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1. Executive Summary

A reasonable summary of the report content in 342 words but you could have focussed on summarising the project rather than the report.

A project proposal was created stipulating the project budget and scope, which was signed by the proposer, budget holder and college. Research into the industry background enabled a thorough understanding of H₂S creation within oil refining, as well as the dangers thereof and the significance of accurately detecting any leaks. The problem definition enabled a broader appreciation of the existing system, which highlighted legacy inadequacies that required intervention in the form of combining the separate gas detection systems, upgrading the controller and gas detectors, and incorporating a serial data link to DCS for live data acquisition.

Ethical, legal and sustainability constraints were elaborated upon, highlighting the important role engineers have when designing and executing projects in today's diverse world with a fragile natural environment and rapidly reducing natural resources.

A functional design specification was created, providing clear and specific objectives that needed to be achieved for the project to succeed. FDS test tables were created for the factory and site acceptance testing periods, as well as a compliance test table for the commissioning phase.

Manufacturer and solution selection required in-depth evaluation and comparisons to be carried out on sensor operating principle and efficiency, controller operation and integration, as well as manufacturer ethical and sustainability attributes. Draeger was found to be the most suitable supplier using their electrochemical H₂S sensor technology by utilising evaluation techniques and matrices, which included comparison tables and a radar graph.

A work breakdown structure was created, which enabled project phases to be created, where each phase was broken down into quantifiable subsections. From this, a detailed Gantt chart was created to allocate timelines to each phase of the project, which will be used to monitor progression during the implementation and commissioning phases, allowing continual improvements to be carried out.

An implementation phase risk assessment was created to identify risks associated with the changes that will be implemented and how these changes will affect incident response, field equipment conformity, operator interfaces and maintenance activities.

Finally, a full labour and parts costing was created to ensure the project stays within the specified budget.

2. Introduction

This report aims to accurately document a gas detection upgrade project that will be carried out on a complex oil refinery. A functional design specification will be created to clearly define the project functionality, followed by detailed testing tables to ensure the functions have been achieved. Research will be carried out using credible sources to gain underpinning knowledge of the project setting, the problem itself, and any legal, ethical and sustainability constraints that need to be adhered to.

Possible solutions will be compared, contrasted and evaluated by reviewing published technical, performance and legislative data, enabling a solution to be selected and justified using professionally recognised methods.

Project lifetime will be illustrated through a breakdown structure, where significant phases or milestones will be identified and further broken down into smaller sections. From the WBS, a detailed Gantt chart will be constructed as well as a risk assessment for the implementation phase. A full costing exercise will be carried out for materials and labour.

3. Project Background and Problem Definition and Constraints

3.1 Background

3.1.1 Industry Background

The project will be carried out on a complex oil refinery. The refinery produces various oil and gas products, including petrol and diesel, kerosene (jet fuel), propane, butane and fuel oil. Citation Needed
redundant word These products are produced by several different processes which utilise a variety of grades of crude oil as a feedstock.

Crude oil is a naturally occurring substance or fossil fuel consisting of a mixture of hydrocarbons in a liquid state that can vary in viscosity. Crude oil is formed from the remains of animals and plants that lived millions of years ago, which were covered by sand and rock, which compressed and heated the remains into crude oil (EIA, 2022) Correctly cited

Crude oil contains sulphur, the levels of sulphur contained in crude oil depend on which grade of crude oil is being referred to, where light grades contain small amounts of sulphur and heavy grades contain large amounts (McKinsey, 2022). Correctly cited

During the refining process, the sulphur compounds need to be removed due to its detrimental effects on product quality, equipment and infrastructure reliability due to its corrosion attributes and negative environmental impact (Intertek, 2022). Correctly cited

Sulphur compounds react with oxygen during combustion, creating a chemical compound called sulphur dioxide (SO₂). When SO₂ is released into the environment, it can cause acid rain, damage to flora, and a reduction in air quality leading to respiratory illnesses in humans and animals (Petro-Online, 2021).

The removal of sulphur compounds in refinery processes is carried out predominantly using hydro-processing catalyst reactors where the sulphur-containing fuel reacts with hydrogen

(H₂) in the catalyst beds. This chemical reaction bonds two H₂ atoms with one sulphur atom to produce H₂S (Javadli & de Klerk, 2012). Correctly cited

The H₂S-producing chemical reactions that occur during hydro-processing are not limited to sulphur compounds; four additional compounds react in an exothermic manner to produce H₂S and are listed below (Javadli & de Klerk, 2012).

Hydro Processing H ₂ S Creation		
Compound	H ₂ Catalyst Reaction	Exothermic Reaction
Mercaptans	$C_2H_5SH + H_2$	$C_2H_6 + H_2S$
Sulfides	$(C_7H_{15})_2S + 2H_2$	$2C_7H_{16} + H_2S$
Thiophenes	 + 4H ₂	$C_4H_{10} + H_2S$
Benzothiophenes	 + 3H ₂	$C_2H_5 + H_2S$
Dibenzothiophenes	 + 2H ₂	 + H ₂ S

Table 1 - Hydro Processing (Javadli & de Klerk, 2012)

H₂S removal is carried out by scrubbers or absorbers integrated into the refinery process streams, where di-ethanolamine (DEA) is utilised as the scrubbing medium. H₂S absorption into DEA occurs at high pressures and low temperatures. The DEA is then returned to the Amine recovery unit (ARU) as H₂S-rich amine. The ARU will recover the H₂S from the rich Amine in an Amine Regenerator, where the rich Amine is distilled at high temperatures and low pressures to remove all H₂S compounds (Ness, et al., 2012). Correctly cited

The H₂S-rich gas produced in the ARU is burned at temperatures of up to 1300° C by ensuring an exact quantity of oxidation air is utilised to facilitate a stoichiometric reaction. The H₂S is processed by the Sulphur Recovery Unit (SRU) into elemental sulphur, which is achieved by a two-step process in the thermal and catalyst reactors. In optimum operating conditions, one third of the H₂S contained in the acid gas feed is burnt and will be converted to SO₂ in the first step. After that, the SO₂ will combine in the reactors with the remaining H₂S to form sulphur. The reaction is as follows: $SO_2 + 2H_2S = 3S + 2H_2O$ (SRE, 2021).

3.1.2 ARU / SRU Gas Detection

Fixed location gas monitors are positioned at strategic locations around the ARU & SRU to enable the efficient detection of leaks that may occur. The detectors are integrated into alarm systems which energise audible and visual alarms throughout the units to warn workers in the

a well written and informative background section with suitable citations

event of a leak. This warning system enables the initiation of reactive processes to take place in a timely manner to mitigate the hazards presented by a leak.

The current gas detection system utilised on the ARU/SRU is made up of the following systems;

you could have cited a source to explain what Ex P means for ATEX rated enclosures

General Monitors Ex P field controller, which powers and controls 15 H₂S detectors, two beacons and two sounders and has an analogue signal to the control room DCS for alarm indication. This controller has an additional analogue output to a digital signal field junction box to provide an alarm signal to the main Draeger fire and gas control cabinet. This alarm signal will energise the gas detected relay to activate the remaining SRU integrated audio/visual alarms.

The Draeger fire and gas controller which is situated in the ARU/SRU Remote Instrument Enclosure (RIE) controls 13 SRU H₂S detectors, 5 ARU H₂S detectors and 8 ARU flammable gas detectors. This controller also energises four integrated audio/visual alarms on the SRU, three sounders on the ARU and six beacons on the ARU. The controller is configured to energise audio/visual alarms in a unit independent manner in the event of a leak.

The Draeger fire and gas controller provides four digital signals to the control room DCS, which are;

- SRU gas leak
- ARU gas leak
- PLC fault
- Detector fault

3.2 Problem Definition

The current system gives indication of a leak, but not exact locations, which causes a delay in reaction time when ascertaining severity, as well as emergency response coordination. In addition to the aforementioned constraints the General Monitors controller is no longer supported due to its age. The General Monitors detectors that need to be replaced are slow to react to gas and replacement parts are no longer available.

The need Punctuation Error unsupported detectors and controller has become apparent in line with the company's ethical and sustainable policies. The need to use products with multiple uses, which have been manufactured in an environmentally friendly manner, whilst complying with strict ethical requirements is paramount.

The new system needs to incorporate a serial data-link which will enable a dedicated DCS graphic of the two process units to be designed and built. This will enable the operator to know exactly where a leak has occurred as well as how severe the leak is, enabling rapid emergency response as well as the ability to isolate the leak in a timelier manner.

3.3 Constraints

The company has a robust vision on its business code of conduct, ethics and cultural values. This vision is achieved through the interlocking values of guiding principles; Safety, Environment, Community, Employees and Governance (Valero, 2022).

3.3.1 Ethical Engineering *This section was worth 5 marks. Do you think you have written enough here?*

Engineering activities can have potentially large and long-lasting negative impact on the general public, industry, engineering community and individual reputation. It is therefore paramount that engineering activities have to be conducted in an ethical manner, which include holding public health, safety and welfare at the forefront of decision making, conforming to engineering standards and legislation and taking responsibility for professional activities conducted (Schwartz, 2014).

Engineers must conduct their activities with integrity, morality, impartiality and excellence, regardless of employer pressure or constraints (Crawford, 2022).

An inclusive approach to engineering has many benefits, some of which include, a broader range of creativity and innovation, increased problem-solving qualities and increased customer satisfaction (Dempsey, 2021).

