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Table of Contents

Tables, Figures and Charts	2
1. Executive Summary	3
2. Introduction	4
3. Project Background, Problem Definition and Constraints.....	5
3.1 Project Background.....	5
3.2 Project Definition.....	6
3.3 Constraints	7
3.3.1 Safety	7
3.3.2 Legal.....	7
3.3.3 Ethical Engineering and Codes of Conduct.....	10
3.3.4 Sustainability.....	10
4. Functional Design Specification and Test Plan.....	12
4.1 Functional Design Specification	12
4.2 Test Planning.....	15
5. Literature Review	21
5.1 PLC and Control System Overview	21
5.2 Solutions.....	21
6. Project Planning, Work Breakdown and Management Techniques.....	30
7. Conclusions and Recommendations	32
8. References.....	33
8.1 Works Cited	33
8.2 Bibliography	35
9. Appendix	36
9.1 Project Proposal	36
9.2 Scoring Matrix and Graphs for Solutions.....	37
9.3 Work Breakdown Structure	40
9.4 Gantt Chart.....	41
9.5 Costing Spreadsheet	42
9.6 Implementation Phase Risk Assessment	43
9.7 Log Entries	45

Tables, Figures and Charts

Figure 1 - Yokogawa TDLS8100 Block Diagram	24
Figure 2 - Neo Monitors LaserGas iQ2 Vulcan Block Diagram	25
Figure 3 - Rosemount 700XA Block Diagram	26
Figure 4 - Approved Project Proposal	36
Figure 5 - Scoring Matrix Criteria Breakdown	39
Figure 6 - Work Breakdown Structure	40
Figure 7 - GANTT Chart	41
Figure 8 - Costing Spreadsheet	42
Figure 9 - Risk Assessment	43
Figure 10 - Risk Matrix	44
Table 1 - Applied Standards	8
Table 2 - IP Ratings	9
Table 3 - Functional Design Specification	14
Table 4 - Functionality Testing Table	18
Table 5 - Compliance Table	20
Table 6 - Identified Solutions	22
Table 7 - Solution Comparison Table	28
Table 8 - Solution Scoring Matrix	37
Chart 1 - Combined Solution Radar Chart	28
Chart 2 - TDLS8100 Radar Chart	37
Chart 3 - LaserGas iQ2 Vulcan Radar Chart	38
Chart 4 - 700XA Radar Chart	38

1. Executive Summary

The project is based in an oil refinery where

Presently, there is no analysis in place to monitor for carbon monoxide or methane in any of the fired heaters located on the refinery. Typically, this has been normal but an update to the DCS control system meant that combustion difficulty became noticeable within the heaters and the issue need to be rectified because it was a safety issue. Three different ^{solutions} products were identified which could provide real-time monitoring for both gases, based off of the information ^{on} that was gathered from the workplace and tabulated into a functional design specification, and initiate a safety shutdown of the heater via the PLC.

Ultimately, Yokogawa's TDLS8100 was chosen as the ideal sensor to implement after comparing the three solutions on key criteria using radar charts. This was due to its low cost of £37,532.65, measurement suitability, SIL rating, HMI interfacing and conformity to designated legal standards. During the research of the TDLS8100, further useful features were identified which were not originally added to the specification but will be added in moving forward to improve the quality of the system.

A budget of £250,000 was provided for the completion of the project. The costings of materials and quoted labour from an on-site contracting company were collated into a spreadsheet and a total cost of £187,792.56 was calculated. This leaves £62,207.44 for additional costs which have currently not been accounted for.

A completion date of 7th April 2023 has been scheduled into a Gantt chart, allowing for roughly 140 working days to meet the deadline. However, some additional contingency time has been added to the chart to allow for discrepancies caused by working patterns, shipping delays or other unforeseen interruptions.

2. Introduction

The aim of this report is to identify a method of continuous and simultaneous carbon monoxide and methane monitoring inside a fired heater's combustion box, then to design a system that will initiate a safety shutdown of the heater if the conditions become unsafe. This project has become necessary for implementation because there has been a total of 53 instances of combustion difficulty initiating events within this heater, which has led to the heater operating with insufficient combustion air and allowing unburned fuel gas into the combustion box – ultimately making the heater unsafe.

This report will define the technical requirements of the system and how they can be tested and verified. It will then compare and contrast three viable solutions that can achieve the desired end product. The comparisons will be completed using a range of project management techniques to guarantee that the correct decision has been made at the end.

In manufacturing, the word product should be reserved for what the company produces

3. Project Background, Problem Definition and Constraints

3.1 Project Background

A global oil refining company with a locally based refinery has an alkylation unit, or 'alky', which uses hydrofluoric (HF) acid as a catalyst to convert isobutane, and other hydrocarbons into alkylate – which is a component used in the blending of gasoline to increase its octane rating without using benzene. The hydrocarbon mixture and the HF acid are transferred into an acid settler, which separates them, allowing the acid to be re-used as a catalyst. After the settler, the mixture is pumped into the unit's distillation section, which features the depropaniser column - a 55-tray distillation column used to remove the different products (including propane, butane and isobutane alkylate). This process requires a lot of heat, so the products flow through two heat exchangers, which take their heat from products being pulled from the distillation column – which in turn cools and condenses the products – prior to entering the column. Some of the products, typically butane and alkylate, don't separate and become 'bottoms', which require extra heat. Therefore, they are pulled from the column and cycled through a fired heater to a temperature between 128°C and 134°C – depending on feed composition. From the heater, the 'bottoms' are put back into the column to separate into the components. The propane, which becomes a vapor, will rise to the top of the column and be put through a water cooler to condense the products. This propane is taken from the overhead system to be sent to a stripper to remove trace HF remaining.

The fired heater has a number of safety shutdowns implemented on itself or associated systems to ensure that the internal conditions don't become dangerous. This include:

- Depropaniser Column – High column pressure
- Depropaniser Column – Low column bottoms level
- Heater – High outlet temperature
- Heater – Low combustion air flow
- Heater – Low feed flow
- Heater – Low fuel gas pressure
- Heater – Low pilot gas pressure
- Control room – Emergency stop button

Problem

3.2 Project Definition

There is no emergency shutdown in place for heater combustion difficulty, which has been identified to have occurred at times. As per a legal commitment to the Health and Safety Executive (HSE), a system to detect combustion difficulty on the heater must be installed – which will specifically be looking for carbon monoxide (CO) and methane (CH₄). This system would implement another 1-out-of-1 voting method of closing the heater's fuel gas XVs – otherwise known as emergency shut-off valves. A 1-out-of-1 system means that only one sensor will be used to detect the gases and initiate the shutdown.

HF acid is highly corrosive, so Monel, a nickel-copper alloy, pipework is used to minimise HF corrosion, due to its corrosion resistance. It is also toxic and flammable, therefore a large number of safety systems exist to prevent a release of containment due to the risks involved, such as environmental contamination or ignition. However, Monel is not totally corrosion resistant, so in the event that any corrosion does occur in the upper regions of the heater, there will not be any risk of flammable gas release because this system will prevent any CH₄ collecting in the area.

3.3 Constraints

Due to the scale of the project, assistance with the installation will be required from local contracting companies based on the refinery. The staff project engineer, project coordinator and control engineers will be involved due to the authorisation levels required to make PLC or control system modifications. Any documents created by hand throughout the project, such as P&IDs, data sheets and loop drawings, must be put into the correct format using AutoCAD and uploaded to the refinery's document control system by the design engineers, located in the refinery's on-site drawing office. There may be specific process conditions that will be needed to carry out testing of the final installation to gather results. These conditions can be achieved through approval and intervention from the control operator and field operators.

3.3.1 Safety

Prior to the commencement of any field works, the involved personnel shall sign a physical work permit, which has been risk assessed by maintenance personnel and approved by operations. (Health and Safety Executive, 2005)

Any work carried out within the Alky must be done in unit specific neoprene PPE to prevent any possible HF reaching the skin. The lowest level of protection is called 'Class A', which consists of a chemical resistant suits and gloves, goggles and a face shield. Any work which requires containment to be broken will be done in an enclosed, air-fed suit with rubber gauntlets and boots. This is the second highest degree of protection and is called 'Class C'. Any waste materials produced within the boundary of the alky must be thoroughly neutralised and tested to ensure that it is not holding on to any acid, which could cause personal or environmental harm. (American Petroleum Institute, 2021)

Any work carried out on top of the heater will require materials to be lifted up. Depending on the dimensions of the objects, either lifting ropes or a crane will be required. In the event of lifting taking place, proper equipment and techniques should be applied as defined by the Lifting Operations and Lifting Equipment Regulations. (Health and Safety Executive, 1998)

3.3.2 Legal

The system is going to be designed entirely within the confines of the refinery and will be made up of objects purchased from a variety of manufacturers, therefore removing any risk of breaching copyright laws through the use of registered intellectual property.

There are a number of standards which must be followed when completing the design, to ensure that the installation is completed correctly and to a quality that complies with HSE and other legal requirements. They are as follows.

Standard	Description
ASME B16.5	Pipe Flanges and Flanged Fittings NPS ½ through 24 metric/inch Standard
API RP 551	Process Measurement Instrumentation
API RP 552	Transmission Systems
API RP 553	Process Instruments and Control
API RP 555	Process Analysers
API RP 556	Instrumentation, Control and Protective Systems for Gas Fired Heaters
BS 7671	IET Wiring Regulations, latest edition
BS EN 60079	Electrical Apparatus for Potentially Explosive Atmospheres
BS EN 60529	Specification for Degrees of Protection Provided by Enclosures (IP Code)
BS EN 60801	Electromagnetic Compatibility for Industrial Process Measurement and Control
BS EN 61000-6-4	Electronic compatibility Generic Emission Standard
BS EN 61000-6-2	Electronic compatibility Generic Immunity Standard
IEC 61508	Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Equipment
IEC 61511	Functional Safety – Safety Instrumented System for the Process Industry Sector
BS EN 10204	Metallic product types of inspection documents
NAMUR NE43	Standardization of the signal level for the breakdown information of digital transmitters
ISO 8573-1	Compressed Air Quality Standard.

