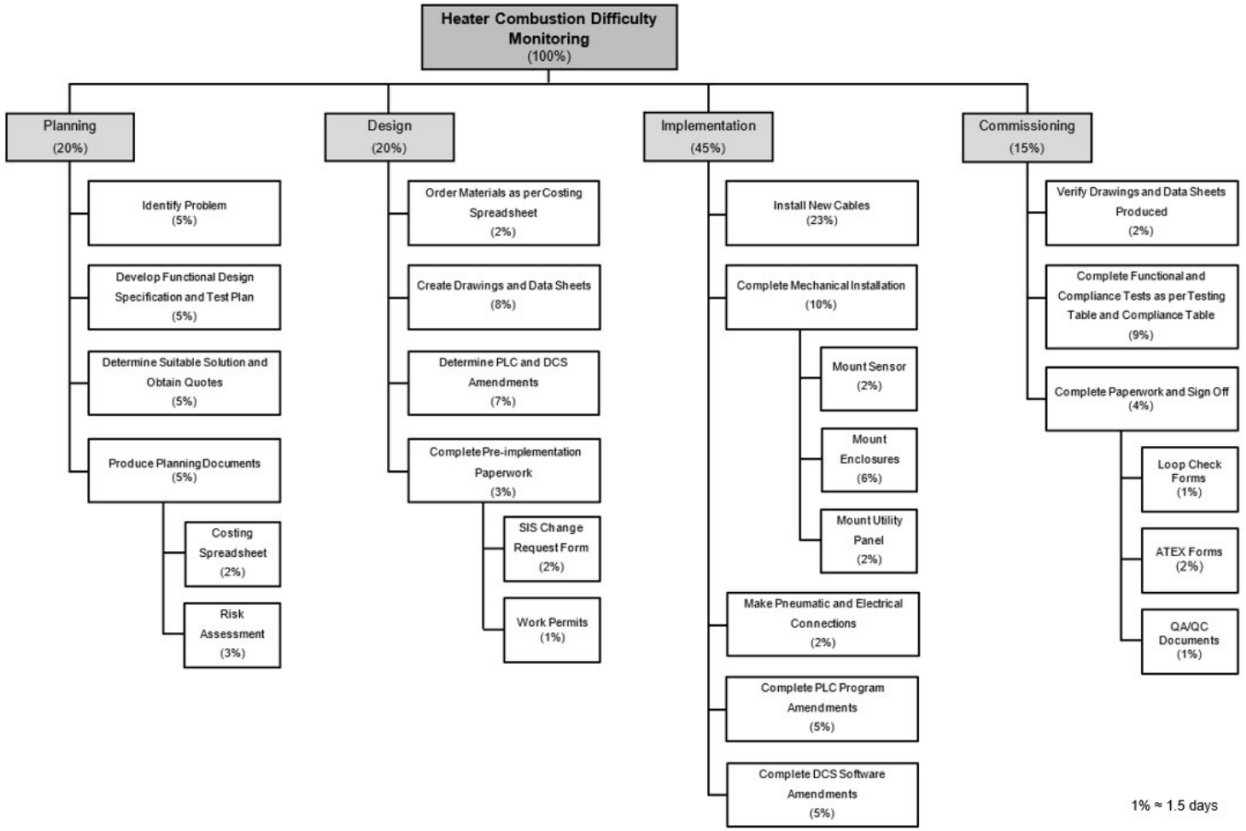


Appendix Figure 33 – Original Gantt Chart

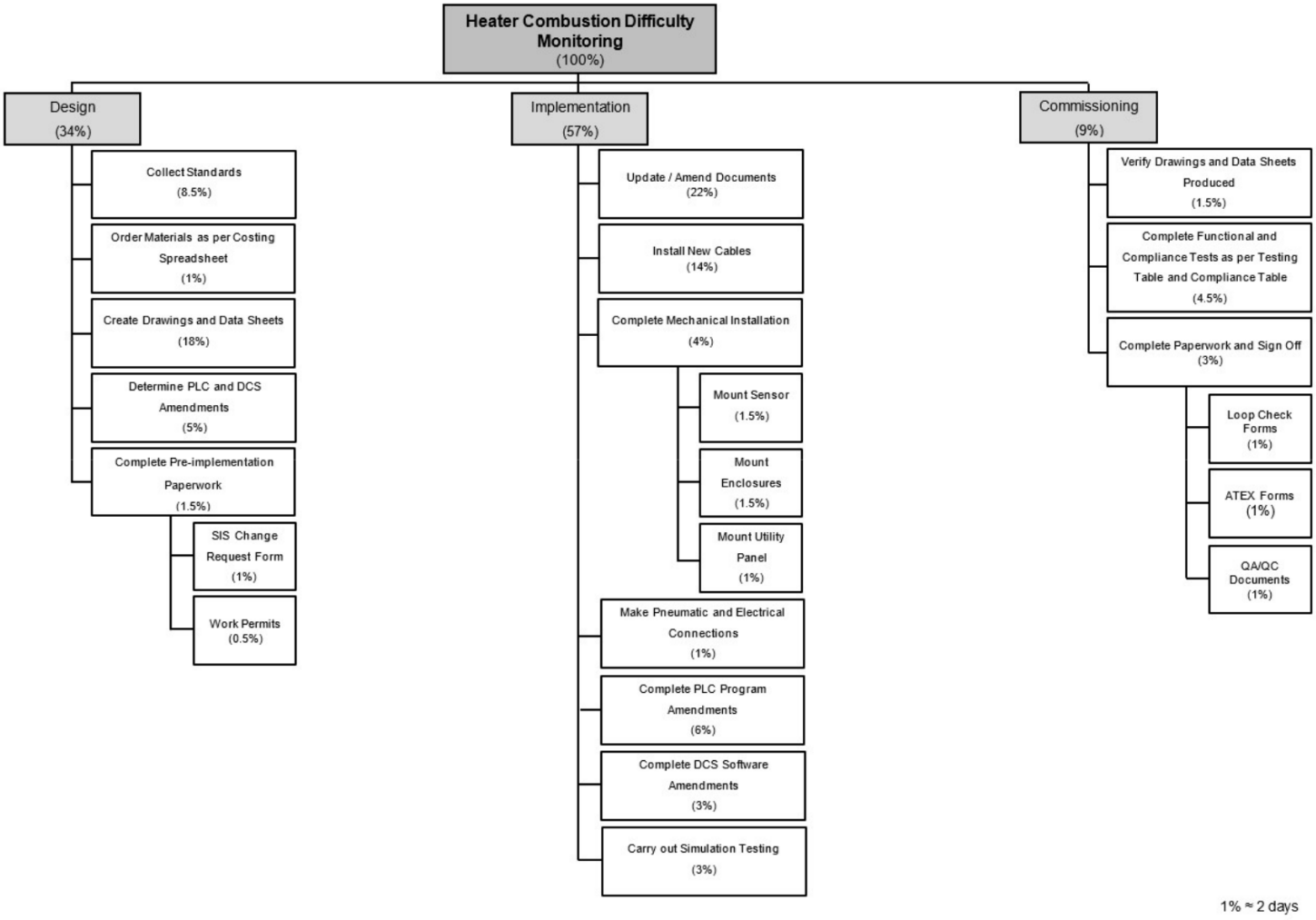
ID	Task Mode	Task Name	Duration	Start	Finish
1		**Heater Combustion Difficulty Project**	**192 days**	**Mon 26/09/22**	**Tue 20/06/23**
2		**Planning Phase**	**30 days**	**Mon 26/09/22**	**Fri 04/11/22**
9		**Design Phase**	**64 days**	**Thu 10/11/22**	**Tue 07/02/23**
10		Collect Standards	16 days	Thu 10/11/22	Thu 01/12/22
11		Order Materials	3 days	Fri 02/12/22	Tue 06/12/22
12		Create Drawings and Data Sheets	45 days	Wed 07/12/22	Tue 07/02/23
13		Determine PLC and DCS Amendments	11 days	Wed 18/01/23	Wed 01/02/23
14		SIS Change Request Form	4 days	Thu 02/02/23	Tue 07/02/23
15		Work Permits	1 day	Thu 15/12/22	Thu 15/12/22
16		**Implementation Phase**	**106 days**	**Fri 30/12/22**	**Fri 26/05/23**
17		Update / Amend Documents	78 days	Wed 08/02/23	Fri 26/05/23
18		Install Cables	50 days	Fri 30/12/22	Thu 09/03/23
19		Complete Mechanical Installation	**13 days**	**Fri 05/05/23**	**Tue 23/05/23**
20		*Mount Analyser and Temperature Transmitter*	5 days	Fri 05/05/23	Thu 11/05/23
21		*Mount Enclosures*	6 days	Fri 12/05/23	Fri 19/05/23
22		*Mount Utility Panel*	3 days	Sat 20/05/23	Tue 23/05/23
23		Make Pneumatic and Electrical Connections	3 days	Wed 24/05/23	Fri 26/05/23
24		Complete PLC Amendments	22 days	Fri 03/03/23	Mon 03/04/23
25		Complete DCS Amendments	10 days	Tue 04/04/23	Mon 17/04/23
26		Carry Out Simulation Testing	9 days	Tue 18/04/23	Fri 28/04/23
27		**Commissioning Phase**	**17 days**	**Mon 29/05/23**	**Tue 20/06/23**
28		Edit Documents Produced as required	3 days	Mon 29/05/23	Wed 31/05/23
29		Complete Functional and Compliance Tests	9 days	Thu 01/06/23	Tue 13/06/23
30		Complete Paperwork and Sign Off	**5 days**	**Wed 14/06/23**	**Tue 20/06/23**
31		*Loop Check Forms*	1 day	Wed 14/06/23	Wed 14/06/23
32		*ATEX Forms*	1 day	Mon 19/06/23	Mon 19/06/23
33		*QA/QC Documents*	1 day	Tue 20/06/23	Tue 20/06/23
34		**Contingency**	10 days	Wed 21/06/23	Tue 04/07/23



Appendix Figure 34 – Updated Gantt Chart

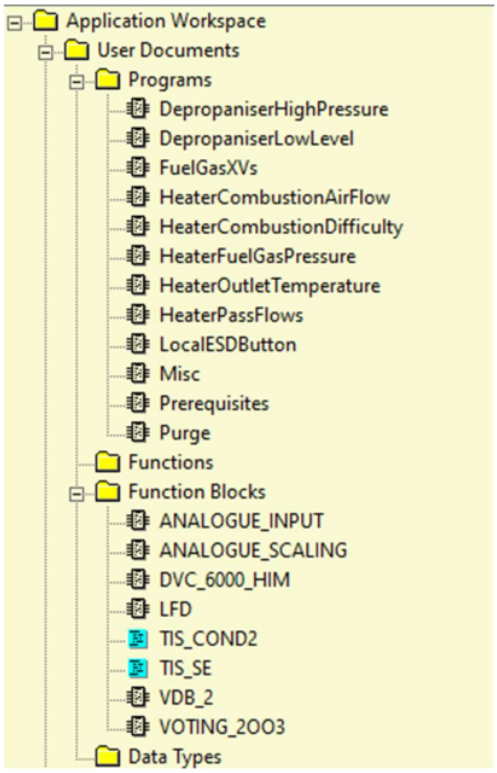


Appendix Figure 35 – Original Work Breakdown Structure

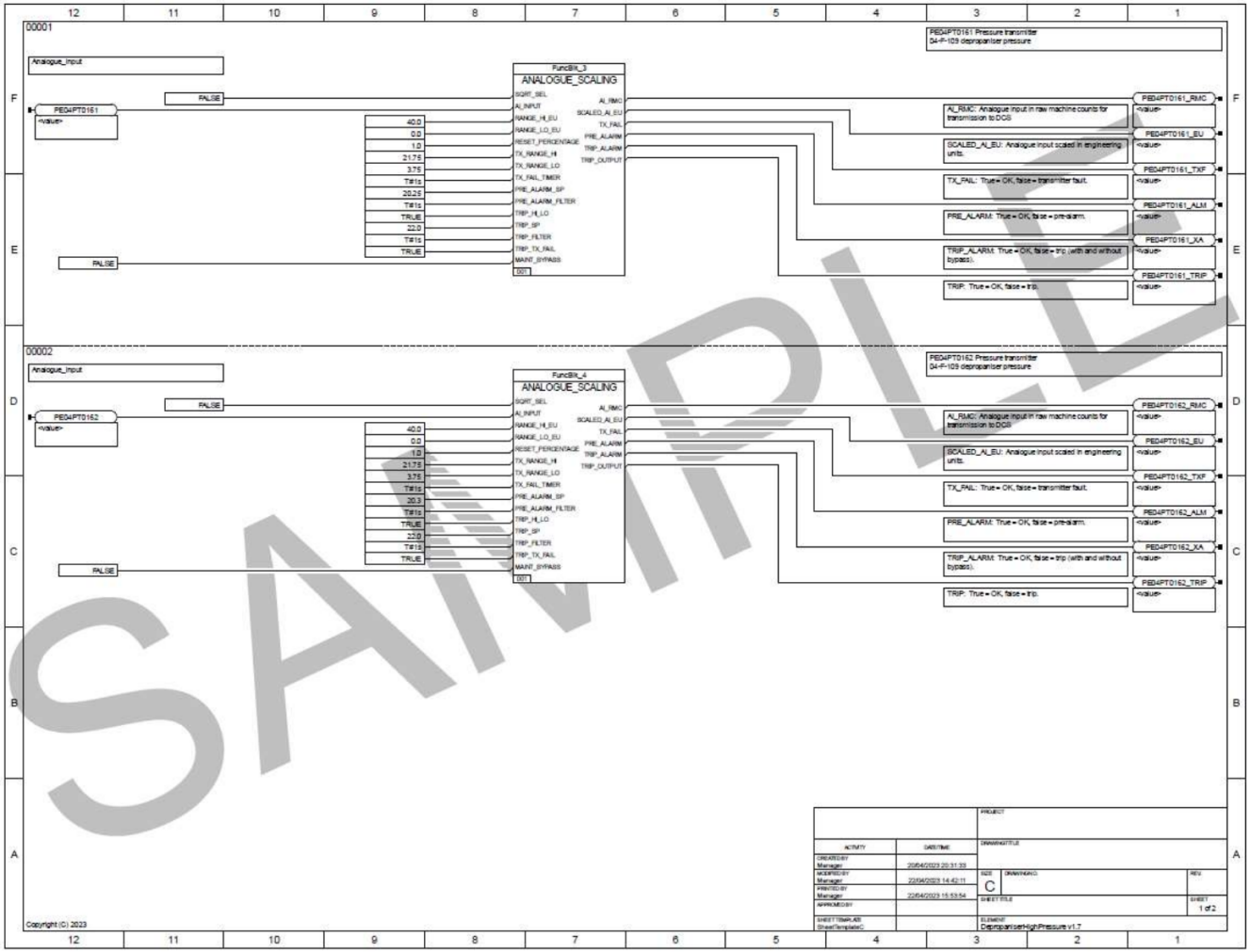


Appendix Figure 36 – Updated Work Breakdown Structure

9.4 PLC Function Block Logic

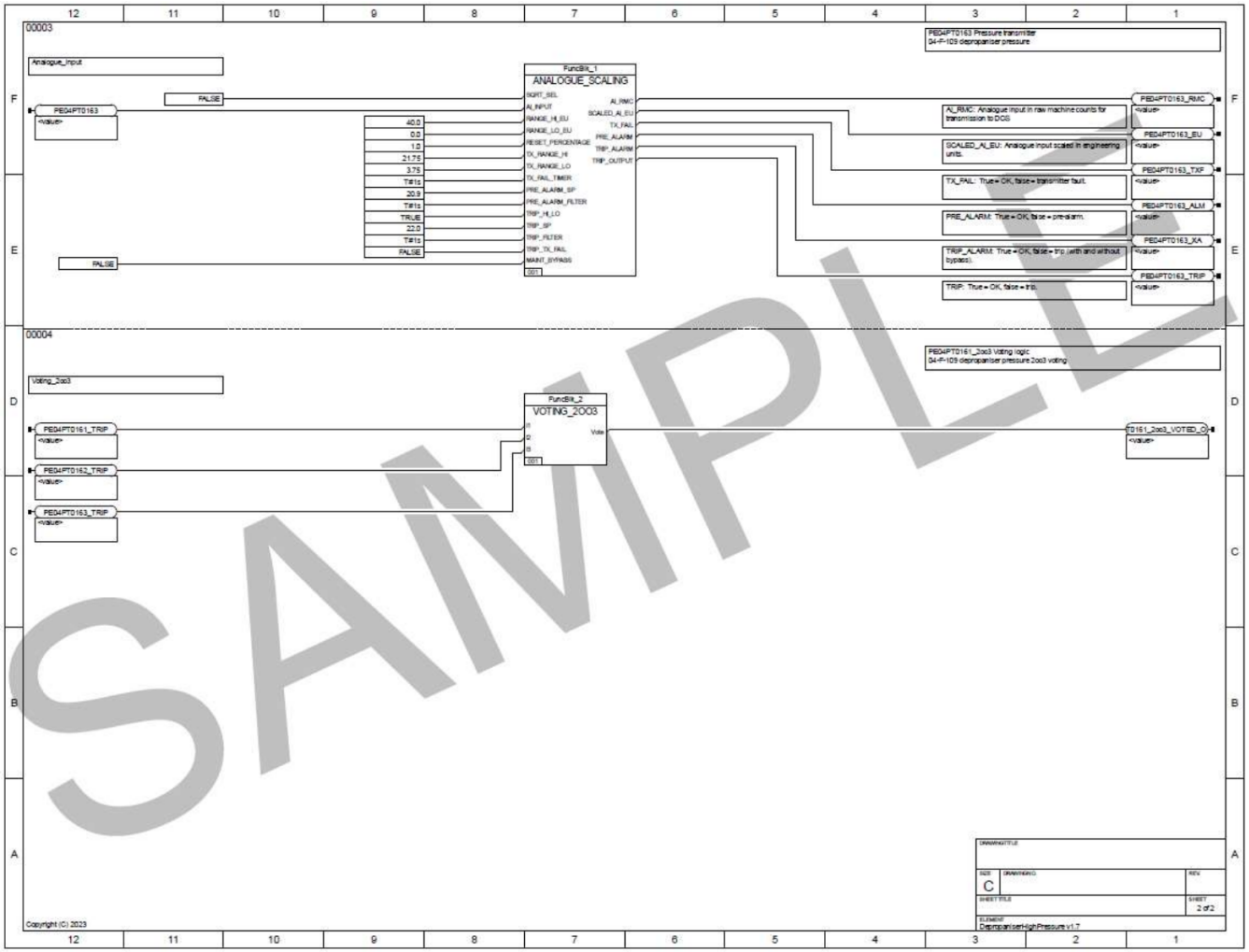


Appendix Figure 37 – TriStation Programs & Function Blocks



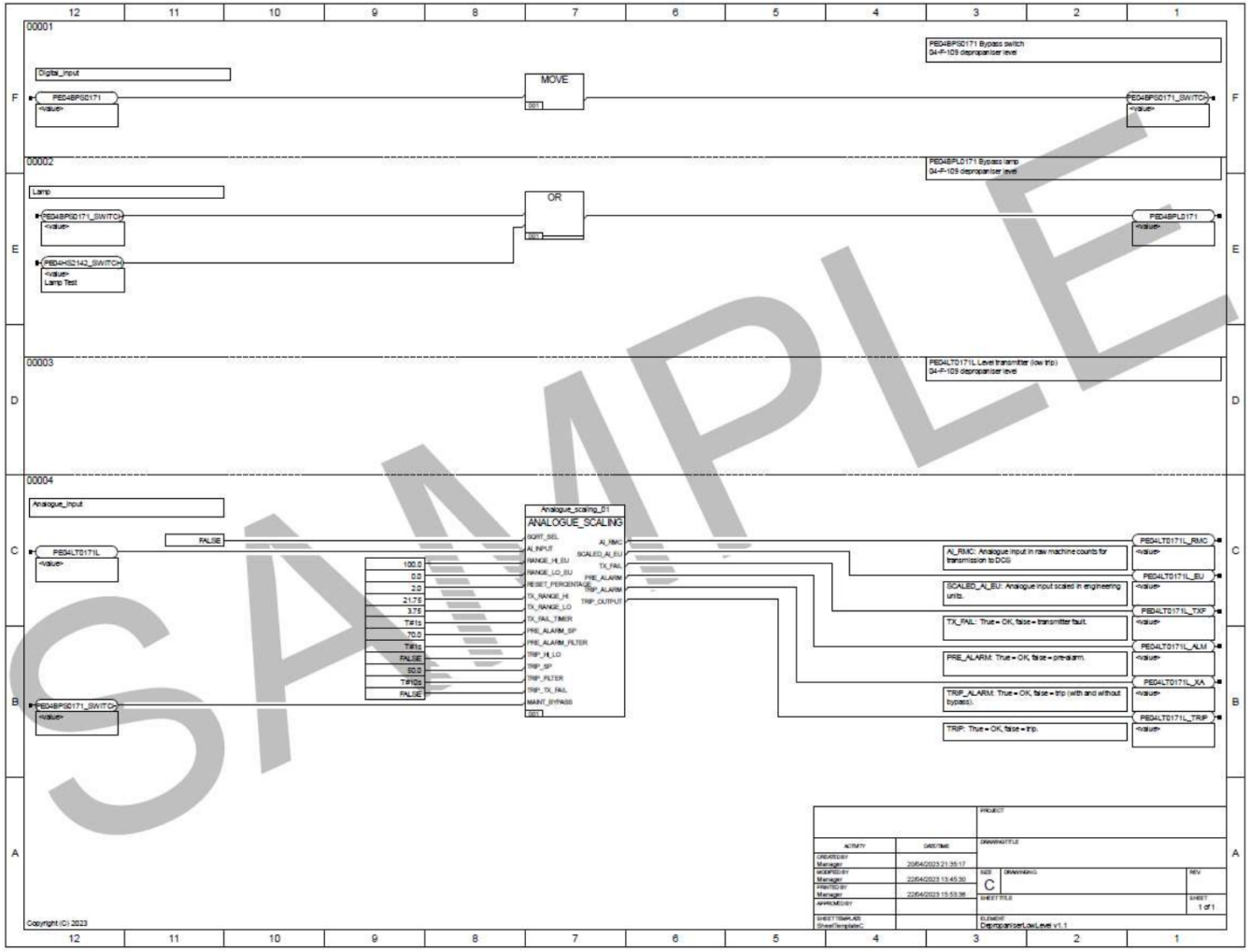
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Appendix Figure 38 – Depropaniser Pressure, Sheet 1



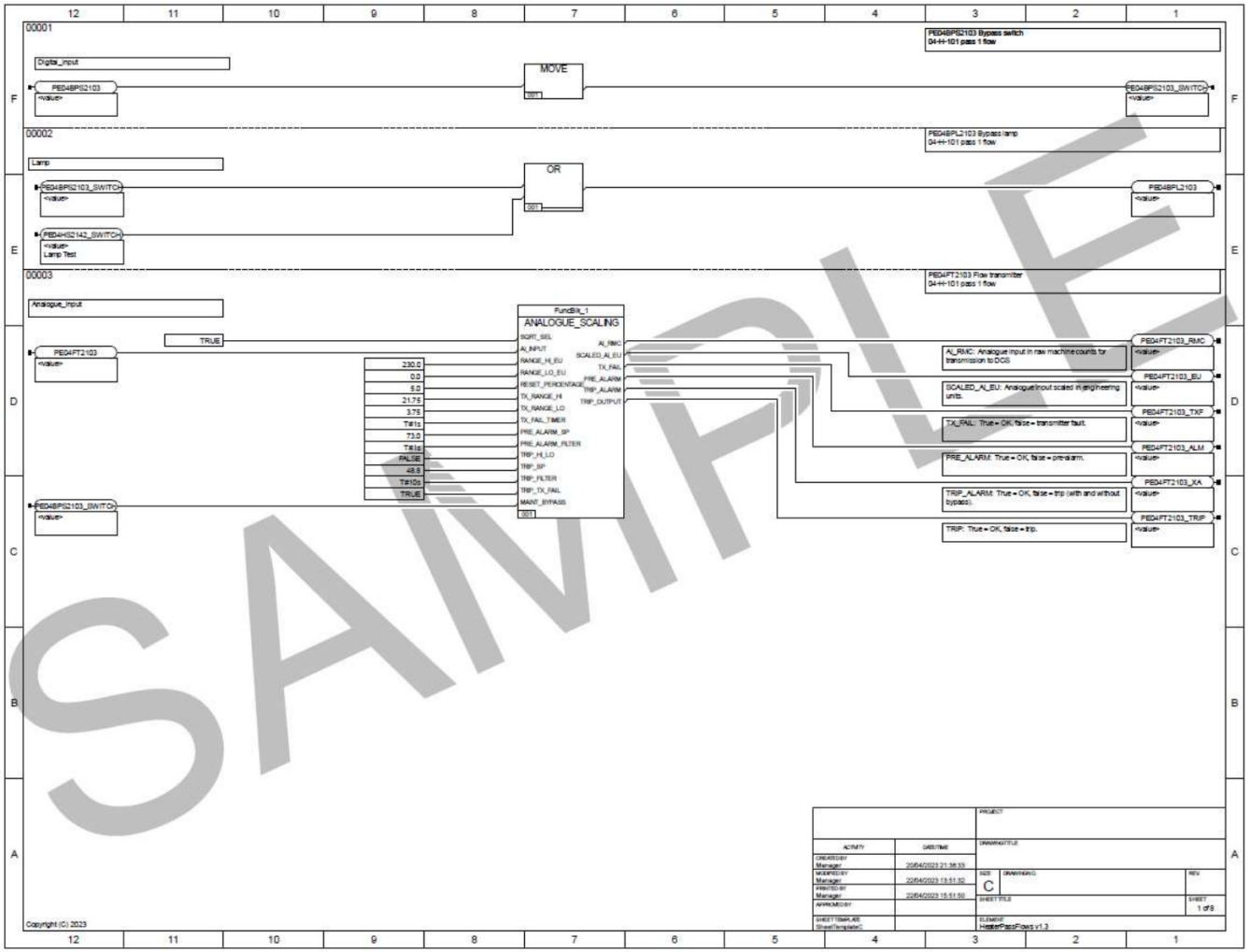
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Appendix Figure 39 – Depropaniser Pressure, Sheet 2



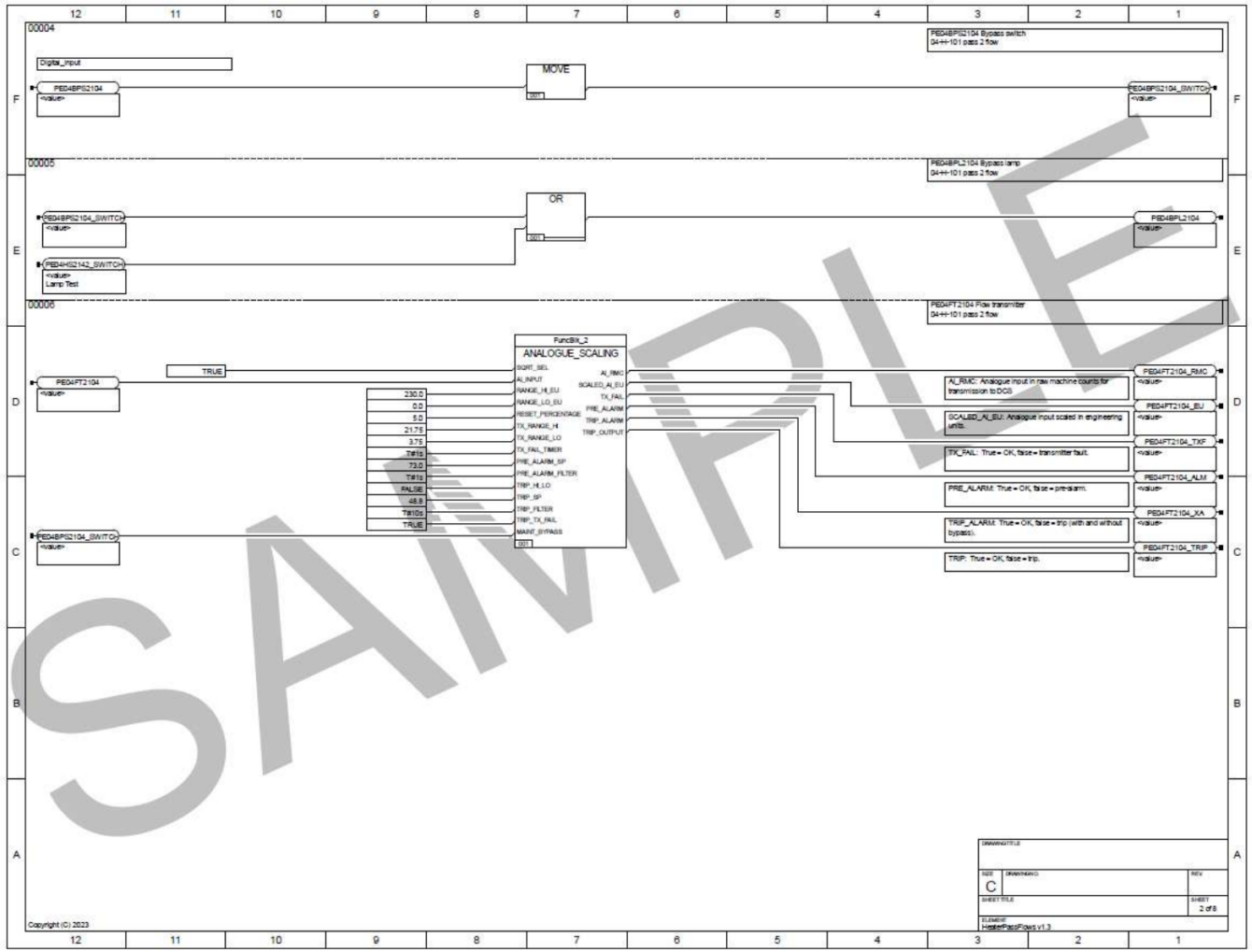
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Appendix Figure 40 – Depropaniser Level