3.3.2 Sustainability *This section was worth 5 marks. Do you think you have written enough here?*

Sustainable engineering is often thought of as environmentally friendly engineering such as reducing material usage, recycling and re-using various components. The modern approach to engineering with sustainability must encompass environmentally friendly engineering in addition to creating solutions that are socially beneficial and adds value to society. An interdisciplinarity approach is required to achieve sustainable engineering, where innovative solutions are created through having a diverse, inclusive and professional mindset (CAL International, 2021) (Institution of Mechanical Engineers, 2020). *only cite one source at a time*

Table 2 shows sustainable engineering principles that should be considered.

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

Table 2 - Sustainable Engineering Considerations (UNESCO , 2015) (CAL International, 2021)

3.3.3 Legal Commercial *This section was worth 5 marks. Do you think you have written enough here?*

Gas detection system selection, operation and maintenance is governed by the company guidelines, in line with Shell Design & Engineering Practices (DEP's), the BSI and the HSE, who provides legislation and guidance through the following publications;

Rather than listing these documents here, it would have been better to read them and cite information relevant to your project.

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

Table 3 - Legal Legislation (BSI, 2015) (HSE, 2002)

Additional guidance is provided by the Council of Gas Detection and Environmental Monitoring (CoGDEM) and International Environmental Technology (IET) (Walsh, 2003).

4. Functional Design Specification and Test Plan

4.1 FDS

A very detailed and clear section, very professionally presented, making clear the deliverable outcomes of the project

This FDS describes the required functionality of each loop to be executed in the ARU/SRU gas detection upgrade together with detailed User Requirement Specifications (URS) for the whole system.

FDS Item	Description	Specification
1	Management of Safety	
1.1	Management of Change and Modifications	Post-FDS approval modifications must be captured by following the company's management of change system. The supplier must be involved in the MOC to ensure a thorough impact assessment is carried out.
2	Maintenance Activities	
2.1 a	Spare Parts	Spare parts list has to be provided by the manufacturer to enable 2-year operation
2.1 b	Mean Time to Repair	The MTTR must be 8 hours and must be supported by the availability of critical spares held on site.
2.2	Maintenance Overrides and Inhibits	Alarm inhibits must be available to enable maintenance activities. Inhibits must be captured using established site procedures
2.3 a	Loss of Power Recovery	The controller and audible/visual alarms must be supplied by separate uninterrupted power supplies (UPS). Seamless UPS switchover must take place in the event of mains power loss, at which time an alarm must be activated to the DCS
2.3 b	Loss of Power Recovery	SHELL DEP 33.64.10.10-GEN stipulates that the UPS must operate for 8 hours in the event of a mains power issue.
2.3 c	Loss of Power Recovery	The 24v power supply must have an N+1 redundancy configuration, where N is the number of supplies for the calculated load.
2.4	Back-up and Recovery	The system must be able to create application software back-ups and recovery implementation from portable devices

Item	Description	Specification
3	Environmental Requirements	
3.1	Hazardous Area Requirements	Equipment installed in a hazardous area must achieve the following ATEX classifications shown in table 4 as a minimum. Refer to drawing 50-ZA-021 refinery master plot plan – hazardous areas
3.2	Electromagnetic Compatibility	The system must comply with the EMC Directive 2004/108/EC. Separation of signal and power cables, galvanic isolation and correct earthing techniques must be adhered to.
3.3	Field Environment Conditions	All external elements of the project must be suitable for operation in the conditions laid out in Table 6. Equipment selection must account, where possible, for the coastal location of the refinery
4	Performance Requirements	
4.1 a	Sequence of Event Recording (SOE)	DeltaV must be utilised as the master sequence of event and alarm recorder.
4.1 b	Sequence of Event Recording (SOE)	The HMI must be used for secondary SoE recording.
4.2 a	System Response Time	The gas detection system must alert an operator through the DCS system of any gas release within 30 seconds, including detector response time.
4.2 b	System Response Time	The gas detection system action time must be less than 500ms
4.3	Processor Loading	The processor must be able to function under full load conditions where all detectors have reached maximum mA output
4.4	Major Accident Survivability	The system must be able to produce an alarm signal in the event of a significant accident, i.e., signal cables open circuit
5	System Interfaces	
5.1 a	Operator Interface	The system must provide the operators with two interfaces for the gas detection system. The primary interface must be the DCS DeltaV control panel, with the secondary being the local HMI housed in the RIE
5.1 b	Operator Interface	Any gas release incident must activate an alarm on DCS with a graphic showing the exact location of the detector in alarm. Information on which detector alarmed first must be available in detail on the graphic
5.1 c	Operator Interface	The controller must relay the fault conditions shown in table 6 through the Modbus serial link to the DCS via DeltaV alarms reporting protocol to NAMUR standards as well as the HMI

Item	Description	Specification
5.1 d	Operator Interface	In addition to the DCS alarms, hardwired fault loops must indicate • System Fault (0mA) • Detector Fault (3.6mA)
5.2	Alarm Levels	Gas detection alarm levels must be set to the thresholds shown in Table 8
6	Power Supplies	
6.1 a	Electrical	The SRU / ARU gas detection system must operate with 110v AC UPS backed-up supplies. The controller and audible/visual alarms must be fed from separate UPS backed-up supplies
6.1 b	Electrical	Manufacturer-supplied 24v power supplies must be able to seamlessly switch to standby supply in the event of a failure.
6.1 c	Electrical	110V supply must meet the parameters set in Table 9
6.2	Earthing Requirements	The system must have separate earthing facilities for protective and intrinsically safe earthing applications.
7	Trip and Reset Philosophy	
7.1	Alarm Acknowledge	The gas-detected alarm output shall be latching. Acknowledge (AKN) switch must silence audible alarms with visual alarms staying active.
7.2	Alarm Reset	The system must only allow a full reset once all detectors are below the alarm thresholds defined in Table 8, after which the hard reset should clear all alarms to DCS in addition to audible/visual alarms
7.3	Alarm Outputs (Audio / Visual)	Alarm outputs shall energise to trip (ETT) for audio/visual alarms
7.4	Alarm Outputs (DCS)	Alarm outputs shall de-energise to trip (DTT) for alarm signals to DCS
8	System Security	
8.1 a	Access Levels	The HMI must incorporate the user groups defined in Table 10
8.1 b	Access Levels	DCS interface shall be read-only
8.2 a	Physical Security	No hardware internet access capability, either directly or through the site network, shall be provided
8.2 b	Physical Security	No provision shall be made for connecting to the system via the cabinet door or panel

Table 4 - Functional Design Specification

Tables 5, 6, 7, 8 and 9 are referred to in the FDS.

Hazardous Area Requirements	
Area Classification	Zone 2
Temperature Classification	T3
Gas Group	IIB
IP Rating	IP65

Table 5 - Hazardous Area Classification

Field Environmental Conditions			
Parameter	Unit	Min	Max
Temperature	°C	-8	30
Humidity	%	65 avg.	
Rainfall	mm (24hrs)	0	40
Pressure	mB	960	1047
Ingress Protection	n/a	65	n/a

Table 6 - Field Environmental Conditions

Fault Actions	
Fault	Action
System Fault	0mA
Detector Fault	3.6mA
Controller Power Supply Failure	UPS switchover
Beacons/Alarms Power Supply Failure	UPS switchover

Table 7 - System Fault Actions

Point Detector Alarm Levels		
Gas	Low	High
H2S	5ppm	10ppm
Hydrocarbon (Propane)	10% LEL	20% LEL

Table 8 - Point Detector Alarm Levels

Electrical Requirements			
Parameter	Unit	Supply	Tolerance
Voltage	Volts (V)	110	5%
Frequency	Hertz (Hz)	60	2%

Table 9 - Supply Voltage and Frequency Requirements

Access Levels	
User	Access
Administrator	Full system access including application configuration
Engineer	Full access to system level including HMI configuration
Technician	Diagnostic application / screen access to aid in fault finding
Viewers	Read only - Timeout default access level.

Table 10 - HMI Access Levels

4.2 Test plan

An excellent section, very thorough treatment, professionally competent

Functional testing will be carried out in two parts. The initial testing will be executed during the factory acceptance test (FAT) prior to shipping, followed by the post installation site acceptance test (SAT). Both Test tables have been reduced in size for illustration.

The FAT tests are intended to ensure the system will be functioning as deemed by the FDS requirements prior to shipping as well as to reduce commissioning time on site. The SAT tests are intended to ensure site related FDS items are met, these include UPS & mains power supply, DCS alerts and alarm levels as well as field alarm and reset testing.

