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Independent Project

Design and Implementation of an SO₂ Detection and Alarm
Monitoring System within the Vale Nickel Refinery, Clydach

Independent Project (ACCA6020)
Electrical & Electronic Engineering

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DECLARATION

I, Luis Lloyd declare that I am the sole author of this Project; that all references cited have been consulted; that I have conducted all work of which this is a record, and that the finished work lies within the prescribed word limits.

This work has not previously been accepted as part of any other degree submission.

FORM OF CONSENT

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Abstract

This project presents the design, installation, and commissioning of a fixed intrinsically safe sulphur dioxide (SO₂) detection and alarm monitoring system within the activation-kiln process areas at Vale Clydach Nickel Refinery. Prior to implementation, the activation-kiln area had no fixed SO₂ detection infrastructure, with monitoring relying solely on portable gas detectors carried by personnel. This approach was inherently reactive, as gas leaks could only be identified when personnel were present, and near-miss incidents had occurred involving uncontrolled exposure to SO₂.

To address these limitations, five electrochemical SO₂ transmitters were installed across the Kiln 1 and Kiln 2 activation areas. Each detector was connected via a two-wire 4–20 mA intrinsically safe loop to the existing Foxboro I/A Distributed Control System (DCS), enabling continuous remote monitoring from the control room. The system incorporates a two-tier alarm strategy, with local sounder and beacon activation at 1 ppm and initiation of the plant evacuation alarm at 2 ppm. A dedicated HMI interface was developed to provide operators with live gas concentration readings, alarm indication, trend monitoring, and system status information.

Commissioning was completed through signal injection testing and SO₂ bump-gas verification, confirming correct signal scaling, alarm functionality, and overall system performance. Due to operational constraints, evacuation alarm testing was undertaken under controlled conditions during reduced site occupancy. The completed system significantly improves plant safety by providing continuous monitoring, reducing reliance on personnel-based detection, and enabling historical trend analysis of gas concentrations.

Contents

Abstract	4
Contents	5
Table of Figures	8
Table of Tables.....	9
1 Introduction	10
1.1 Background and Context	10
1.2 Problem Statement	11
1.3 Project Aim	11
1.4 Objectives	12
1.5 Project Scope	12
1.6 Structure of the Report	13
2 Literature Review.....	14
2.1 Sulphur Dioxide as an Industrial Hazard.....	14
2.2 Hazardous Area Classification and Protection Method Selection.....	14
2.3 Fixed Versus Portable Gas Detection	16
2.4 Sensor Technology and Detector Selection	17
2.5 Intrinsically Safe Barrier Selection	19
2.6 Distributed Control System Selection	19
2.7 Summary.....	20
3 Design Methodology	21
3.1 Methodological Approach.....	21
3.2 System Design and Development Process	21
3.3 System Implementation.....	24
3.4 Testing and Commissioning	24
3.5 Data Collection and Evaluation Criteria	25
3.6 Constraints and Limitations	25
3.7 Ethical and Environmental Considerations.....	25
3.8 Summary.....	25
4 System Design, Development and Implementation	26
4.1 System Overview.....	26
4.2 Equipment Selection	27
4.2.1 Crowcon Xgard Type 1 SO ₂ Transmitter	27

4.2.2	Pepperl+Fuchs KFD0-CS-Ex1.50P Galvanic Isolator	29
4.2.3	Clifford and Snell YL40 Sounder/Beacon.....	29
4.3	Intrinsically Safe Loop Design and Verification	30
4.3.1	Entity Parameter Verification.....	30
4.3.2	Voltage Drop Calculation.....	32
4.4	Signal Transmission and 4–20 mA Loop Configuration	32
4.5	DCS Integration and Alarm Logic Configuration	34
4.5.1	Analogue Input Block Configuration.....	34
4.5.2	Alarm Threshold Configuration.....	36
4.5.3	Digital Input and Output Configuration	37
4.5.4	Alarm Logic Implementation	37
4.5.5	System Monitoring and Validation	41
4.6	Evacuation Alarm Tie-In	42
4.7	HMI Development	43
4.8	Physical Installation Overview.....	46
4.9	Operator Training	48
4.10	Project Costing	51
4.11	Summary.....	52
5	Engineering Documentation and System Verification	53
5.1	Introduction	53
5.2	Engineering and Design Documentation	53
5.3	DSEAR Compliance Dossier.....	54
5.4	Control System Configuration	56
5.5	Commissioning Records.....	56
5.6	Summary of Project Deliverables.....	58
6	Results and Discussion.....	59
6.1	Introduction	59
6.2	Signal Injection Test Results.....	59
6.3	Bump Gas Commissioning Results.....	61
6.4	Alarm Activation Results	63
6.5	Evacuation Alarm Test	63
6.6	DSEAR Inspection Results	64
6.7	System Performance	64
6.8	Discussion.....	64
6.9	Summary.....	65