Table 1 - Applied Standards

When making component selection evaluations, the API RP 551, 552, 553, 555 and 556 standards will be employed to ensure that proper decision making is applied. These standards will provide general notes on a variety of sensors and where they are best utilised but will also focus on specific requirements and recommendations for heater instrumentation systems.

IEC 61511 is the most important standard, due to the implementation of a safety system. This is a standard which relates to IEC 61508, 'Functional Safety of Electrical and Electronic Safety-

related Systems'. This standard defines the requirements that a plant must conform to when relying on safety systems, to achieve functional safety. IEC 61511 addresses safety instrumented systems (SISs), along with the safety instrumented functions (SIFs) they perform, and the hazard and risk assessments (H&RAs) used to define their specification. The functional safety life-cycle is used to achieve these. The standard also outlines a framework for identifying the safety integrity level (SIL) of an entire system, which must be calculated. (International Electrotechnical Commission , 2017)

The NAMUR NE43 standards set the upper and lower analogue output. When the process variable being measured drops below 4mA, the outputs holds at its lower limit, which is 3.6mA, and when the process variable goes above 20mA, it holds at the upper limit, which is above 21mA. These analogue values can be used to generate fault alarms on the PLC, providing some diagnostic information. (Yokogawa, 2014)

The ATEX rating of the objects being installed will have to comply with that defined on the 'hazardous area' drawing for the alkylation unit, which is readily available in the document management system. Additionally, each item must have the CE European Union compliance mark, an ATEX certificate number from a responsible body and an ATEX symbol. (The British Standards Institution, 2014)

The ingress protection, or IP, rating of an enclosure defines the level of protection it has against solid foreign bodies – typically dust or other small particles – and water. The presence of fine powder catalyst used in other parts of the oil refinery mean that any enclosures need to be able to withstand large quantities of dust. (International Electrotechnical Commission, 2013) (The British Standards Institution, 2013)

Rating	Solids	Water
0	No protection	No protection
1	Protected against solid objects over 50mm	Protected against vertically falling drops of water
2	Protected against solid objects over 12.5mm	Protected against vertically falling water drops up to 15 degrees from the vertical
3	Protected against solid objects over 2.5mm	Protected against spraying water
4	Protected against solid objects over 1mm	Protected against splashing water
5	Protected against dust	Protected against low pressure jets of water
6	Dust-tight	Protected against strong jets of water

Table 2 - IP Ratings

A new electrical installation means that the IET Wiring Regulations will be followed to ensure the installation methods are correct. (The Institution of Engineering and Technology, 2018)

The sensor is going to be flange-mounted due to limited options available for mounting. The size of the stud bolts and the torque that must be applied to the bolts, in ft·lb, will have to be determined from the flange size that will be used. Additionally, any gaskets used must be suitable for use with HF acid. (The American Society of Mechanical Engineers, 2020)

3.3.3 Ethical Engineering and Codes of Conduct

The company has two lists which must be followed when selecting products and services: The Approved Manufacturers List (AML) and the Approved Vendors List (AVL). To get onto the list, manufacturers and vendors must provide the company with specific information, which includes their ethical and sustainability records. This information is then compared to the companies 'Conduct Guidelines for Business Partners' and a team determines if they are suitable. These business partners are expected to achieve health, safety and environmental excellence throughout its operations and ensure that their operations are conducted with respect to the company's human rights policies. Alongside these conditions, the business partners must comply with the law at all times and not take part in bribery or corruption, distribute sensitive data or breach intellectual property rights. If the business partners are deemed non-compliant, the business relationship is terminated. Therefore, any manufacturers or vendors required for the project will either need to be on the list or be approved beforehand.

3.3.4 Sustainability

Marc Rosen (2012) identifies the key requirements of engineering sustainability as the following:

1. Sustainable resources
2. Sustainable processes
3. Increased efficiency
4. Reduced environmental impact
5. Fulfilment of other aspects of sustainability

Due to the nature of the industry being worked in, these requirements need to be implemented to reduce environmental impact. In many cases, alternatives in the refining process are unavailable, so reductions need to be made elsewhere. A primary focus will be on resources and processes, in which it is important to identify how sustainable the materials used in manufacturing are and the environmental impact of obtaining, processing or transporting

them. In many cases, modern manufacturers implement recycled or substituted materials in place of the design's original requirement to reduce the environmental impact of excavation, particularly in the case of precious metals. Therefore, it is important to identify a manufacturer's sustainability report when considering products. to ensure they are reducing their impact, whilst also considering the full life cycle of the products. (Hsiao, 2019)

4. Functional Design Specification and Test Plan

4.1 Functional Design Specification

An excellent section that clearly outlines the deliverables of the project

The following is the criteria that the installation must meet to be deemed a success. These points include the technical requirements of the components, the interactions of the components, and the resources and time frame allocated for completion.

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%
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 a nitrogen or 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 at 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 DeltaV Distributed Control System (DCS) via serial link (RS 232).
21	PLC Output Operability	PLC must close both fuel gas XV's upon detection of high CO or CH ₄ levels.

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 DeltaV when any alarm is activated on the HMI. Transmitter fault alarm generated on DeltaV when output mA is outside of the 4-20mA range.

Table 3 - Functional Design Specification

4.2 Test Planning

A very good section giving clear guidelines on how the system will be tested

The first table below identifies the functional tests which will be completed, based on the criteria defined in the FDS, and the outcomes that are desired. There will be some overlap between testing and multiple tests may be completed at the same time. Additionally, these tests are tabulated as per the FDS and is not necessarily in the order in which the tests will or can be completed. These tests will be completed at the end of the implementation phase, but prior to the final commissioning of the installation. The second table confirms if the installation conforms to the standards, and additional planning criteria, which were detailed in the FDS. Proving the functionality and conformity of the system can be used as a measure of success.

If any tests or compliance do not produce the expected results, they will be analysed to identify why they didn't achieve it and what the next steps will be towards rectifying the issue.

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.	Analyser configuration can be completed through HART communication protocol			
7	Connect to analyser and change configuration, using either Emerson 475 or Emerson TREX HART communicators.	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.			
8, 11, 16						
9	Connect the utility air or nitrogen to the panel and open valve. Verify that a flow increase is seen on the indicator	Panel allows for air or nitrogen flow from a utility point through the tubing and fittings. Flow rate can be adjusted using restriction				

	and adjust as required. Connect validation cylinders to the installed fittings.	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.			
22, 23	View the DCS graphics in the control room. Have a second	Process readings are noticed on DeltaV DCS graphics. Live process values respond			

	technician or engineer simulate milliamps on the loop and	to change in mA, using calibrated mA source. DCS alarms activate when alarm conditions are met.		
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Table 4 - Functionality 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	Sensor is SIL 2 rated.			

	confirm the sensor's SIL rating, as per BS EN 61508				
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Table 5 - Compliance Table

5. Literature Review

There are currently no sensors in place to specifically monitor heater performance and the combustion box for CH₄ and CO, but there are other sensors installed which provide real-time monitoring of other process conditions - such as fuel gas pressure or oxygen content - and initiate shutdown functions within the PLC. The PLC is used for all of the safety shutdown systems on the unit and, alongside the DCS, cannot be replaced. The solution will be based around the measurement method used and any additional requirements of these methods, which haven't been captured previously. An overview of the PLC and the control system can be found below.

5.1 PLC and Control System Overview

Invensys Systems, Inc. (2009), owned by Schneider Electric, defines the Tricon PLC as "a state-of-the-art programmable logic and process controller that provides a high level of system fault tolerance". The PLC's system integrity is maintained through 'Dual Power Supply Redundancy' and 'Triple Modular Redundancy', in which the control program is executed in parallel by three identical channels. The three channels are isolated from each other, preventing any system faults from moving between channels. A Tricon PLC is made up of a maximum of 15 chassis. These include one main chassis, with up to 6 I/O modules, and a possible 14 expansion chassis, with up to 8 I/O modules each. In total, the PLC can support up to 118 I/O modules, either analogue or digital, and has potential for expansion with optional communications modules which support common protocols, such as Modbus and Ethernet.

The DeltaV distributed control system is produced by Emerson and is used on all areas of the refinery. DeltaV is a windows-based platform with a combination of servers, workstations and controllers. The I/O for the control system is achieved through the use of 'Characterisation Modules', or CHARMs. A variety of CHARMs can be implemented into a 'CHARM I/O Card', or CIOC, to provide a range of capabilities, including analogue and digital inputs and outputs. The information being sent and received by the CHARMs are displayed on 'faceplates', which give Operators real-time monitoring and control of field equipment. (Emerson, 2022)

5.2 Solutions

Not exactly Harvard, date should be at the end of the sentence and a page number added. Quotes should be double not single.

The American Petroleum Institute (2019) states that 'A combustibles analyser (catalytic bead) will typically detect CO, hydrogen, and other combustibles (excluding methane). Since the methane molecule cracks at a high temperature, detecting methane typically requires a separate sensor'. The requirement of a second sensor for detecting methane causes issues for installation, due to limited mounting locations and space. It can also be deemed as a

potential source of ignition during purging activities, so isolation will be required during heater start-up and shutdown.