In addition to the FAT and SAT testing, a site compliance test table (table 10) has been created and must be completed during the commissioning stage of the project. Where necessary company procedures must be updated to reflect the appropriate functional design specification

FDS Item	Description	Expected Outcome	Actual Outcome	Pass / Fail	Evidence / Reference
1.1	Company MOC system must be utilised to capture FDS changes	Modifications made to the FDS has been captured using the company's MOC system.			
2.1 a	Spare parts list	Spare parts list provided by manufacturer enabling 2-year operation			
2.1 b	Mean time to repair	MTTR of 8 hours			
2.4	Back Up and Recovery	System backups made and stored for 5 years minimum			
3.2	Electromagnetic Compatibility	Appropriate cable separation and earthing techniques applied			
3.3	Field Environmental Conditions	Equipment is suitable for environmental conditions stated in table 5			
4.3	Processor Loading	Manufacturer proof of no more than 50% loading on processor			
8.1 a	Access Levels	HMI access levels are structured as stated in table 9			
8.2	Engineering Interface Availability	There is no provision made for connecting to the system through the front door			

Table 11 - FDS Compliance Test Table

Factory Acceptance Test (FAT)					
FDS Item	Description	Expected Outcome	Actual Outcome	Pass / Fail	Evidence / Reference
2.2	Maintenance Overrides / Inhibits	Individual control cards can be inhibited for maintenance			
2.3 c	Loss of Power Recovery	24v Power supplies have N+1 redundancy configuration			
3.1	Hazardous Area Requirements	Field installed equipment is ATEX rated as a minimum: Zone 2 IIB T3 & IP65			
4.1 b	Sequence of Event Recording	The HMI can be used for secondary SOE recording			
4.2 b	System Response Time	The as detection action time to gas sensed above alarm levels is less than 500ms			
4.4	Major Accident Survivability	Open circuit loop produces an alarm			
5.1 a	Operator Interface	HMI operator interface is supplied			
5.1 c	Operator Interface	System Fault, Gas detector fault and both power supply failures initiate an alarm on HMI			
5.2	Alarm Levels - H2S	Controller Alarm levels set to 5ppm - low and 10ppm - high for H2S			
5.2	Alarm Levels - Propane	Controller Alarm levels set to 10% LEL - low and 20% LEL - high			
6.1 b	Electrical Requirements	Power supplies seamlessly switch to standby supply in the event of a failure			
7.1	Trip and Reset Philosophy	The "gas detected" alarm output is latching			
7.1	Trip and Reset Philosophy	Audible alarms are silenced by the AKN switch with visual alarms still energised			
7.2	Trip and Reset Philosophy	Full reset is only allowed once all detectors are below minimum gas threshold			
7.3	Trip and Reset Philosophy	Alarm outputs energise to trip for audio/visual alarms			
7.4	Trip and Reset Philosophy	Alarm outputs de-energise to trip for alarm signals to DCS			

Table 12 - FDS Test Plan - FAT

Site Acceptance Test (SAT)					
FDS Item	Description	Expected Outcome	Actual Outcome	Pass / Fail	Evidence / Reference
2.3 a	Loss of Power Recovery	The Controller and audio/visual alarms are supplied by separate 110v AC UPS power supplies			
2.3 b	Loss of Power Recovery	8 Hour operation capacity			
4.1 a	Sequence of Event Recording	DeltaV utilised as master sequence of events recorder			
4.2 a	System Response Time	DCS alert generated within 30seconds of a gas release			
4.4	Major Accident Survivability	Open circuit loop produces a DCS alarm			
5.1 a	Operator Interface	Two operator interfaces are available; DCS (Primary) and RIE HMI (Secondary)			
5.1 b	Operator Interface	DCS graphic indicates exact location and concentration of gas release			
5.1 b	Operator Interface	DCS graphic indicates which detector alarmed first			
5.1 c	Operator Interface	System Fault, Gas detector fault and both power supplies failures initiate an alarm on DCS			
5.1 d	Operator Interface	System fault (0mA) and detector fault (3.6mA) loops are hardwired to DCS			
5.2	Alarm Levels - H2S	DCS Alarm levels set to 5ppm - low and 10ppm - high for H2S			
5.2	Alarm Levels - Propane	DCS Alarm levels set to 10% LEL - low and 20% LEL - high			
6.1 a	Electrical Requirements	The system is supplied by UPS backed-up 110v AC supply			
6.1 a	Electrical Requirements	The Controller and audible/visual alarms are fed from separate UPS backed up supplies			
6.1 c	Electrical Requirements	Table 6 voltage and frequency requirements are met within tolerance - 110v (5%) @ 60 Hz (2%)			
6.2	Earthing Requirements	Separate, dedicated earthing facilities are provided for Protective and IS earthing			
7.1	Trip and Reset Philosophy	Audible alarms are latching and silenced by the AKN switch with visual alarms still energised			
7.2	Trip and Reset Philosophy	Alarm outputs de-energise to trip for alarm signals to DCS			
8.1 b	DCS Interface	DCS interface is read-only			

Table 13 - FDS Test Plan - SAT

5. Literature Review

5.1 Requirement Criteria

The system must detect H₂S gas and produce an alarm on a DCS graphic, whilst initiating audible and visual unit alarms along with all technical requirements stipulated in the FDS. The total cost of the solution must not exceed £145 000.

Figure 1 shows the system overview.

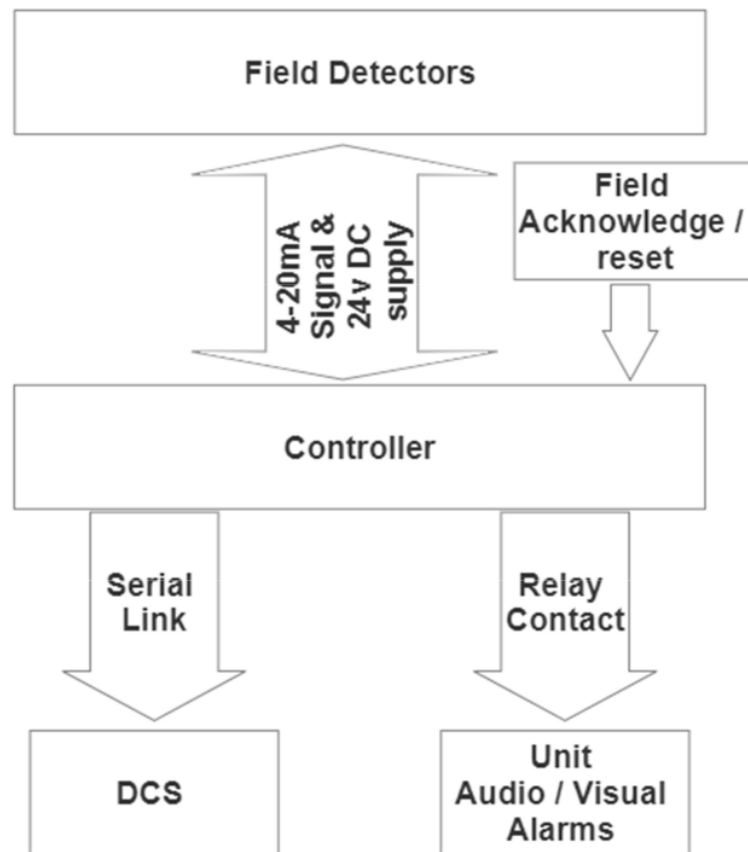


Figure 1 - System Overview

The system overview shows that the only variables that need to be considered are the controller manufacturer and field detection measuring principal technology.

The selection process will be conducted in a manner which includes environmental, sustainability and ethical constraints.

5.2 Solution Selection

5.2.1 Field Detection Measurement Technology Overview

The two most widely used toxic gas detection technologies are Electrochemical and Semiconductor. The third technology used is line of sight detection, utilising a transmitter and receiver. Appendix table 1 has been created to assist in gaining a broader understanding of the sensor technologies, which is further elaborated upon below.

Electrochemical sensors are generally the most widely utilised technology implemented in portable and fixed gas detection systems. These sensors are usually amperometric devices, meaning that the current produced directly corresponds to the concentration of target gas sensed (Emerson, 2019) (Moore & Spitler, 2003). Improper Citation *ly cite one source at a time*

Advantages of electrochemical sensors include the ability operate effectively in harsh industrial conditions, low power consumption and capacity for miniaturisation without limiting effectiveness (Emerson, 2019).

Disadvantages include narrower ambient temperature range, due to electrolyte freezing or drying out and sensor drift caused by alkaline metals and silicone vapours which coat the sensor surface (Emerson, 2019).

Semiconductor sensors have been used in gas sensing applications since the 1960's. The sensors utilise embedded biased electrodes to measure the variations in resistance in a thin metal oxide film constructed from tin or tungsten oxide, which is combined with other catalysts, oxides and dopants to aid in sensor selectivity. To ensure the sensor operates with optimal response time and sensitivity the metal film is heated by a heater circuit (Emerson, 2019) (Nikolic, et al., 2020).

Advantages include an extremely long lifespan and the ability to operate in extreme ambient conditions as well as in corrosive environments (Emerson, 2019).

Disadvantages include high energy consumption by heater circuit, poor selectivity due to chlorine gas, mercaptan and NOx compound interference and sleep effect, where the sensor becomes less reactive to the target gas over time. The sleep effect can be mitigated by regular maintenance activities exposing the sensor to calibration gas (Emerson, 2019) (Nikolic, et al., 2020). Improper Citation *You should cite one source at a time.*

Line of sight gas detection has historically been solely utilised for hydrocarbon gas detection. In recent years tuneable laser diode technology has enabled other gasses to be sensed, including H2S (Teledyne Technologies, 2021).

The system is based on a transmitted beam of light of pre-determined intensity, that is received by a receiver, which measures the received light intensity to determine whether gas is present. When some of the transmitted light is absorbed by the gas cloud, the received beam intensity will reduce which allows for the system to produce an output (Spectrex, 2022)

The measurement principle is based on the Beer-Lambert absorption equation, which is shown in table 13, where the absorption coefficient (E) is a function of the wavelength, and referred to as the “spectral fingerprint” which is utilised to distinguish between different chemicals (Spectrex, 2022).