7	Conclusions and Recommendations	66
7.1	Project Conclusions	66
7.2	Recommendations and Development.....	67
7.3	Final Project Outcome	68
8	Reflection	69
8.1	Introduction	69
8.2	Technical and Professional Development	69
8.3	Challenges and Lessons Learned	70
8.4	Future Professional Development	71
9	References.....	72
10	Appendices.....	74
	APPENDIX A: Intrinsically Safe Loop Calculations	74
	APPENDIX B: AutoCAD Loop Drawings	77
	APPENDIX C: DSEAR Inspection Schedule.....	80
	APPENDIX D: Crowcon Calibration and Test Report.....	85
	APPENDIX E: Equipment Datasheets.....	86
	APPENDIX F: ATEX and IECEx Certificates.....	93
	APPENDIX G: Risk Assessment and Method Statement	98
	APPENDIX H: Cable Block Diagram	100
	APPENDIX I: DCS Configuration Specification.....	102
	APPENDIX J: Evacuation Defeat Panel Drawings.....	115
	APPENDIX K: Operator Training Materials / HMI Graphics	117
	APPENDIX L: Procurement Quotations	118
	APPENDIX M: Individual Loop Calibration Certificates	122
	APPENDIX N: Installation Photographs	126

Table of Figures

Figure 2.1: Activation kiln hazardous area classification drawing showing Zone 2 designation (Vale Ltd).....	15
Figure 2.2: Comparative specification overview of fixed electrochemical SO ₂ detectors evaluated during selection [17].	18
Figure 3.1: SO ₂ gas detection system architecture showing signal path from hazardous area detector through IS barrier to Foxboro DCS, alarm outputs, and evacuation tie-in.	22
Figure 3.2: Project lifecycle Gantt chart showing planned milestones from project initiation through to final submission, SO ₂ Detection Monitoring System, OCU Group Vale Clydach Refinery.	23
Figure 4.1: Detailed SO ₂ gas detection system architecture showing hazardous area instrumentation, intrinsically safe signal transmission, DCS integration, and alarm outputs	26
Figure 4.2: Crowcon Xgard product selection diagram highlighting the intrinsically safe electrochemical variant used for SO ₂ detection [12].	28
Figure 4.3: IS loop entity parameter verification calculation sheet Loop A131_1, document ref 128A-A131-1	31
Figure 4.4: AutoCAD loop drawing A131_1 showing SO ₂ detector, intrinsically safe barrier, marshalling interface, and DCS analogue input termination across hazardous and safe area boundaries.	34
Figure 4.5: Foxboro DCS AIN compound block configuration for SO ₂ detection loop A131_1 showing module assignment, scan period, and scaling parameters.	35
Figure 4.6: Foxboro DCS alarm configuration for SO ₂ detection loop A131_1 showing AL1 (1 ppm) and AL2 (2 ppm) thresholds.	36
Figure 4.7: SO ₂ detection system alarm logic flow diagram showing signal processing, fault detection, alarm thresholds, and system response.	38
Figure 4.8: Foxboro ICC logic block A131_LG showing implementation of SO ₂ alarm logic using Boolean operations to combine multiple detector alarm states, including high alarm, unacknowledged, and inhibit conditions.	40
Figure 4.9: Foxboro DCS AIN faceplate display for SO ₂ detection loop A131_1 showing live measurement and scaling in engineering units.	41
Figure 4.10: Evacuation defeat panel external connections drawing showing SO ₂ defeat and evacuation relay integration with the existing plant evacuation alarm circuit, drawing (128A-000-19496).	42
Figure 4.11: FoxView HMI overview screen for SO ₂ detection system showing detector locations and live SO ₂ concentration readings.	43
Figure 4.12: FoxView HMI faceplate display for SO ₂ detection loop showing real-time measurement and alarm status.	44
Figure 4.13: FoxView HMI trend display for SO ₂ detection system showing time-based variation in SO ₂ concentration.	45
Figure 4.14: Crowcon Xgard Type 1 SO ₂ detector installed at low level on Unistrut fixing adjacent to process flange, Kiln 1 activation area.	46
Figure 4.15: IS panel 128A-MB-I-030 showing installed Pepperl+Fuchs KFD0-CS-Ex1.50P galvanic isolators and intrinsically safe wiring, Kiln 1 hazardous area.	47

Figure 4.16: Clifford and Snell YL40 sounder/beacon installed outside Zone 2 boundary, Kiln 1 activation area.	48
Figure 4.17: Operator training document showing SO ₂ detector locations, channel identification, and alarm response procedure for kiln areas.	50
Figure 5.1: DSEAR detailed inspection certificate confirming satisfactory result in accordance with BS EN 60079-17 [11].	55
Figure 5.2: Crowcon calibration and commissioning report for Kiln Plant 1 and 2 SO ₂ detection system.	57
Figure 6.1: 4–20 mA signal injection testing using a calibrated Fluke loop calibrator during commissioning of SO ₂ detection.	60
Figure 6.2: Extract from calibration and commissioning certificate showing analogue scaling verification and alarm setpoints for loop A231_2.	62