An alternative method of measuring both methane and carbon monoxide simultaneously is non-dispersive infrared analysis (NDIR). NDIR analysers provide quantitative analysis and work on the principle of infrared absorption in which an infrared spectrum is produced continuously. The type of molecule identified is based on the wavelengths and frequencies which are absorbed, whilst the absorption strength determines the concentration of the gas. Multiple components can be found with a single analyser that has multiple detectors, assuming there is no overlap between wavelengths. Otherwise, band-pass filters can be installed, but this is affected by issues including dirt accumulation on the sensor lens. (Lipták, 2003) An updated approach to NDIR are tuneable diode laser spectrometers (TDLS), which also operates on the principle of infrared absorption but can be easily fine-tuned for a narrow wavelength range and can be compensated using a temperature sensor. (Lackner, 2007)

Gas chromatography can also be used to break down a process fluid and identify the individual components – in either a percentage range or as a measure of parts-per-billion. Chromatographs take a sample of the process stream and breaks out down over a time period, which can range from as little as 60 seconds to 20 minutes. However, the timing is determined by the number of components being identified. (American Petroleum Institute, 2020)

From the possible measurement options identified, the following manufacturers and models have been selected for evaluation. No suitable catalytic bead analysers could be identified, despite being recommended by API 556. This is due to the requirement of measuring both CO and CH₄, which cannot be achieved by many lone sensors.

Manufacturer	Model Number	Measurement Type
Yokogawa	TDLS8100	Tuneable Diode Laser Spectrometer
Neo Monitors	LaserGas iQ2 Vulcan	Tuneable Diode Laser Spectrometer
Rosemount	700XA	Gas Chromatograph

Table 6 - Identified Solutions

There are two types of TDLS on the market. The typical in-situ analyser requires two flange entries, allowing for the sensor to be mounted on one side of a pipe or vessel and the diode laser to be mounted on the other. However, the sensors made by Yokogawa and Neo Monitors are both probe type analysers, which only require one flange entry and has the diode laser and sensor built into one module. This makes them both viable options because only a single

flange is available for mounting. Both of the TDLS sensors can have an external temperature sensor connected to it to provide a real-time compensated reading. If separate temperature measurement options are unavailable, the Neo probe has internal temperature measurement to accurately measure the gas concentration with a varying temperature, whereas the Yokogawa probe can be programmed with a temperature value, if the process temperature is near-constant. The Yokogawa probe can only use the internal temperature value if the temperature of the process being measured is the same as ambient – so is therefore not applicable. If required, they also have the option of pressure compensation. (Neo Monitors, 2018) (Yokogawa, 2022) *citations should be given one at a time*

The Rosemount700XA contains multiple detectors for identifying different components. These include:

- Thermal Conductivity Sensor (TCD)
- Flame Ionization Detector (FID)
- Flame Photometric Detector (FPD)

Carbon monoxide measurement can be achieved by the TCD and methane measurement by the FID. Although a viable option for measuring both CO and CH₄ simultaneously, the main drawback of implementing a gas chromatograph is the long analysis time. These analysers require samples to be taken from the process and conditioned before the analysis procedure can begin – therefore, not providing constant monitoring. (Rosemount, 2020)

Shown below are block diagrams displaying how each of the three solutions would be implemented. These block diagrams show the major components of their respective systems and the types of connections they make within it. In general, the block diagrams are very similar to each other, with the connections back to the power, PLC and DCS being identical for each.