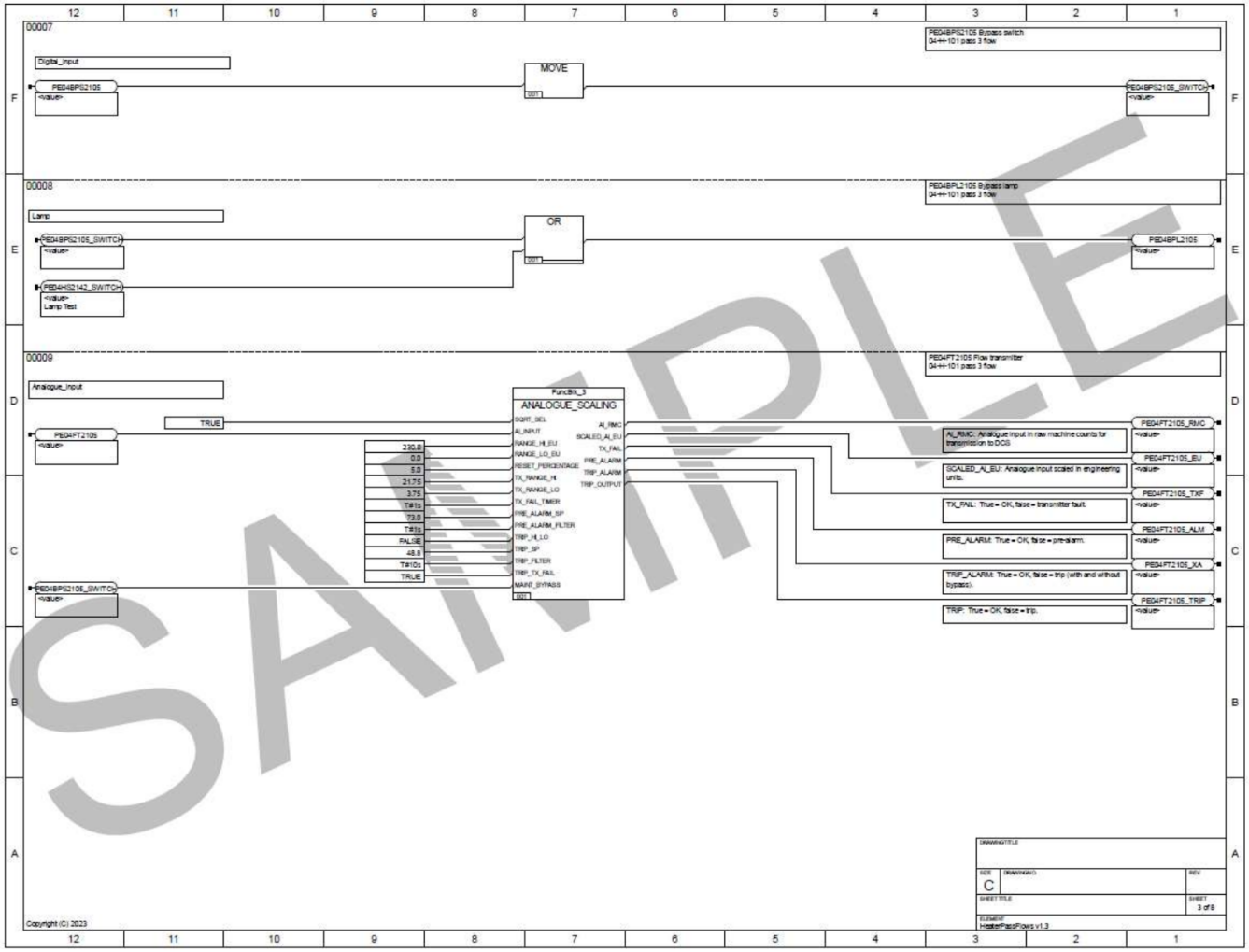
Appendix Figure 41 – Heater Pass Flows, Sheet 1

SAMPLE



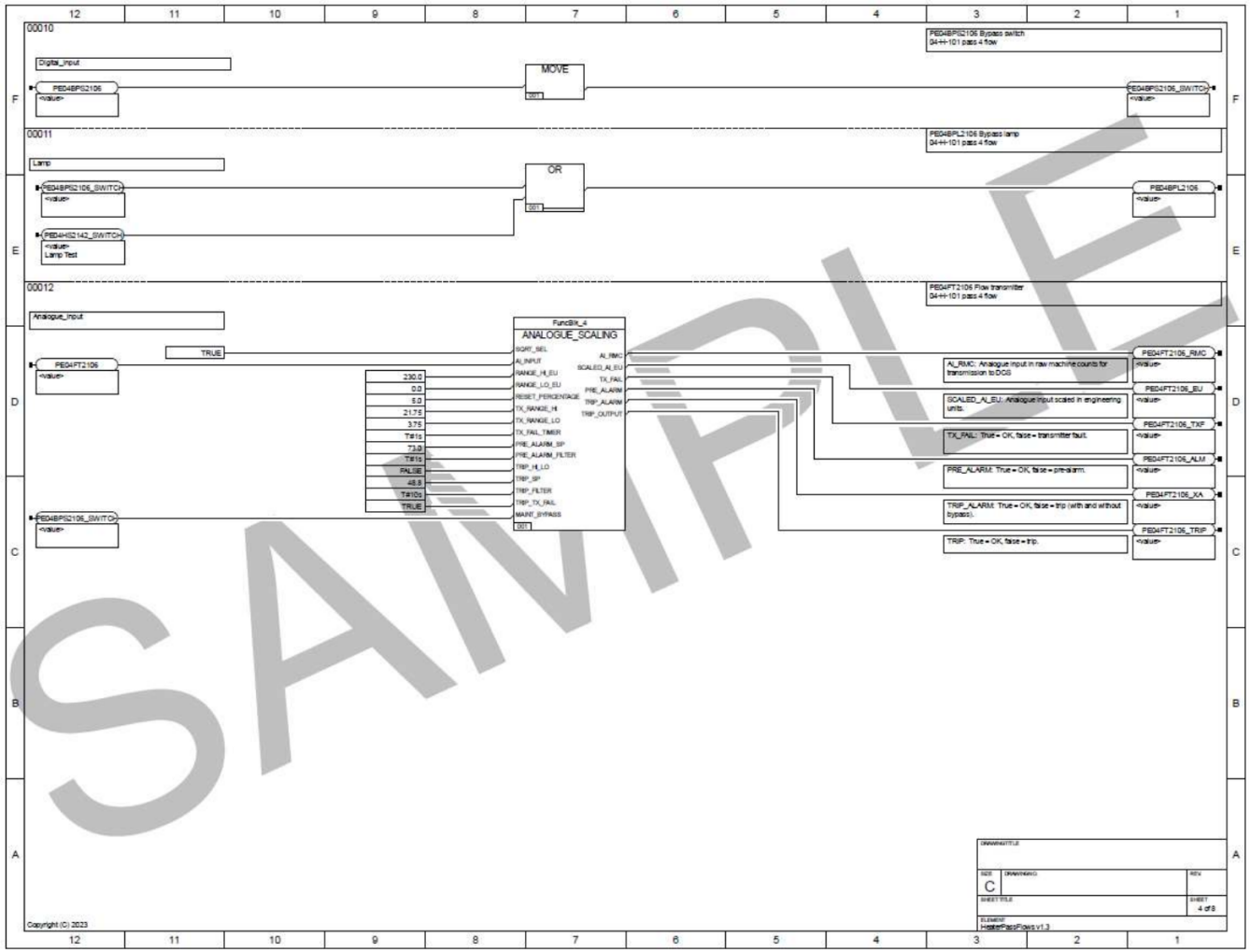
Appendix Figure 42 – Heater Pass Flows, Sheet 2

SAMPLE



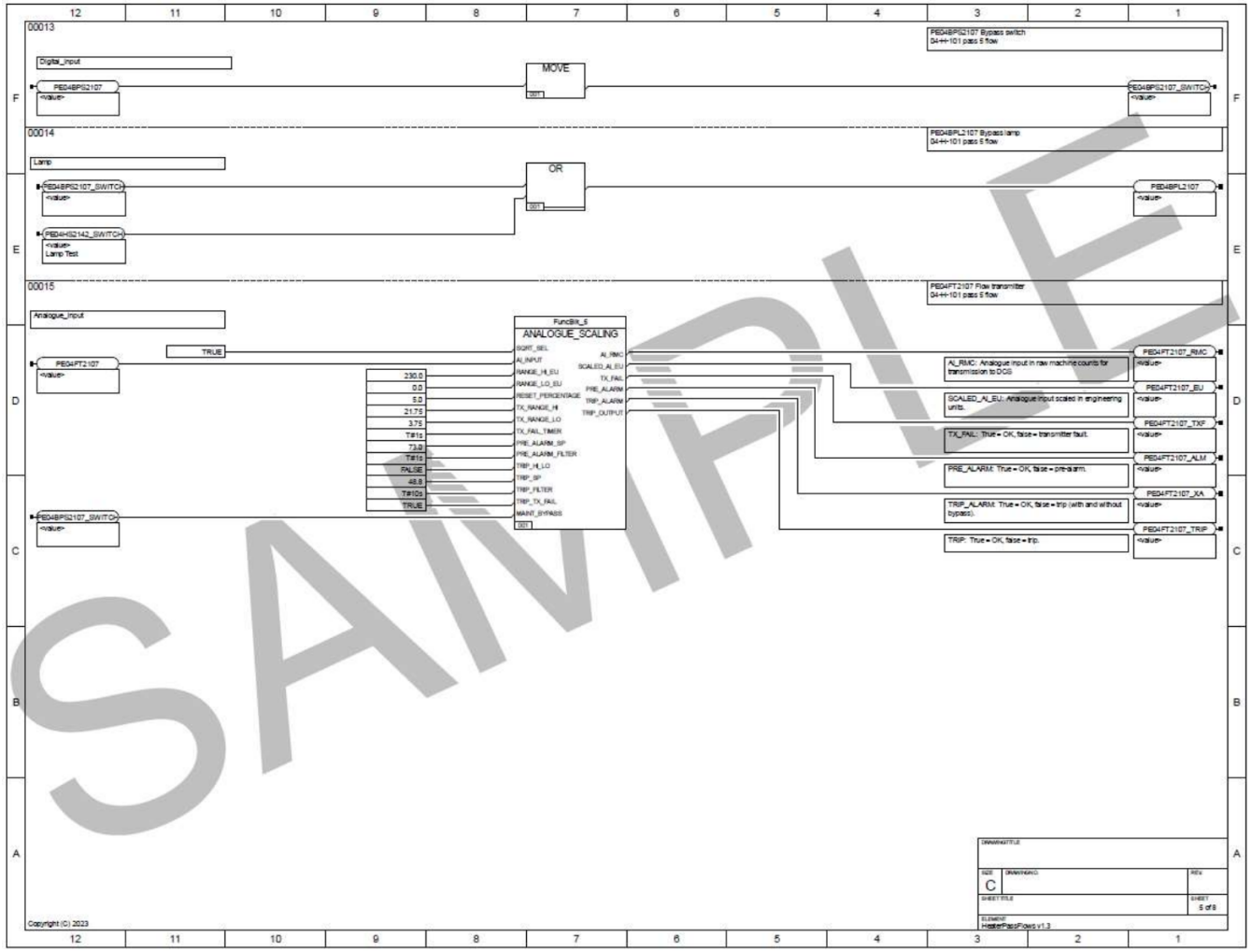
Appendix Figure 43 – Heater Pass Flows, Sheet 3

SAMPLE



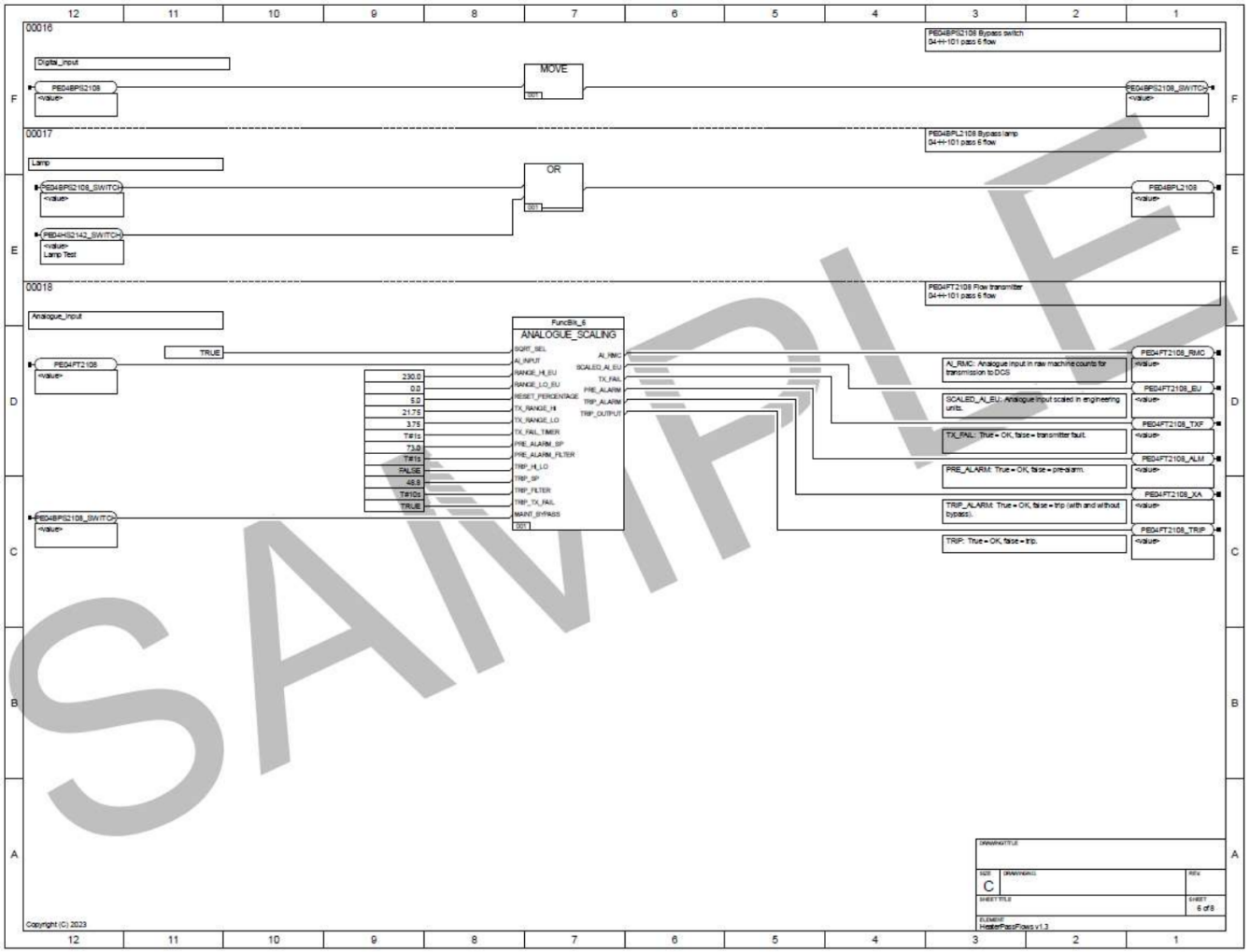
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Appendix Figure 44 – Heater Pass Flows, Sheet 4



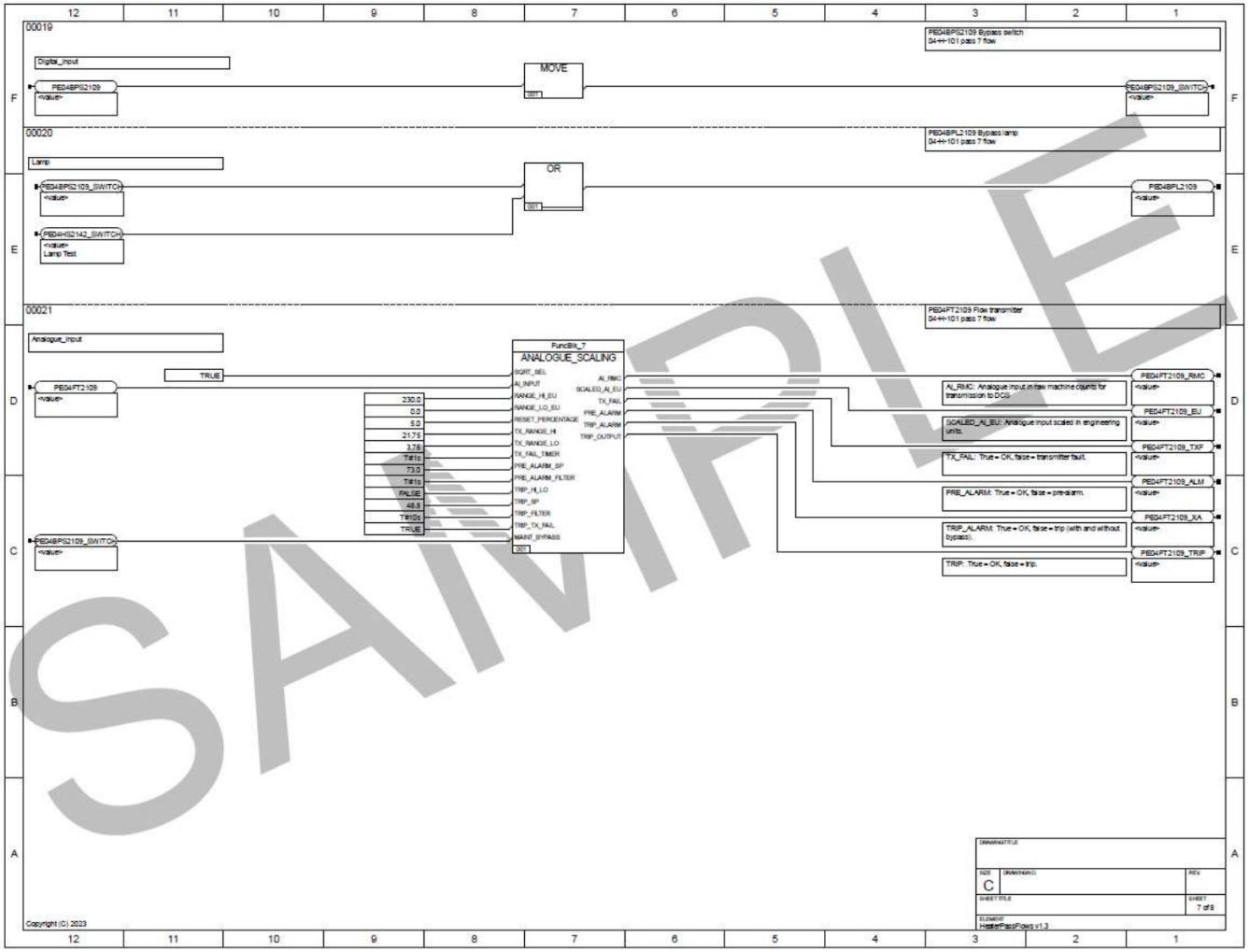
Appendix Figure 45 – Heater Pass Flows, Sheet 5

SAMPLE



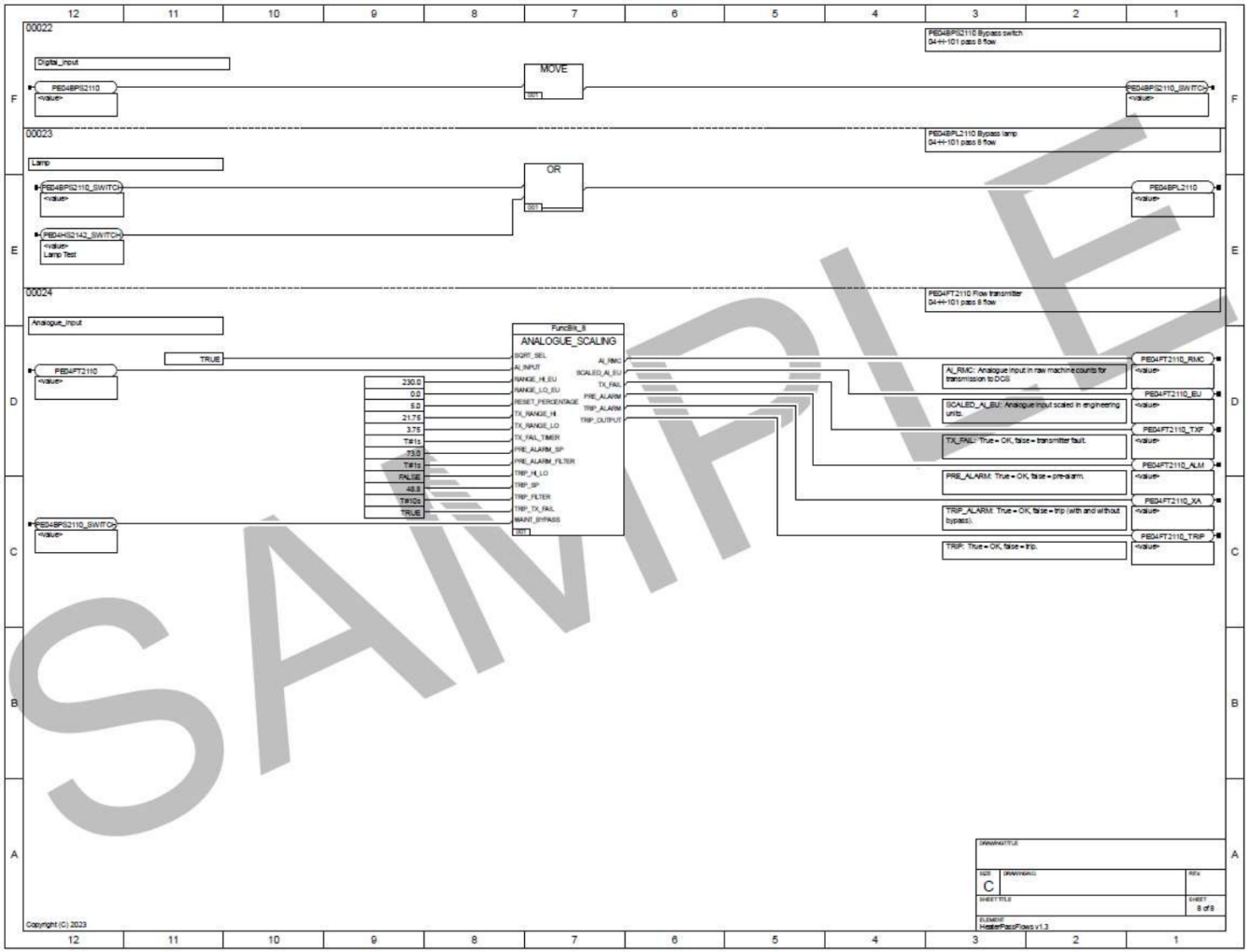
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Appendix Figure 46 – Heater Pass Flows, Sheet 6



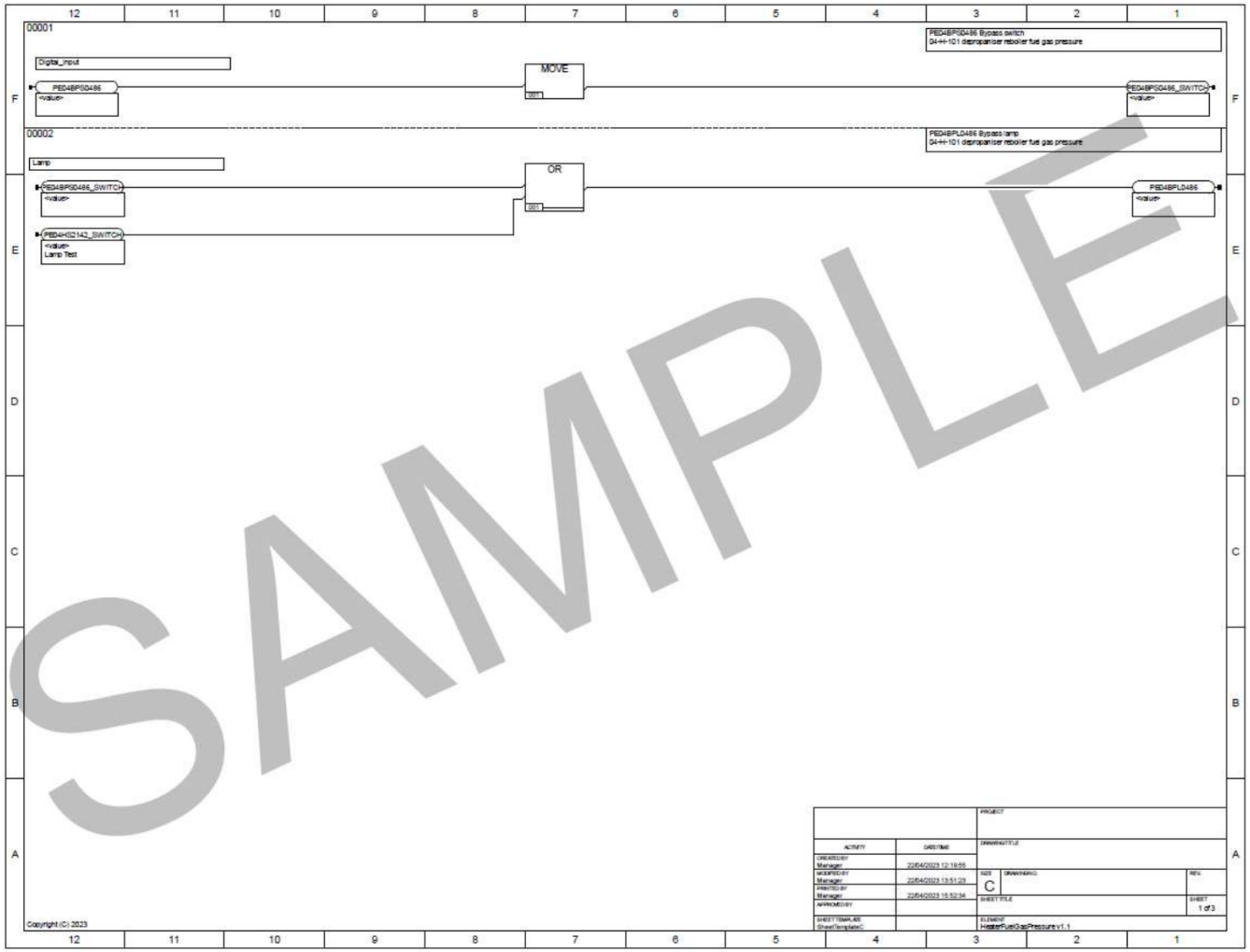
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Appendix Figure 47 – Heater Pass Flows, Sheet 7



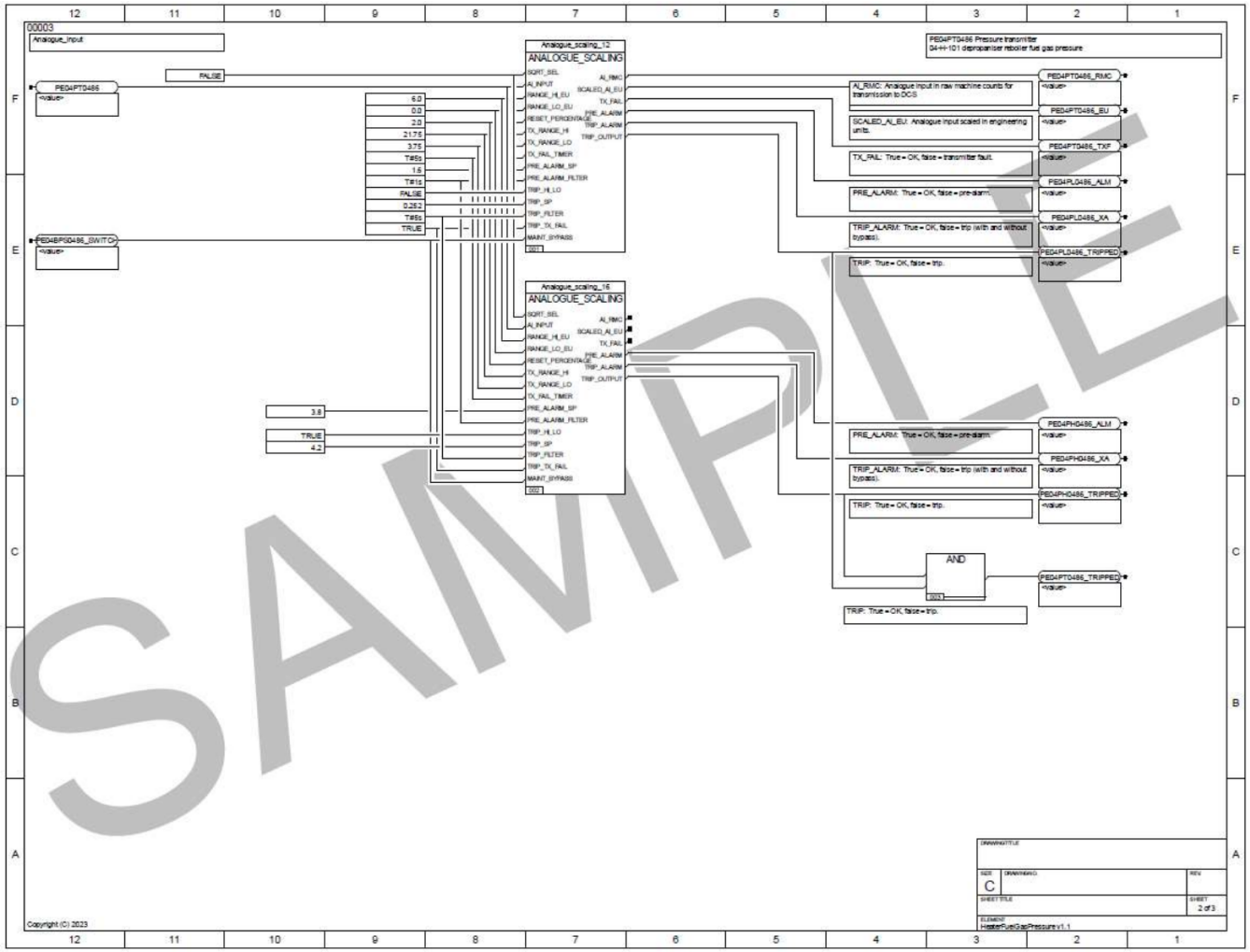
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Appendix Figure 48 – Heater Pass Flows, Sheet 8