Beer-Lambert Absorption Equation	
$I = I_0 \times \exp(-E \times C \times L)$	
Variable	Description
I	Radiation intensity after passing through gas
I ₀	Intensity of radiation with no gas cloud
-E	Target gas absorption coefficient
C	Measured gas concentration
L	Optical path length of IR beam through cloud

Table 14 - Beer-Lambert Absorption Equation (Spectrex, 2022)

Advantages of open path gas detection systems include extremely fast response times (<5 seconds), low maintenance intervals, long life span and immunity to false alarm activation attributed to the unique absorption characteristics of the target gas (Teledyne Technologies, 2021) (Spectrex, 2022).

When citing two sources at the same time, it is not possible to see which information is from which source. Disadvantages include alignment hinderances such as existing infrastructure and maintenance activities which cause a “beam block” situation rendering the system non-operational. Furthermore, the exact location of gas releases cannot be ascertained due to measurement distances reaching 60m (Gandhi, et al., 2015).

5.2.2 Manufacturer Selection

From the various manufacturers providing H2S gas detection systems the following three have been found to be viable as they are included in the company’s approved vendor list; Draeger, GazDetect and Groveley Detection.

Draeger supplies the Polytron 7000 H₂S field detector which operate with electrochemical cells, whereas GazDetect supplies semiconductor technology H₂S detectors named the OLCT710TP. Groveley Detection supplies the GD1 MK3 toxic open path detector, which is produced by Teledyne Simtronics in Norway, utilising tuneable laser diode technology.

The three solutions are proposed as follow:

1. Draeger Regard 7000 controller with Polytron 7000 field detectors.
2. GazDetect MX43 controller with OLCT710TP field detectors.
3. Draeger Regard 3920 controller with Groveley GD1 MK3 LOS detectors.

The Draeger Regard 7000 system can be integrated into the existing Draeger infrastructure requiring less additional modules. The existing Draeger infrastructure will be utilised as a termination point for field detectors from where the signals will be routed to the new controller and housing. This solution will ensure all H₂S and hydrocarbon gas sensing is controlled through one controller.

The GazDetect MX43 solution calls for the H₂S sensing controller and hydrocarbon sensing controller to be separated due to the limited channels available. This solution is still viable as the DCS input is still through a serial link providing the real time data required. Hydrocarbon release reporting will continue utilising the existing controller, which will require a PLC to ensure data is reported in real time.

Groveley do not supply a dedicated controller, site standards have deemed the Draeger Regard 3920 as a suitable controller and is utilised on various sonic leak detection systems currently installed. The 3920 has 16 channels, which will suffice, as the point detectors will no longer be needed. Utilising this system will reduce accuracy of release location, but can be deemed acceptable as operator intervention is required regardless of solution utilised. Operators would need to locate the source of the release using portable devices.

A comparison of the three controller solutions have been made in table 15.

Manufacturer and Model	Draeger Regard 7000	GazDetect MX43	Groveley using Regard 3920
Operating Temperature	0-55 Deg C	-20 to +50 Deg C	0-55 Deg C
Operating Humidity	5-95%RH	n/a	0 - 100% RH
Transmission time of data	1 second	n/a	1 Second
Operating Voltage	19.2V - 28.8V DC	100 - 240Vac 40-60Hz	24V DC
Current Draw	1.0A @ 24V	500mA	600mA
Input	4-20mA	4-20mA / 0-5V	4-20mA
Number of available Channels	Multiples of 8 per docking station - up to 24 docking stations - Total 192	32 analogue or digital inputs (RS485)	16 Channels
Internal communication protocol	Ethernet	Modbus	n/a
Output communication protocol	HART / Modbus / Profibus / Profinet	Modbus	TCP/IP / Profibus
Approvals	IEC/EN 61508 :2010 / ATEX / NFPA 72 :2016 / CE / EN 45544-1 /2/3 :2015 / EN 50271 :2018 / EN 50104 :2019 / CE	EMC EN50270 / CE / ATEX	ATEX / CE / EMC 89/68/EEG / LV Directive 72/23/EEG, 93/68EEG
Monitoring Functions	Input voltage / Total current / Temperature	Event Datalogger	Optional addition of RVP3900 (remote view panel) for visualisation / datalogging
Configuration	HMI	HMI	Config 3900 Software

Table 15 - Controller Comparison

A scoring matrix has been created to assist in ascertaining which solution is most suited. Appendix table 2 shows the scoring matrix utilised to create the radar graph shown in figure 2.

The GazDetect solution is seen to have scored the least, this is attributed to the fact that the sensor technology is not widely used in on shore facilities and is more suited to offshore oil and gas platforms. Energy consumption scored low due to the semiconductor sensing technology

requiring a heater circuit to ensure effective and accurate operation. No sustainability data was found for this manufacturer and technical support could be an issue due to no UK support being available. More frequent maintenance required to ensure sensors are not affected by the semiconductor “sleep effect” phenomenon.

The Groveley solution scored the highest with regards to cost, due to less detectors being required as well as utilising the Regard 3920 controller with limited functionality. Technical support is well established due to various Draeger systems currently installed around the facility. Draeger has an excellent sustainability record as well as clearly defined future initiatives to be a more sustainable, ethical and environmentally friendly company. A drawback to this solution would be the hindrances during detector and receiver alignment and beam block situations. Energy consumption is much higher in this solution attributed to powering the lasers.

The Draeger Regard 7000 system with Polytron detectors scored the least in the costing matrix, but does provide scope for future expansion due to the modular design. This solution scored the highest in the energy consumption matrix due to the electrochemical sensor technology utilised. Maintenance scored the lowest of all solutions due to the 3 monthly calibrations required on the cells. Draeger sustainability and technical support has been elaborated upon in the previous section.

All three solutions had the same score for availability due to the global semiconductor shortage. The company does have a priority shipping agreement with Draeger which does reduce lead times where possible, but this has not been included in the scoring.

Excellent choice, well considered.

Following a thorough review of all the data comparisons made, the solution that will be implemented is the Draeger Regard 7000 controller utilising the Polytron 7000 detectors. This solution has been chosen due to the low energy consumption of the system, the proven technical support as well as the suppliers environmental, ethical and sustainability record. Draeger has strict ethical operating guidelines, which encompass, but are not limited to, equality in the workplace, a robust non-retaliatory system to whistleblowing, zero tolerance on slavery and forced labour and a commitment to not sell products to terrorist organisations (Draeger, 2021).

Further consideration has been given to the effect the solution will have on the company's liability assessments that are carried out by insurance companies. The assessment criteria include the CE marking, EMC compliance and ATEX approval of new equipment amongst various other conformity legislation. Following a thorough equipment selection review by the company's appointed conformity representative, a conclusion has been made that the equipment provided by Draeger exceeds the stipulated criteria.

This diagram clearly shows that solution 1 is best in most areas and is a suitable choice based on reasoning. However, it should have appeared before the choice was made on the previous page.

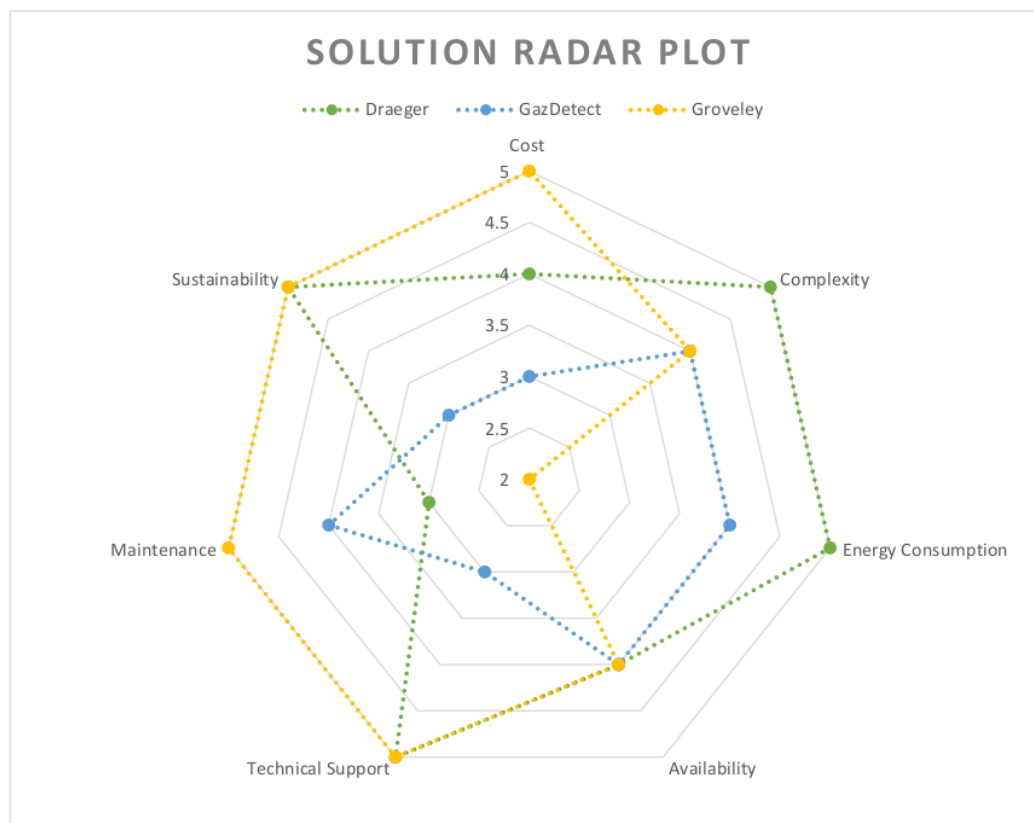


Figure 2 - Solution Radar Plot

Appendix tables 6 i and ii show the costing spreadsheets for contractor supplied materials and labour and manufacturer supplied equipment respectively. The total cost for the project will be £111 439.03, which is comfortably within the budget and leaves contingency funds which will be used to account for any unplanned costs.