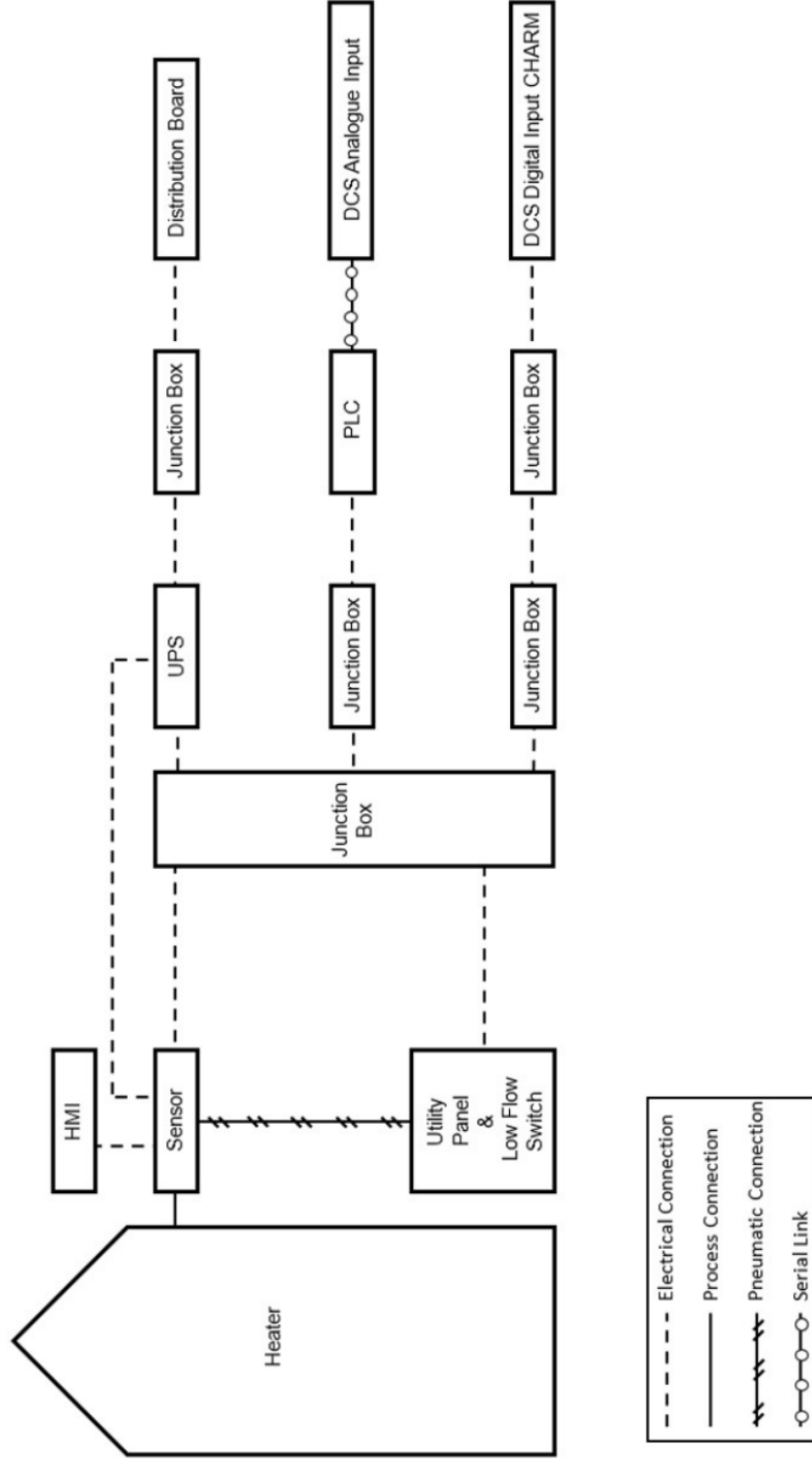


Figure 1 - Yokogawa TDL8100 Block Diagram

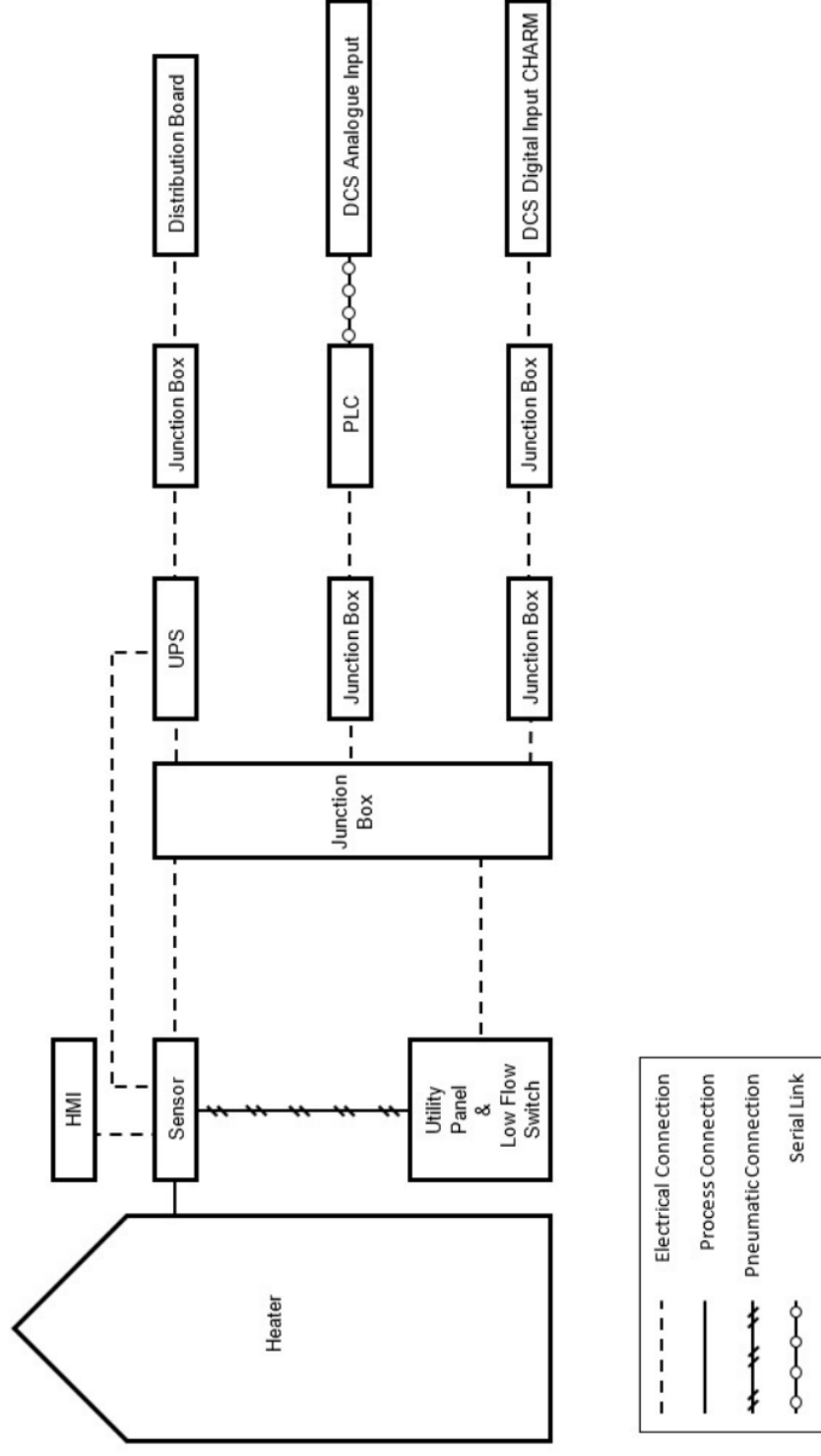


Figure 2 - Neo Monitors LaserGas IQ2 Vulcan Block Diagram

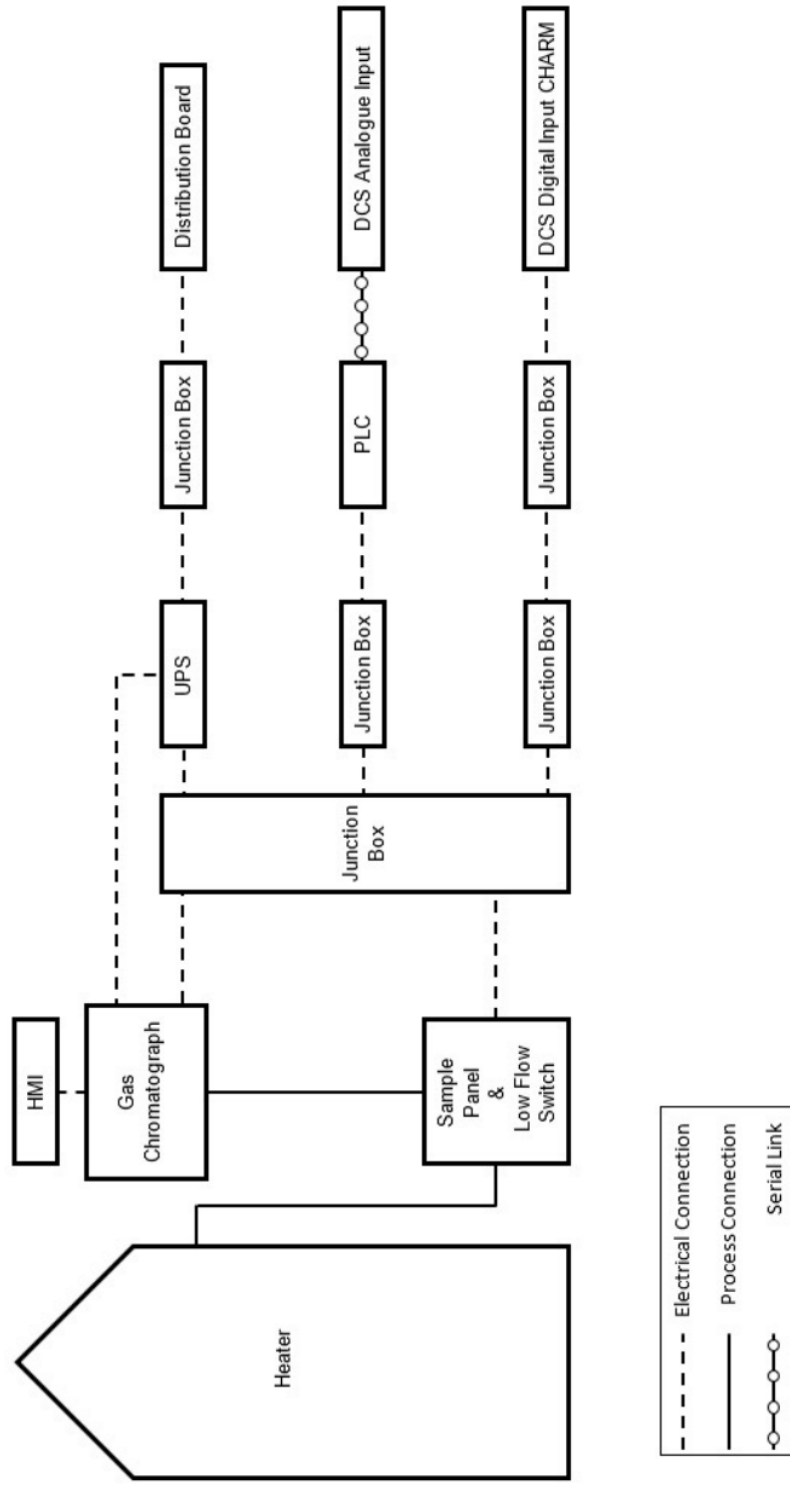


Figure 3 - Rosemount 700XA Block Diagram

	Solution 1	Solution 2	Solution 3
Manufacturer	Yokogawa	Neo Monitors	Rosemount
Model	TDLS8100	LaserGas iQ2 Vulcan	700XA
Measurement Principle	Tuneable Diode Laser Spectrometer	Tuneable Diode Laser Spectrometer	Gas Chromatograph
Power Supply and Consumption	• 24VDC • 20W maximum (without HMI) • 60W maximum (with HMI)	• 24VDC • 30W maximum	• 24VDC • 150W maximum
Output Capabilities (Quantity)	• 4-20mA analogue output (2) • 1A / 24VDC relay output (2)	• 4-20mA analogue output (6) • 1A / 30VDC relay output (6)	• 4-20mA analogue output (6) • 24VDC Digital Outputs (5)
Input Capabilities (Quantity)	• 4-20mA analogue input (2)	• 4-20mA analogue input (2)	• 4-20mA analogue input (2) • 0.5A / 30VDC Digital Inputs (5)
Communication Protocols (Quantity)	• Ethernet (1) – RJ45 connector • HART	• Ethernet (TCP/IP) digital output (1)	• Serial Communication Ports (3) – Configurable as RS-232, RS-422 or RS-485 • Ethernet (2) – RJ45 connector (1) and 4-wire (1)
ATEX Rating	II 2 G Ex db IIC T6 Gb	II 2 GD Ex e IIC T5 Gb	Ex db IIC Gb T6/T4/T3
IP Rating	IP66	IP66	IP66
SIL rating	IEC61508 SIL2	-	-
HMI	Optional	Built-in display	Optional

Operating Temperature	-20°C to 55°C	-40°C to +55°C	-20°C to 60°C
Operating Humidity	0 to 95%RH at 40°C		0 to 95%RH
Purge Gas Requirements	• Instrument air • Nitrogen	• Nitrogen	• Nitrogen
	(Yokogawa, 2022)	(Neo Monitors, 2018)	(Rosemount, 2020) (Rosemount, 2022)

Table 7 - Solution Comparison Table

Alongside this table, the solutions have been scored on a range of criteria to determine the feasibility of each solution – with the criteria including analyser cost, technical support and communication options. A combined graph of all solutions can be seen below.

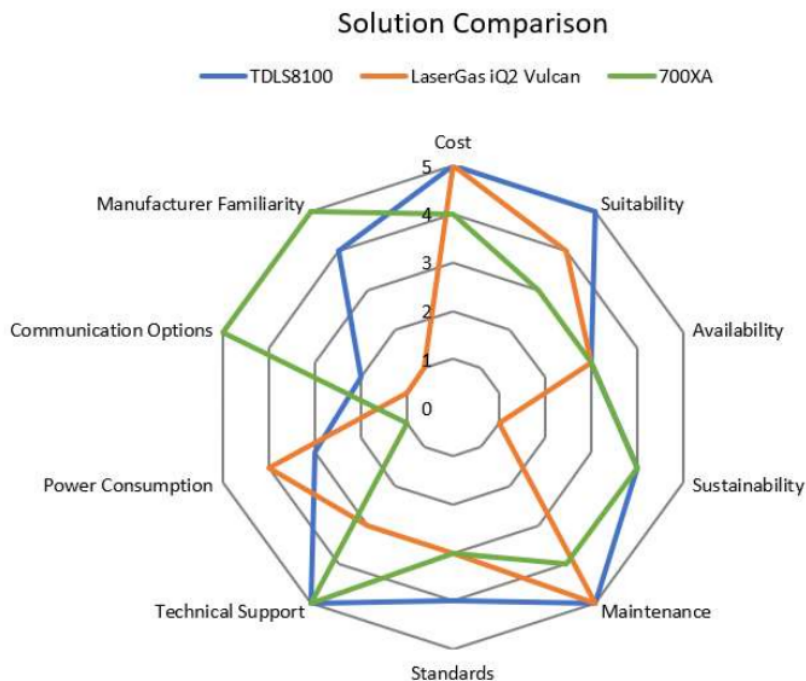


Chart 1 - Combined Solution Radar Chart

To ease the visualisation of the chart for comparative purposes, three individual charts can be found in the appendix, all of which have been filled to display the area coverage more accurately. Found alongside these in the appendix are the breakdowns of the scoring and the solutions' assigned scores.

From the charts, it can be seen that Yokogawa's TDLS8100 has been deemed the most suitable solution. This solution scored the highest in analyser cost, suitability, maintenance and technical support. The lowest score achieved was for the number of communication options it had, but the options available are more than sufficient for what is required. The next closest solution was Rosemount's 700XA GC, but it received low scores for suitability and power consumption, which impacted the decision too heavily.