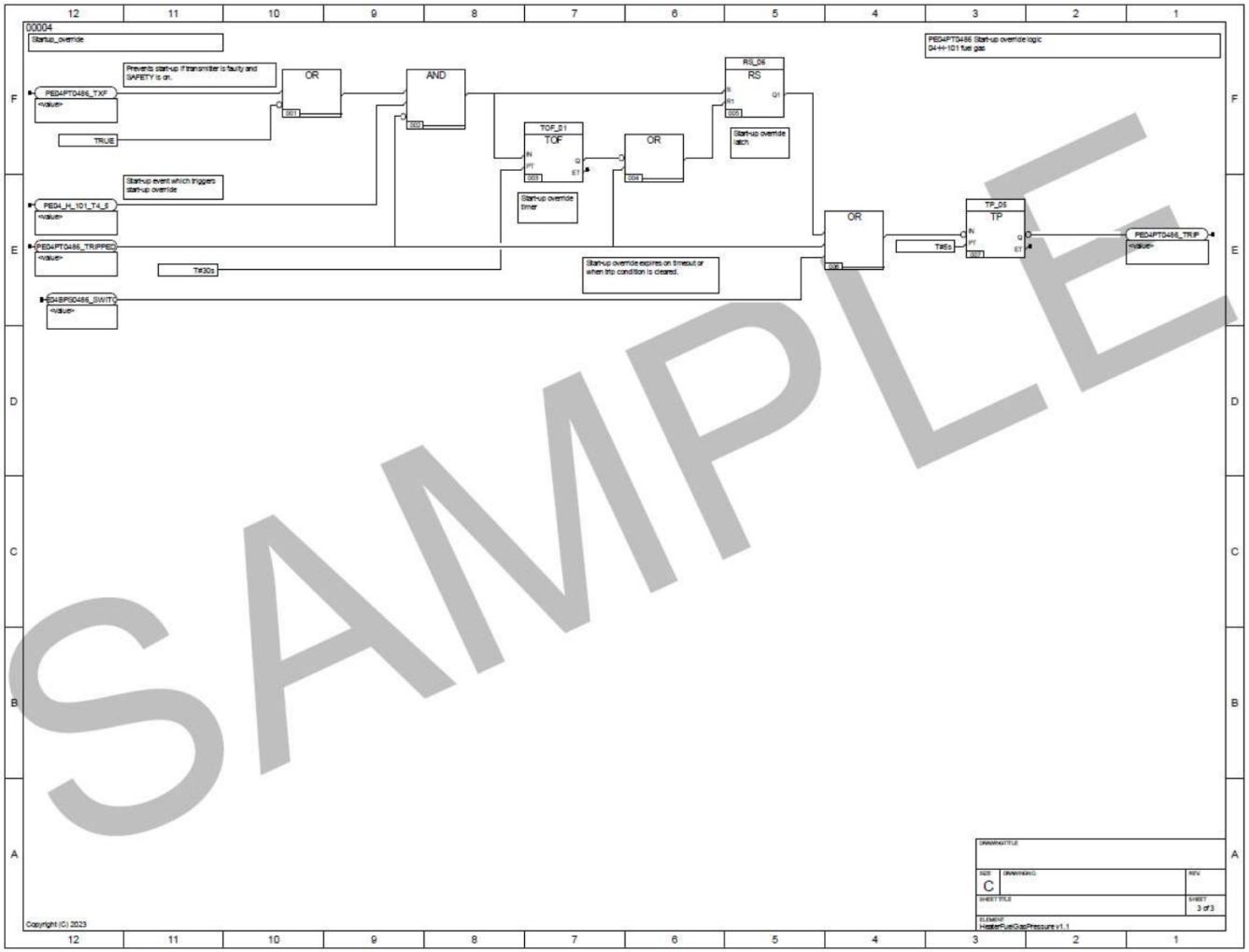


SAMPLE

Appendix Figure 49 – Heater Fuel Gas Pressure, Sheet 1

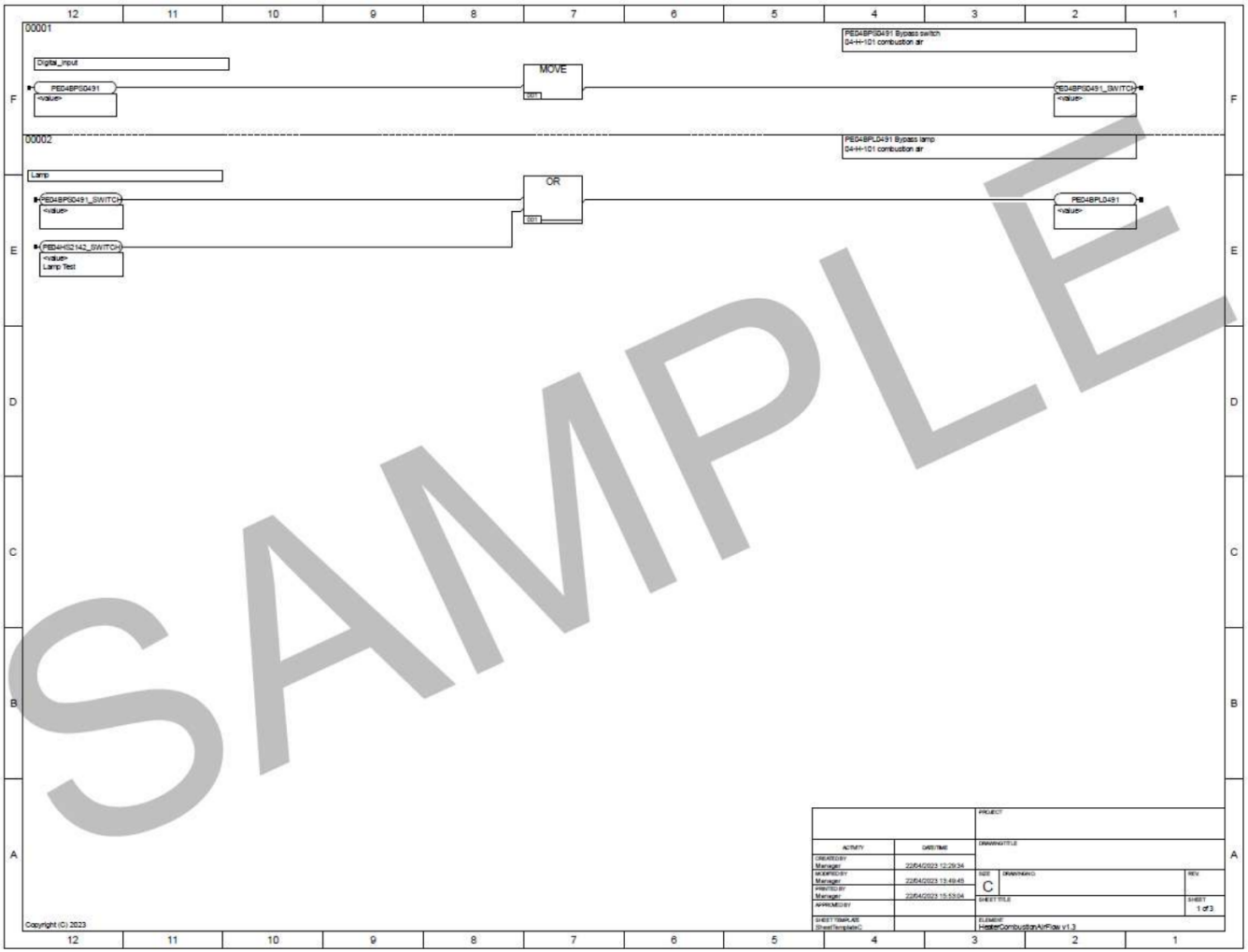


Appendix Figure 50 – Heater Fuel Gas Pressure, Sheet 2



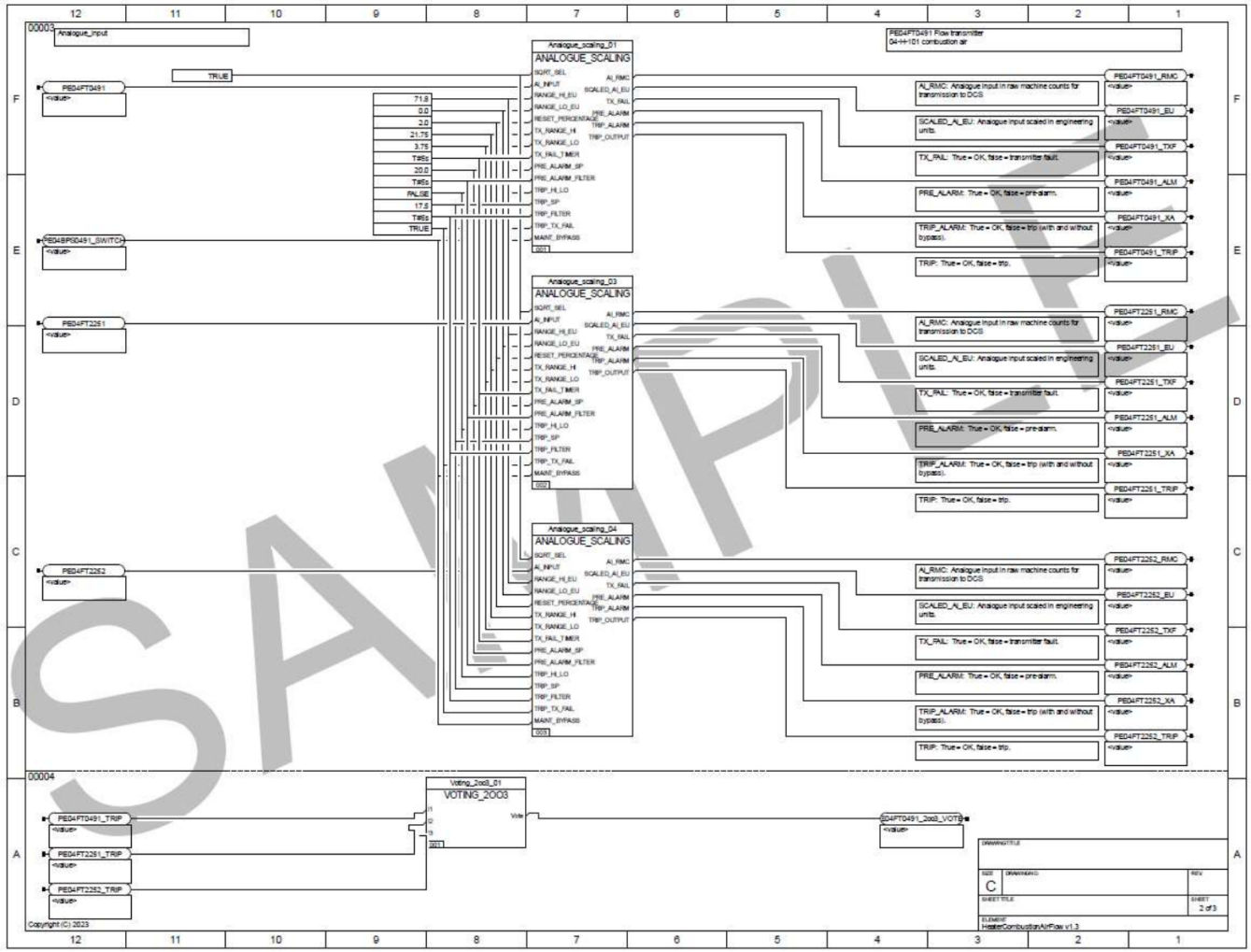
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Appendix Figure 51 – Heater Fuel Gas Pressure, Sheet 3



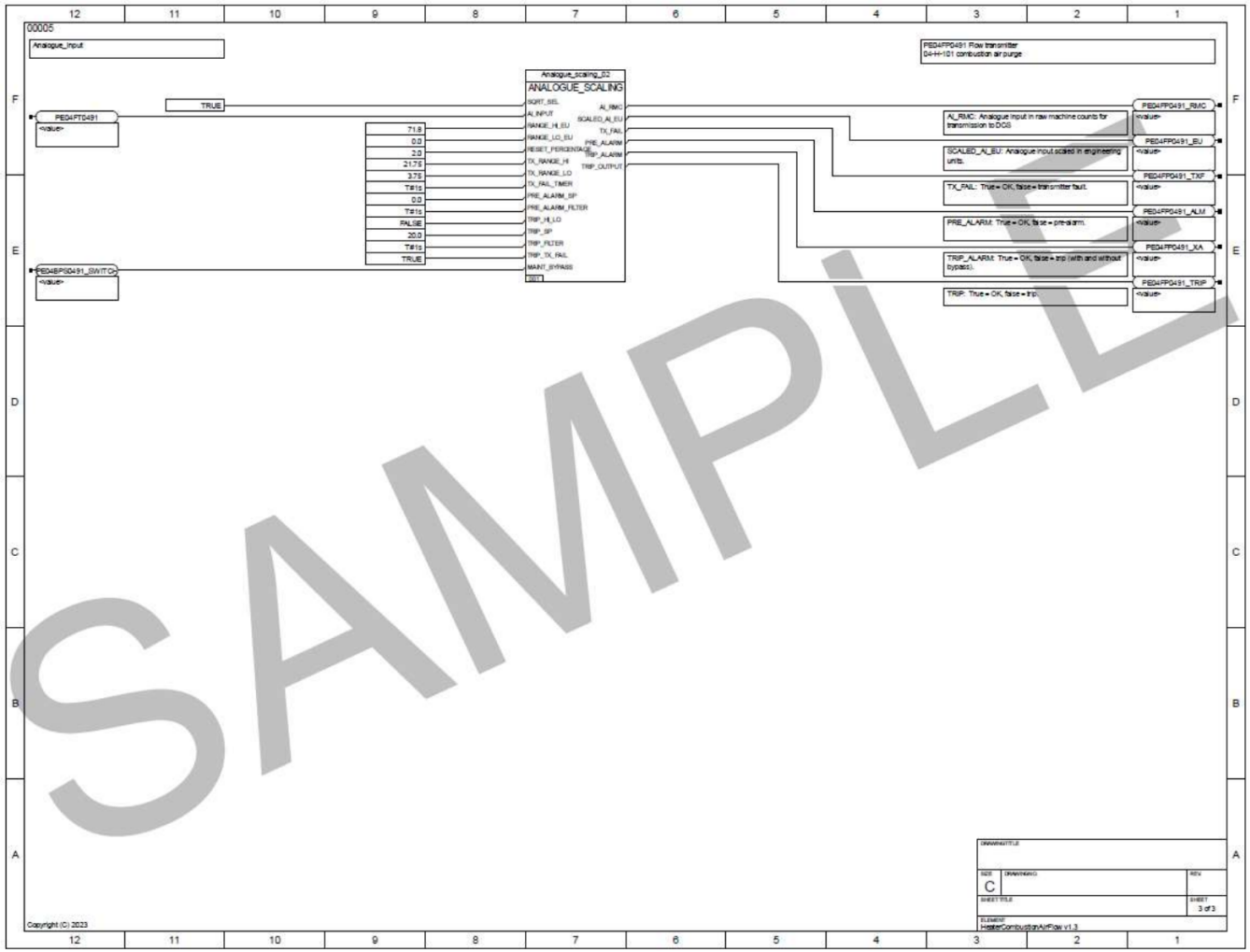
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Appendix Figure 52 – Heater Combustion Air Flow, Sheet 1



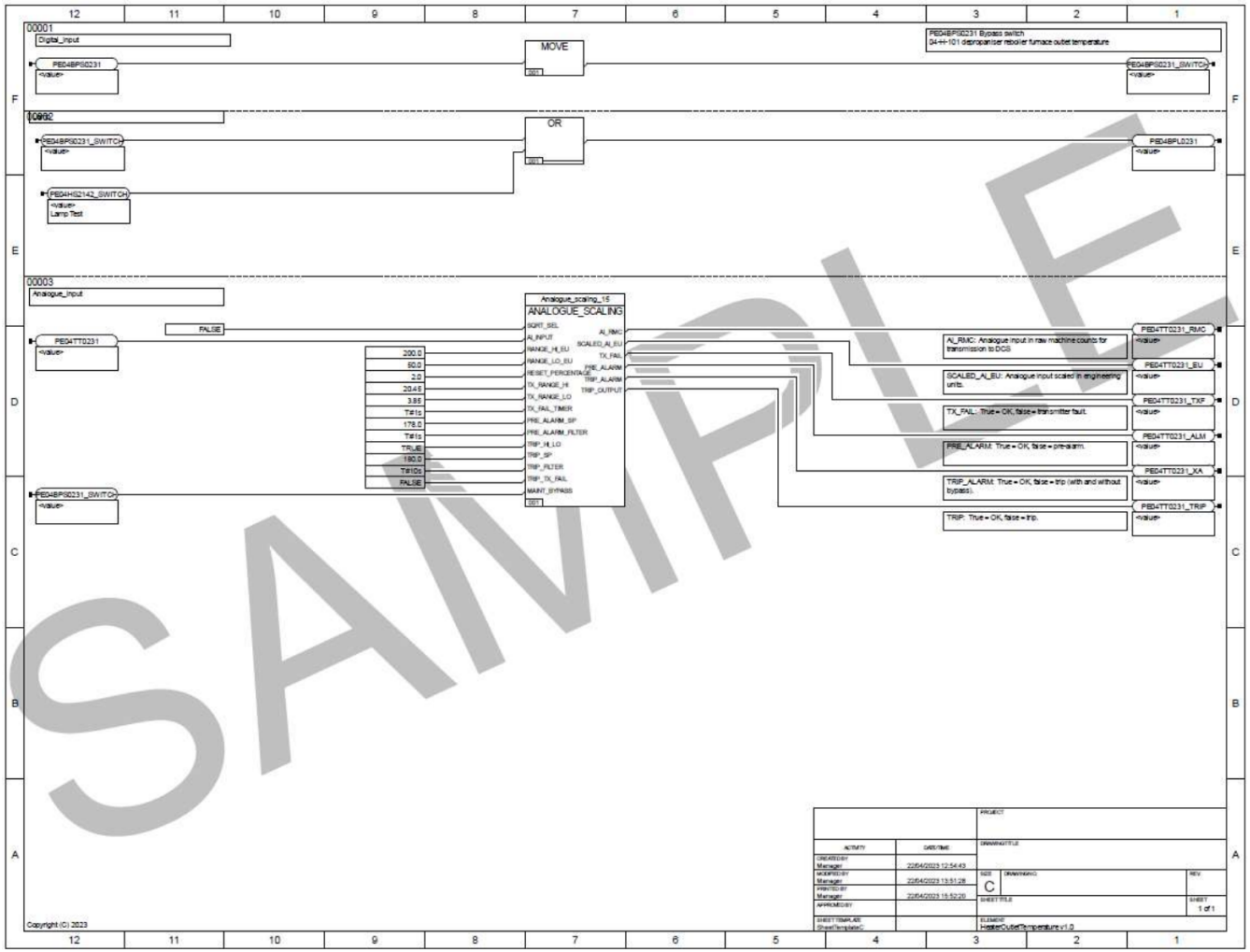
Appendix Figure 53 – Heater Combustion Air Flow, Sheet 2

SAMPLE



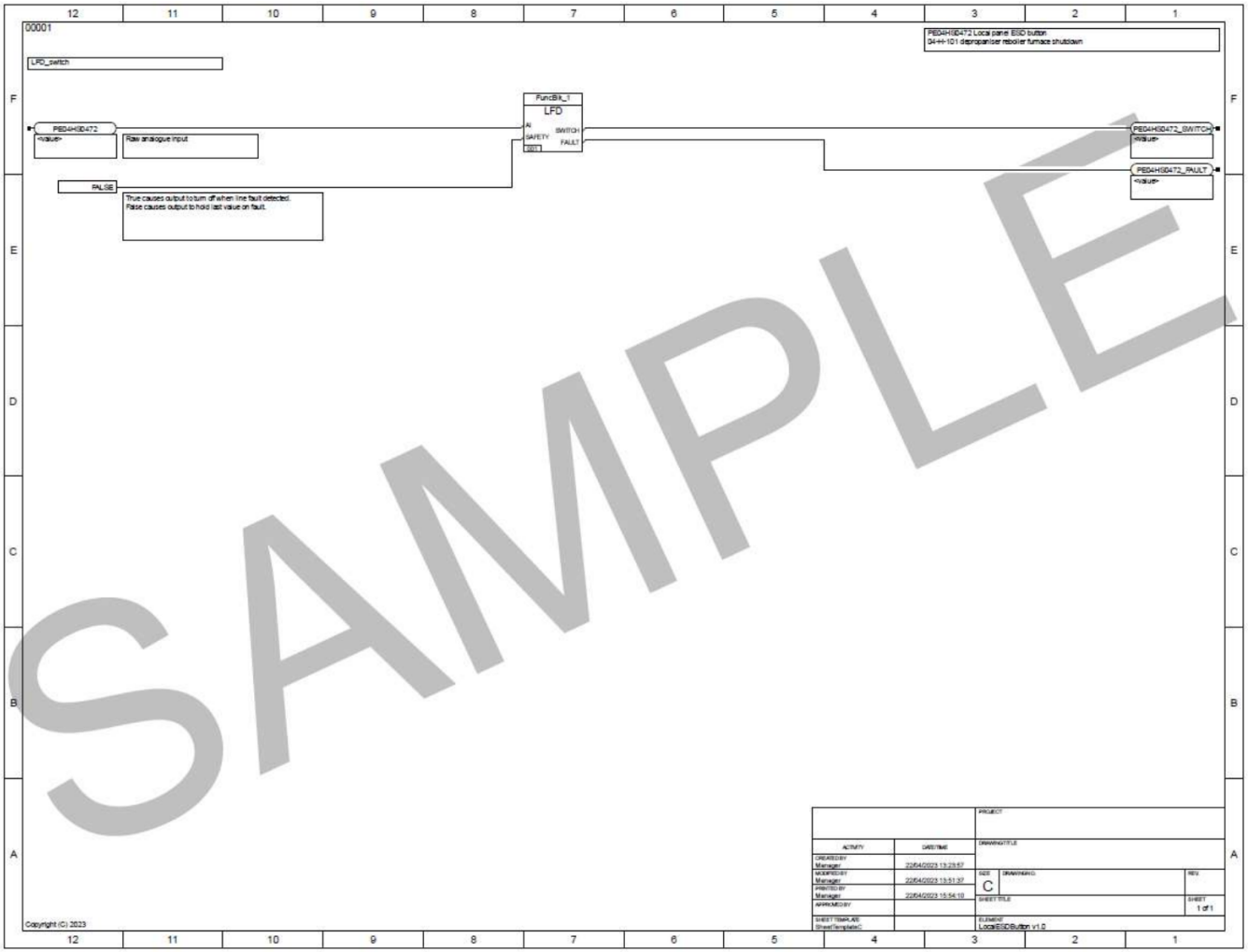
Appendix Figure 54 – Heater Combustion Air Flow, Sheet 3

SAMPLE



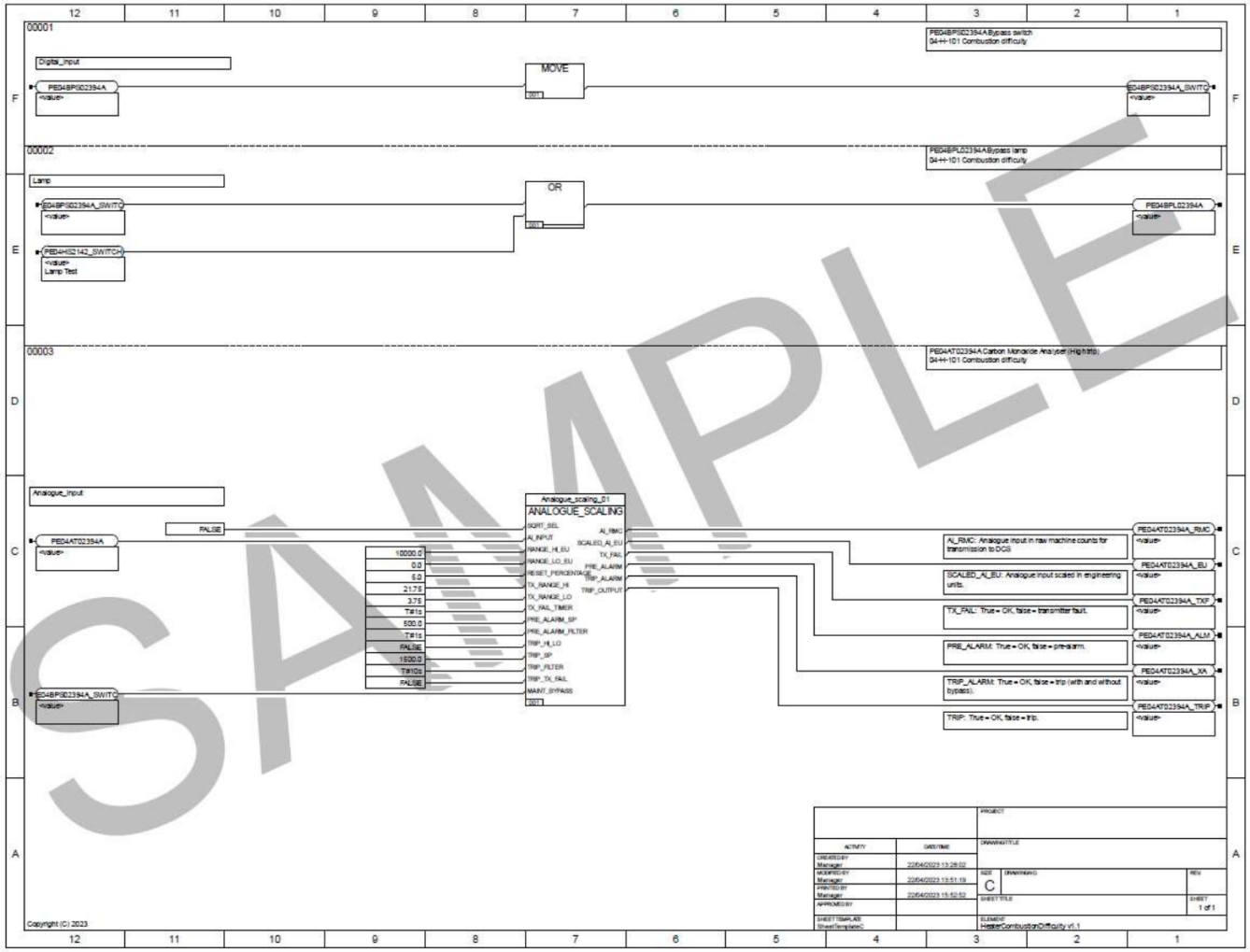
SAMPLE

Appendix Figure 55 – Heater Outlet Temperature, Sheet 1



SAMPLE

Appendix Figure 56 – Local Heater ESD Button, Sheet 1



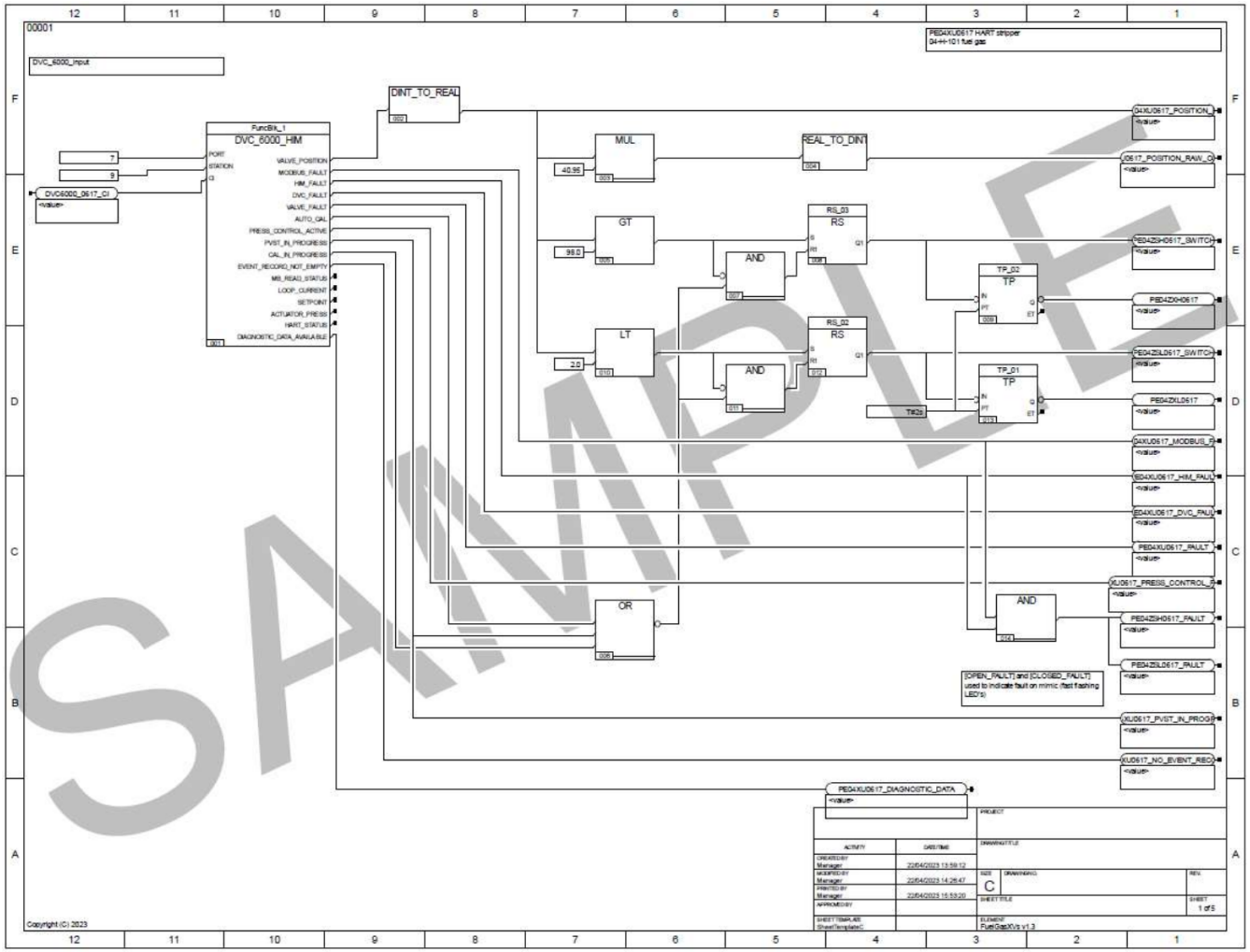
Appendix Figure 57 – Heater Combustion Difficulty, Sheet 1