DSC graphic design will be carried in-house under the guidance of the DCS specialist and therefore will not be added to the costing. In the event graphic design costs do arise, the costs will be absorbed by the contingency funds. The DCS system is very modern and has capacity for improvements and additions.

The company holds stock of temporary portable gas detectors which will need to be utilised during the implementation and commissioning phases, therefore no hire cost will be included in the costings.

4. Project Planning, Work breakdown and Management Techniques

A work breakdown structure (WBS) was created to provide a visual representation of the overall project objectives, without a timeline sequence as seen in appendix image 2. The overall project completion time is represented as 100% it was then subdivided into four phases each representing a percentage of the overall time as shown in the WBS simplification in figure 3 below.

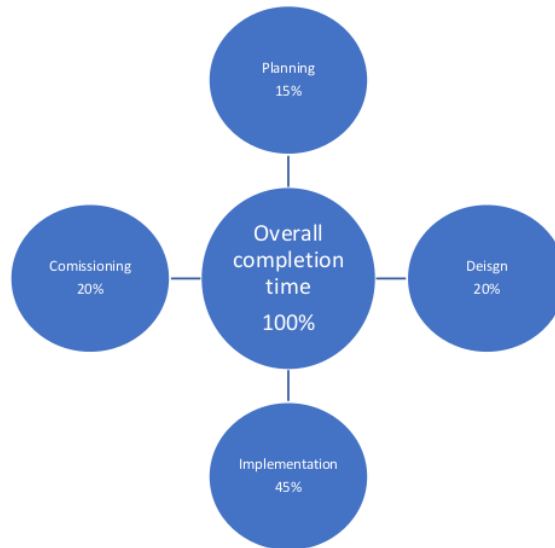


Figure 3 - WBS Simplification

Each phase was subdivided into individual elements which need to be completed throughout that particular phase, with each assigned a percentage of time that has been allocated to it, serving as project milestones. The implementation phase required the most time due to ground works, mechanical and electrical installation, whereas the planning required the least.

The WBS enabled a detailed Gantt chart (appendix image 3) to be created, which defined start and finish dates and enabled project progression monitoring through the use of the milestones. The project progression must be continually monitored to assist in identifying any concerns or issues that may arise. Solutions can be implemented to rectify the identified issues, ensuring the project is executed in an efficient manner, on time and on budget.

In addition to ensuring the project is completed on time and on budget, periodic progress or status reports will be utilised to continually improve the project by thoroughly evaluating current status against projected outcomes. The project monitoring data can be utilised to improve future projects (Indeed, 2021). Correctly cited

Delays attributed to ongoing industrial strikes and the holiday season have been factored into the Gantt timeline.

The company's management of change system (MOC) will be utilised to ensure the project conforms to company and legal engineering standards. The MOC system is audited by the HSE and ensures diverse, competent and relevant team is involved in decision making. Due to intellectual property rights and GDPR regulations this document will not be shared in this report.

A risk assessment has been created for the implementation phase as illustrated in appendix figure 4, which encompass broader design risks related to quality assurance, cyber security, routine operation, operator interfaces, maintenance procedures and incident response. The risks and consequences were identified and quantified to produce an initial risk classification. Thereafter existing safeguards were identified to ascertain whether the risk would be reduced, after which additional safeguards and controls were implemented to reduce the risks further.

The company has a robust risk assessed permit to work system, under which site implementation and commissioning activities will be controlled.

The risk matrix in appendix figure 5 was utilised to identify and quantify risk severity by comparing risk consequence, likelihood and frequency. The resulting risk level provides clear guidance on whether the risk is broadly acceptable, tolerable within ALARP (as low as reasonably possible) or whether further risk reduction measures need to be implemented.

5. Conclusions and Recommendations

The industry background research enabled a thorough understanding of the source of H₂S in an oil refinery, highlighting the inherent dangers that it poses to workers and infrastructure alike. The need for a replacement H₂S gas detection system and the legal, ethical and sustainability constraints were elaborated upon. These constraints were found to be invaluable for engineers in the quest to achieve more for our and future generations alike.

The FDS proved to be a useful engineering tool enabling clear outcomes to be stipulated and achieved through utilising test tables.

Solution research highlighted the significant variations in measurement technology available, allowing ethical and sustainability guidelines to be utilised. Reducing energy consumption without compromising functionality was a priority and was achieved by selecting the Draeger Regard solution and electrochemical cells.

Although the Groveley LOS system would have been a suitable solution, a recommendation would be to utilise this system as boundary monitoring in addition to the fixed gas detection system. The Regard controller can easily accommodate the additional inputs provided by the LOS system to reduce risk further. This recommendation highlights the ethical and sustainable nature of the design, where future expansion has been incorporated.

A stakeholder matrix could have been used during the solution selection process, enabling a broader understanding of all stakeholders' interests.

The WBS enabled milestones to be created and further reduced to provide a visual representation of the project, including time allocation to subsections. From this, the Gantt chart provided detailed timelines. Both proved to be excellent project management systems.

The Implementation and commissioning phase will be kept on track as defined by the Gantt chart by utilising the engineering management and continual improvement techniques discussed.

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7. Appendix

1. Project Proposal

SGEL6000 INDEPENDENT PROJECT

PROJECT PROPOSAL DOCUMENT

Student Name : Lourens Brits
Project Title : ARU/SRU Gas Detection Upgrade
Date : 10/10/2022
Budget : £145 000

Project Description

The proposed project will be based around a Sulphur Recovery Unit (SRU) / Amine Recovery Unit (ARU), on an oil refinery. The SRU and ARU are used to remove Hydrogen Sulphide (H₂S) from various refinery process streams. This removal is achieved by converting the H₂S gas to elemental Sulphur. These Units contain large concentrations of H₂S, which is extremely toxic to humans. The units require accurate and reliable gas detection systems to ensure workers are aware of any leaks that may occur.

Why is the project needed?

The existing system consists of three different subsystems, all added over many years. The three different subsystems are made up of different detector manufacturers, some of which are susceptible to sulphur poisoning rendering the detector ineffective. The gas detectors are wired into two different multi-channel controllers, both of which are obsolete. The critical safety nature of this equipment requires an up-to-date system to be installed, commissioned and tested.

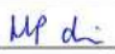
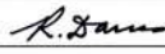
The following persons will be involved in the project.

Budget Holder / Department Lead – Martin Oliver (Analyser Supervisor)
Design engineer – Jamie Dunn (Insight Contractor Engineer)
Contractor Resources – Roscoe Howell (Instrument supervisor)

Project Completion

Installation and commissioning April 2023

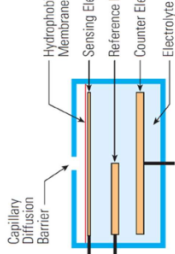
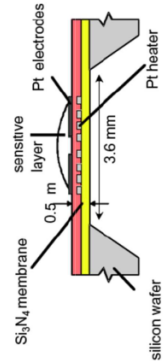
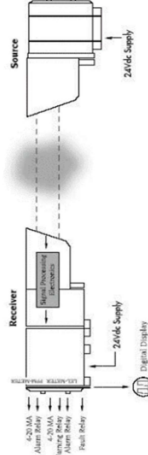
Agreement for project proposal

Student Signature:  Date: 06/10/22
Industrial Supervisor Signature:  Date: 06/10/22
Academic Tutor Signature:  Date: 7/10/22

Appendix Figure 1 - Project Proposal

2. Scoring matrix for solutions

i. Sensing Technology Comparison Table

H2S Gas Detection - Sensing Technology Comparison			
Technology	Operating Principle	Illustration	Limitations
Electro-chemical	As H2S gas passes through a gas permeable membrane, an oxidation or reduction chemical reaction occurs between Anode and Cathode electrodes suspended in electrolyte. This reaction creates a current which can be sensed and amplified to produce a scaled output value.		Narrow temperature range. High temperatures and very dry conditions can cause electrolyte evaporation, whereas very cold conditions can reduce sensor response.
Semi-conductor	A platinum heater element is utilised to raise the resistive film (sensitive layer) temperature to an optimal range for the designated gas. The gas molecules react on the metal oxide (sensitive layer) surface to form ions that alter the resistance of the film. Biased electrodes are embedded in the metal oxide layer to measure the changes in resistance, which is proportional to the gas concentration. H2S is a reducing gas, similar to H2 or CO, which causes a reduction in resistance. Silicon nitride is utilised as an insulation medium.		- High power consumption needed for semiconductor film temperature control. - Susceptibility to interference gases such as Nitrous Oxides (NOx) and mercaptans. - Baseline shifts or "sleep effect" requiring frequent calibration gas exposure to ensure correct operation. - Sensor life expectancy >10 Years. - Wide variety of gases can be detected. - Robust and tolerance to extreme ambient conditions.
Line of Sight	Toxic gas LOS detection utilises a tunable laser diode to scan for single gas wavelength absorption. When the target gas passes through the optical field between source and receiver, the target gas absorbs its unique wavelength, which is detected by the receiver and converted to a concentration.		- LOS blockages in the form of scaffolding or maintenance activities renders the system useless - known as beam block. - Alignment can be affected by surrounding activities. - Multipoint wavelength analysis can be utilised to reduce false alarm activations. - Rapid response to gas <5seconds - Little maintenance required. - Can be utilised to replace