6. Project Planning, Work Breakdown and Management Techniques

A work breakdown structure (WBS), Figure 6, was developed to separate the project up into four phases:

- Planning
- Design
- Implementation
- Commissioning

The phases were further divided to the key steps that each phase contains. These will serve as the key milestones that will be completed in each phase as the project progresses. Each division was assigned a percentage value, which determines roughly how much of the project's timescale will be allocated per phase. As expected, the implementation phase was deemed the most time consuming due to the practical efforts involved, whereas the planning and design phases were assumed to be identical in demand.

The WBS was then used to calculate timings for a GANTT chart, Figure 7, which sets deadlines for completion based on the assigned start date. The chart was designed with each division having a designated colour to aid with visualisation. The estimated completion date for the project was April 7th, which provided a duration of 140 working days from September 26th. However, seasonal holidays were included. Additionally, personnel only work one Friday every fortnight. At the end of the chart, 10 additional working days were assigned as 'Contingency' to provide some extra space for unaccounted for delays. Possible delays include workforce vacation or sickness, material delays due to supply chain issues, ongoing industrial strike action or alternative work being prioritised over project completion.

A costing spreadsheet was generated containing both material and labour costs. The majority of the materials were ordered through local suppliers, however some had to be ordered directly from the manufacturers and required quotes. Due to the amount of work being carried out, an on-site contractor will be assisting and a quote for their labour costs was unavoidable. The total cost as per the spreadsheet was £187,792.56, which leaves £62,207.44 left for additional costs that may arise. Some unaccounted for costs include materials which will be obtained from the site stores and staff labour costs - due to wage information being private.

Also, a risk assessment, Figure 9, was completed based on some of the engineering risks associated with the project. This risk assessment was based off of the company's risk matrix, Figure 10. No risks were captured relating to the installation works for the implementation

phase because conditions can change. The risk assessment completed on the permit to work will capture these hazards. The company's Management of Change (MOC) system will be used to monitor and verify that the system conforms to valid legal standards.

7. Conclusions and Recommendations

The purpose of the report was to identify a method of monitoring a fired heater for combustion difficulty. The method that was identified was the TDLS8100 tuneable diode laser spectrometer, produced by Yokogawa. This was chosen for its ability to measure both carbon monoxide and methane simultaneously and in real-time, which made it more advantageous than Rosemount's 700XA and its long analysis times - which would delay safety shutdown functions. Although near-identical in operation to Neo Monitor's LaserGas iQ2 Vulcan, the TDLS8100 was designed to be SIL 2 rated, as per IEC61508 – which was crucial to the system's design. Additionally, the TDLS8100 was the only option to feature the HART protocol, which is important not only for set-up and calibration, but for remote fault finding. The selection process was streamlined through a scoring matrix and radar charts to focus on the most important attributes – such as functionality, sustainability and cost.

You could have commented on the other design aspects of the project

Although not initially captured in the FDS, the TDLS8100 allows for temperature compensation from an external source. This is important for accuracy because the fired heater's temperature will vary, depending on the feed rate. Therefore, this should be added to the block diagram and the FDS moving forward. A variety of temperature measurement options are available in the on-site stores, so they won't require adding to the costing spreadsheet. There is also an option for pressure compensation, but this is not currently anticipated for use because the heater's internal pressure is controlled.

Some project management principles were applied to provide a path for completion. A WBS was used to identify the phases and milestones that make-up the project, whilst a Gantt chart designated timescales to ensure the project stayed on track for a timely completion. Alongside these, a risk assessment was created to assign hazards to some of the most important milestones, to ensure they are implemented to a high standard.

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9. Appendix

9.1 Project Proposal

SGEL6000 INDEPENDENT PROJECT

PROJECT PROPOSAL DOCUMENT

Student Name: Jordan Gough

Project Title: Heater Combustion Difficulty Safety Shutdown

Date: 30/09/2022

Budget: £250,000

Description of Project

The project is to design and install a system which detects carbon monoxide and methane at the top of a heater, indicating combustion difficulty. This system must act as a safety system which will shut down the heater and is required as per a commitment to the HSE.

The system includes the installation of a detection method, additional temperature measurement devices, instrument cable and the required loop components. It will also require the modification of a Schneider Triconex PLC and Emerson Delta V Automation Control System. The project must comply with site standards for the materials used but must also conform to the required ATEX standards for the area, as specified by the ATEX zone drawings.

Due to the scale of the project, assistance with the installation will be required from local contracting companies based on the refinery. Some aspects of the project will require involvement from the Staff Project Engineer and Project Coordinator, due to the authorisation levels required to make PLC modifications.

The budget available to complete the project is £250,000. This must include the materials required and the engineering and installation costs, whilst allowing some freedom for contingency. The project must be completed before the end of March 2023, due to the need to progress onto other projects taking place throughout the refinery within 2023.

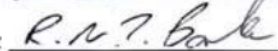
Agreement for project proposal

Student Signature:



Date: 30/09/2022

Industrial Supervisor Signature:



Date: 6/10/22

Academic Tutor Signature:



Date: 7/10/22

Figure 4 - Approved Project Proposal

9.2 Scoring Matrix and Graphs for Solutions

The table below shows the scores assigned to each of the criteria per solution.

	TDLS8100	LaserGas iQ2 Vulcan	700XA
Cost	5	5	4
Suitability	5	4	3
Availability	3	3	3
Sustainability	4	1	4
Maintenance	5	5	4
Standards	4	3	3
Technical Support	5	3	5
Power Consumption	3	4	1
Communication Options	2	1	5
Manufacturer Familiarity	4	1	5

Table 8 - Solution Scoring Matrix

The following graphs display the same information as that in Chart 1 but are easier to visualise when separated.

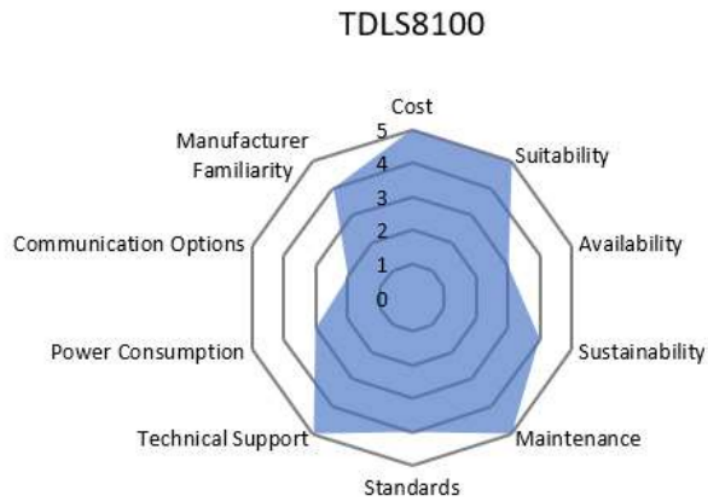


Chart 2 - TDLS8100 Radar Chart

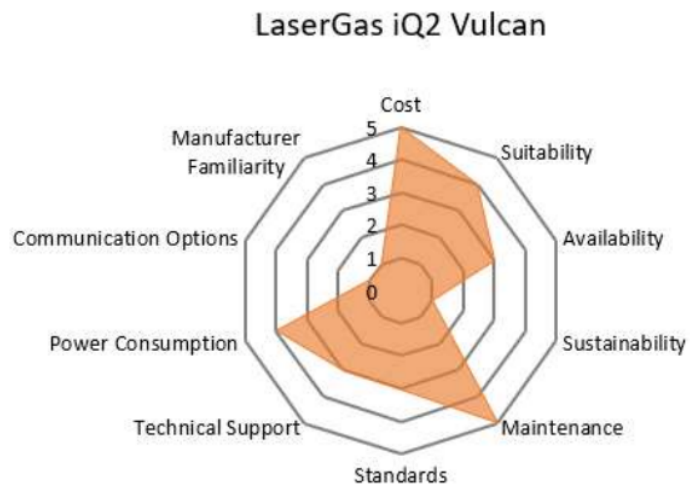


Chart 3 - LaserGas iQ2 Vulcan Radar Chart

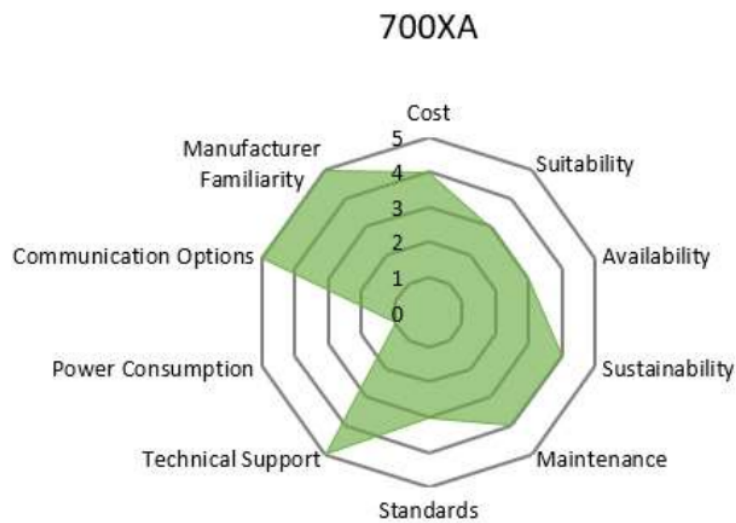


Chart 4 - 700XA Radar Chart

The breakdown of what each score represents can be found in Figure 5.