SAMPLE



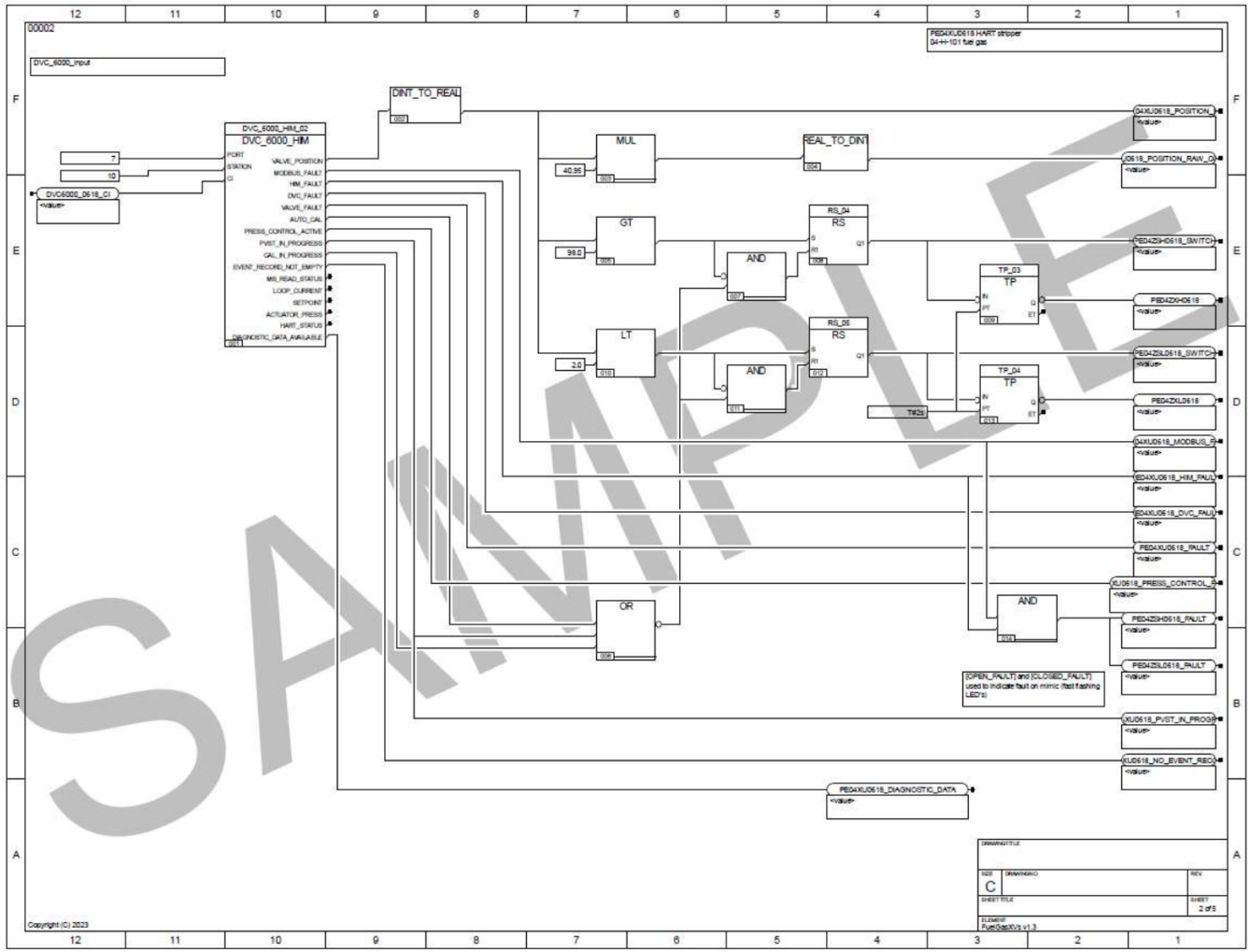
SAMPLE

Appendix Figure 58 – Heater Combustion Difficulty, Sheet 2



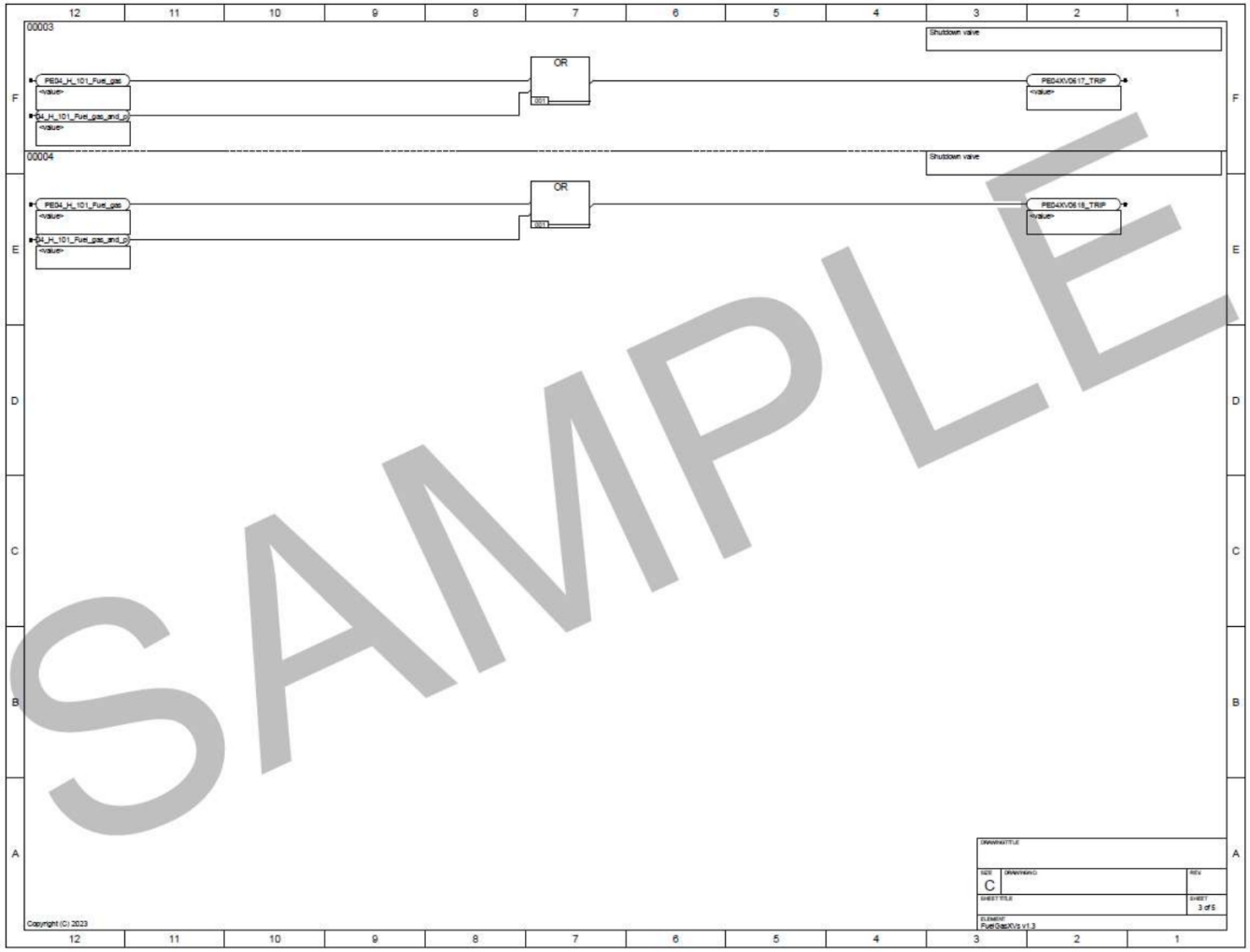
Appendix Figure 59 – Fuel Gas Valves, Sheet 1

SAMPLE



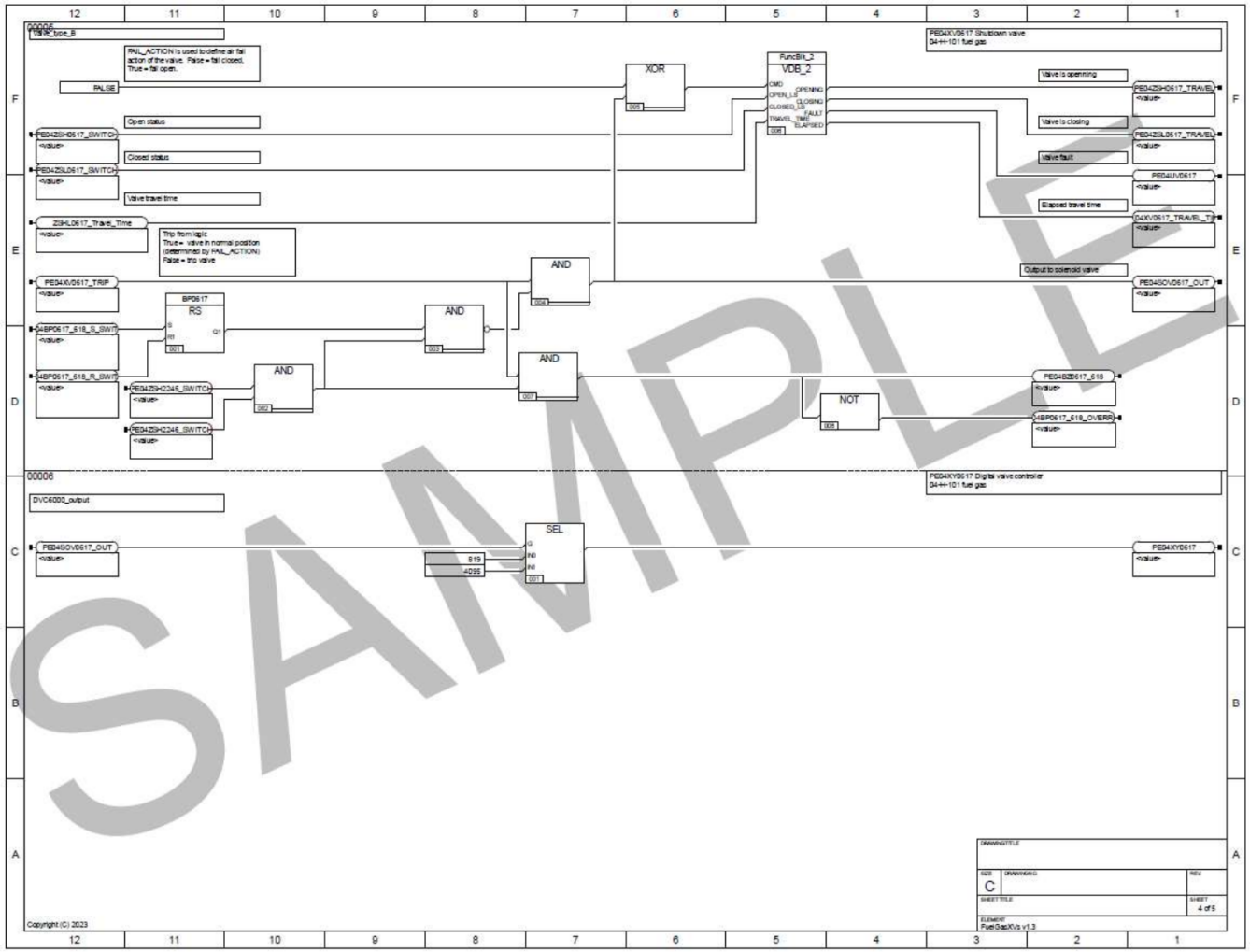
Appendix Figure 60 – Fuel Gas Valves, Sheet 2

SAMPLE

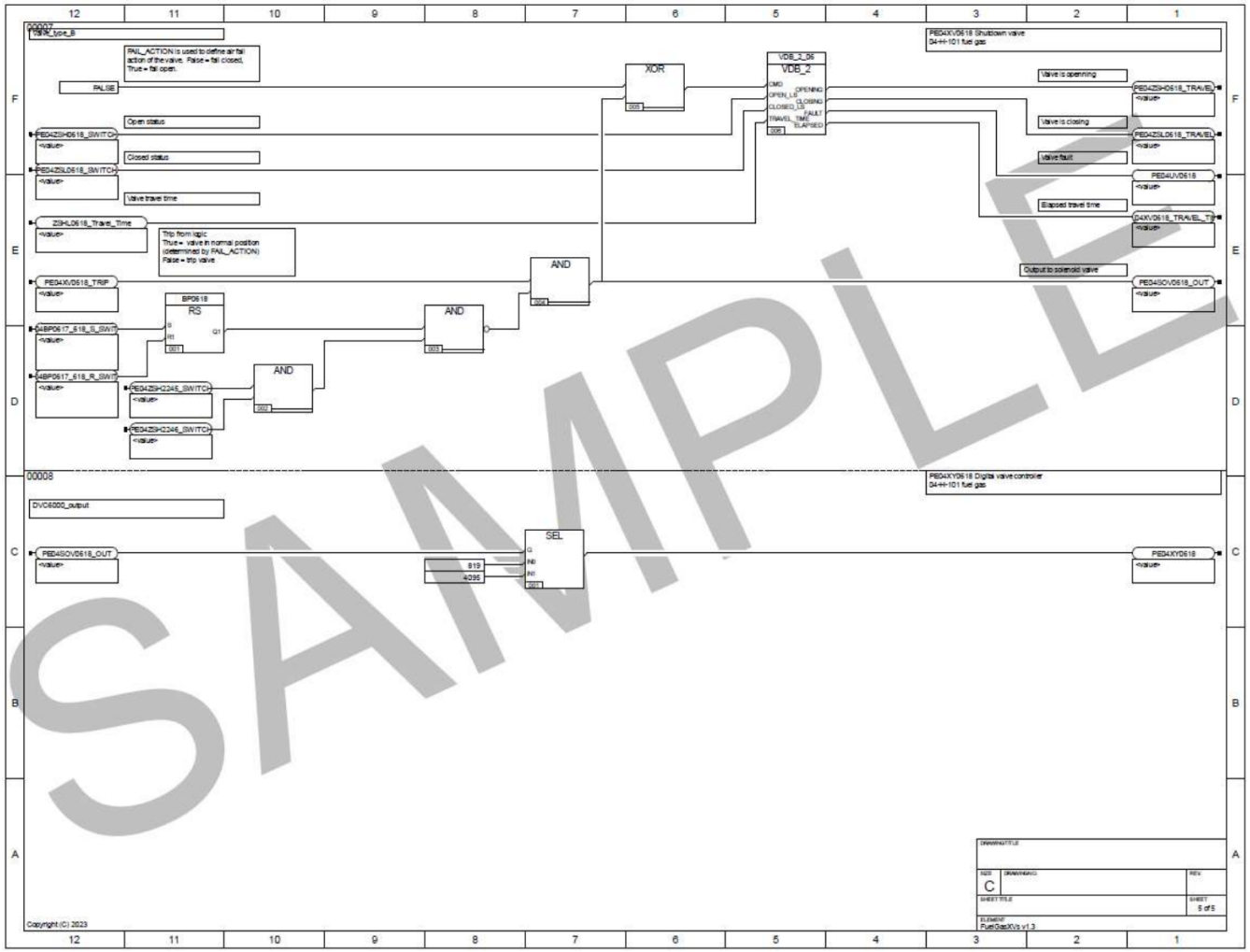


Appendix Figure 61 – Fuel Gas Valves, Sheet 3

SAMPLE

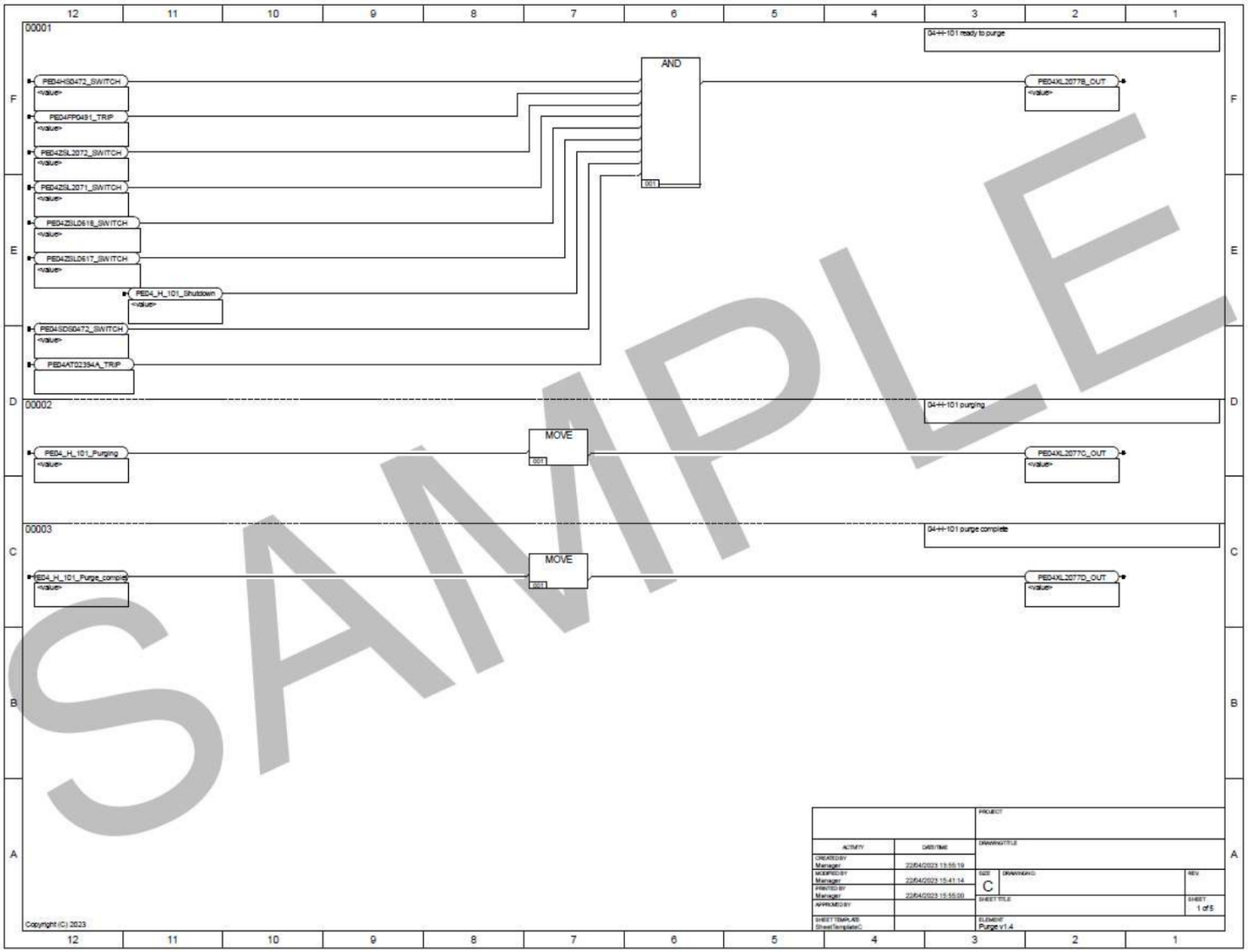


Appendix Figure 62 – Fuel Gas Valves, Sheet 4



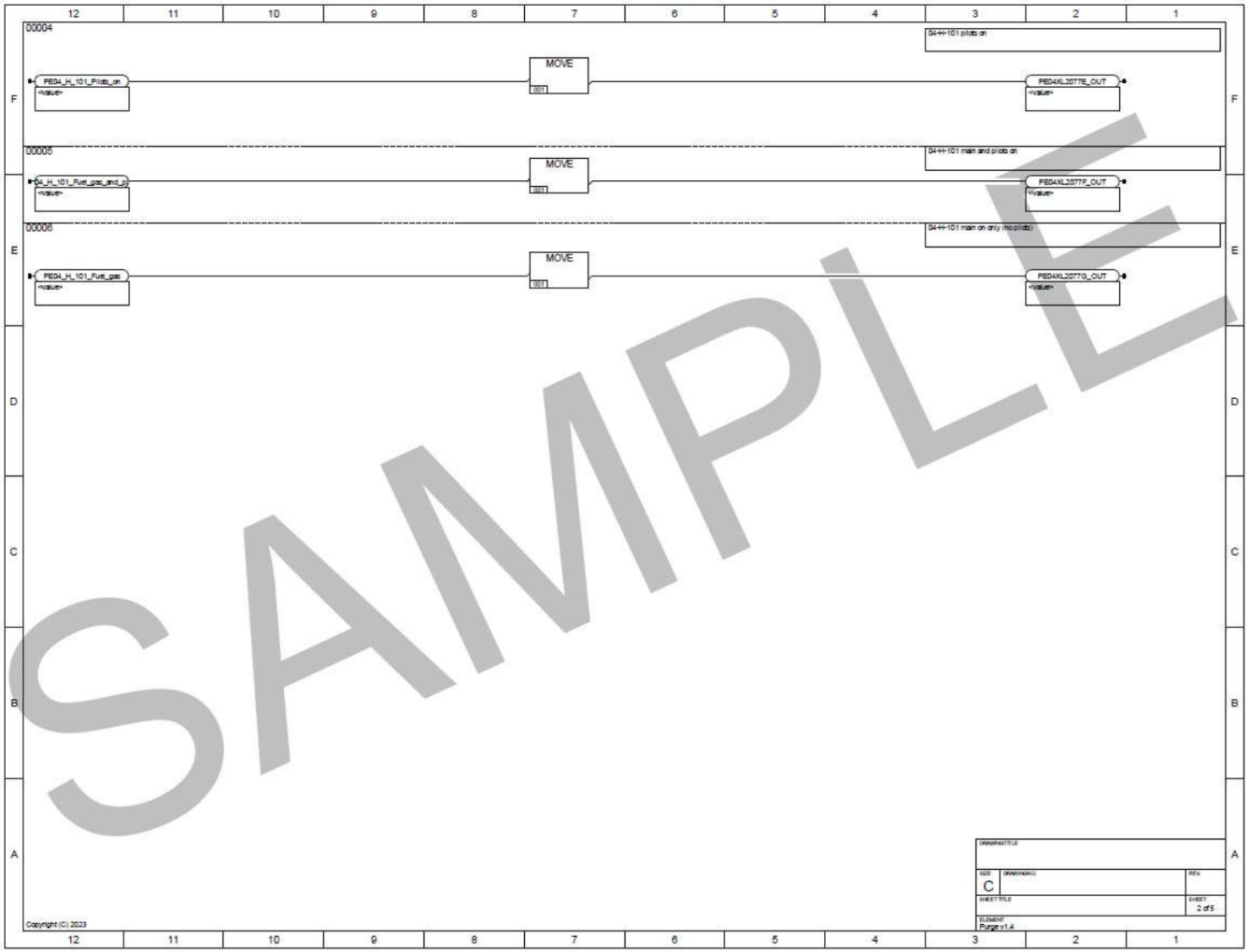
Appendix Figure 63 – Fuel Gas Valves, Sheet 5

SAMPLE

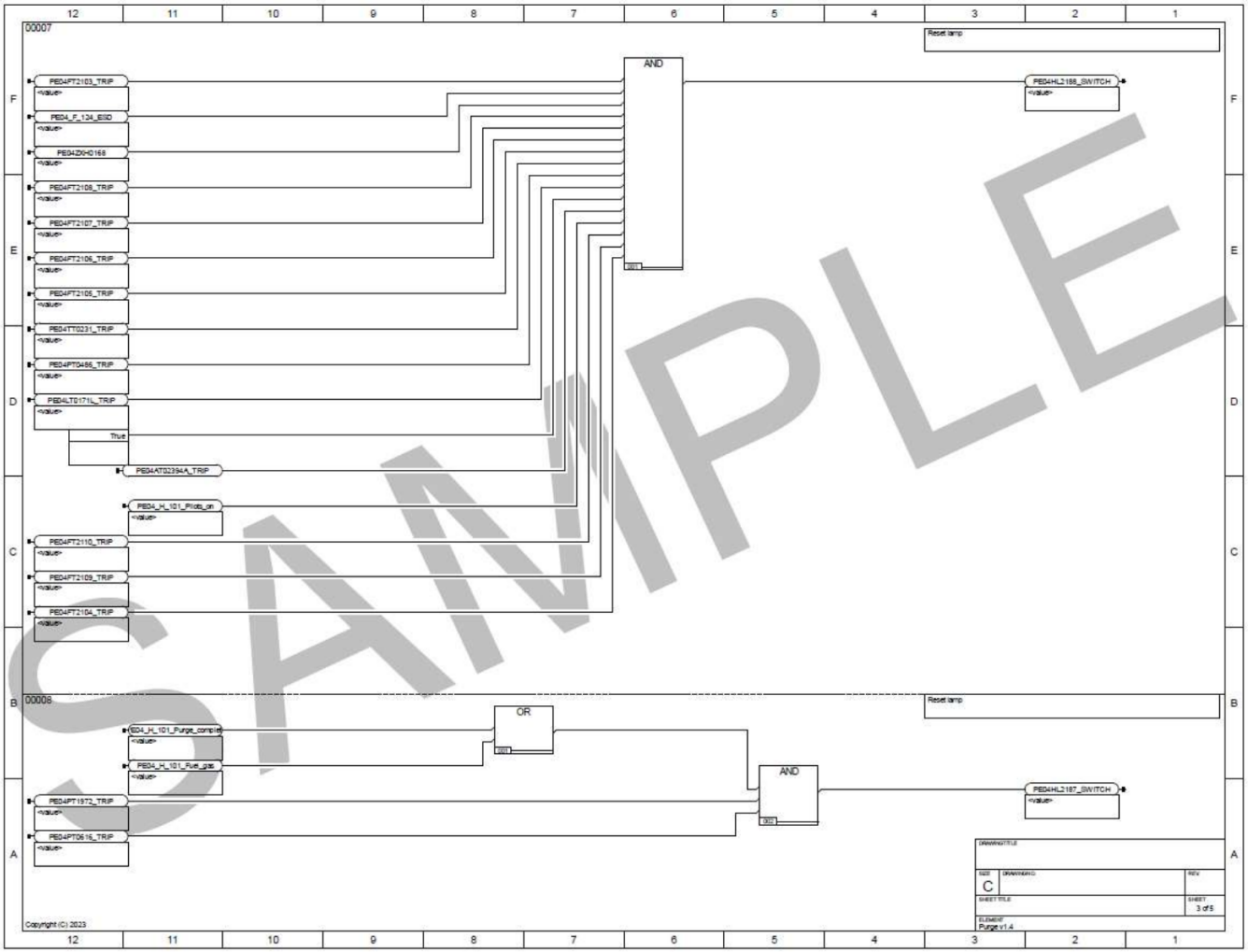


Appendix Figure 64 – Heater Purge, Sheet 1

SAMPLE

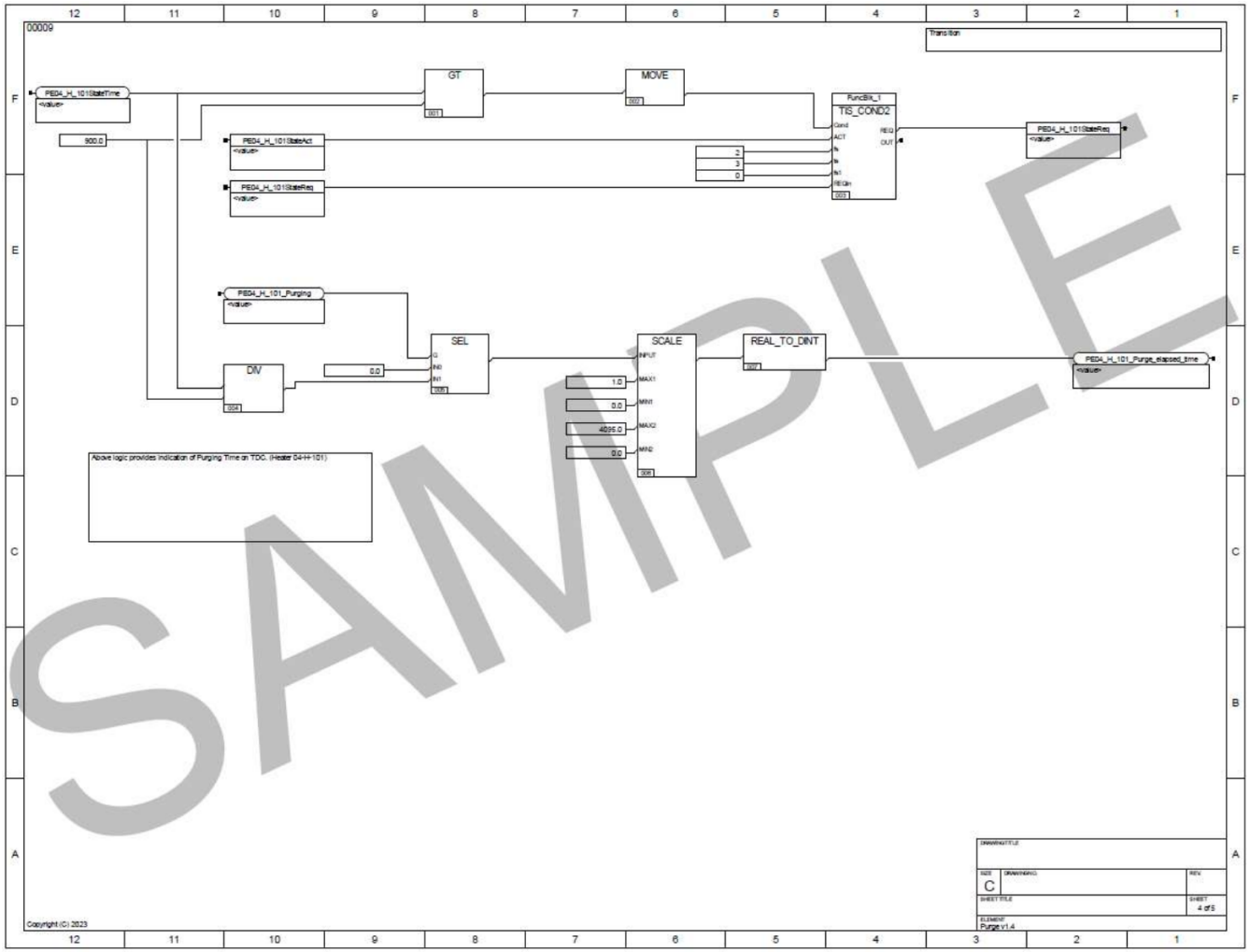


Appendix Figure 65 – Heater Purge, Sheet 2



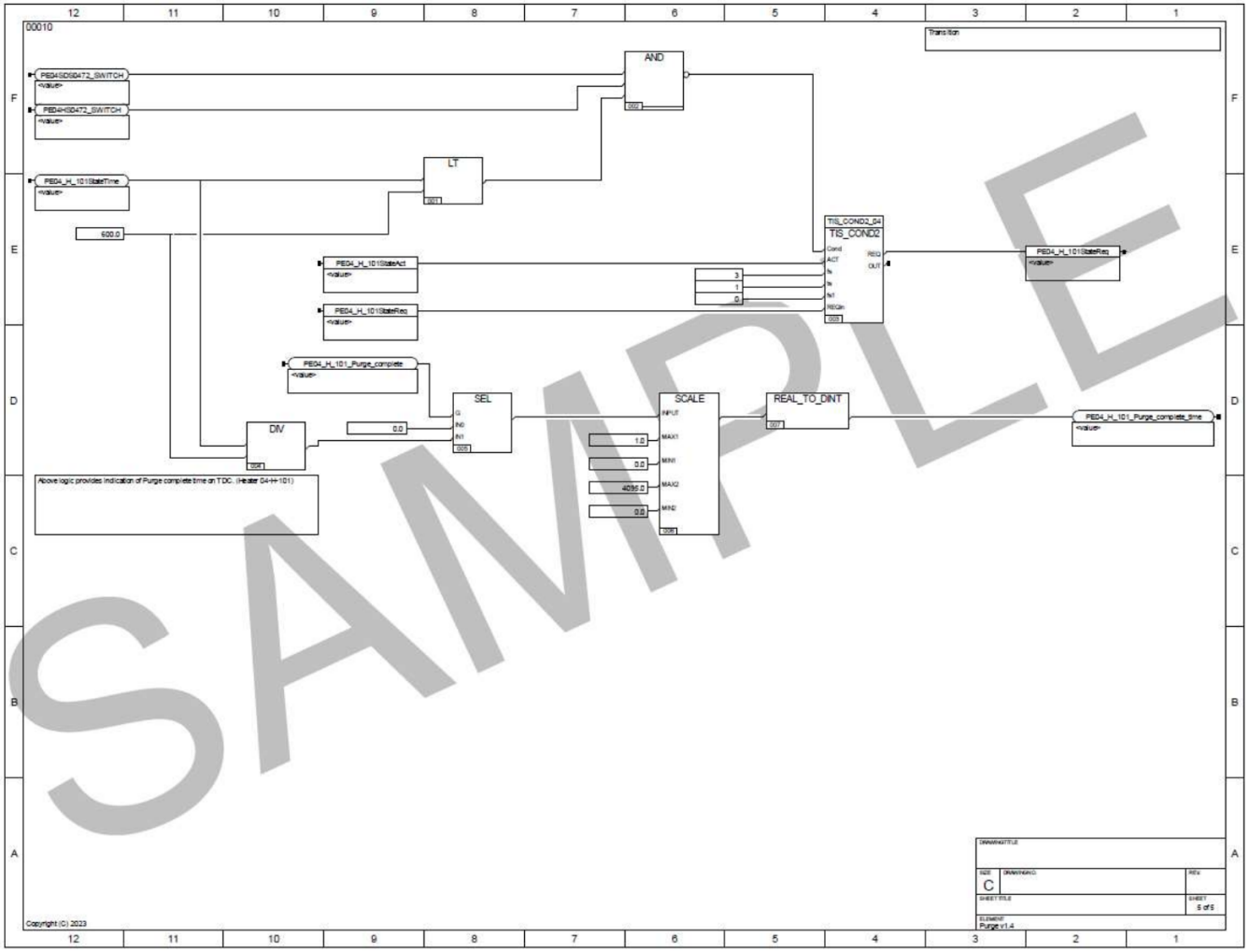
Appendix Figure 66 – Heater Purge, Sheet 3