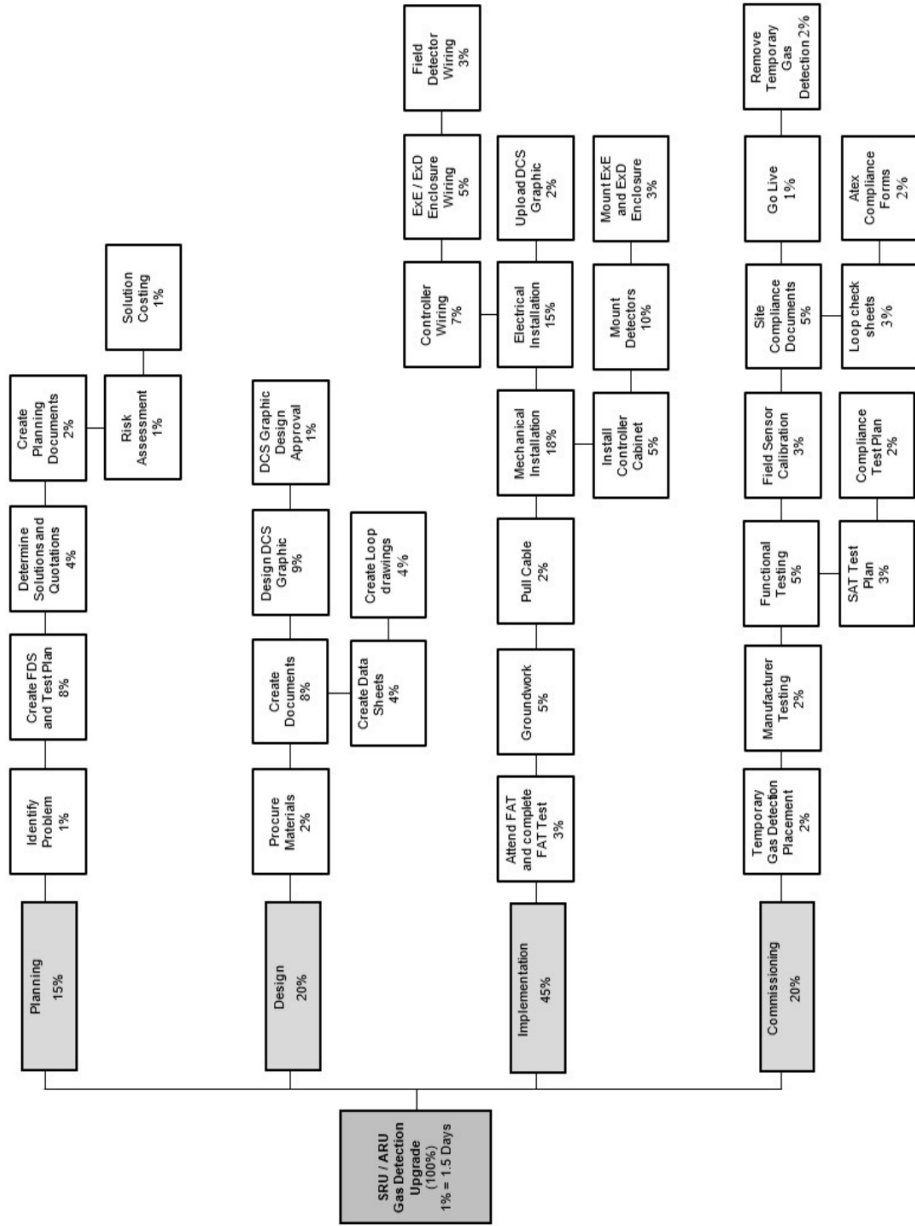
Appendix Table 1 - Sensing Technology Comparison (Gandhi, et al., 2015) (Emerson, 2019) (MSA, 2022) (Teledyne Technologies, 2021) (Parameswari & Qiliang, 2022) (Spectrex, 2022)

ii. Manufacturer Selection Scoring Matrix

Solution Scoring Matrix						
Overall cost of the Project						Justification
	1	2	3	4	5	
Draeger - Electrochemical				X		Total cost £105 000
GazDetect Semi-Conductor			X			Total cost £112 000
Groveley - Open Path					X	Total Cost £100 000
Complexity (1 - Very Complex - 5 Least complex)						Justification
	1	2	3	4	5	
Draeger - Electrochemical					X	Existing components can be integrated into new system
GazDetect Semi-Conductor				X		Whole system needs to be replaced
Groveley - Open Path				X		Complex alignment and setup procedure
Energy Consumption						Justification
	1	2	3	4	5	
Draeger - Electrochemical					X	Electrochemical cells <50mW
GazDetect Semi-Conductor				X		Semiconductor cell > 1w
Groveley - Open Path		X				Transmitter and Receiver <25W
Availability (1 Long Lead Time - 5 Ready to Ship)						Justification
	1	2	3	4	5	
Draeger - Electrochemical			X			<8 Weeks
GazDetect Semi-Conductor			X			<8 Weeks
Groveley - Open Path			X			<8 Weeks
Technical Support						Justification
	1	2	3	4	5	
Draeger - Electrochemical					X	UK service centre with company knowledge
GazDetect Semi-Conductor			X			French Service Centre - no Company knowledge
Groveley - Open Path					X	UK service centre with company knowledge
Maintenance						Justification
	1	2	3	4	5	
Draeger - Electrochemical			X			3-monthly calibrations
GazDetect Semi-Conductor				X		6-monthly calibrations
Groveley - Open Path					X	No calibration required
Sustainability						Justification
	1	2	3	4	5	
Draeger - Electrochemical					X	Excellent sustainability report
GazDetect Semi-Conductor			X			No current Sustainability report
Groveley - Open Path					X	Emerson - Excellent sustainability report

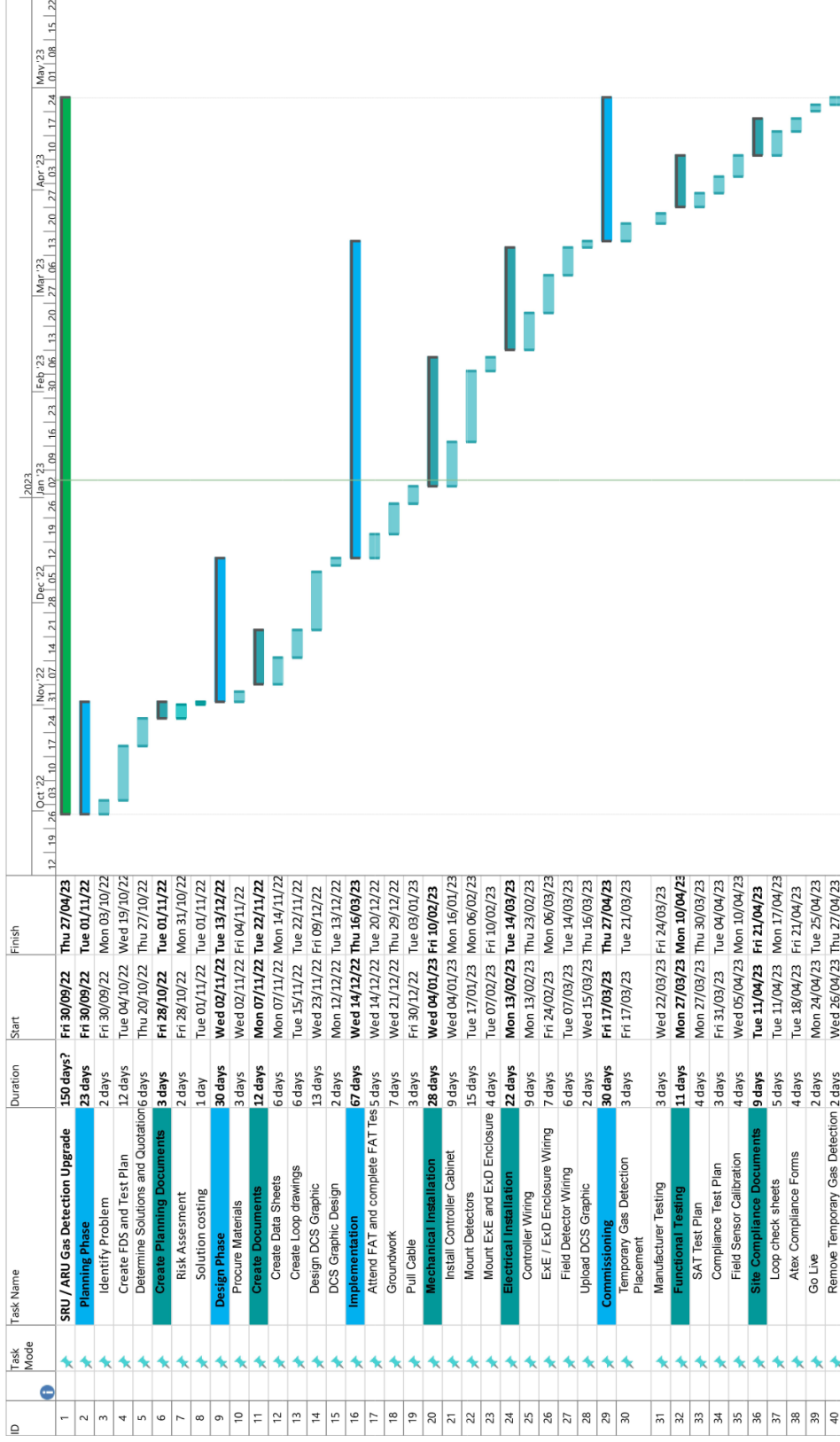
Appendix Table 2 - Selection Scoring Matrix