Criteria				
Analysed Cost				
1	2	3	4	5
More than £200,000	£150,000-£200,000	£100,000-£150,000	£50,000-£100,000	Less than £50,000
Sustainability				
1	2	3	4	5
Very Poor	Poor	Fair	Good	Excellent
Availability				
1	2	3	4	5
Unspecified Lead Time	Long Lead Time	Fair Lead Time	Short Lead Time	Readily Available
Sustainability				
1	2	3	4	5
No Sustainability Report Available	Poor Sustainability Report	Fair Sustainability Report	Good Sustainability Report	Excellent Sustainability Report
Maintenance				
1	2	3	4	5
Very High Costs	High Costs	Fair Costs	Low Costs	Minimal Costs
Standards				
1	2	3	4	5
No Required Standards Met	Few Required Standards Met	Many Required Standards Met	All Required Standards Met	Additional Standards Met
Technical Support				
1	2	3	4	5
No Technical Support	Poor Technical Support	Fair Technical Support	Good Technical Support	Excellent Technical Support
Power Consumption				
1	2	3	4	5
More than 100W	75W - 100W	50W - 75W	25W - 50W	Less than 25W
Connectivity				
1	2	3	4	5
1 Connectivity Option	2 Connectivity Options	3 Connectivity Options	4 Connectivity Options	5+ Connectivity Options
Manufacturer Familiarity				
1	2	3	4	5
No Equipment Installed	Rarely Installed	Sometimes Installed	Frequently Installed	Often Installed

Figure 5 - Scoring Matrix Criteria Breakdown

9.3 Work Breakdown Structure

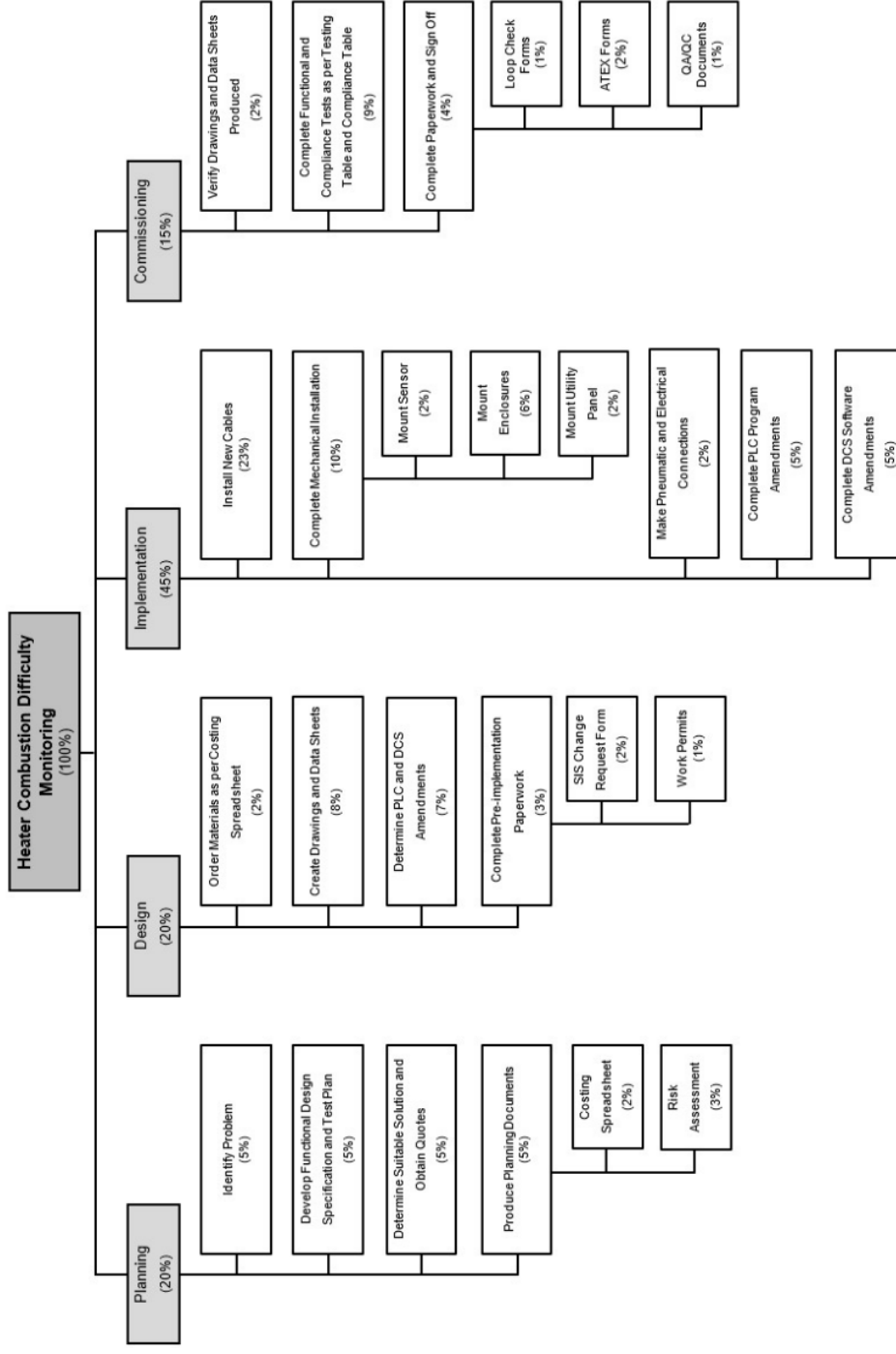


Figure 6 - Work Breakdown Structure

Planning should start from January

9.4 Gantt Chart

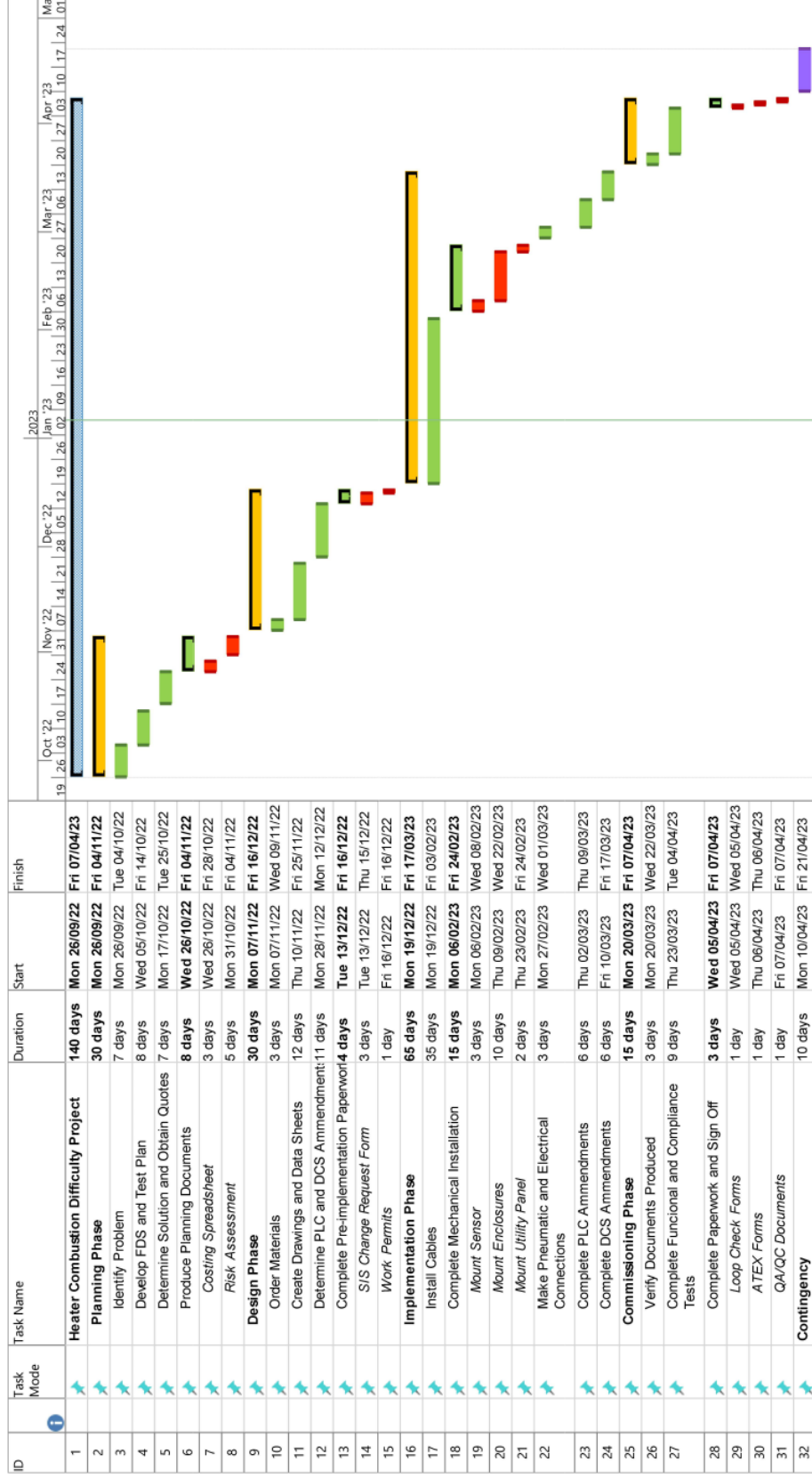


Figure 7 - GANTT Chart

9.5 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 Scree	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 Seamlss	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 Ptfе 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