SAMPLE



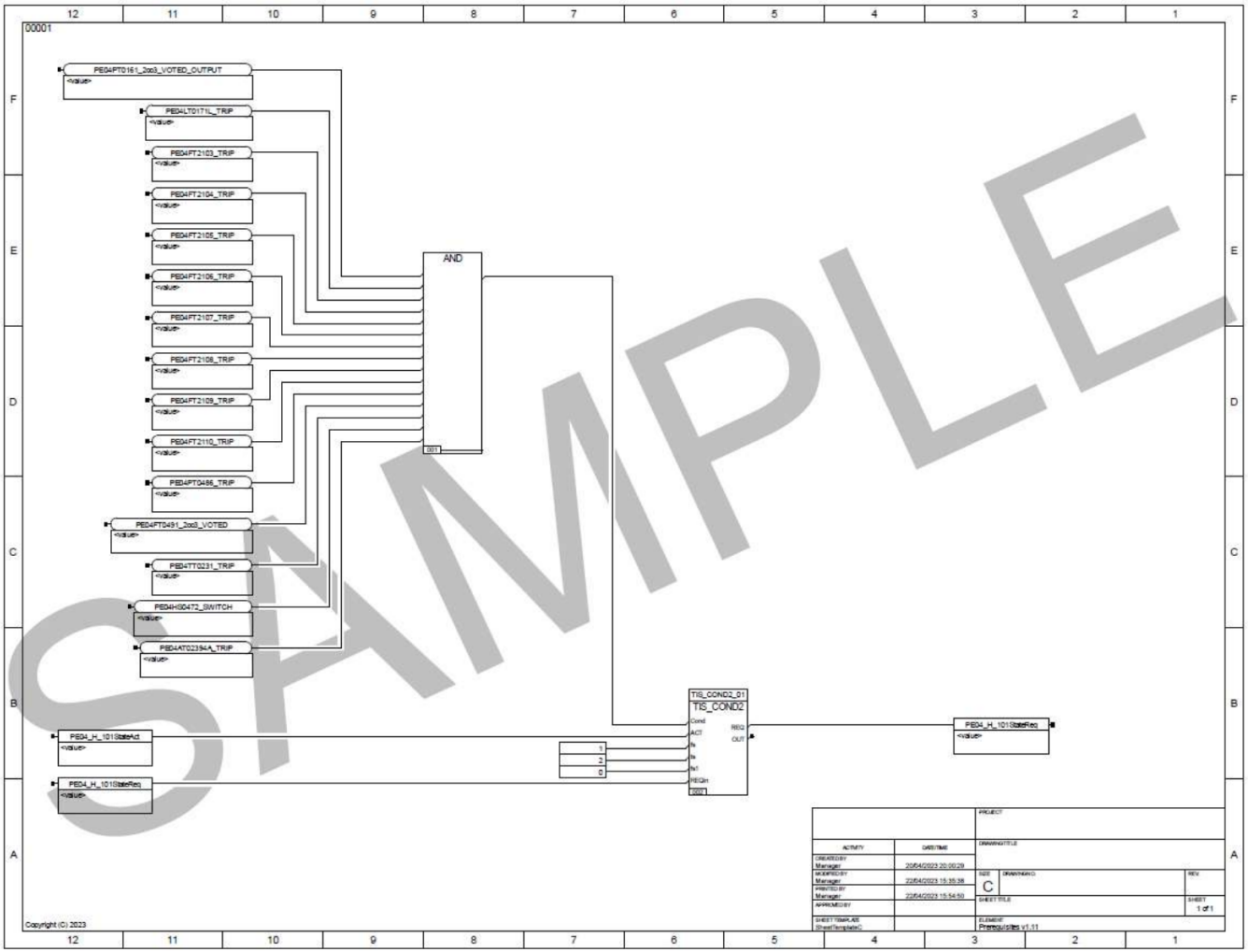
SAMPLE

Appendix Figure 67 – Heater Purge, Sheet 4



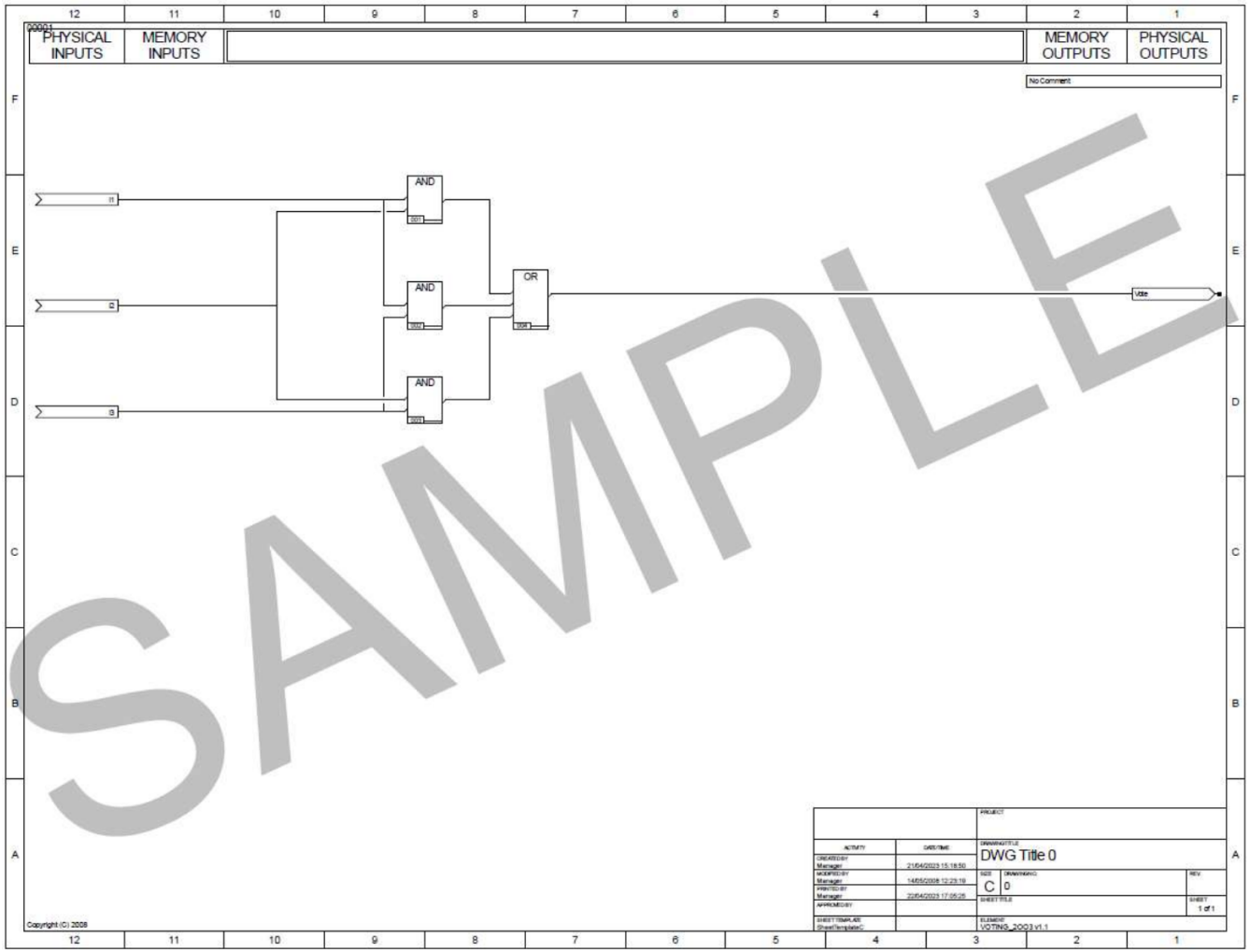
SAMPLE

Appendix Figure 68 – Heater Purge, Sheet 5



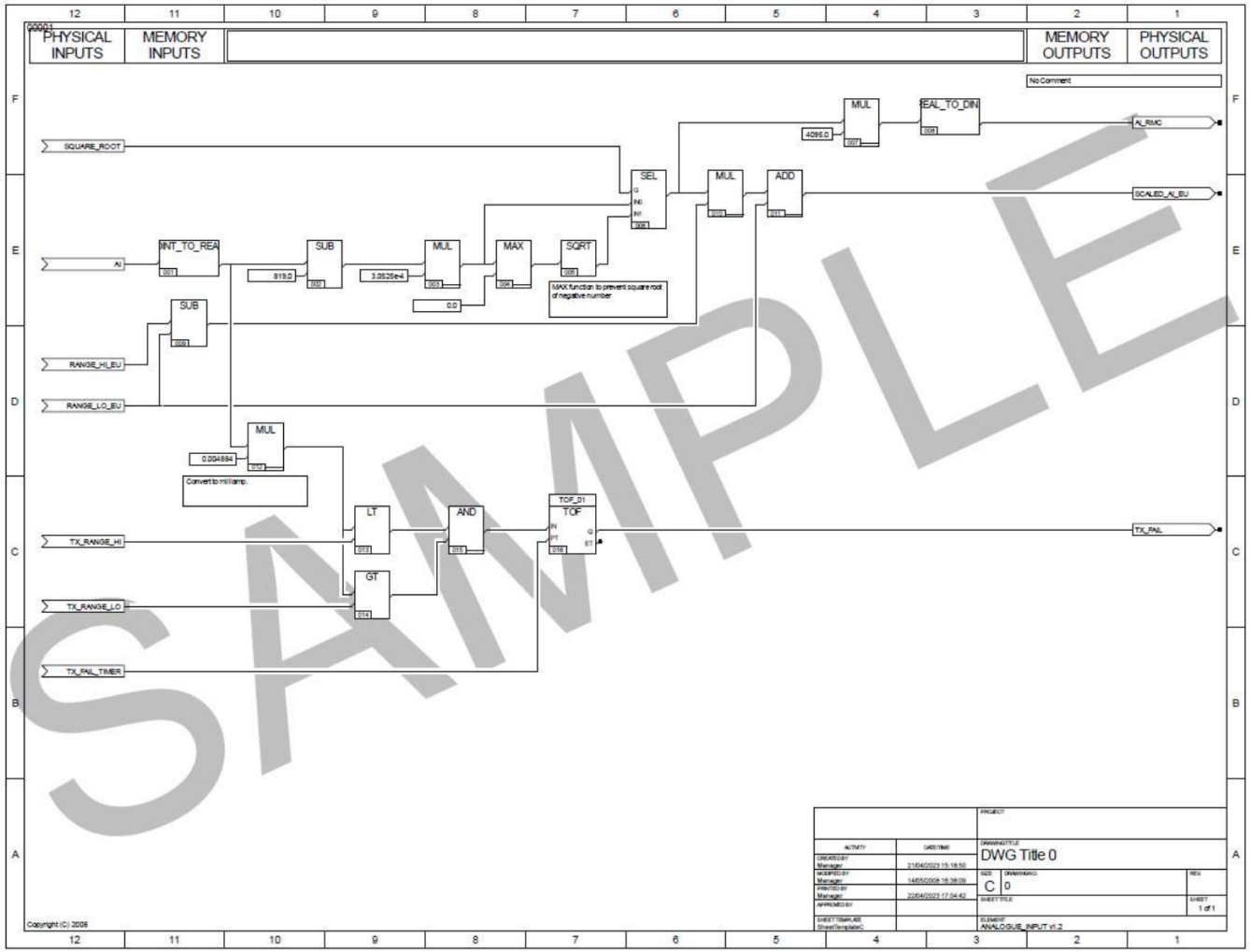
Appendix Figure 69 – Heater Trips

SAMPLE



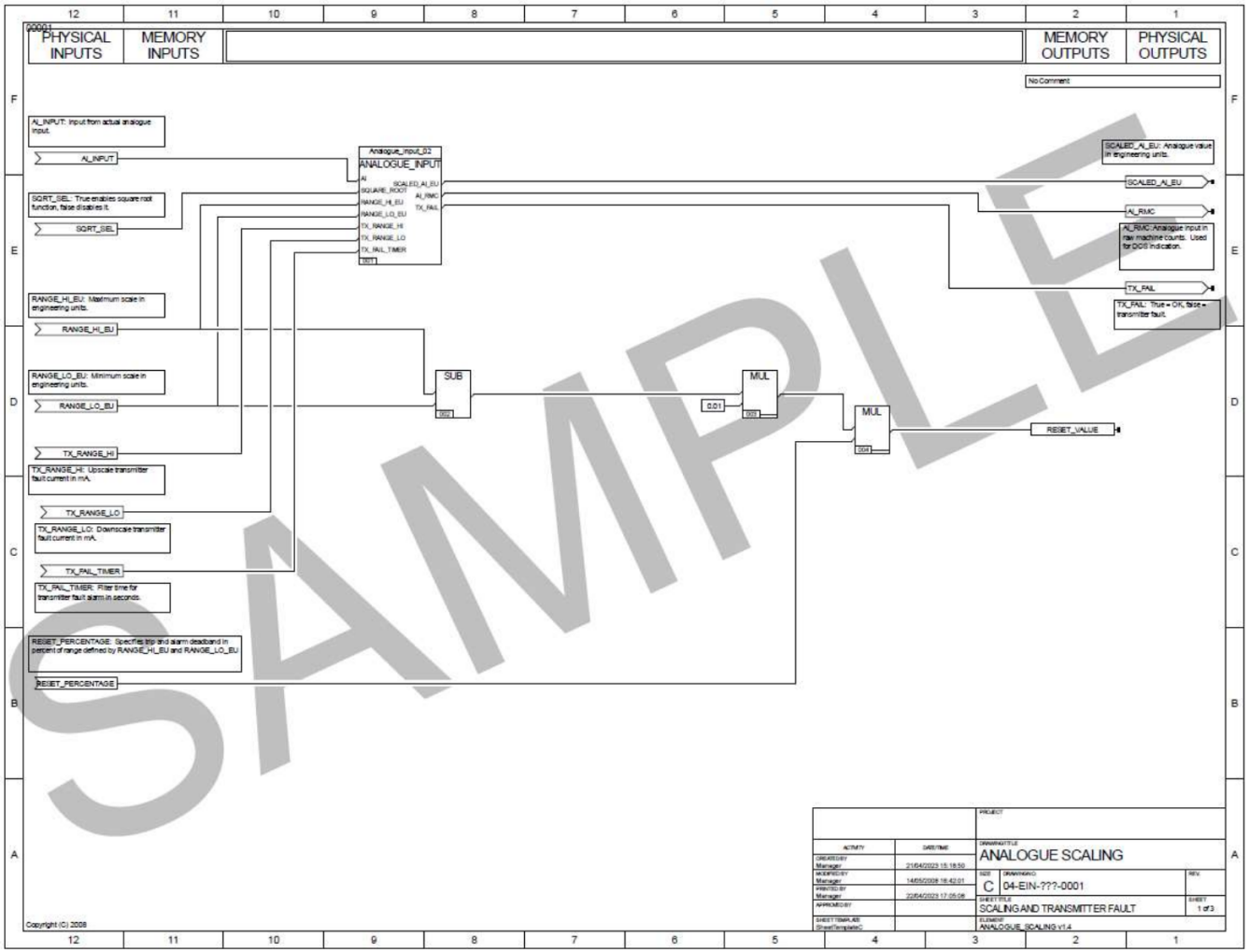
SAMPLE

Appendix Figure 70 – 2-out-of-3 Voting



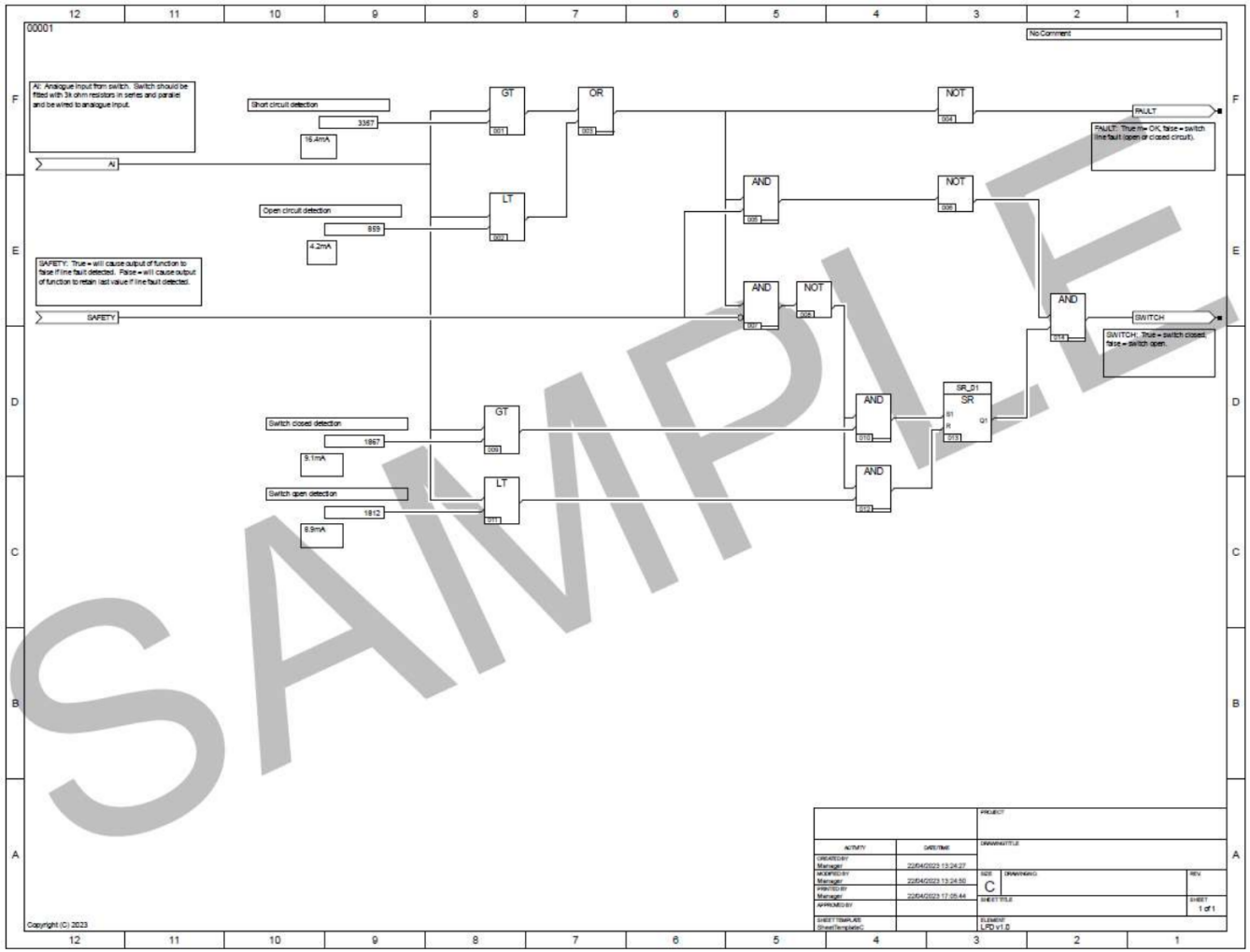
SAMPLE

Appendix Figure 71 – Analogue Input



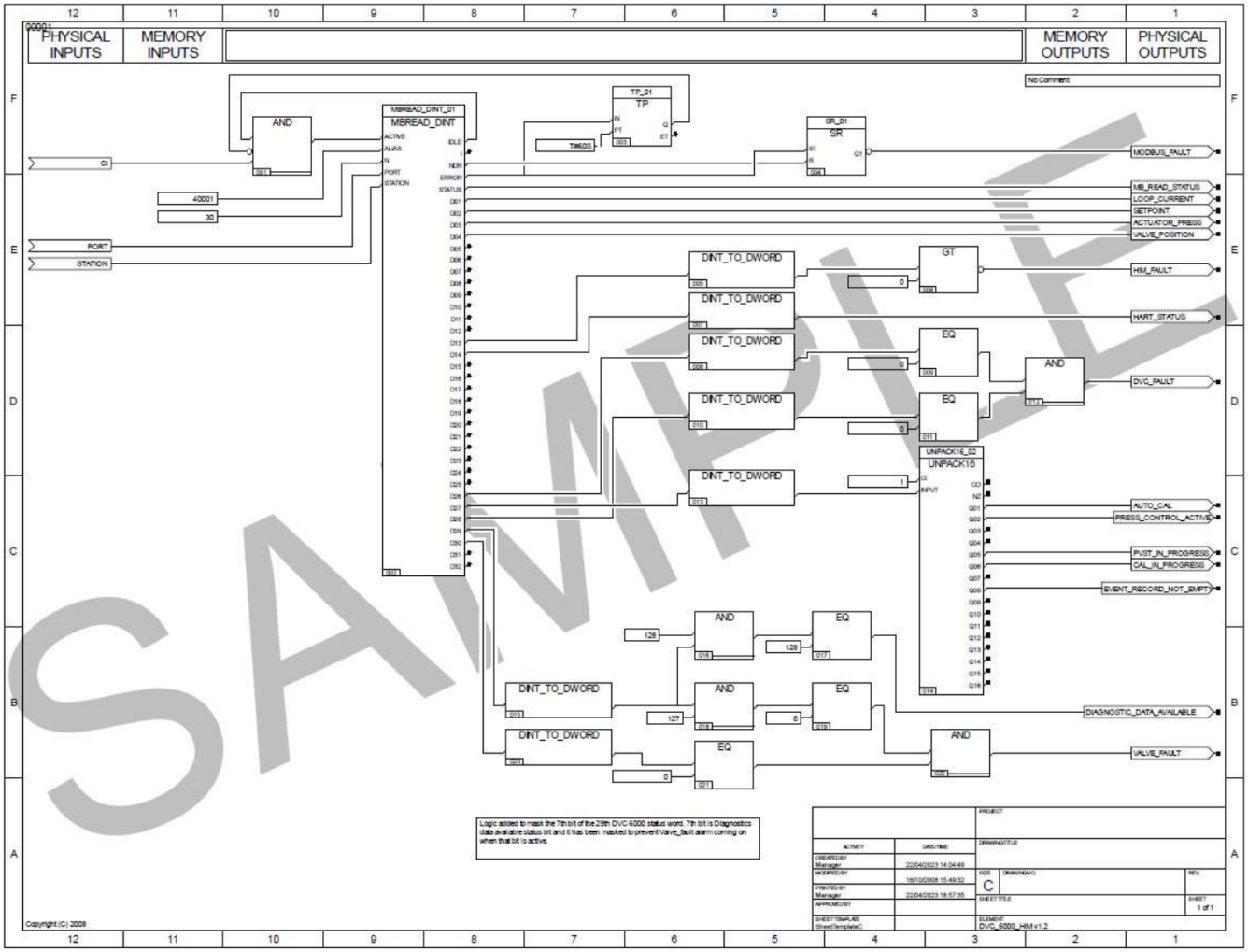
Appendix Figure 72 – Analogue Scaling

SAMPLE



Appendix Figure 73 – Line Fault Detection

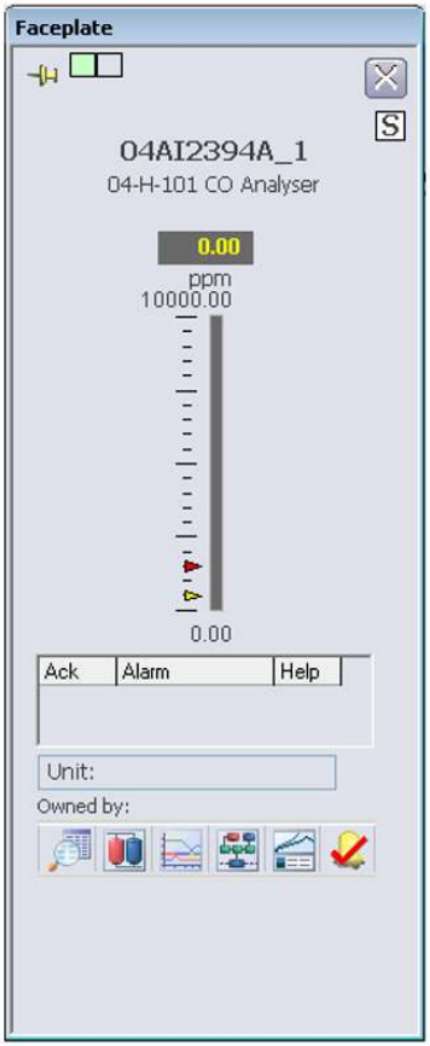
SAMPLE

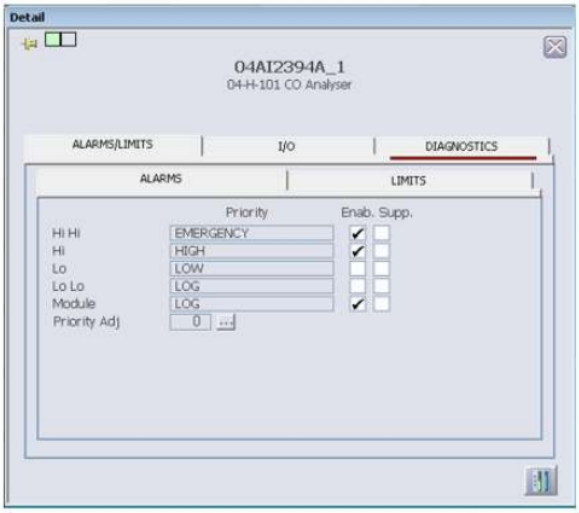


Appendix Figure 74 – DVC6200

SAMPLE

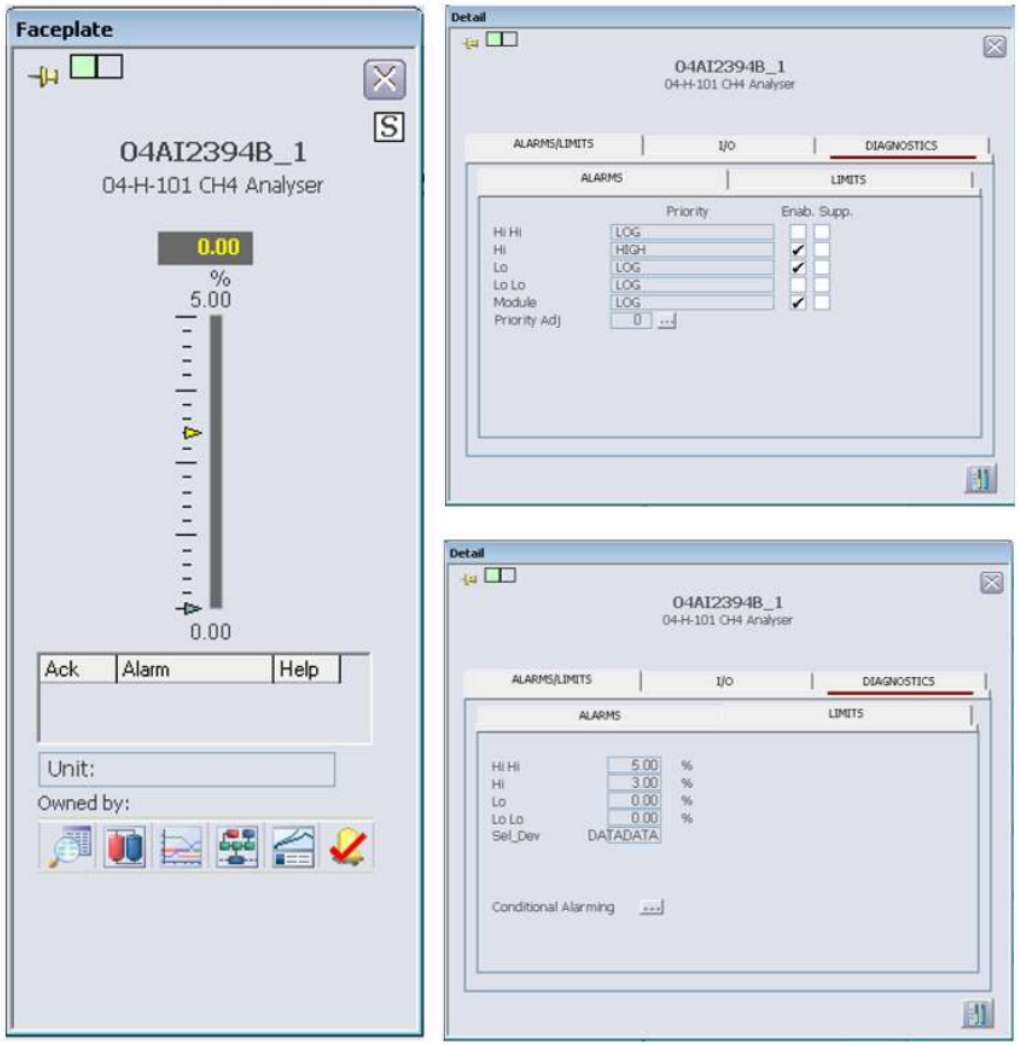
9.5 Delta V Graphics



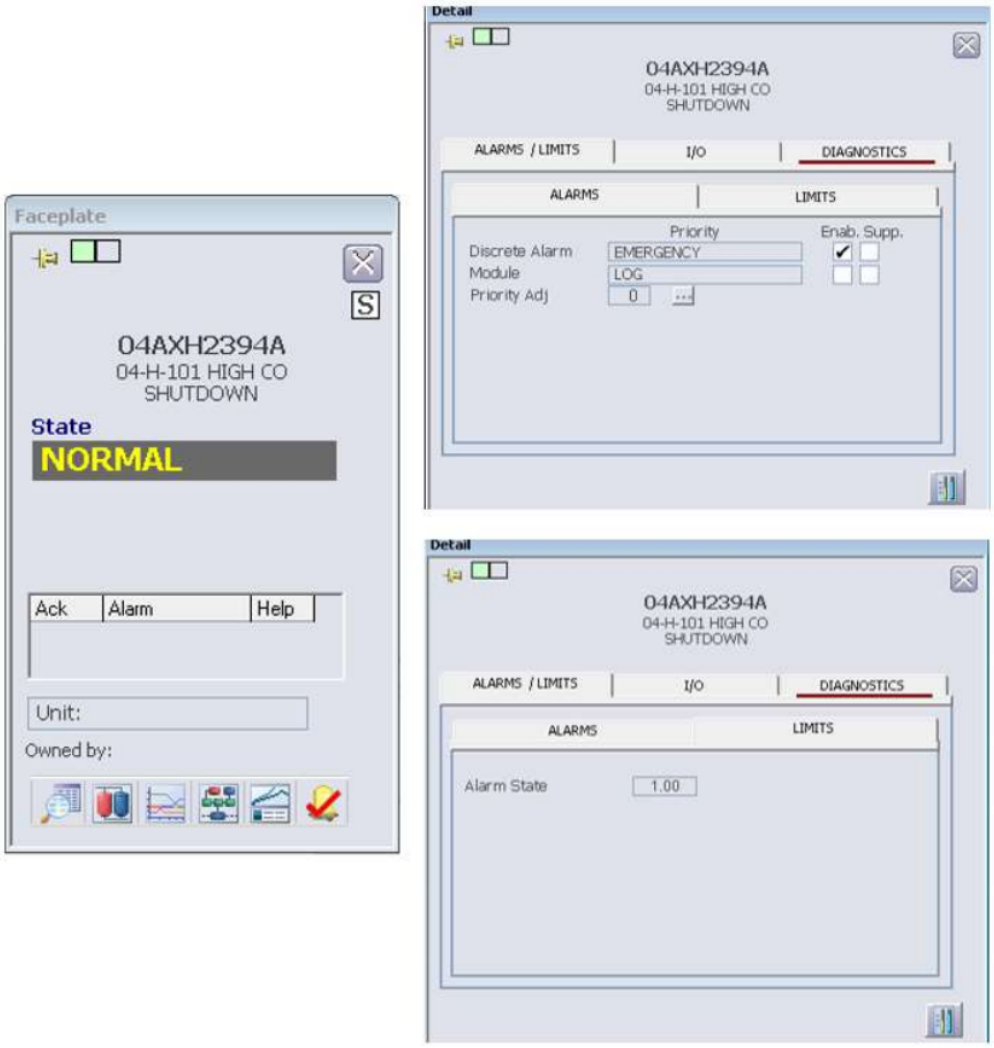




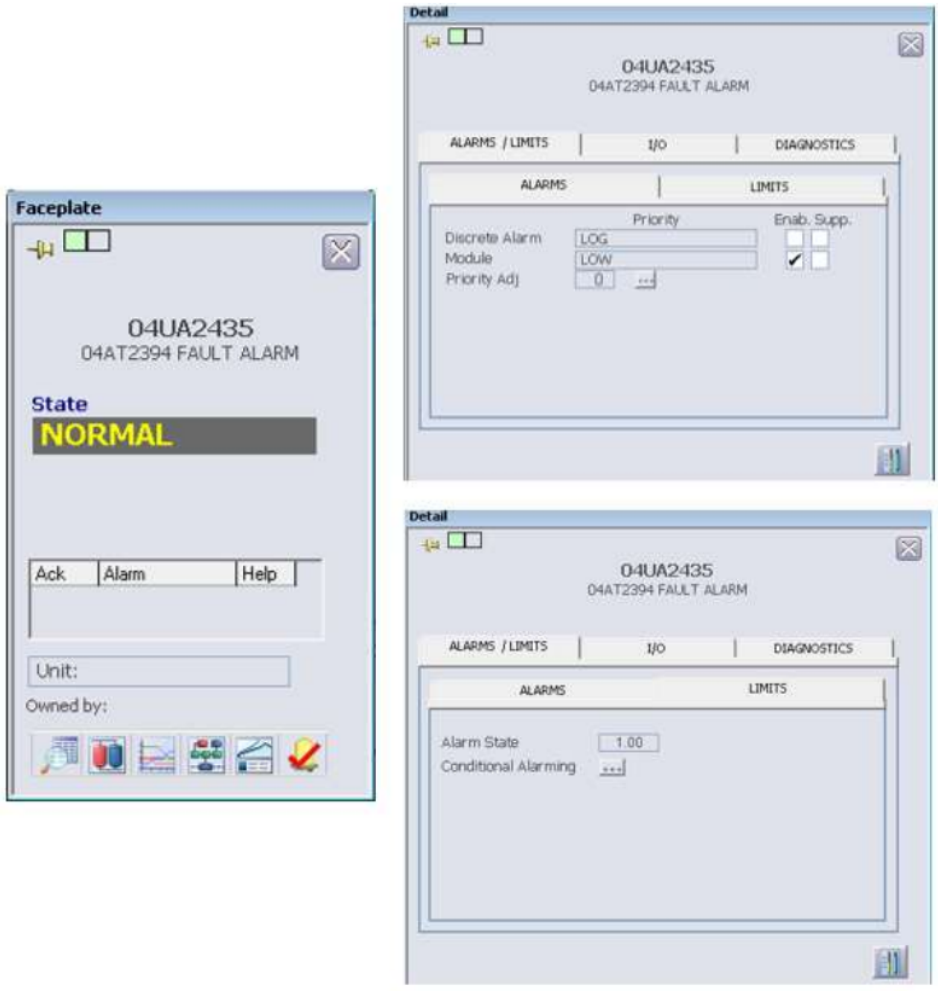
Appendix Figure 75 – 04AI2394A Faceplate, Alarm Details & Alarm Limits



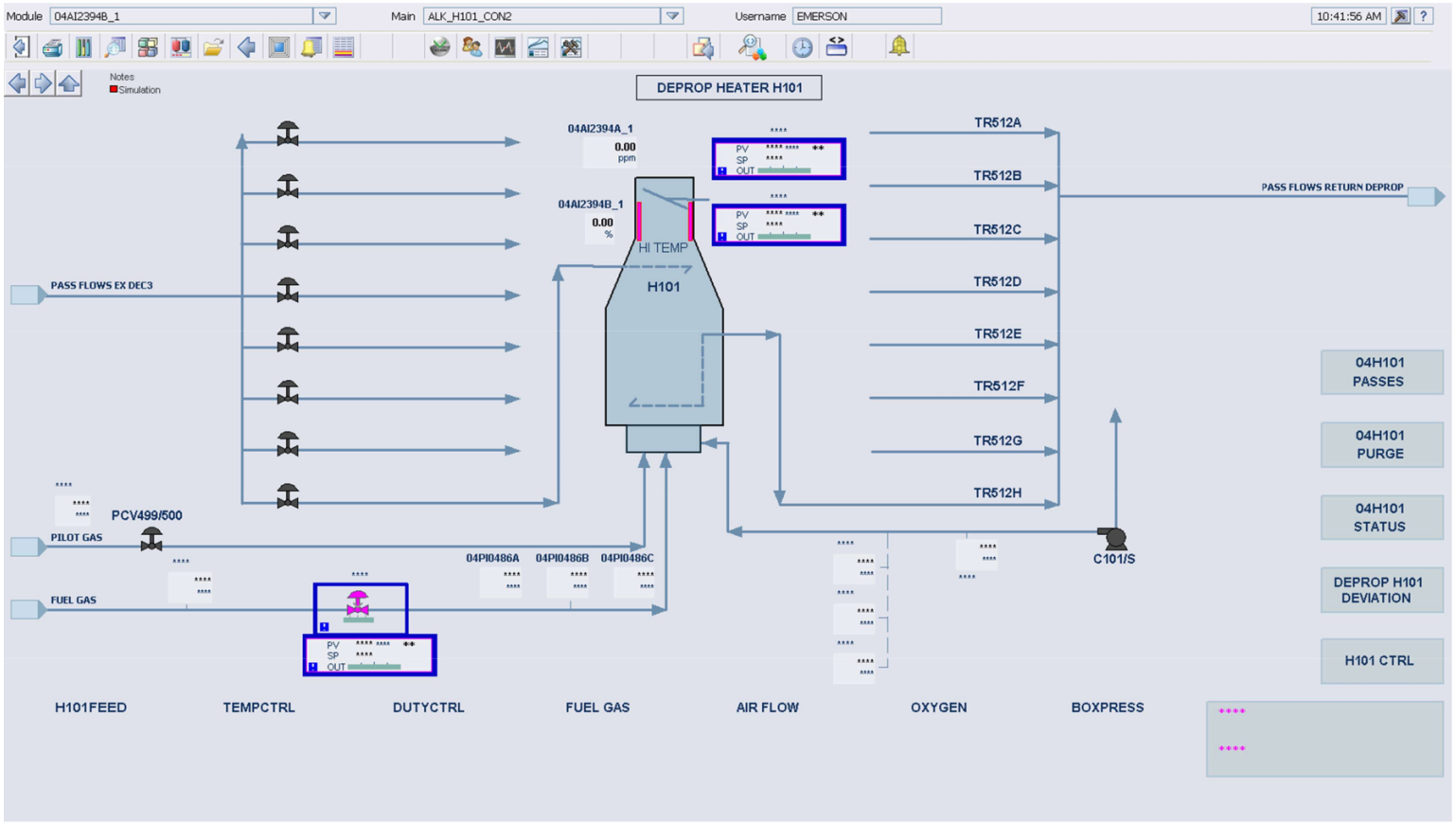
Appendix Figure 76 – 04AI2394B Faceplate, Alarm Details & Alarm Limits



Appendix Figure 77 – 04AXH2394A Faceplate, Alarm Details & Alarm Limits



Appendix Figure 78 – 04UA2435 Faceplate, Alarm Details & Alarm Limits



Appendix Figure 79 – Alky Depropaniser Reboiler Graphic

9.6 Testing and Compliance Tables

Item Number(s)	Functional Test	Expected Result	Actual Result	Success / Failure	Evidence
3	Complete analyser validation checks using validation gas cylinders and measure the output mA	Analyser produces 4mA output when no validation gases are applied. Analyser produces 20mA when 10000PPM of Carbon Monoxide is applied and when 5% methane is applied.			
5, 13	Verify loop connections and apply power to the loop	110VAC measured at UPS input and 24VDC measured at UPS output, using calibrated multimeter. Analyser powers up when 24V is applied to the power terminals.			
6	Manually generate a fault in the loop and measure the output mA	Analyser produces below 3.6mA or above 21mA when a fault is generated in the loop.			
7	Connect to analyser and change configuration, using either Emerson 475 or Emerson TREX HART communicators.	Analyser configuration can be completed through HART communication protocol			
8, 11, 16	Change through HMI display screens and note the parameters and alarms which are present.	Analyser HMI display shows real time diagnostic and monitoring information. Fault alarms generated on HMI when power supply or purge air is lost.			
9	Connect the utility air to the panel and open valve. Verify that a flow increase is seen on the indicator and adjust as required. Connect validation cylinders to the installed fittings.	Panel allows for air flow from a utility point through the tubing and fittings. Flow rate can be adjusted using restriction valve on flow indicator. Gas cylinders successfully connect to the panel.			
15	Isolate the UPS using the safety switch outside the Ex d enclosure. Measure the voltages at the input and output of the UPS.	No voltage measured when power supplies in Ex d enclosure are isolated using safety switch.			
20, 21	View the program using a laptop connected to the PLC and verify all the changes have been made. Have a second technician or engineer simulate milliamps on the loop and monitor inputs and outputs on the screen.	Analogue inputs and outputs, and digital outputs are noticed in PLC program. Analogue inputs respond to change in mA, using calibrated mA source. Digital outputs trigger when mA trip point is reached, using calibrated mA source. Trip point is at 1500PPM, or 6.4mA.			

22, 23	View the DCS graphics in the control room. Have a second technician or engineer simulate milliamps on the loop and	Process readings are noticed on Delta V DCS graphics. Live process values respond to change in mA, using calibrated mA source. DCS alarms activate when alarm conditions are met.			
24, 25	Connect a thermocouple calibrator to the temperature transmitter and inject a millivoltage.	Change in mA output is noticed on the connected HART communicator. Change in temperature indication noticed on the HMI.			

Appendix Table 2 – Updated Testing Table

Item Number(s)	Compliance Check	Expected Result	Actual Result	Success / Failure	Evidence
1	Compare total cost to budget	Total cost falls below £250,000.			
2	Compare project end date to project plan	Project was completed on or before deadline.			