3. WBS



Appendix Figure 2 - WBS

4. Gantt Chart



Appendix Figure 3 - Gantt Chart

5. Risk Assessment for Implementation Phase

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 (PAP) Pre Start-Up (PSU) / After Start-Up (ASU)	Consequence Level	Likelihood Level	Mitigated Risk
ENGINEERING HARDWARE & DESIGN	Wire diagram	New equipment installed without accurate wiring diagrams	Lost time - Maintenance activities take longer	Business	I	E	TR	None	I	E	TR	Update wiring diagrams to reflect newly installed equipment and loops	After Start - Up (ASU)	I	D	BA
ENGINEERING HARDWARE & DESIGN	Line diagram	New equipment installed without P&ID / Datasheet updates	Lost time - Maintenance activities take longer	Business	I	E	TR	None	I	E	TR	Update P&ID and datasheets to reflect newly installed equipment	After Start - Up (ASU)	I	D	BA
ENGINEERING HARDWARE & DESIGN	Cybersecurity	Uncontrolled access to controller programme	Affect system effectiveness of operation	Safety	III	E	Level 2	RIE door swipe card access	III	D	Level 1	Ensure Controller has no portable device access (USB port) on front of controller.	Pre Start - Up (PSU)	I	D	BA
ENGINEERING HARDWARE & DESIGN	Design temperature	Field Equipment temperature rating not suitable for hazardous area	Risk of fire / explosion	Safety	III	C	Level 1	Existing Equipment conforms to area temperature rating	I	E	TR	Ensure replacement equipment conforms to area temperature classification	Pre Start - Up (PSU)	I	D	BA
BUILDINGS	Water ingress	Water ingress from inclement weather	Power trips	Safety	II	C	TR	Building integrity inspections up to date	II	B	BA	Controller enclosure inspection during periodic preventative maintenance	After Start - Up (ASU)	II	AA	BA
OPERATING METHODS	Routine operation	Installation of new hardware leads to operator confusion on alarm Acknowledge & reset	Confusion leading to lost time and delay in alarm all clear, post activation	Business	I	E	TR	None - Accept / Reset location and functionality disparity between operations shifts	I	E	TR	Relocate Accept / Reset button to outside SHU RIE and create appropriate signage	Pre Start - Up (PSU)	I	D	BA
OPERATING METHODS	Routine operation	Maintenance unfamiliar with new equipment operation	Lost time - Maintenance activities take longer	Business	I	E	TR	None	I	E	TR	Familiarisation training to maintenance team as well as operating procedures	After Start - Up (ASU)	I	D	BA
INSTRUMENTATION & CONTROL (include computer systems)	Operator interface	Operators not aware of new DCS graphic showing H2S detection overview	Confusion leading to lost time when dealing with a H2S release	Safety	II	E	Level 1	None	II	E	Level 1	Operator familiarisation training on new DCS graphic and update ops training manual	Pre Start - Up (PSU)	I	E	TR
ENGINEERING METHODS	Maintenance procedures	Maintenance procedures not updated	Lost time - Maintenance activities take longer	Business	I	E	TR	None	I	E	TR	Update Maintenance Procedures	Pre Start - Up (PSU)	I	D	BA
INSTRUMENTATION & CONTROL (include computer systems)	Trips and Alarms	Ops personnel not aware of initial gas release indication	Confusion leading to lost time when dealing with a H2S release	Safety	III	C	Level 1	Existing emergency response procedure	II	C	TR	Operator familiarisation training on new DCS graphic and update ops training manual	Pre Start - Up (PSU)	I	D	BA

Appendix Figure 4 - Risk Assessment for Implementation Phase

Business	Consequence					Likelihood	Qualitative Description	Scenario frequency per annum		
	Environment	Community	Safety							
<£100 Million	Catastrophic - Serious contamination of ground water or water course, extensive loss of aquatic life.	Public Evacuation or National Media Coverage	>10 Fatalities On Site or Multiple Fatalities Off Site	TR	Level 1	Level 2	Level 3	Level 4	Level 4	Level 5
<£10MM to £100MM	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	TR	TR	Level 1	Level 2	Level 3	Level 3	Level 4
<£1MM to £10MM	Severe - Hazardous material spillage or release, significant effect, e.g. Visible fish kill	Shelter in Place or Country Media Coverage	Permanent Disabling Injury (e.g. Amputation) or Single Fatality	BA	TR	TR	Level 1	Level 2	Level 2	Level 3
<£100K to £1MM	Significant - Strong or offensive odours or noise, major breach of permitted emissions	Shelter in Place or Local Area Media Coverage	Serious Injury to Permanent Injury (e.g. Burn)	BA	BA	TR	TR	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	BA	BA	BA	BA	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.	BA	BA	BA	BA	BA	BA	TR
				AAA	AA	A	B	C	D	E
				Rare - equivalent to being killed by a lightning strike, or twice in the industry	Ramose, has occurred once or twice in the industry	Unlikely that the event will occur at this facility.	Conditions may allow the event to occur within industry using similar technology	Conditions may allow the event to occur at this facility during its lifetime	Likely to occur at this facility once every 10 years.	Likely to occur.
				10.7 to 10.6	10.4 to 10.5	10.5 to 10.4	10.4 to 10.3	10.3 to 10.2	10.2 to 10.1	10.1 to 1

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 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 1:	Level 1 sign off is required: 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.
	The risk is acceptable if all controls are in place and recommended good practise is followed.

Appendix Figure 5 - Risk Assessment Matrix

6. Costing Spreadsheets
i. Labour Costing

E&I Integrity Job Sheet									
1. Outline Scope of Work						Originator		L. Brits	
MWO Number		6908098				Originator Extension		2745	
Service Order No.						Originator Contact		SRU / ARU	
Task Priority		High							
Date of Notification						Task Completion Date			
Task to Commence on									
Description of Work		SRA/ARU Gas Detection Labour							
2. Detailed Scope of Work						Contractor Reference			
Provide Detailed Scope of Work		Dig trench 20m @ 1m deep - pull 20 pair cable - close trench - install and wire controller cabinet - install / wire 2 x enclosures - mount / wire detectors							
Labour Plan				Total Hours		Hourly Cost		Total Cost	
Excavations for 20 pair cable		Excavator + Driver hire		8		£100.00		£800.00	
		Dig trench 20m @ 1m deep		8		£20.00		£160.00	
		Close Trench		8		£20.00		£160.00	
20 Pair Cable		Pull Cable		32		£17.50		£560.00	
Controller Cabinet		Install New Controller Cabinet		16		£17.50		£280.00	
		Wire Controller Cabinet		150		£17.50		£2,625.00	
ExD Enclosure		Install ExD enclosure		8		£17.50		£140.00	
ExE Enclosure		Install ExE enclosure		8		£17.50		£140.00	
		Electrical / wiring works		24		£17.50		£420.00	
		Fabricate Mounts		16		£17.50		£280.00	
Gas Detectors		Fit Detectors		24		£17.50		£420.00	
		Electrical works		16		£17.50		£280.00	
		Total Hours		318		Planned Labour Cost		£6,265.00	
3. Materials									
Item		Description		Qty		Cost		Total Cost	
20 Pair Cable		Supply Cable to specification		1		£3,249.00		£3,249.00	
		Unistrut - Galvanised 6m		3		£25.00		£75.00	
Consumables		Zebs - Galvanised 6mm		100		£0.40		£40.00	
		Bolts - Galvanised M10 x 25mm		100		£0.35		£35.00	
		Washers - Galvanised 6mm		100		£0.04		£4.00	
		M20 Inst. Glands		45		£10.00		£450.00	
		M40 Inst. Gland		1		£19.50		£19.50	
		M20 Potted Gland		10		£15.00		£150.00	
Quote approval		Signature		Date		Planned Materials Cost		£4,022.50	
Project Owner									
Valero Budget Holder									
Contract Manager						Total cost - Labour / Materials		£10,287.50	

Appendix Table 3 - Labour Costing

ii. Manufacturer Component Costing

Draeger Costing Table				
P/N	Description	Cost	Qty	Total
9209378	Regard 7000 Control Panel	£21,258.63	1	£21,258.63
9209378	Compact Housing for Dashboard	£4,085.10	1	£4,085.10
9209378	Regard 7000 input / Output modules	£18,849.05	1	£18,849.05
8317710	Polytron 7000 Transmitters (4-20mA HART)	£889.01	17	£15,113.17
8317990	Polytron 7000 Docking Station	£40.41	17	£686.97
8317860	Sensor Diagnostic Dongle Polytron 7000	£184.08	17	£3,129.36
6810595	Draeger-Sensor H2S	£379.40	17	£6,449.80
9209222	EXE Junction Box Complete with 90 x WDU2.5 terminals, Entries: 1 x M40 & 20 x M20 bottom	£829.68	1	£829.68
9209221	EXD Junction Box Entries 8 x M20 in bottom Face, 2 x M20 top face.	£3,416.18	1	£3,416.18
1965206	Installation	£6,375.00	1	£6,375.00
1965205	Commissioning	£850.00	1	£850.00
1965205	FAT	£750.00	1	£750.00
1965205	SAT	£1,000.00	1	£1,000.00
1940430	Crating and Shipping	£1,500.00	1	£1,500.00
		Total Net Cost		£84,292.94
		Total incl. 20% VAT		£101,151.53