Figure 8 - Costing Spreadsheet

9.6 Implementation Phase Risk Assessment

Main Category	Sub Category	Hazard Identified	Consequence	Consequence Type	Consequence Level	Likelihood Level	Initial Risk	Existing Safeguards/Controls	Consequence Level	Likelihood Level	Existing Risk	Additional Safeguards/Controls	Pre Approval (PSU) / After Start (ASU) Recommendation	Consequence Level	Likelihood Level	Mitigated Risk
ENGINEERING HARDWARE & DESIGN	Line diagram	Installation of new hardware conducted without any AS BUILT updates, drawing updates	Difficulties in maintaining the hardware leading to lost time if a fault occurs, or a failure occur later in service	Business	I	E	TR	Transmittal issued for loop sheets under PM20_0089	I	E	TR	AS BUILT loop sheets issued under PM20_0089	Pre Approval (PA)	I	D	BA
		Installation of new hardware conducted without any AS BUILT updates, drawing updates	Difficulties in maintaining the hardware leading to lost time if a fault occurs, or a failure occur later in service	Business	I	E	TR	Transmittal issued for IB drawings under PM20_0089	I	E	TR	AS BUILT IB drawings and cable schedules issued under PM20_0089	Pre Approval (PA)	I	D	BA
		Installation of new hardware conducted without any AS BUILT updates, drawing updates	Difficulties in maintaining the hardware leading to lost time if a fault occurs, or a failure occur later in service	Business	I	E	BA	Transmittal issued for PSD under PM20_0089	I	E	BA	AS BUILT PSD issued under PM20_0089	Pre Approval (PA)	I	D	BA
INSTRUMENTATION & CONTROL (includes computer systems)	Standard I/O validation	PLC changes conducted without detailed history of changes made to PLC logic revision. As a result, older edition of program could potentially be installed lacking additional ESD functionality	Confusion leading to lost time if a fault occurs, or a failure occur later in service	Safety	IV	C	Level 2	PLC change request form to be completed to manage the change	IV	B	Level 1	Submit PLC change request form to Instrument SIS Engineer for approval. Action item to update "Current logic folder" with the most recent edition T2 file to prevent confusion of differing logic (PSU)	Pre Approval (PA)	IV	A	TR
		PLC program changes conducted without correct approval, and/or testing (I/O validation)	Changes made to PLC program leading to SIS failure on demand, and greater loss of containment potential and personnel exposure.	Safety	IV	C	Level 2	Ally unit PLC Safety Requirement Specification states how every safety function is tested, and reducing each risk and risk reduction required to keep the risk to ALARP. Functions tested on site and signed off. Test prior to unit start. Ally unit PLC cause and effect diagram defines each trip input and corresponding alarm. Periodic testing of PLC logic and hardware end to end conducted with operations and instrument PMs.	IV	B	Level 1	Download changes to PLC and update PDFs for latest logic on the V drive. Save latest program to the V drive. Carry out PLC logic tests by performing Operations and Instrument PMs previously issued in "ROUTINE OPERATION" and "INSTRUMENTATION & CONTROL".	Pre Start - Up (PSU)	IV	A	TR
INSTRUMENTATION & CONTROL (includes computer systems)	Trips and Alarms	PLC changes conducted without correct approval, and/or testing (I/O validation)	Confusion leading to lost time to investigate PM anomalies where new hardware not referenced but in situ.	Business	I	E	TR	Site procedures including Risk Assessment and management of change framework.	I	D	BA	Complete Site Test Procedure for Routine PM.	After Start - Up (ASU)	I	C	BA
		Installation of new software leads to operator confusion, and/or unsafe restart heater following shutdown.	Confusion leading to lost time, delay in heater refilling	Business	I	E	TR	Operator to have passed workshop competency tests	I	E	TR	Update ALLY Operator PMS training manual	Pre Start - Up (PSU)	I	D	BA

Figure 9 - Risk Assessment

Business	Consequence			Safety	Likelihood	Qualitative Description	Scenario frequency per annum	Level 1	Level 2	Level 3	Level 4	Level 5
	Environment	Community	Safety									
>£100 Million	Catastrophic - Serious contamination of ground water or watercourse with loss of aquatic life.	Public Evacuation or National Media Coverage	>10 Fatalities On Site or Multiple Fatalities Off Site	VI	TR	Level 1	Level 2	Level 3	Level 4	Level 4	Level 4	Level 5
>£10MM to £100Million	Major - Serious toxic effect on beneficial or protected species, significant fish kill over a five mile range.	Public Evacuation or Country Media Coverage	2 to 10 Fatalities On Site or One Fatality Off Site	V	TR	TR	Level 1	Level 2	Level 3	Level 3	Level 3	Level 4
>£1MM to £10MM	Severe - Hazardous material into water course with half mile effects, e.g. visible fish kill.	Shelter in Place or County Media Coverage	Permanent Disabling Injury (e.g. Amputation) to Single Fatality	IV	BA	TR	TR	Level 1	Level 2	Level 2	Level 2	Level 3
>£100K to £1MM	Significant - Strong or offensive odours or noise, fish kill, breach of permitted emissions	Shelter in Place or Local Area Media Coverage	Serious Injury to Permanent Injured (e.g. Burn)	III	BA	BA	TR	TR	Level 1	Level 1	Level 1	Level 2
>£10K to £100K	Noticeable - Nuisance off site, discernible odours, minor breach of permit conditions	Community Warning or Local Media Coverage	Recordable to Lost Time	II	BA	BA	BA	BA	TR	TR	TR	Level 1
<£10K	Minor - Nuisance On site only, No off site effects	No to minor impact to people or No Media Coverage.	Minor to First Aid.	I	BA	BA	BA	BA	BA	BA	BA	TR
					AAA	AA	A	B	C	D	E	
					Likelihood							
					Qualitative Description							
					Scenario frequency per annum							

Level 4 or 5	Level 4 or 5 risk shall initiate the Risk Management process and a short term interim risk reduction together with long term implementation plan must be presented to Risk Management Committee for approval.
Level 2 or 3	Level 4 or 5 sign off is required: Approval to Operate with Risk Form.
Level 2 or 3	Level 2 or 3 risk shall initiate the Risk Management process and a risk reduction plan must be presented to Risk Management Committee for approval.
Level 2 or 3	Level 2 or 3 sign off is required: Approval to Operate with Risk Form
Level 1	Level 1 sign off is required on: Approval to Operate with Risk Form.
TR - Risk is tolerable if ALARP	Further control measure must be investigated and implemented if reasonable to do so. If the consequences are "IV" or higher an ALARP demonstration may be required to determine what is reasonable.
BA - Broadly Acceptable	If the consequences are between "I" and "III" then a qualitative risk assessment can be used for ALARP demonstration. Contact PSM personnel for further advice regarding ALARP demonstration.
BA - Broadly Acceptable	The risk is acceptable if all controls are in place and recommended good practise is followed.

Figure 10 - Risk Matrix

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	8.5	101
14	30/12/2022	Conclusions and Recommendations	5	106
15	06/01/2023	Executive Summary and Introduction	5	111
16	09/01/2023	General Formatting	2	113
17				
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30				

Log Entry Sheet

Log Number	1
Date	30/09/2022
Duration (hrs)	3
Accumulated time (hrs)	3

Record of activities and achievements

A project was identified within the Management of Change system that required completion due to an agreement with the HSE. Information was gathered from various documents and via email communication with engineering personnel in both Instruments and Process Safety, detailing what was required of the project. The information gathered was used to create a project proposal outlining what the project will entail, why it is required, who will be involved, the budget allocated for the project and when it must be completed by.

Plans for next week

Present project proposal to workplace supervisor and gain approval to acquire funding to commence with project. Once approved, begin expanding on the project proposal to create the detailed problem background containing more specific information.

Signed _____ Signed _____

Log Entry Sheet

Log Number	2
Date	07/10/22
Duration (hrs)	3
Accumulated time (hrs)	6

Record of activities and achievements

Gained approval on the project proposal, which provided a guarantee that a budget would be made available to carry out the project.

A variety of documents were gathered from the document management system, such as P&IDs, method statements, and information regarding the standards followed on-site. Following the collection of these documents, some progress was made towards the project background.

Plans for next week

Gather any other required information and continue writing project background.

Signed _____ Signed _____

Log Entry Sheet

Log Number	3
Date	14/10/2022
Duration (hrs)	5
Accumulated time (hrs)	11

Record of activities and achievements

Carried out some research into IEC 61508 and IEC 61511 standards, as it is arguably the most important standard that must be adhered to during the project completion. This information was added to the project background. Alkylation unit training manuals were also obtained to find more specific information, which is required for the project background, regarding how the unit operates and how the project will factor in.

Plans for next week

Gather further information regarding the specifics of the standards being followed and save manuals or standards which are relevant.

Signed _____ Signed _____

Log Entry Sheet

Log Number	4
Date	21/10/2022
Duration (hrs)	5
Accumulated time (hrs)	16

Record of activities and achievements

Identified the standard followed for working inside a HF alkylation unit, however the standard was not available without purchase. Hazardous area drawings for the location in which the installation will occur were collected and the requirements were checked to determine what was required in regard to ATEX standards, or BS EN 60079.

Plans for next week

Begin writing the functional design specification using the information collected until that point. Use the functional design specification as a means of identifying anything that is missing.

Signed _____ Signed _____

Log Entry Sheet

Log Number	5
Date	28/10/2022
Duration (hrs)	8.5
Accumulated time (hrs)	24.5

Record of activities and achievements

Started the functional design specification, listing the criteria that must be met during the design and implementation of the system. This included budget, time scale, sensor requirements, loop components, additional features and PLC interfacing.

Plans for next week

Add any missed information to the functional design specification and begin writing a testing plan, which will be used to determine the success of the project.

Signed _____ Signed _____

Log Entry Sheet

Log Number	6
Date	04/11/2022
Duration (hrs)	8.5
Accumulated time (hrs)	33

Record of activities and achievements

Finalised the functional design specification, which ended with 23 different items to meet - which were split between legal standards, technical requirements and general information.

A test plan was started, which will allow for the FDS items to be tested using defined methods that should produce the desirable results. The FDS items have been cross referenced to the test plan to ensure the tests can be tracked.

Plans for next week

Review documentation and add any additional testing methods and desired results that need to be carried out to the test plan which have been missed.