4	Ensure the installation complies with ASME B16.5	Correct nuts and bolts are used for the flange on the analyser, and they have been torqued to correct ft·lb value.			
17	Ensure the installation complies with BS 7671	Correct cable types are used, run and terminated correctly inside any enclosures used.			
18	Complete ATEX inspection form for any installed electronics or enclosures and confirm BS EN 60079 compliance	Electronics and enclosures meet all of the criteria on the company's 'ATEX Initial Inspection' forms and are deemed appropriate for the area, as per hazardous area drawings.			
19	Review the documentation provided by the manufacturer and confirm the sensor's SIL rating, as per BS EN 61508	Sensor is SIL 2 rated.			

Appendix Table 3 – Compliance Table

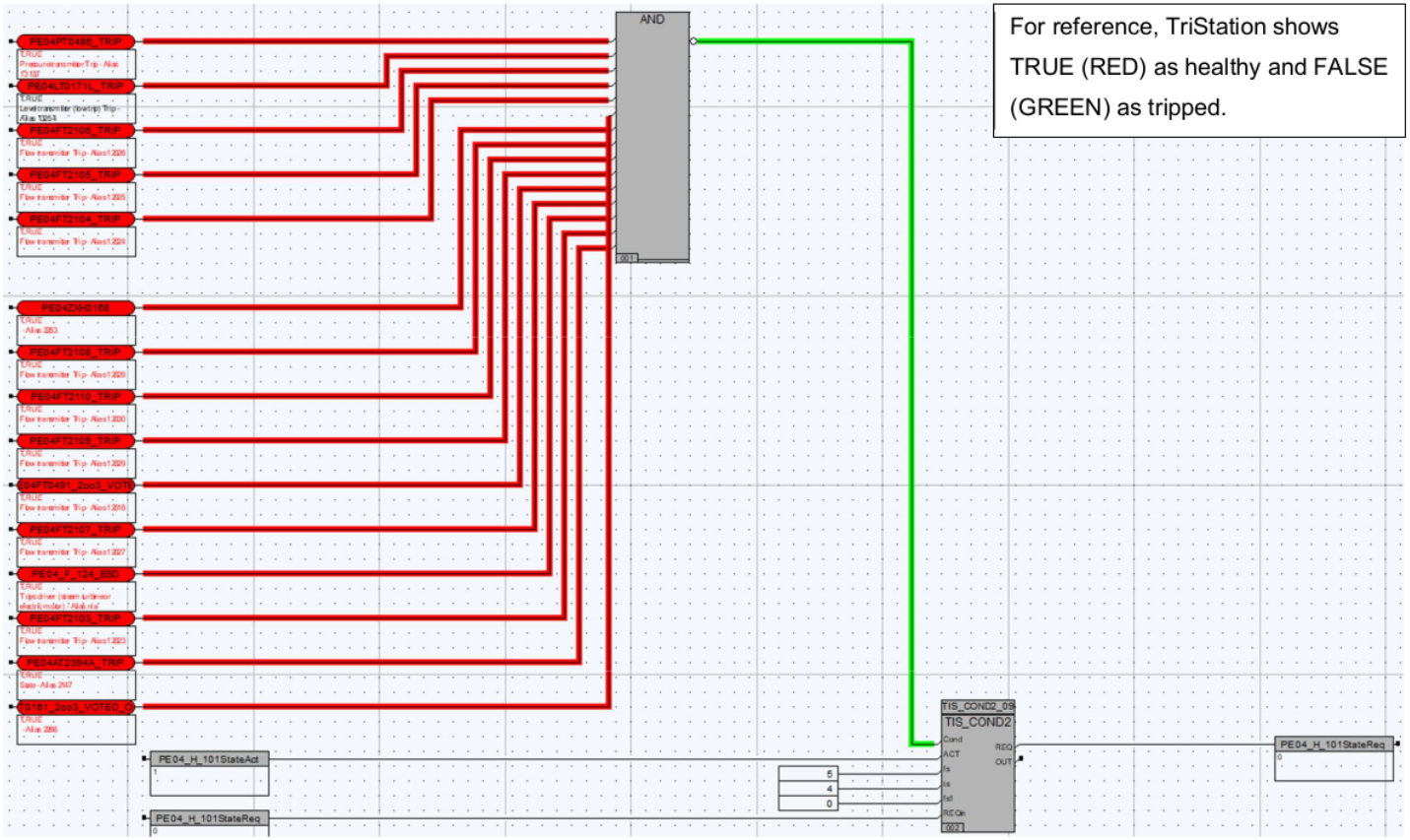
Item Number(s)	Functional Test	Simulation Test	Expected Result	Actual Result	Success / Failure	Evidence
3	Complete analyser validation checks using validation gas cylinders and measure the output mA	Unable to simulate	Analyser produces 4mA output when no validation gases are applied. Analyser produces 20mA when 10000PPM of Carbon Monoxide is applied and when 5% methane is applied.			
5, 13	Verify loop connections and apply power to the loop	Unable to simulate	110VAC measured at UPS input and 24VDC measured at UPS output, using calibrated multimeter. Analyser powers up when 24V is applied to the power terminals.			
6	Manually generate a fault in the loop and measure the output mA	Unable to simulate	Analyser produces below 3.6mA or above 21mA when a fault is generated in the loop.			
7	Connect to analyser and change configuration, using either Emerson 475 or Emerson TREX HART communicators.	Unable to simulate	Analyser configuration can be completed through HART communication protocol			
8, 11, 16	Change through HMI display screens and note the parameters and alarms which are present.	Unable to simulate	Analyser HMI display shows real time diagnostic and monitoring information. Fault alarms generated on HMI when power supply or purge air is lost.			
9	Connect the utility air to the panel and open valve. Verify that a flow increase is seen on the indicator and adjust as required. Connect validation cylinders	Unable to simulate	Panel allows for air flow from a utility point through the tubing and fittings. Flow rate can be adjusted using restriction valve on flow indicator. Gas cylinders successfully connect to the panel.			

	to the installed fittings.					
15	Isolate the UPS using the safety switch outside the Ex d enclosure. Measure the voltages at the input and output of the UPS.	Unable to simulate	No voltage measured when power supplies in Ex d enclosure are isolated using safety switch.			
20, 21	View the program using a laptop connected to the PLC and verify all the changes have been made. Have a second technician or engineer simulate milliamps on the loop and monitor inputs and outputs on the screen.	Simulate PLC logic using the TriStation emulator by forcing the inputs and ensuring the outputs change state when viewing.	Analogue inputs and outputs, and digital outputs are noticed in PLC program. Analogue inputs respond to change in mA, using calibrated mA source. Digital outputs trigger when mA trip point is reached, using calibrated mA source. Trip point is at 1500PPM, or 6.4mA.			
22, 23	View the DCS graphics in the control room. Have a second technician or engineer simulate milliamps on the loop and	Simulate inputs into the Delta V DCS Test Rig and ensure changes are noted on the built faceplates prior to downloading to the live control panel.	Process readings are noticed on Delta V DCS graphics. Live process values respond to change in mA, using calibrated mA source. DCS alarms activate when alarm conditions are met.			
24, 25	Connect a thermocouple calibrator to the temperature transmitter and inject a millivoltage.	Configure Rosemount 644 transmitter in workshop and function check using thermocouple calibrator and multimeter.	Change in mA output is noticed on the connected HART communicator. Change in temperature indication noticed on the HMI.			

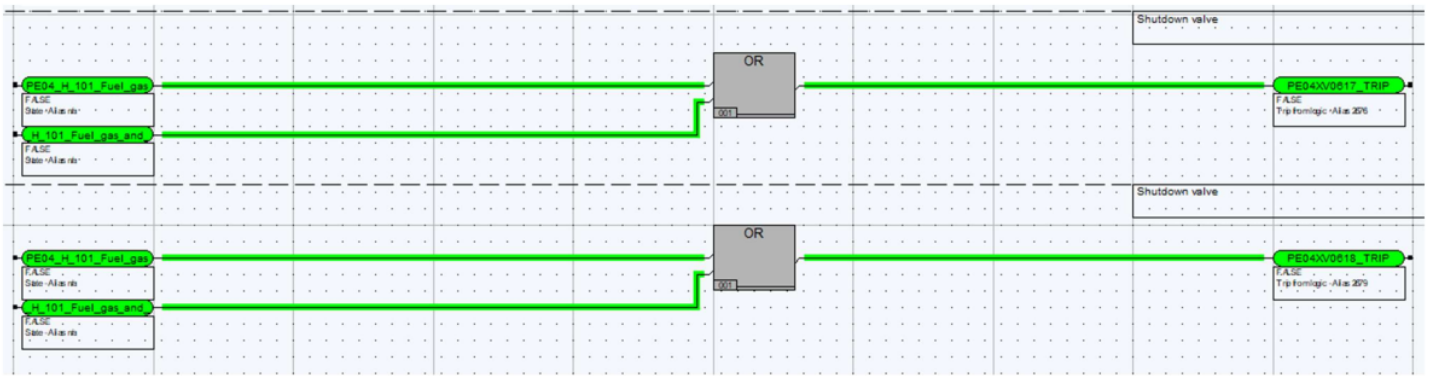
Appendix Table 4 – Further Updated Testing Table

9.7 Testing, Compliance and FDS Evidence

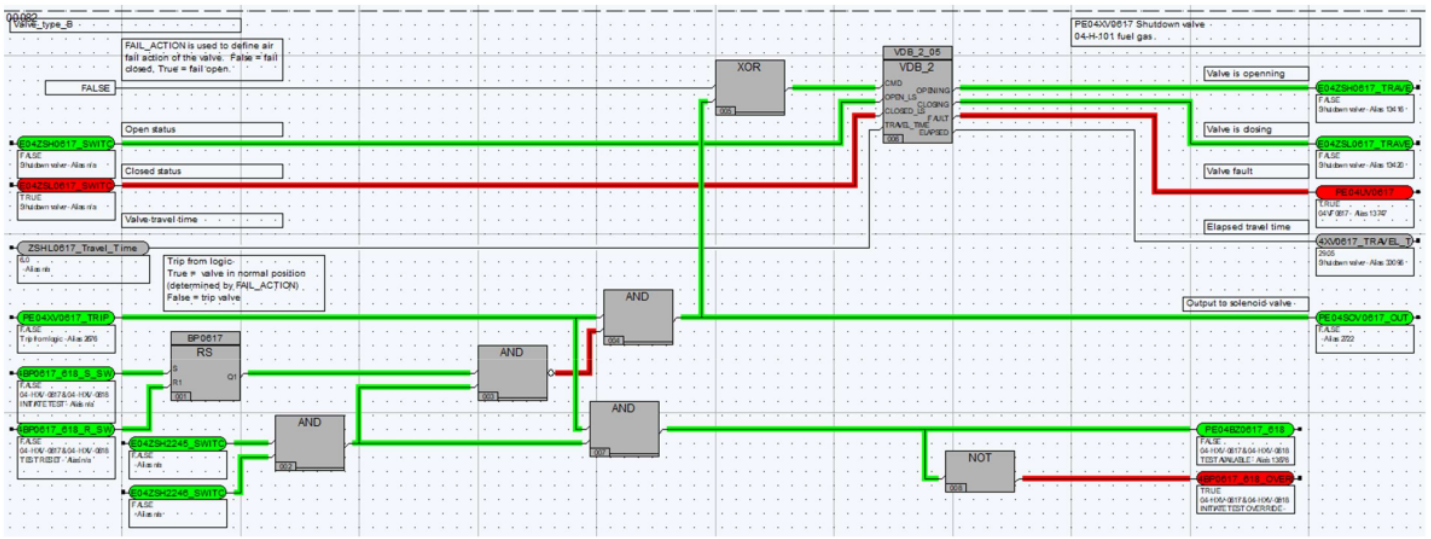
9.6.1 PLC Testing



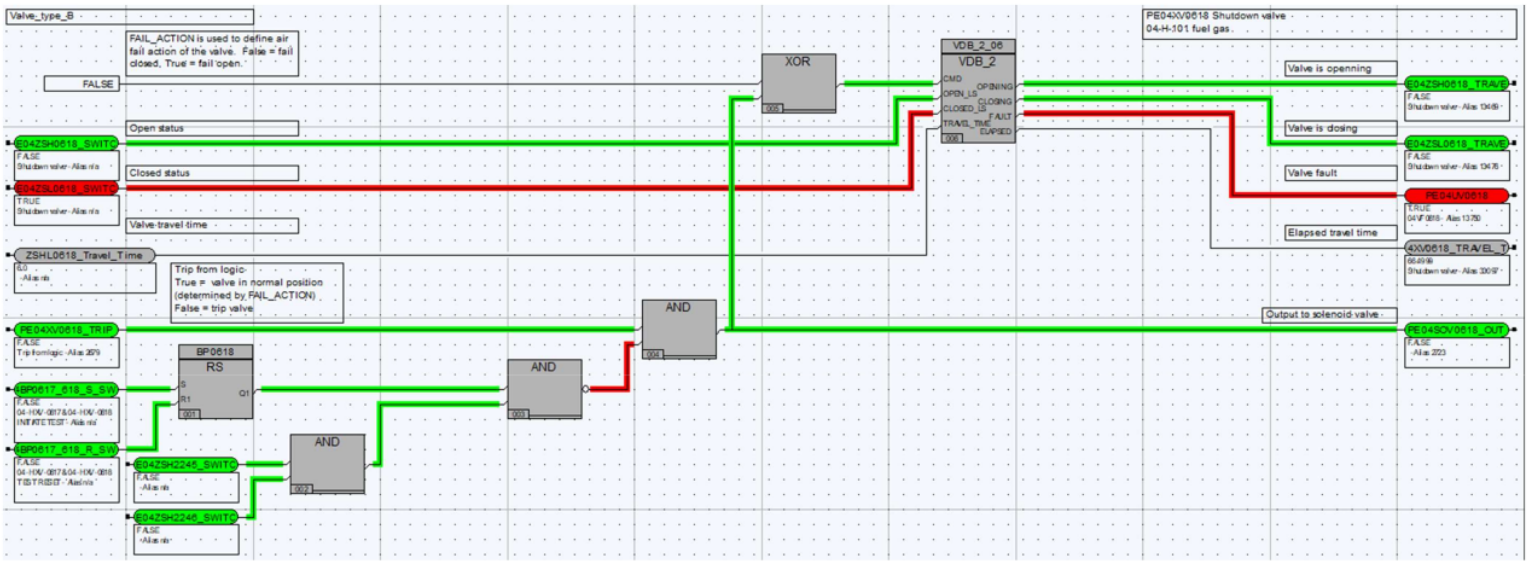
Appendix Figure 80 – 04AT2394A_TRIP Healthy



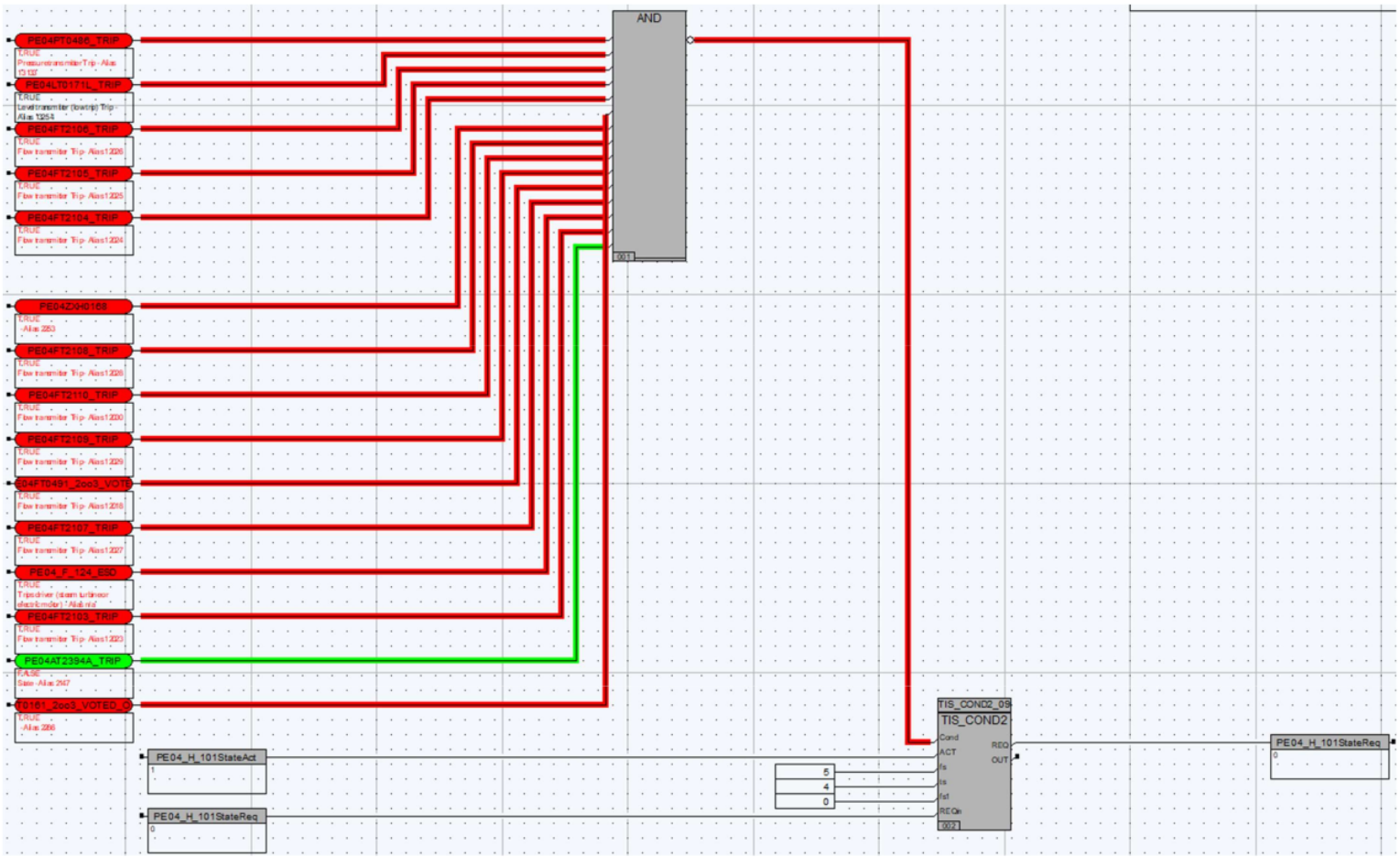
Appendix Figure 81 – Fuel Gas XVs Healthy