Appendix Table 4 – Manufacturer Component Costing

7. Logbook entries

SGEL6000

Independent Project

Log Book

Lourens Brits

1809797

ARU/SRU Gas Detection Upgrade

2022 - 2023

Summary of Entries

Log Entry	Date	Brief Description of Activity	Duration (hrs)	Accumulated time (hrs)
1	29/09/22	Project objectives discussion	8	8
2	06/10/2022	Project Proposal creation	4	12
3	13/10/2022	Unit walk around – familiarisation	4	16
4	20/10/2022	Research SRU/ARU operation	16	32
5	27/10/2022	Research constraints	10	42
6	03/11/2022	Create FDS	12	54
7	10/11/2022	Create FDS test tables	12	66
8	17/11/2022	Research possible solutions	16	82
9	24/11/2022	Research sensor technology	12	94
10	01/12/2022	Creating costing spreadsheet	10	104
11	08/12/2022	Create solution scoring matrix and radar chart	10	114
12	15/12/2022	Research project management techniques	12	126
13	22/12/2022	Create work breakdown structure	14	140
14	29/12/2022	Create Gantt chart	6	146
15	05/01/2023	Complete risk assessment and conclusions	8	154
16	09/01/2023	Review report and submit	2	156

Log Entry Sheet

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

Record of activities and achievements

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

- Project objectives

Replace obsolete gas detectors.

Replace obsolete controller and combine individual subsystems into one controller.

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

Overall cost shall not exceed £145 000

- Obsolete monitor identification

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

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

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

Plans for next week

- Create project proposal and ensure it is signed by budget holder

Signed _____ L. Brits _____

Signed _____

Log Entry Sheet

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

Record of activities and achievements

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

Plans for next week

- Process unit familiarisation.
- Field equipment familiarisation
- Controller familiarisation

Signed _____ L. Brits _____

Signed _____

Log Entry Sheet

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

Record of activities and achievements

The unit field gas detection was scoped to ensure published location, material and equipment data is accurate in relation to field installations. No irregularities were noted.

Notes were made on system integration as well as locations and the condition of junction boxes illustrated in the existing loops.

Plans for next week

Carry out research into SRU/ARU operation:

- How is H₂S produced by refining oil?
- Effects on humans?
- Effect on site infrastructure?

Signed _____ L. Brits _____

Signed _____

Log Entry Sheet

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

Record of activities and achievements

Thorough research was carried out into the process that take place to remove sulphur from refining process streams, how it is transported to the ARU and recovered / processed in the SRU.

This is a complex process and required research utilising various credible sources.

H₂S was found to not only be extremely toxic to humans but also adversely affect infrastructure

Plans for next week

Carry out research into project / engineering constraints

Signed _____ L. Brits _____

Signed _____

Log Entry Sheet

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

Record of activities and achievements

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

Plans for next week

Create FDS

Signed _____ L. Brits _____

Signed _____

Log Entry Sheet

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

Record of activities and achievements

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

Plans for next week

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

Signed _____ L. Brits _____

Signed _____

Log Entry Sheet

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

Record of activities and achievements

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

Plans for next week

Review relevant literature in relation to manufacturers and the solutions that can be implemented to achieve the design specifications.

Create a system overview of to gain a better understanding of variables to aid in decision making

Signed _____ L. Brits _____

Signed _____

Log Entry Sheet

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

Record of activities and achievements

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

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

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

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

Plans for next week

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

Signed _____ L. Brits _____

Signed _____

Log Entry Sheet

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

Record of activities and achievements

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

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

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

Electrochemical cells were found to be the most suitable technology.

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

Plans for next week

Create a costing spreadsheet to aid in solution selection.

Signed _____ L. Brits _____

Signed _____

Log Entry Sheet

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

Record of activities and achievements

A costing spreadsheet was created for each manufacturer. This included all components required for sensing H₂S and the controller utilised for data acquisition, alarm activation / reset and reporting to DCS.

Draeger – Electrochemical : £105 000

GazDetect – Semiconductor: £ 112 000

Groveley – Line of sight : £ 100 000

Plans for next week

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

Signed _____ L. Brits _____

Signed _____

Log Entry Sheet

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

Record of activities and achievements

A scoring matrix was created utilising the following parameters;

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

The resulting scores were illustrated using a radar graph.

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

Plans for next week

Carry out research into project management techniques.

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

Signed _____ L. Brits _____

Signed _____

Log Entry Sheet

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

Record of activities and achievements

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

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

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

Plans for next week

Create a work break down structure

Carry out research into the companies Risk assessment standards

Signed _____ L. Brits _____

Signed _____

Log Entry Sheet

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

Record of activities and achievements

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

- Planning
- Design
- Implementation
- Commissioning

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

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

Plans for next week

Create a detailed Gantt Chart.

Signed _____ L. Brits _____

Signed _____

Log Entry Sheet

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

Record of activities and achievements

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

Plans for next week

Conduct a Risk assessment relating to the changes that will be implemented during the project.

Signed _____ L. Brits _____

Signed _____

Log Entry Sheet

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

Record of activities and achievements

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

Plans for next week

Review report and submit.

Signed _____ L. Brits _____

Signed _____

Log Entry Sheet

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

Record of activities and achievements

The report was reviewed and submitted

Plans for next week

Signed _____ L. Brits _____

Signed _____

1809797

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

75/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

Text Comment. A reasonable summary of the report content in 342 words but you could have focussed on summarising the project rather than the report.

PAGE 5

PAGE 6

QM

Citation Needed

Cite Source:

Please use the link below to find links to information regarding specific citation styles:

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Text Comment. redundant word

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 7

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

QM

Correctly cited

Citation method conforms to Harvard standard, well done.

PAGE 8

Text Comment. a well written and informative background section with suitable citations

Text Comment. you could have cited a source to explain what Ex P means for ATEX rated enclosures

QM

Punctuation Error

Punctuation error

PAGE 9

Text Comment. This section was worth 5 marks. Do you think you have written enough here?

Text Comment. a

Text Comment. This section was worth 5 marks. Do you think you have written enough here?

Text Comment. only cite one source at a time

PAGE 10

Text Comment. This section was worth 5 marks. Do you think you have written enough here?

Text Comment. Rather than listing these documents here, it would have been better to read them and cite information relevant to your project.

PAGE 11

Text Comment. A very detailed and clear section, very professionally presented, making clear the deliverable outcomes of the project

PAGE 12

PAGE 13

PAGE 14

PAGE 15

Text Comment. An excellent section, very thorough treatment, professionally competent

PAGE 16

PAGE 17

PAGE 18

PAGE 19

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Improper citation:

Improperly cited material. Please use the link below to find links to information regarding specific citation styles: http://www.plagiarism.org/plag_article_citation_styles.html

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PAGE 20

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Text Comment. When citing two sources at the same time, it is not possible to see which information is from which source.

PAGE 21

Text Comment. Excellent choice, well considered.

Text Comment. This diagram clearly shows that solution 1 is best in most areas and is a suitable choice based on reasoning. However, it should have appeared before the choice was made on the previous page.



Correctly cited

Citation method conforms to Harvard standard, well done.

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GRADING FORM: NEW CSG-RUBRIC

LOURENS BRITS

75

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 An excellent and extensive range of sources consulted and cited correctly using the Harvard method. (8/10) Sections 3, 5 and 8: Extent of reading, use of credible sources, use of Harvard method for listing and citing Listed correctly and mostly correctly cited except for places where two sources are cited at the same time. (6/10) Total = 14/20

14

2. KNOWLEDGE AND UNDERSTANDING



Section 3: Project background and problem definition Clear explanations given particularly with reference to the chemical process. (4/5) Section 3: Project constraints: Ethical. A brief explanation provided with reference to sources (2/5) Section 3: Project constraints: Sustainability A brief explanation given with reference to sources (2/5) Section 3: Project constraints: Legal/Commercial A brief explanation given with reference to sources (2/5) Total; = 10/20

10

3. COGNITIVE AND INTELLECTUAL



Section 4: Functional Design Specification An excellent section, very comprehensive analysis presented (5/5) Section 4: Test planning Excellent method presented, very thorough and professional (4/5) Section 5: Evaluation of solutions and justification of final solution Very good analysis with useful radar diagram (4/5) Section 7: Conclusions and Recommendations A good

17

section that explains the outcomes and shows the way forward (4/5) Total = 17/20

4. PRACTICAL APPLICATION



Section 6: Project Plan An excellent and detailed plan but only the implementation phase was needed, some reference to contingencies (5/5)
Section 6: Working breakdown structure, costing exercise and management techniques Very detailed and thorough (4/5) Appendix: Risk assessment for implementation phase Excellent and professional assessment of risk (4/5)
Appendix: Planning phase log-book entries. Good evidence of management of project through the log-book (4/5) Total = 17/20

17

5. TRANSFERABLE SKILLS



Section 1: Executive summary A good summary (4/5) All Sections: Presentation quality of the report, diagrams, charts, tables, figure numbering, page and section numbering etc Excellent structure and presentation (4/5) All Sections: Quality of the writing style, use of punctuation and grammar Very good, generally well written (4/5)
Word count limit not exceeded Total words declared as 3865 within 10% over the 3600 limit (5/5) Total = 17/20

17