Signed _____ Signed _____

Log Entry Sheet

Log Number	7
Date	11/11/2022
Duration (hrs)	8.5
Accumulated time (hrs)	41.5

Record of activities and achievements

Upon reviewing safety documentation, some of the testing methods and results were expanded on to include shutdown PLC checks as per the SIL testing requirements. Due to the nature of several FDS items, a compliance table was also created to ensure that the legal standards were met without carrying out any practical tests.

The testing table ended with 14 items and the compliance table with 6 items. The only item missing was item 10 (Utility Panel Construction) because there is no functional test that can be completed and there isn't a legal standard to meet.

Plans for next week

Begin the literature review and solution decision making process.

Signed _____

Signed _____

Log Entry Sheet

Log Number	8
Date	18/11/2022
Duration (hrs)	8.5
Accumulated time (hrs)	50

Record of activities and achievements

Before identifying the solution, information regarding the Siemens Tricon PLC and Emerson Delta V distributed control system was collected. This information was gathered to identify the input and output options available, ensuring that the chosen solution was able to interact with both of them. The analogue process readings will be sent to Delta V via serial link, RS232, but there will be a need for digital inputs directly to the DCS.

Plans for next week

Determine the possible measurement methods that can be implemented for simultaneous carbon monoxide / methane measurement. Once determined, identify the manufacturers that can be installed using the 'approved manufacturers list' and select the most appropriate models that they produce.

Signed _____ Signed _____

Log Entry Sheet

Log Number	9
Date	25/11/2022
Duration (hrs)	8.5
Accumulated time (hrs)	58.5

Record of activities and achievements

Identified three possible methods of simultaneous carbon monoxide / methane measurement:

- Catalytic Bead (CB)
- Gas Chromatography (GC)
- Tuneable Diode Laser Spectroscopy (TDLS)

Unable to find a suitable CB measurement option, so one GC and two TDLS were selected. These were:

- Rosemount 700XA
- Yokogawa TDLS8100
- Neo Monitors LaserGas iQ2 Vulcan

The data sheets and manuals of each were saved to use for the upcoming decision making process.

Plans for next week

Design block diagrams for each of the three systems. Use suitable decision making methods to determine which sensor will be chosen for use in the system.

Signed _____ Signed _____

Log Entry Sheet

Log Number	10
Date	02/12/2022
Duration (hrs)	8.5
Accumulated time (hrs)	67

Record of activities and achievements

Block diagrams were developed for each system, showing the key components and connections of each.

The manuals and data sheets for each sensor were used to pick out key technical data that could be used for comparison purposes. The data was tabulated for easy comparison.

A Microsoft Excel spreadsheet of ten criteria and a scoring matrix were created. This was used to rate the products on different aspects, which would ultimately influence the decision. Using radar charts, the TDLS8100 by Yokogawa was chosen for use.

Plans for next week

Determine and order the materials required from the online catalogue or on-site stores in the enterprise resource planning software, then gain quotes for 'non-stock' items which are unavailable in either.

Signed _____ Signed _____

Log Entry Sheet

Log Number	11
Date	09/12/2022
Duration (hrs)	17
Accumulated time (hrs)	84

Record of activities and achievements

A list of required materials to complete the installation was generated.

Using the enterprise resource planning software, named SAP, purchase orders were raised for many common materials that were available through the online catalogue - such as cable, glands and pipe fittings. Nothing was readily available in the on-site stores.

Yokogawa was contacted to obtain a quote for the sensor, HMI, utility panel and any other additional requirements that they may suggest.

A request was also sent to an on-site contracting company for a labour cost quote.

Plans for next week

Begin developing the planning documents required for breaking down the project, initially beginning with the work breakdown structure and Gantt chart.

Signed _____ Signed _____

Log Entry Sheet

Log Number	12
Date	16/12/2022
Duration (hrs)	8.5
Accumulated time (hrs)	92.5

Record of activities and achievements

A work breakdown structure (WBS) was designed to split the project up in four phases, and many sub-phases, then work-load percentages were assigned to each:

- Planning (20%)
- Design (20%)
- Implementation (45%)
- Commissioning (15%)

Using Microsoft Project, a Gantt chart was made using the percentages designated on the WBS to determine the time scales based off of a 26/09/2022 to 07/04/2023 timeline.

Plans for next week

Continue with the planning documents, focusing on the risk assessment and costing spreadsheet.

Signed _____ Signed _____

Log Entry Sheet

Log Number	13
Date	23/12/2022
Duration (hrs)	8.5
Accumulated time (hrs)	101

Record of activities and achievements

A risk assessment was carried out using the Microsoft Excel sheet provided in work, which is always used for management of change (MOC) risk assessments. This assessment focused on the hazards associated with improper implementation - such as incorrect PLC modifications - rather than job site hazards, due to the greater risks. The future work permits will capture local hazards.

Both the labour (£71,028.56) and Yokogawa (£100,095.28) quotes had been returned, so a costing spreadsheet was created on Microsoft Excel. A total cost of £187,792.56 was determined - currently £62,207.44 under budget, allowing for additional costs that could arise.

Plans for next week

Write the conclusions and recommendations for the reports.

Signed _____ Signed _____

Log Entry Sheet

Log Number	14
Date	30/12/2022
Duration (hrs)	5
Accumulated time (hrs)	106

Record of activities and achievements

Conclusions and recommendations section added to report.

Following research carried out into the TDLS8100, recommendations were made to add external temperature measurement which would connect to the sensor and provide real-time temperature compensation.

Plans for next week

Use the final report to write an introduction and executive summary.

Signed _____ Signed _____

Log Entry Sheet

Log Number	15
Date	06/01/2023
Duration (hrs)	5
Accumulated time (hrs)	111

Record of activities and achievements

The final body of the report was used to write the introduction and executive summary.

Plans for next week

General formatting.

Signed _____ Signed _____

Log Entry Sheet

Log Number	16
Date	09/01/2023
Duration (hrs)	2
Accumulated time (hrs)	113

Record of activities and achievements

Time was spent ensuring that the report was formatted correctly, and no errors were present.

Plans for next week

Signed _____ Signed _____

FINAL GRADE

GENERAL COMMENTS

Instructor

76/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

Text Comment. The project is based in an oil refinery where

Text Comment. solutions

Text Comment. on

PAGE 5

Text Comment. result

Text Comment. In manufacturing, the word product should be reserved for what the company produces

PAGE 6

PAGE 7

Text Comment. Problem

PAGE 8

PAGE 9

PAGE 10

PAGE 11



Spelling

Spelling error

PAGE 12

PAGE 13

Text Comment. An excellent section that clearly outlines the deliverables of the project

PAGE 14

PAGE 15

PAGE 16

Text Comment. A very good section giving clear guidelines on how the system will be tested

PAGE 17

PAGE 18

PAGE 19

PAGE 20

PAGE 21

PAGE 22

Text Comment. Not exactly Harvard, date should be at the end of the sentence and a page number added. Quotes should be double not single.

PAGE 23

PAGE 24

Text Comment. citations should be given one at a time

PAGE 25

PAGE 26

PAGE 27

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PAGE 32

PAGE 33

Text Comment. You could have commented on the other design aspects of the project

PAGE 34

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PAGE 41

PAGE 42

Text Comment. Planning should start from January

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PAGE 46

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PAGE 48

PAGE 49

PAGE 50

PAGE 51

PAGE 52

PAGE 53

PAGE 54

PAGE 55

PAGE 56

PAGE 57

PAGE 58

PAGE 59

PAGE 60

PAGE 61

PAGE 62

PAGE 63

GRADING FORM: NEW CSG-RUBRIC

JORDAN GOUGH

76

1. ENGAGEMENT WITH LITERATURE



Sections 3 and 5: Engagement in research, judicial use and critical evaluation sources for project constraints and literature review of solutions
Excellent evidence of use of sources in all aspect of

14

the report. (7/10) Sections 3, 5 and 8: Extent of reading, use of credible sources, use of Harvard method for listing and citing Correct cited in most cases and listed with additional bibliography (7/10)
Total = 14/20

2. KNOWLEDGE AND UNDERSTANDING

 Section 3: Project background and problem definition Detailed explanations of both are given but they are difficult to follow being clothed in specialised technical terms. (4/5) Section 3: Project constraints: Ethical. A good section with clear statements on this important subject. (3/5) Section 3: Project constraints: Sustainability This section provides clear statements (3/5) Section 3: Project constraints: Legal/Commercial A good section that outlines all legal requirements (4/5) Total = 14/20

14

3. COGNITIVE AND INTELLECTUAL

 Section 4: Functional Design Specification An excellent section that clearly outlines the deliverables of the project (5/5) Section 4: Test planning A very good section giving clear guidelines on how the system will be tested (4/5) Section 5: Evaluation of solutions and justification of final solution Excellent section with full justification of choice of final solution. (4/5) Section 7: Conclusions and Recommendations A good section. However, you could have commented on the other design aspects of the project. (3/5) Total = 16/20

16

4. PRACTICAL APPLICATION

 Section 6: Project Plan Very good planning although there was no need to plan back to October and the 10 days allowed for contingency is unspecified. (3/5) Section 6: Working breakdown structure, costing exercise and management techniques Excellent evidence of these issues shown in the report (4/5) Appendix: Risk assessment for implementation phase Excellent coverage of risk (4/5) Appendix: Planning phase log-book entries. Good evidence of logging progress (3/5) Total = 14/20

14

5. TRANSFERABLE SKILLS

 Section 1: Executive summary A good brief summary covering all aspects of the project. However, it could have started better. (4/5) All Sections: Presentation quality of the report, diagrams, charts, tables, figure numbering, page, and section numbering etc Excellent presentation etc. (4/5) All Sections: Quality of the writing style, use of punctuation and grammar Fluid writing style and use of punctuation and grammar (5/5) Word count limit not exceeded No (5/5) Total = 18/20

18