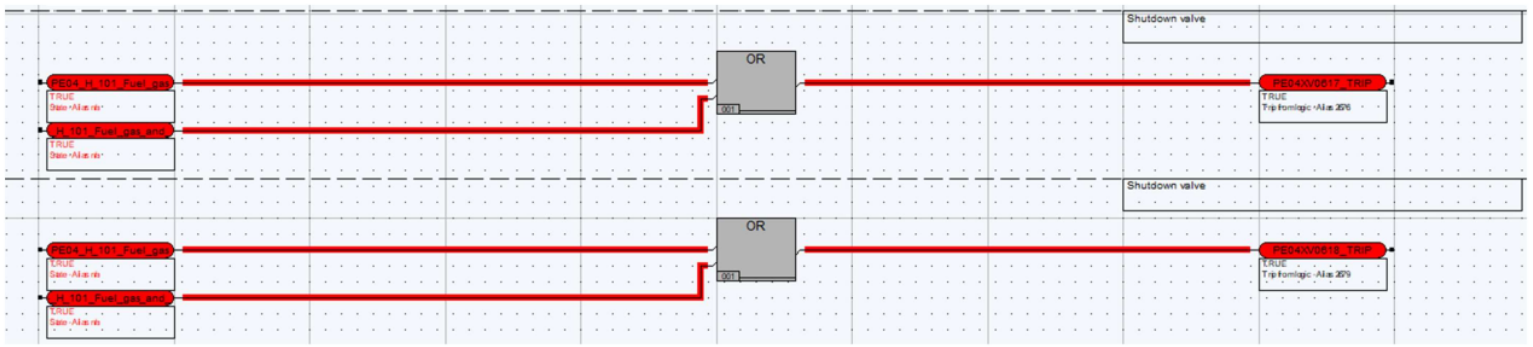
Appendix Figure 82 – 04XV617 Open



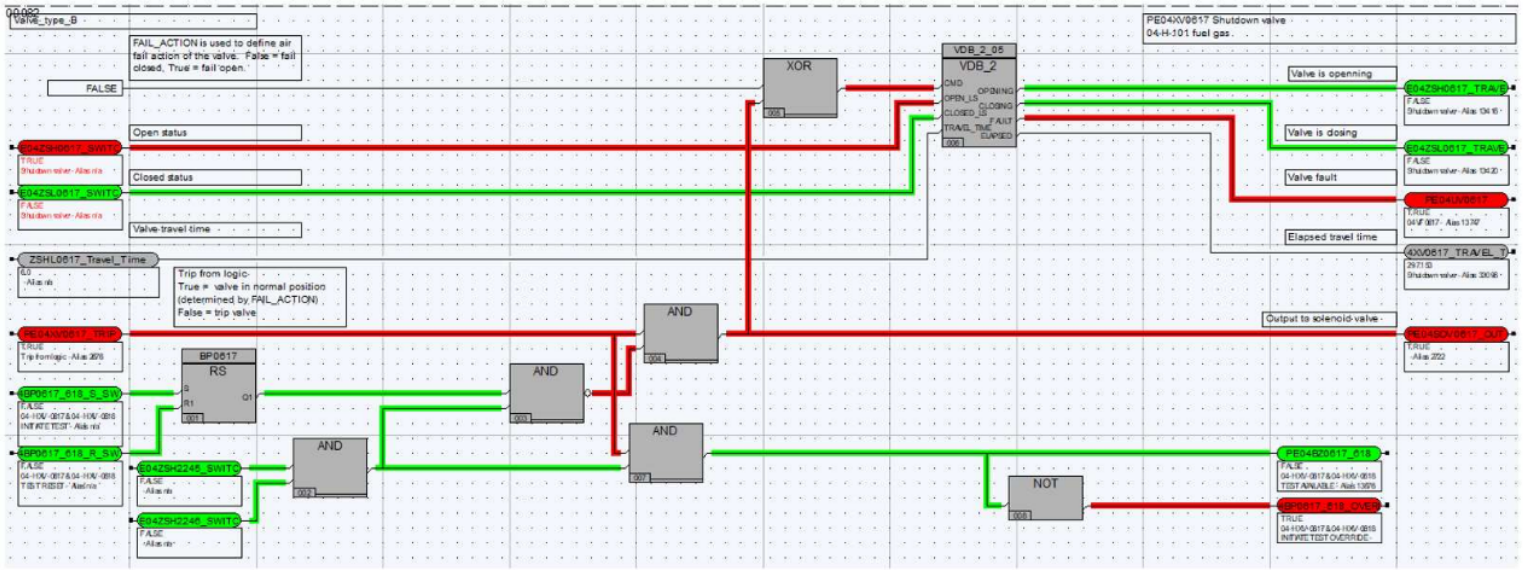
Appendix Figure 83 – 04XV618 Open



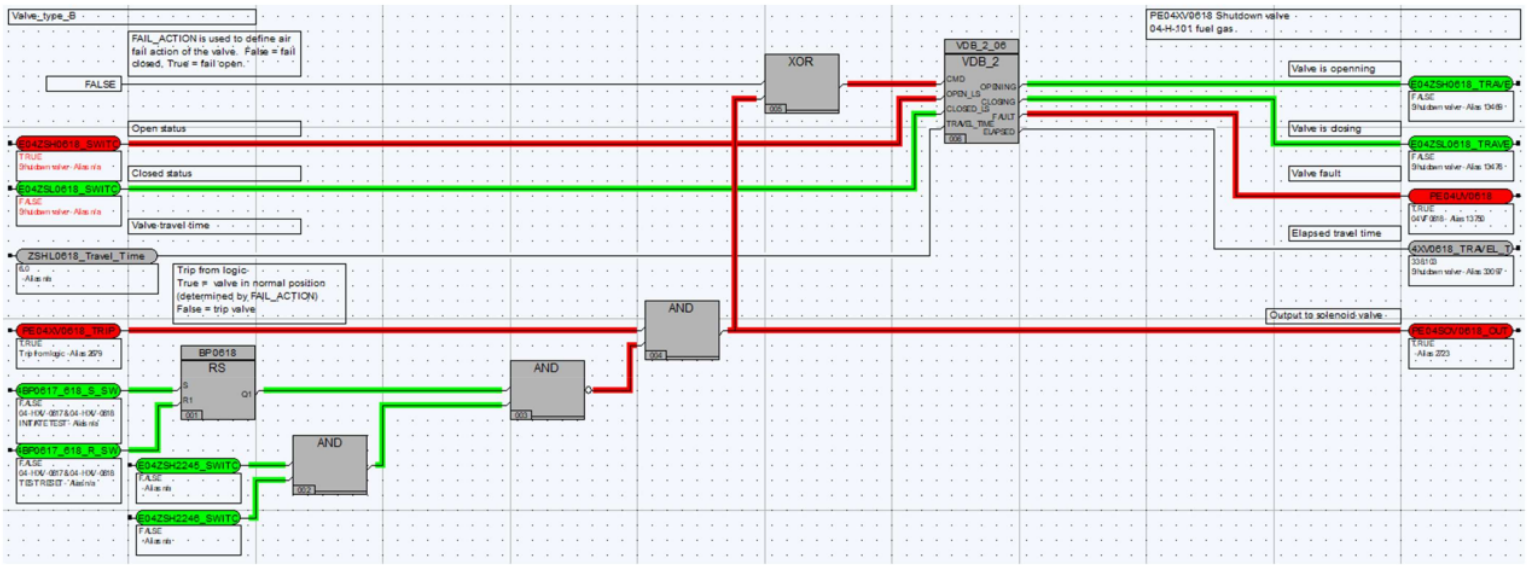
Appendix Figure 84 – 04AT2394A_TRIP Tripped



Appendix Figure 85 – Fuel Gas XVs Tripped

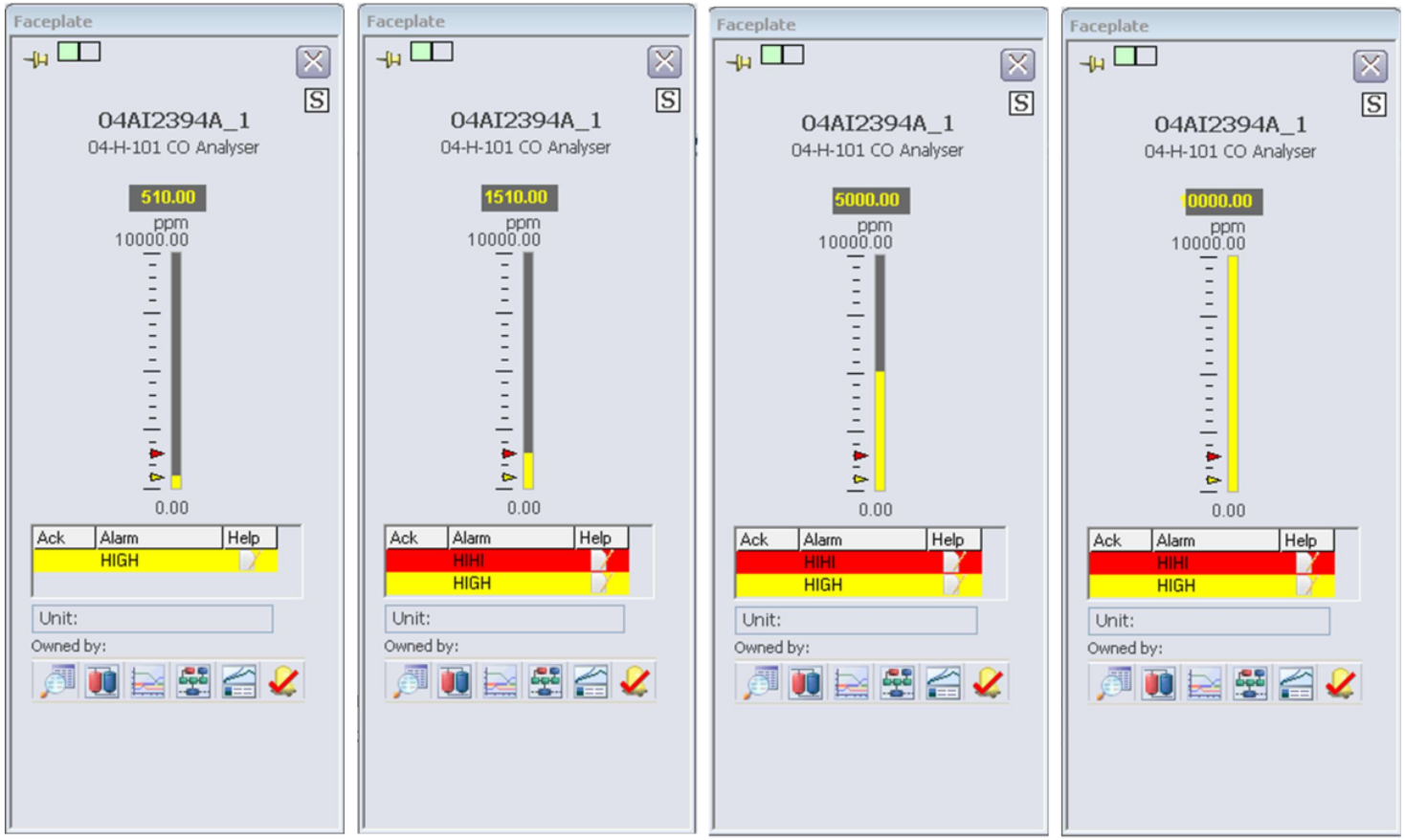


Appendix Figure 86 – 04XV617 Closed



Appendix Figure 87 – 04XV618 Closed

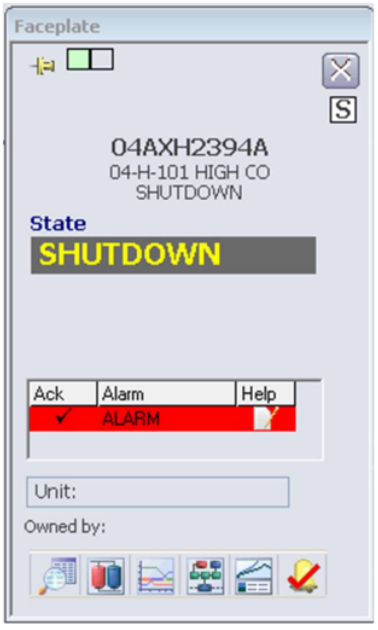
9.6.2 DCS Testing



Appendix Figure 88 – 04AI2394A Testing



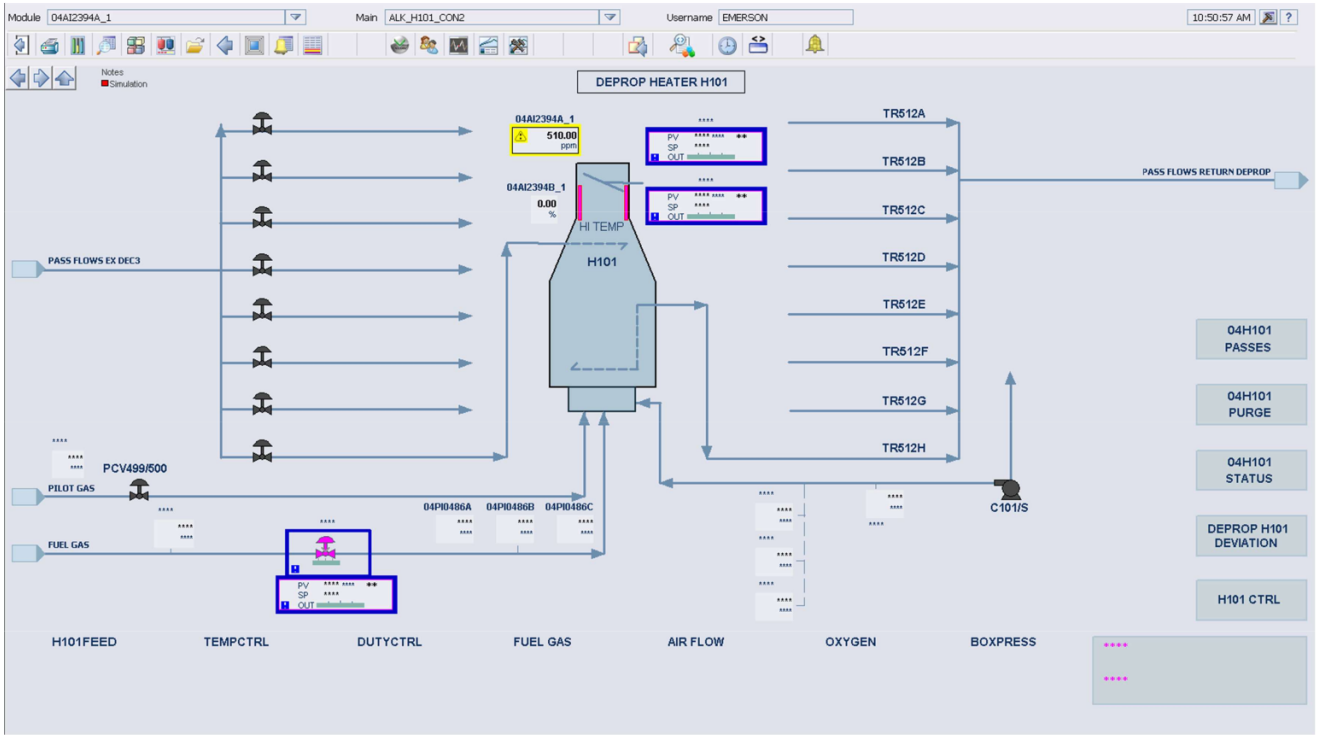
Appendix Figure 89 – 04AI2394B Testing



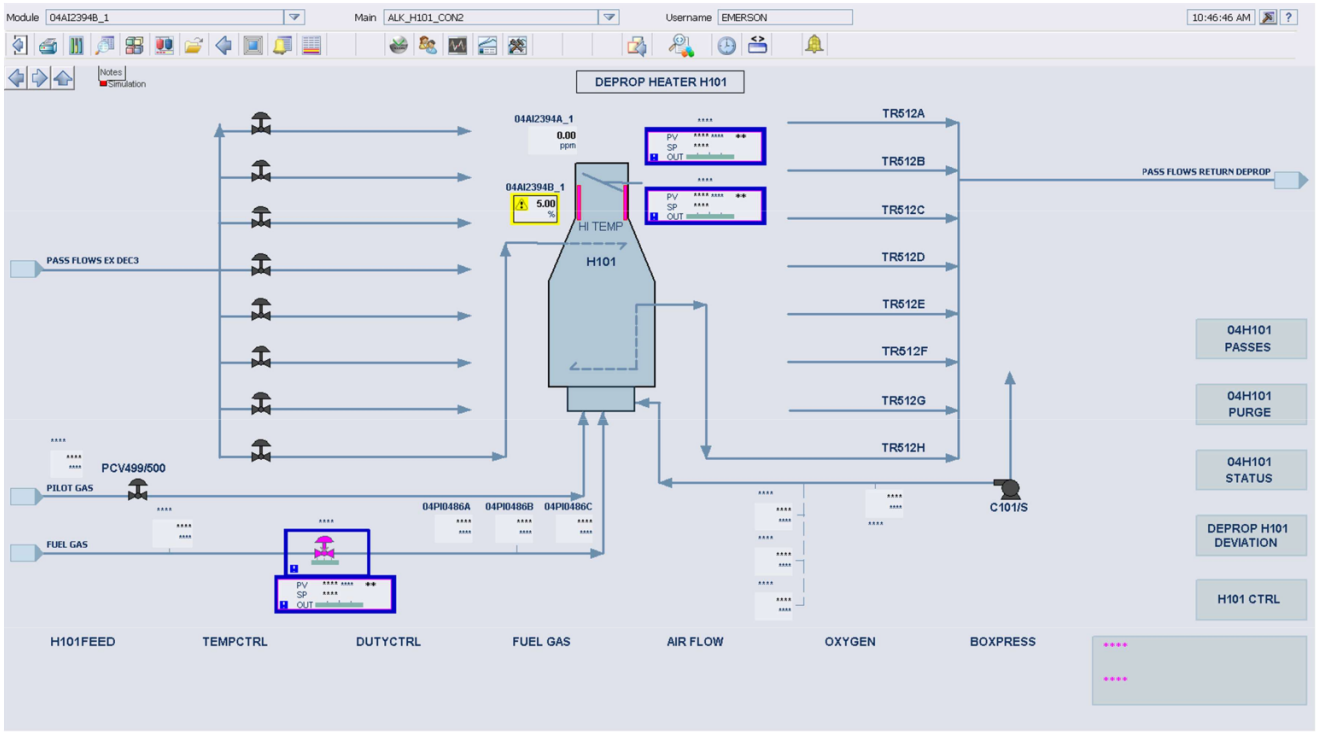
Appendix Figure 90 – 04AXH2394A Testing



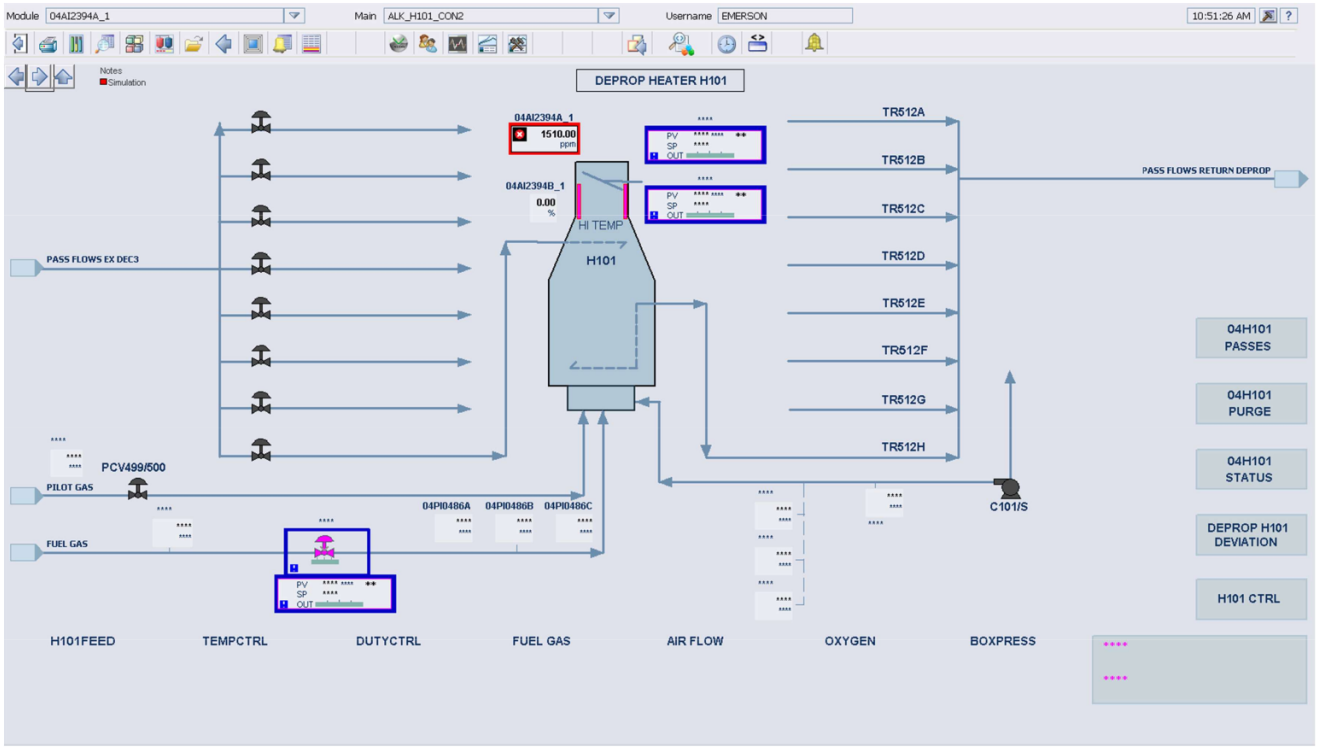
Appendix Figure 91 – 04UA2435 Testing



Appendix Figure 92 – Heater Graphic High CO Testing



Appendix Figure 93 – Heater Graphic High CH4 Testing



Appendix Figure 94 – Heater Graphic High-high CO Testing

Ack	Time In	Unit	Module	Description	Alarm	Help	Message	Priority
	21-Apr-23 10:58:43 AM		04AXGI2394A	04-H-101 HIGH CO SHUTDOWN	ALARM		SHUTDOWN	EMERGENCY
	21-Apr-23 10:57:56 AM		04AI2394A_1	04-H-101 CO Analyser	HIHI		High High Alarm Value 1510 Limit 1!	EMERGENCY
	21-Apr-23 10:57:56 AM		04AI2394A_1	04-H-101 CO Analyser	HIGH		High Alarm Value 1510 Limit 500	HIGH
☐	21-Apr-23 10:58:11 AM		04AI2394B_1	04-H-101 CH4 Analyser	HIGH		High Alarm Value 5 Limit 3	HIGH

Appendix Figure 95 – Alarm List Testing

9.6.3 Temperature Transmitter Testing



Appendix Figure 96 – Temperature Transmitter Testing, 0°C



Appendix Figure 97 – Temperature Transmitter Testing, 650°C



Appendix Figure 98 – Temperature Transmitter Testing, 1300°C

Datasheets should not be included, it is important that you read them and quote relevant data with Harvard method of citation in main report.

9.6.4 Compliance and FDS Checks

General Specifications

Model TDLS8200
Probe type
Tunable Diode Laser Spectrometer

GS 11Y01D03-01EN

■ Overview

Yokogawa's TDLS™8200 is a dual laser gas analyzer that measures the concentration of O_2, CO, and CH_4 which are important for combustion control and safety related measurements with the ability to measure various other NIR absorbing gases.

The TDLS8200 is installed in-situ, directly into the process eliminating the need for sample extraction and conditioning providing a near real time measurement. The single flange design reduces installation costs and expands installation flexibility where traditional cross-duct analyzers were not feasible due to obstructions or accessibility. Based on solid-state technology means virtually no measurement drift and reduced calibration frequency. The analyzer auto-gain feature and reference cell ensures measurements are unaffected by dynamic process conditions, upsets, or varying background composition to maintain real time measurements.

The modular design of the TDLS8200 allows for full field serviceability with the ability to replace components without having to return the analyzer to the manufacturer. A storage period of up to 50 days of data, spectra, and history files (validation and configuration changes) allow for advanced diagnostics and provides invaluable information into analyzer performance and process details.



TDLS8200 with YH8000 HMI Unit

■ Features

- **Dual laser measurement technology allows for O_2, CO, and CH_4 to be measured in-situ with a single analyzer**
- **TruePeak™ combined with smart laser technology**
  - Measurement integrates the area of the absorbance and gets a true, interference-free analysis under changing pressure, temperature, and background.
  - Laser Detector Module is replaceable on site without any calibration or adjustment.
  - Internal reference cell in the Laser Detector Module ensures peak locking during trace measurements.
  - Laser Detector Modules are isolated from aggressive and corrosive processes.
  - On board diagnostics and low TCO(*1) (no moving parts, high MTTF(*2) for components)
    *1: Total Cost of Ownership
    *2: Mean Time To Failure
- **IEC61508 SIL certified,**
  SIL 2 capability for one TDLS8200 use.
  SIL 3 capability for duplicate TDLS8200s use
- **Intuitive touchscreen HMI YH8000**
  - YH8000 offers intuitive touch screen operation and simple menu structure in multiple languages allowing for control of up to four analyzers simultaneously (including TDLS8000 and TDLS8100)
- **HART and Modbus TCP communications standard**
- **8-stage auto-gain adapts to difficult applications**
  - Auto-gain enables wide signal ranges against dynamic variation of transmission.
- **Full field serviceability with 50 days of data and spectra storage**
- FM (US, Canada), IECEx, ATEX/UKEX, hazardous area, Korea (Applying), NEPSI (Applying), Japan (Applying) approvals based on Explosionproof/flame proof.
- **In-situ analysis and near real time measurements (2-5 seconds, 1 second optional)**
- **Process pressures up to 500 kPa abs., process temperatures up to 850°C, and process gas flow velocity 1 m/s or more.**
  Note: Maximum process temperatures, pressures, and flow velocity will vary by application.

Typical gases measured include:

- Oxygen, carbon monoxide, and methane in process applications.
  Process temperatures can be as high as 850°C, and process pressures can be as high as 500kPa abs.

TDLS, TruePeak are trademarks or registered trademarks of Yokogawa Electric Corporation.
All other company and product names mentioned in this document are trademarks or registered trademarks of their respective companies.

Please select appropriate equipment in accordance with the laws and regulations of the relevant country/region, when it is used in a location where explosive atmospheres may be present.

YOKOGAWA ◆

Yokogawa Electric Corporation
2-9-32, Nakacho, Musashino-shi, Tokyo, 180-8750 Japan

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Appendix Figure 99 – TDLS General Specification, Sheet 1 *(Yokogawa, 2023)*

■ STANDARD SPECIFICATIONS

- **TDLS8200 Probe type Tunable Diode Laser Spectrometer**

Measurement object:
O_2, CO, CO or CH_4 concentration in combustion exhaust gas and process gas
If other gas measurements are required, consult with Yokogawa
Measurement system:
Tunable diode laser spectroscopy
Light source; Near-infrared tunable diode laser

Measured components and ranges:

Measured component	Min. range	Max. range
O_2	0-1%	0-25% (*2)
CO (*1)	0-200 ppm	0-10,000 ppm
CH_4 (*1)	0-5%	

*1: Please consult Yokogawa if CO and CH_4 component coexists.
*2: In the case of explosionproof type, oxygen concentration shall not exceed that found in normal air, typically 21%.

Safety and EMC conformity standards:
Safety conformity standards:
CE, UKCA EN61010-1, EN61010-2-030
UL UL61010-1, UL 61010-2-030
CSA CAN/CSA-C22.2 No.61010-1, CAN/CSA-C22.2 No.61010-2-030
GB GB30439 Part 1
Installation altitude: 2000 m or less
Installation category:
I (Anticipated transient overvoltage 330V)
Measuring category: O (Other)
Pollution degree: 2, Indoor/Outdoor use
Note: Installation category, called overvoltage category, specifies impulse withstand voltage. Pollution degree indicates the degree of existence of solid, liquid, gas or other inclusions which may reduce dielectric strength.
EMC conformity standards:
CE, UKCA EN55011 Class A Group 1
EN61326-1 Class A Table 2 (For use in industrial location), EN61326-2-3
RCM EN55011 Class A Group 1
KC KN11 Class A Group 1, KN61000-6-2 (Korea Electromagnetic Conformity)
Laser classification:
CSA E60825-1:15,
GB7247.1-2012, FDA 21 CFR part 1040.10, Class 1 laser product
SIL Certification:
IEC 61508:Functional safety of Electrical/electronic/programmable electronic related systems; SIL 2 capability for single analyzer use, SIL 3 capability for dual analyzer use.
However, analog output (AO-4, AO-5), contact output (2 points), contact input (2 points), contact output for valve drive (2 points), digital communication (HART, Modbus/TCP) are outside the scope of the certification.
RoHS conformity standards: EN IEC 63000:2018

Information of the WEEE Directive
This product is purposely designed to be used in a large scale fixed installations only and, therefore, is out of scope of the WEEE Directive. The WEEE Directive does not apply. The WEEE Directive is only valid in the EU and UK.
Display: 128 x 64 dots LCD; On Sensor Control Unit Status LEDs; (Green: Power, Orange: DO, Red: Fault)
Display items:
Gas concentration, Transmission, Process gas temperature (AI), Process gas pressure (AI), System status, Alarm information, System information (Product serial no., Laser detector module serial no., Output signal, IP address, HART address, Optical path length, Analyzer internal temperature)
Analog output:
5 points, 4 to 20 mA DC (Isolated from the power supply and ground, Max. load resistance 550 Ω)
Output types; Gas concentration, Transmission, Process gas temperature, Process gas pressure
Output range; 3.0 to 21.6 mA DC
Digital communications:
HART; On analog output signal 1 (AO-1)
Load resistance; 250 to 550 Ω (Include cable resistance)
Ethernet; RJ-45 connector
Protocol; Modbus/TCP
Communication speed; 100 Mbps
Digital output: 2 points, contact rating 24V DC, 1A
DO;
Function: Activate during Warning / Calibration / Validation / Warm up / Maintenance conditions
Contact Specification:Relay contact output (Isolated from the power supply and ground), C-contact (NC/NO/COM)
Fault;
Function: Activate during Fault condition or when the system power is off
Contact Specification:Relay contact output (Isolated from the power supply and ground), A-contact (NC/COM)
Valve control output: 2 points
Function; Activate calibration, validation or blow-back solenoid valves for zero, span or validation gas.
Output signal; 24V DC, 500 mA Max. per terminal
Alarm:
Warning; Gas concentration low, Gas concentration high, Transmission low, Process pressure low, Process pressure high, Process temperature low, Process temperature high, Validation required, Validation failure, Zero calibration error, Span calibration error, External alarm, Detector signal high, Absorption too high
Fault; Laser module temperature low, Laser module temperature high, Laser temperature low, Laser temperature high, Peak center out of range, Reference peak height low, Transmission lost, Reference transmission low, Reference peak height high, Laser unit failure, Laser module error, File access error, E2PROM access error

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Appendix Figure 100 – TDLS General Specification, Sheet 2 *(Yokogawa, 2023)*

Digital input: 2 points
Function; External Alarm/Calibration start/ Validation start/Blow-back start/Stream switch (Valve control)
Contact specification; Zero voltage contact input (Isolated from the power supply and ground)
Input signal; Open signal: 100 kΩ or more, Close signal: 200 Ω or less
Analog input: 2 points
Signal type; 4 to 20 mA DC (Isolated from the power supply and Ground), with selectable powered/unpowered function
Input signal range; 2.4 to 21.6 mA DC
Input types; Process gas temperature, Process gas pressure
Transmitter power supply; 15 V DC or higher (at 20 mA DC) 26 V DC or less (at 0 mA DC)
Self-diagnostics:
Laser detector Unit temperature, Laser temperature, Detector signal level, Memory read/write function, Peak locking condition
Calibration:
Calibration method; Zero/Span calibration
Calibration mode; Manual
Validation:
Validation method; Up to 2 points
Validation mode; Manual, Auto (Time initiated, Remote initiate (DI/Modbus)), Semi-Auto (YH8000)
Power supply: 24V DC +/-10%
Power consumption:
Max. 25W; TDLS8200 only
Max. 60W; with YH8000 and 2 solenoid valves
Protection degree: IP66, Type 4X
Material: Case; Aluminum alloy
Wetted materials: Fused silica, 316 SS(eq.), BK-7 glass, Teflon encapsulated FKM, ASE wool, Alloy 800, 800H/HT (or equivalent, only for High temp.)
Paint color:Mint green (RAL 190 30 15 or equivalent)
Weight (approx.):
Probe part (Standard); 0.7 m 2.7 kg, 1 m 4.3 kg, 1.5 m 7.0 kg, 2 m 9.8 kg
Probe part (High temp.); 1 m 20.0 kg, 1.5 m 25.0 kg
Analyzer part; explosion proof; Approx. 16.5 kg general purpose; 15.6 kg (Not include flange)
Process gas condition:
Process gas temperature; Max. 850ºC, Application dependent
Process gas pressure; Max.500 kPa abs., Min. 90 kPa abs., Application dependent
Process gas velocity; over 1m/s (recommendation over 5 m/s)
Dust in process gas; When the process dust load is high, please consult with Yokogawa.

Note: When using TDLS8200 as CE/UKCA marking compliance product, it has following limitation. General purpose model (-G1, -G2): The upper limit of the measurement gas pressure is 50kPa in gauge pressure. The unstable gas defined by following cannot be measured. An unstable gas in this context is a gas liable to transform itself spontaneously, producing a sudden pressure increase. Such transformation as an example can result from a relatively small variation of an operating parameter (e.g. pressure, temperature, presence of catalyzing material) in a confined volume. This includes gases that are classified as chemically unstable gases according to CLP Regulation (EC) No 1272/2008 as amended. Typical examples of unstable gases: acetylene (UN 1001), methyl acetylene (UN 1060), vinylfluoride (UN 1860), ozone and dinitrogen oxide (UN 1067). For further examples, see Table 35.1 of the UN Manual of Tests and Criteria.
Warm-up time: 5 min.
Installation condition:
Ambient operating temperature; -20 to 55ºC
Storage temperature; -30 to 70ºC
Humidity; 0 to 95%RH at 40ºC (Non-condensing)
Mounting flange type; ASME B16.5, DIN, JIS
Gas connections; 1/4NPT or Rc1/4
Cable entries; 1/2NPT or M20x1.5mm, one hole. 3/4NPT or M25x1.5mm, three holes
Purge gas connections;
1/4NPT or Rc1/4
If other gas connections are required, please consult with Yokogawa.
Purge gas; Theoretically, instrument air could be used as a purge gas for all the below applications except for oxygen measurement. Choosing between using nitrogen or instrument air or purge gas will ultimately depend upon further application details and the desired precision of the measurement. All gases should be clean and dry.
Recommended purge gases: N_2 (99.99% or greater, application dependent)
Purge gas flow rates;
Optic: 2 to 20L/min (Application dependent) 100 to 200mL/min (explosionproof) * Not more than 10 kPa at the inlet for explosionproof.
Process window/Reflector: 0.5 to 100 L/min (Application dependent)

Hazardous area classifications:

Division1, Zone1 Explosionproof
TDLS8200-D1 (FM Approval for US)
Division system:
Type pf protection:
Explosion proof; Class I, Division 1, Groups A, B, C, D, T6
Dust-Ignitionproof; Class II/III, Division 1, Groups E, F, G T6
Enclosure rating: Type4X
Applicable standards:

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Appendix Figure 101 – TDLS General Specification, Sheet 3 *(Yokogawa, 2023)*

QUINT-PS/1AC/24DC/40

Power supply unit



Data sheet
104317_en_02

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1 Description

QUINT POWER power supply units – Superior system availability with SFB technology
Compact power supply units of the new QUINT POWER generation maximize the availability of your system. With the SFB technology (Selective Fuse Breaking Technology), six times the nominal current for 12 ms, even the standard power circuit-breakers can now also be triggered reliably and quickly. Faulty current paths are switched off selectively, the fault is located and important system parts continue to operate. Comprehensive diagnostics are provided through constant monitoring of output voltage and current. This preventive function monitoring visualizes critical operating modes and reports them to the control unit before an error can occur.

Features

Superior system availability

- Using SFB technology (6 times the nominal current for 12 ms), circuit breakers are tripped quickly and important system parts remain in operation
- Through the preventive monitoring of output voltage and current and the transmission of critical operating states to the controller
- Through reliable starting of difficult loads with POWER BOOST power reserve
- Long mains buffering > 35 ms
- high MTBF > 530,000 h (40 °C)

Worldwide use

- Input voltage from 85 V AC ... 264 V AC
- Input voltage from 90 V DC ... 350 V DC

Flexible use

- Adjustable output voltage
- Can be used in Class I, Division 2, Groups A, B, C, D (Hazardous Location) ANSI-ISA 12.12

Appendix Figure 102 – Power Supply Data Sheet, Sheet 1 *(Phoenix Contact, 2015)*

4 Technical data

Input data	
Nominal input voltage	100 V AC ... 240 V AC
Input voltage range	85 V AC ... 264 V AC
Short-term input voltage	300 V AC
Input voltage range	90 V DC ... 300 V DC (UL 508: ≤ 250 V DC)
AC frequency range	45 Hz ... 65 Hz
Frequency range DC	0 Hz
Current consumption	8.8 A (120 V AC) 4.6 A (230 V AC) 9.5 A (110 V DC) 4.7 A (220 V DC)
Inrush current limitation	< 15 A (typical)
I^2t	< 1.7 A^2s
Power failure bypass	> 35 ms (120 V AC) > 35 ms (230 V AC)
Typical response time	< 0.7 s
Protective circuit	Transient surge protection Varistor, gas-filled surge arrester
Input fuse, integrated	20 A (slow-blow, internal)
Choice of suitable fuses	16 A ... 20 A (AC: Characteristics B, C, D, K)
Discharge current to PE	< 3.5 mA
Output data	
Nominal output voltage	24 V DC ±1 %
Setting range of the output voltage	18 V DC ... 29.5 V DC (> 24 V DC, constant capacity restricted)
Output current	40 A (-25°C ... 60°C, U_{OUT} = 24 V DC) 45 A (with POWER BOOST, -25°C ... 40°C permanently, U_{OUT} = 24 V DC) 215 A (SFB technology, 12 ms) 45 A (U_{in} ≥ 100 V AC, ≥ 120 V DC)
Magnetic fuse tripping	B2 / B4 / B6 / B10 / B16 / B25 / C2 / C4 / C6 / C13
Efficiency	> 92 % (for 230 V AC and nominal values)
Rise time	< 0.1 s (U_{OUT} (10 % ... 90 %))
Residual ripple	< 30 mV_{PP} (with nominal values)
Connection in parallel	Yes, for redundancy and increased capacity
Connection in series	Yes
Protection against surge voltage on the output	< 35 V DC
Resistance to reverse feed	max. 35 V DC
Power consumption	
Maximum power dissipation NO-Load	14 W
Power loss nominal load max.	80 W
DC OK active	
Output description	U_{OUT} > 0.9 x U_N: High signal
Voltage/current	18 V DC ... 24 V DC / ≤ 20 mA (short-circuit resistant)
Status display	U_{OUT} > 0.9 x U_N: "DC OK" LED green / U_{OUT} < 0.9 x U_N: Flashing "DC OK" LED
DC OK floating	
Output description	Relay contact, U_{OUT} > 0.9 x U_N: Contact closed
Voltage/current	30 V AC / 0.5 A , 24 V DC / 1 A
Status display	U_{OUT} > 0.9 x U_N: "DC OK" LED green / U_{OUT} < 0.9 x U_N: Flashing "DC OK" LED

Appendix Figure 103 – Power Supply Data Sheet, Sheet 2 *(Phoenix Contact, 2015)*

Features and benefits

Fulfill your needs within one model family with a customizable transmitter design



- DIN head and field mount form factors
- 4–20 mA/HART® with Selectable Revision 5 and 7, FOUNDATION Fieldbus or PROFIBUS® PA Protocol support
- SIL 3 Capable: IEC 61508 certified by an accredited third-party agency for use in safety instrumented systems up to SIL 3 [minimum requirement of single use (1oo1) for SIL 2 and redundant use (1oo2) for SIL 3]
- Enhanced display with Local Operator Interface (LOI)
- LCD display
- Integral transient protection
- Enhanced accuracy and stability
- Transmitter-sensor matching with Callendar-Van Dusen constants
- Variety of enclosures

Access information when you need it with asset tags

Newly shipped devices include a unique QR code asset tag that enables you to access serialized information directly from the device. With this capability, you can:

- Access device drawings, diagrams, technical documentation, and troubleshooting information in your MyEmerson account
- Improve mean time to repair and maintain efficiency
- Ensure confidence that you have located the correct device
- Eliminate the time-consuming process of locating and transcribing nameplates to view asset information

Contents

Features and benefits 2
Ordering information 5
Specifications 17
Dimensional drawings 32
Product certifications 46

Appendix Figure 104 – Rosemount 644 Data Sheet, Sheet 1 *(Emerson, 2022)*

Rosemount 644 selection guide

Rosemount 644 HART Transmitters

HART head mount and field mount





- Single or dual sensor inputs for RTD, thermocouple, mV, and ohm
- DIN A head mount and field mount transmitters
- SIL3 Capable: IEC 61508 certified by an accredited third party agency for use in safety instrumented systems up to SIL 3 (minimum requirement of single use [1oo1] for SIL 2 and redundant use [1oo2] for SIL 3)
- LCD display
- Enhanced display with LOI
- Integral transient protection
- Diagnostic suite
- Enhanced accuracy and stability
- Transmitter–sensor matching with Callendar-Van Dusen constants

Rosemount 644 FOUNDATION Fieldbus



- Single sensor input for RTD, thermocouple, mV, and ohm
- DIN A head mount transmitter
- Standard function blocks: two analog inputs, one PID, and one backup Link Active Scheduler (LAS)
- LCD display

Appendix Figure 105 – Rosemount 644 Data Sheet, Sheet 2 *(Emerson, 2022)*

I1 ATEX Intrinsic Safety

Certificate:	[Headmount HART®]: Baseefa12ATEX0101X [Headmount Fieldbus/PROFIBUS®]: Baseefa03ATEX0499X [Railmount HART]: BAS00ATEX1033X
Standards:	EN IEC 60079-0: 2018, EN 60079-11: 2012
Markings:	[HART]: Ⓔ II 1 G Ex ia IIC T6...T4 Ga [Fieldbus/PROFIBUS]: Ⓔ II 1 G Ex ia IIC T4 Ga

See Table 29 for entity parameters and temperature classifications.

Special Conditions for Safe Use (X):

1. The equipment must be installed in an enclosure which affords it a degree of protection of at least IP20 in accordance with the requirements of IEC 60529. Non-metallic enclosures must have a surface resistance of less than 1 GΩ; light alloy or zirconium enclosures must be protected from impact and friction when installed in a Zone 0 environment.
2. When fitted with the Transient Protector Assembly, the equipment is not capable of withstanding the 500 V test as defined in Clause 6.3.13 of EN 60079-11:2012. This must be taken into account during installation.

N1 ATEX Type n – with enclosure

Certificate:	BAS00ATEX3145
Standards:	EN 60079-0: 2012+A11: 2013, EN 60079-15: 2010
Markings:	Ⓔ II 3 G Ex nA IIC T5 Gc ($-40\ °C \le T_a \le +70\ °C$)

NC ATEX Type n – without enclosure

Certificate:	[Headmount Fieldbus/PROFIBUS®, Railmount HART®]: Baseefa13ATEX0093X [Headmount HART]: Baseefa12ATEX0102U
Standards:	EN IEC 60079-0: 2018, EN 60079-15: 2010
Markings:	[Headmount Fieldbus/PROFIBUS, Railmount HART]: Ⓔ II 3 G Ex nA IIC T5 Gc ($-40\ °C \le T_a \le +70\ °C$) [Headmount HART]: Ⓔ II 3 G Ex nA IIC T6...T5 Gc; T6($-60\ °C \le T_a \le +40\ °C$); T5($-60\ °C \le T_a \le +85\ °C$)

Special Conditions for Safe Use (X):

1. The Rosemount 644 Temperature Transmitter must be installed in a suitably certified enclosure such that it is afforded a degree of protection of at least IP54 in accordance with IEC 60529 and EN 60079-15.
2. When fitted with the Transient Protector Assembly, the equipment is not capable of withstanding the 500 V test as defined in Clause 6.5 of EN 60079-15: 2010. This must be taken into account during installation.

Appendix Figure 106 – Rosemount 644 Data Sheet, Sheet 3 *(Emerson, 2022)*

521.5.2 Single-core cables armoured with steel wire or steel tape shall not be used for an a.c. circuit.

NOTE: The steel wire or steel tape armour of a single-core cable is regarded as a ferromagnetic enclosure. For single-core armoured cables, the use of aluminium armour may be considered.

543.2 Types of protective conductor

543.2.1 A protective conductor may consist of one or more of the following:

(i) A single-core cable

(ii) A conductor in a cable

(iii) An insulated or bare conductor in a common enclosure with insulated live conductors

(iv) A fixed bare or insulated conductor

(v) A metal covering, for example, the sheath, screen or armouring of a cable

(vi) A metal conduit, metallic cable management system or other enclosure or electrically continuous support system for conductors

(vii) an extraneous-conductive-part complying with Regulation 543.2.6.

543.2.2 Where a metal enclosure or frame of a low voltage switchgear or controlgear assembly or busbar trunking system is used as a protective conductor, it shall satisfy the following three requirements:

(i) Its electrical continuity shall be assured, either by construction or by suitable connection, in such a way as to be protected against mechanical, chemical or electrochemical deterioration

(ii) Its cross-sectional area shall be at least equal to that resulting from the application of Regulation 543.1, or verified by test in accordance with the appropriate part of BS EN 61439 series

(iii) It shall permit the connection of other protective conductors at every predetermined tap-off point.

543.2.3 A gas pipe, an oil pipe, flexible or pliable conduit, support wires or other flexible metallic parts, or constructional parts subject to mechanical stress in normal service, shall not be selected as a protective conductor.

543.2.4 A protective conductor of the types described in items (i) to (iv) of Regulation 543.2.1 and of cross-sectional area 10 mm^2 or less, shall be of copper.

543.2.5 The metal covering including the sheath (bare or insulated) of a cable, in particular the sheath of a mineral insulated cable, trunking and ducting for electrical purposes and metal conduit, may be used as a protective conductor for the associated circuit, if it satisfies both requirements of items (i) and (ii) of Regulation 543.2.2.

Appendix Figure 107 – Wiring Regulations Extract for Armoured Cable *(The Institution of Engineering and Technology, 2018)*

Title: Hazardous Area Initial Inspection Document Ex. i			
PP-EEL-FRM-0042	Rev 4.0	Issued: 24 10 2017	Page 1 of 6

Project Title:	04-AT-2394A installation	PJN / WR No:		/	
		Contract No :			

Reference to BS EN-60079-17 must be made in conjunction with the completion of this certificate

Equipment 'Tag' Number	04-TT-0070	Unit	ALKY
Equipment	Temperature Tx	Junction Box No.	04-AT-2394 SJB
Location	Top of 04-H-101	Junction Box location	Top of 04-H-101
		Elevation	Top of 04-H-101

			Acceptable?			
Item	Description of item to be checked		Yes	N/A	No	Comments
	Apparatus					
1.	ATEX Certification number on equipment Baseefa 12 ATEX 0101X					
2.	Type of apparatus (Simple or zoned) Zoned					
3.	Manufacturer Rosemount					
4.	Series or type 644 5A I 1 Q 4 Q T DC					
5.	Serial Number 6132189					
6.	Apparatus is installed in:- (refer to Area Classification Drawings.) 50-ZA-001-04 sht 1	Zone 1 (ATEX Cat. 2)				
		Zone 2 (ATEX Cat. 3)	✓			
7.	ATEX certified apparatus carries CE mark		✓			

Appendix Figure 108 – Temperature Transmitter ATEX Inspection Form, Sheet 1

				Acceptable?			
Item	**Description of item to be checked**			**Yes**	**N/A**	**No**	**Comments**
	Apparatus						
8.	Is Certificate of conformity available? List notfying body & conformity number				✓		
	_____						
9.	**Tick applicable For apparatus installed in Zone 1 (ATEX Cat 2) or Zone 2 (ATEX Cat. 3) classified area**						
	ATEX certified apparatus marked	Ex	**II 2 G**				
		Ex	**II 3 G**	✓			
10.	Hazardous area equipment Protection level is correct?		**EEx "ia"**	✓			
			EEx "ib"				
			EEx "ic"				
11.	Apparatus gas group is **correct** for hazardous area			✓			
12.	Apparatus temperature class is **T3** or greater(Temp class T1 or T2 unacceptable)	T No.	4	✓			
13.	Apparatus has IP rating of **IP54** or greater	IP No.	66	✓			

Appendix Figure 109 – Temperature Transmitter ATEX Inspection Form, Sheet 2

colegsirgâr

SGEL6000

Independent Project

Log Book

Jordan Gough

Heater Combustion Difficulty Safety Shutdown

2022 - 2023

Summary of Entries

Log Entry	Date	Brief Description of Activity	Duration (hrs)	Accumulated time (hrs)
1	30/09/2022	Project Identification and Proposal	3	3
2	07/10/2022	Proposal Approval and Background	3	6
3	14/10/2022	Project Background	5	11
4	21/10/2022	Project Background and Standards	5	16
5	28/10/2022	Functional Design Specification	8.5	24.5
6	04/11/2022	Functional Design Specification and Test Planning	8.5	33
7	11/11/2022	Test Planning and Compliance Table	8.5	41.5
8	18/11/2022	Literature Review	8.5	50
9	25/11/2022	Literature Review	8.5	58.5
10	02/12/2022	Literature Review	8.5	67
11	09/12/2022	Obtaining Quotes	17	84
12	16/12/2022	Planning Documents	8.5	92.5
13	23/12/2022	Planning Documents	17	109.5
14	30/12/2022	Conclusions and Recommendations	5	114.5
15	06/01/2023	Executive Summary and Introduction	5	119.5
16	09/01/2023	General Formatting	2	121.5
17	13/01/2023	Presentation Preparation	2	123.5
18	20/01/2023	Presentation	6	129.5
19	27/01/2023	-	0	129.5
20	03/02/2023	Loop Drawings	17	146.5
21	10/02/2023	Loop Drawings	17	163.5
22	17/02/2023	P&ID	8.5	172
23	24/02/2023	SIS Documents	17	189

24	03/03/2023	Obtain Copy of Software	17	206
25	10/03/2023	PLC Software Installation and Modifications	20	226
26	17/03/2023	PLC Modifications	20	246
27	24/03/2023	PLC Modifications	20	266
28	31/03/2023	PLC Modifications	20	286
29	07/04/2023	PLC and DCS Modifications	34	320
30	14/04/2023	DCS Modifications and Report	20	340
31	21/04/2023	Simulation Testing and Report	30	370
32	28/04/2023	Report	10	380

Log Entry Sheet

Log Number	19
Date	27/01/2023
Duration (hrs)	0
Accumulated time (hrs)	129.5

Record of activities and achievements
No progress made

Plans for next week
Create loop drawings for the three analyser loops. Begin familiarising with the analyser manual in anticipation of set-up and configuration.

Signed _____ Signed _____

Log Entry Sheet

Log Number	20
Date	03/02/2023
Duration (hrs)	17
Accumulated time (hrs)	146.5

Record of activities and achievements

The necessary information to create the three electrical loop diagrams (power, signal and fault loops) for the analyser was gathered. Utilising the information and the earlier block diagram, the drawings were created by hand as a draft form ready for transferring to AutoCAD as per company standard.

Time was spent reading through the manual to begin broadening an understanding of how it will be configured and calibrated.

Plans for next week

Create drawings for specific junction boxes to show where the new cables will be introduced into any already existing enclosures. Create loop drawing for updated temperature transmitter loop and detailed drawings for power and signal junction boxes which are shown simplistically on the loop drawings.

Industrial strike action has now finished, so progress of cable installation must be followed up on to ensure it is continuing.

As time allows, continue with manual familiarisation.

Signed _____ Signed _____

Log Entry Sheet

Log Number	21
Date	10/02/2023
Duration (hrs)	17
Accumulated time (hrs)	163.5

Record of activities and achievements

Loop drawing modified for the analyser signal to include the temperature indication loop, which is being used for temperature compensation input on the sensor, and the low flow sensor that is on the utility panel. Junction box drawings were received from the manufacturer for the power and signal junction boxes used within the sensor loop - due to the number of cables and components present, it is beneficial to show a detailed view. Existing junction box and cable interconnection drawings updated to show new cable connections.

Cable installation is once again progressing.

Plans for next week

Update P&ID to include the newly implemented equipment and produce hook up drawings to display the pipework connections that must be made. Begin typing up initial date sheets for analyser and temperature transmitter.

Signed _____ Signed _____

Log Entry Sheet

Log Number	22
Date	17/02/2023
Duration (hrs)	8.5
Accumulated time (hrs)	172

Record of activities and achievements

P&ID updated to include the analyser loop and the changes being made to the existing temperature loop. A hook-up drawing was created to show the purge connections made between the utility points and the utility panel. The utility panel's internal connections were displayed on a hook-up drawing provided by the manufacturer. Initial data sheets were created from the site template on Microsoft Word for the temperature indication and analyser.

Drawings are being continuously sent to the drawing office to be reproduced on AutoCAD and put into the correct format for the site's document management system. Data sheets retained until the information has been finalised.

Cable installation nearing completion. Working alongside some of the electrical contractors, cable glanding work commenced and cables were put into the enclosures to protect them. However, no terminations were made.

Plans for next week

Work alongside the SIS engineer to begin filling out SIS change request form, to update the PLC program.

Signed _____ Signed _____

Log Entry Sheet

Log Number	23
Date	24/02/2023
Duration (hrs)	17
Accumulated time (hrs)	189

Record of activities and achievements

Worked alongside SIS engineer and SIS change request form completed and submitted for approval to modify the Triconex PLC program.

Cable installation completed by electrical contractors. Again, working alongside the contractors, the cable glanding was also completed and cables were put into the enclosures as much as they could be. Any cables that were without an enclosure thus far were covered, to protect them from the weather, and tied out of the way to prevent them from any impact.

Plans for next week

Use the vendor documentation to complete the SIL verification calculations, to determine the overall SIL rating of the system.

Get electrical contractors to begin fabrication of metalwork to support future junction boxes.

Signed _____ Signed _____

Log Entry Sheet

Log Number	24
Date	03/03/2023
Duration (hrs)	17
Accumulated time (hrs)	206

Record of activities and achievements

Completed SIL verification calculations using the documentation provided by the instrument manufacturer.

Factory acceptance testing for sensor and delivery date delayed until May. Obtained a copy of the Triconex software to install on a desktop PC at home, due to restrictions with installing on PC at work.

Electrical contractors began fabrication works for the upcoming junction box installation using supporting unistrut and traywork.

Plans for next week

Install software and obtain a copy of the PLC program to make modifications at home which can be downloaded onto a test PLC for simulation tests to be carried out and prove the changes are functional.

Signed _____ Signed _____

Log Entry Sheet

Log Number	25
Date	10/03/2023
Duration (hrs)	20
Accumulated time (hrs)	226

Record of activities and achievements

Encountered problems with installing software at home due to missing prerequisite software. Eventually managed to get the programming software and other prerequisite software to install. Due to the restrictions and authorisations required to use the PLC software in work, proper training for modification has not been received and thus the time spent making the modifications will be delayed.

Supporting metal work fabrication and installation ongoing in anticipation of junction boxes.

Plans for next week

Continue building knowledge for PLC software usage and attempt to make modifications.

Signed _____ Signed _____

Log Entry Sheet

Log Number	26
Date	17/03/2023
Duration (hrs)	20
Accumulated time (hrs)	246

Record of activities and achievements

Incorrect version (V4.16) of TriStation software installed on home desktop PC and unable to open the Alky PLC program. Updated version required (4.17), currently exploring options of obtaining it.

Supporting metal work installation completed ready for junction boxes to be mounted on to and cables to be run between enclosures and instruments.

Plans for next week

Continue with PLC work. If problems continue, shift focus onto designing the Delta V DCS graphics - including how the faceplates should look and what information is required. Also need to identify where the readings need to be displayed on the heater overview screens and on the ESD cause and effect screens.

Signed _____ Signed _____

Log Entry Sheet

Log Number	27
Date	24/03/2023
Duration (hrs)	20
Accumulated time (hrs)	266

Record of activities and achievements

Updated version of TriStation acquired and installed on home desktop PC. Now able to open and modify the PLC program. Instead, started a new program and began specifically the heater logic. This prevents the program from becoming too large and increasing download times.

DCS modifications put on hold due to PLC software now working.

Plans for next week

Continue with PLC modifications.

Signed _____ Signed _____

Log Entry Sheet

Log Number	28
Date	31/03/2023
Duration (hrs)	20
Accumulated time (hrs)	286

Record of activities and achievements

Progress is slow due to lack of formal training, but PLC program modifications are continuing. Some issues encountered when needing to create function blocks. However, this issue was resolved eventually.

Plans for next week

Finalise PLC modifications and begin DCS modifications.

Signed _____ Signed _____

Log Entry Sheet

Log Number	29
Date	07/04/2023
Duration (hrs)	34
Accumulated time (hrs)	320

Record of activities and achievements

PLC modifications finalised. This included adding two analogue inputs to the existing program, building the analogue scaling for the inputs, configuring the analogue and digital outputs and adding the new analyser to the heater shutdown, start-up and purge logic.

Following finalisation of PLC modifications, the creation of the Delta V faceplates began. Using the range, alarm and trip schedule a total of four new faceplates were identified as being required. As with using TriStation, creating Delta V control modules was an unfamiliar task. So, Emerson manuals and training guides had to be followed. Two analogue faceplates created thus far for the carbon monoxide and methane indications.

Plans for next week

Create the digital faceplates for the alarms and update the heater graphic.

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Log Entry Sheet

Log Number	30
Date	14/04/2023
Duration (hrs)	20
Accumulated time (hrs)	340

Record of activities and achievements

Finalised the other two faceplates for Delta V. These are the alarms that indicate the safety shutdown has been initiated or the fault alarm is up. The two indication faceplates were added to the overall Alky heater graphic.

Started project write-up.

Plans for next week

Carry out simulation testing of the DCS graphics and the PLC modifications.

Signed _____ Signed _____

Log Entry Sheet

Log Number	31
Date	21/04/2023
Duration (hrs)	30
Accumulated time (hrs)	370

Record of activities and achievements

Carried out simulation testing of the Delta V faceplates and the PLC modifications. Practical test carried out for the fault alarm because it is a physical input to DCS, so was achievable on the DCS test rig. No test PLC available for detailed testing, so tests were carried out through forcing inputs.

Both the Delta V software and the TriStation PLC software have built-in emulation options.

Plans for next week

Finalise project report.

Signed _____ Signed _____

Log Entry Sheet

Log Number	32
Date	28/04/2023
Duration (hrs)	10
Accumulated time (hrs)	380

Record of activities and achievements
Write-up finalised and general formatting concluded.

Plans for next week
Submit report.

Signed _____ Signed _____

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GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

68 /100

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QM

Good Structure

Report is structured exactly as stated in the assignment brief.

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PAGE 7

Text Comment. A good set of acknowledgements

PAGE 8

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QM

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Text Comment. The first assignment was an opportunity to plan and consider these things. I hope that you now appreciate the importance of better preparation of FDS documentation and that this will assist you in your next project.

PAGE 11

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Text Comment. don't instruct your reader

PAGE 14

PAGE 15

Text Comment. Don't instruct your reader, they are not carrying out this project so you don't need to tell how they should do it.

Text Comment. was

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PAGE 16

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Text Comment. This is a very small range of sources for a level 6 project that has informed your design process

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Text Comment. Datasheets should not be included, it is important that you read them and quote relevant data with Harvard method of citation in main report.

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GRADING FORM: NEW CSG-RUBRIC

JORDAN GOUGH **68**

1. ENGAGEMENT WITH LITERATURE

Section 3: Judicial use and critical evaluation of technical literature in the design of the project
There is very good evidence of this in the report though you must not include datasheets in the appendix (3/5)
Section 8: Extent of reading, range of credible sources and use of Harvard **5**

method
The citation list is small for a level 6 project, but additional sources are found in the bibliography (2/5)

5/10

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 this seen in the detailed designs and analysis of the system needs.

8

8/10

3. COGNITIVE AND INTELLECTUAL

Section 5: Testing and analysis of results
There is excellent evidence of testing items that could be tested with a clear plan for those items that are pending due to difficulties in completing the project with the reasons given. (7/10)
Section 5: Critical evaluation of the project outcomes
A highly critical evaluation given with reasons. (7/10)
Section 6: Conclusions and recommendations
Excellent attempt at concluding the project within the limitation imposed

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by delays outside the author's control. Recommendations give a clear way forward. (7/10)

21/30

4. PRACTICAL APPLICATION

Section 4: Deployment method, use of material, tools, equipment and techniques in the construction of the project.
Very good methods in design and program modifications and simulations. However, limitation imposed meant that little was constructed or installed physically. (6/10)
Section 4: Quality of the final product or system.
For what could be achieved, the quality is high. (6/10)
Sections 5, 6 and appendix: Management of the design process including use of plans, costing spreadsheet and log book.
There is good evidence of management of the project and of interaction with the company's MOC system. However, event that appear outside the author's control should have been foreseen and better planning would have enabled a high completion percentage. Log-book shows progress through the design and implementation phase. (6/10)

18

18/30

5. TRANSFERABLE SKILLS

Section 1: Acknowledgements, executive summary and introduction.
There are 3 good sections (4/5)
All Sections: Presentation quality of the report, diagrams, charts, tables, figure numbering, page and section numbering etc.
Well presented and structured. However, datasheet should not be included in the appendix. (4/5)
All Sections: Quality of the writing style, use of punctuation and grammar.
Report writing style is sometimes awkward and contains spelling some errors. (3/5)
Word count limit not exceeded (5/5)

16/20

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