Table of Tables

Table 3.1: Comparison of explosion protection methods considered for Zone 2 instrumentation.	16
Table 3.2: Comparative evaluation of fixed and portable gas detection approaches....	17
Table 4.1: Key Evaluation Data of the effectiveness and reliability of the system.	25
Table 5.1: SO ₂ detector locations and tag references.	27
Table 5.2: Summary of principal equipment selected for the SO ₂ detection system. ...	29
Table 5.3: Entity parameter verification Loop A131_1 (representative of all five loops). ...	30
Table 5.4: 4–20 mA loop signal scaling for SO ₂ concentration.	33
Table 5.5: Analogue Input Assignments.	35
Table 5.6: Foxboro DCS digital output and input block assignments, Kiln 1 SO ₂ detection system.	37
Table 5.7: DCS alarm logic configuration SO ₂ detection system.	41
Table 5.8: Project cost summary, SO ₂ detection system.	51
Table 6.1: Principal development and verification records.	58
Table 7.1: 4–20 mA signal injection test results all five SO ₂ detection loops.	59
Table 7.2: Bump gas commissioning results final calibration phase.	61
Table 7.3: Alarm activation verification results.	63

1 Introduction

1.1 Background and Context

Vale Clyde Nickel Refinery, established in 1902 by Ludwig Mond, remains the world's only facility operating the Mond carbonyl process to refine nickel to a purity of 99.9% [1]. The process involves the controlled reaction of impure nickel with carbon monoxide to produce nickel tetracarbonyl, $\text{Ni}(\text{CO})_4$, which is subsequently thermally decomposed to deposit refined nickel. A critical stage within this cycle is the activation kiln, where sulphur dioxide (SO_2) is intentionally introduced to enhance nickel surface reactivity prior to carbonyl formation [1]. Whilst chemically essential to the process, this stage generates a persistent and significant occupational health hazard for personnel working within the activation kiln area.

Sulphur dioxide is a colourless, corrosive, and acutely toxic gas with a vapour density of approximately 2.26 relative to air, meaning it is heavier than air and will accumulate at low levels within an enclosed or semi-enclosed industrial environment [2]. In the United Kingdom, SO_2 is subject to a Workplace Exposure Limit (WEL) of 0.5 ppm as an eight-hour time-weighted average (TWA) and 1 ppm as a fifteen-minute short-term exposure limit (STEL), as defined under EH40/2005 [3]. These are among the most stringent occupational exposure thresholds in British industrial legislation, reflecting the acute respiratory and systemic harm that even brief exposure can cause at concentrations above the WEL.

The refinery operates as a lower-tier establishment under the Control of Major Accident Hazards Regulations 2015 (COMAH) [4], which impose a statutory duty on the operator to prevent major accident scenarios involving scheduled dangerous substances, including SO_2 . The Control of Substances Hazardous to Health Regulations 2002 (COSHH) [5] additionally require the employer to assess exposure risks, implement adequate controls, and monitor personnel exposure to hazardous substances. The activation-kiln area carries a Zone 2 hazardous area classification under IEC 60079-10-1, arising from the presence of nickel carbonyl and associated process gases, and all electrical equipment installed within the zone must comply with the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) [6] and be selected and installed in accordance with IEC 60079-14 [7].

Despite the regulatory framework and known hazards associated with SO_2 , monitoring within the activation kiln area has historically relied on portable gas detectors carried by personnel. This approach is inherently reactive, as gas leaks are only detected when individuals are present, and provides no continuous monitoring or historical record of gas concentrations. As a result, there is limited visibility of developing hazards and potential exposure risks within the area.

This project was therefore proposed and approved as a safety critical project to address these limitations through the design and implementation of a permanently installed fixed SO_2 detection and alarm monitoring system within the activation-kiln area. The system provides continuous monitoring of high-risk locations, real-time alarm indication, and integration with the existing plant control system, enabling operators to monitor conditions from a safe environment.

1.2 Problem Statement

At the time this project was initiated, the activation-kiln area at the refinery had no fixed SO₂ detection infrastructure. Area monitoring relied entirely on portable gas detectors carried by individual operatives during routine work activities in and around the kiln. This arrangement introduced several critical safety limitations.

Firstly, the detection methodology was entirely reactive. A gas release could only be identified once personnel had already entered the affected area, either through activation of their portable detector or, in some cases, by the smell of SO₂ at concentrations high enough to be perceptible. At this stage, exposure had already occurred. Near miss incidents had been recorded where personnel entered the activation-kiln area without a detector, resulting in uncontrolled and unquantified exposure. In addition, the absence of fixed monitoring meant there was no way to determine how long a release had been present or what concentrations had been reached, preventing any meaningful assessment of exposure levels. This absence of monitoring capability represents a failure to adequately assess and control exposure risks as required under COSHH Regulation 10 [5].

Secondly, the reliability of portable detection as a primary safety control is limited. Portable devices are susceptible to battery depletion, calibration drift, and human factors such as failure to carry, activate, or maintain the device correctly [8], [9]. In an environment where SO₂ is routinely present as part of normal operations, reliance on personnel-based detection places significant dependence on individual behaviour as the primary safeguard.

Finally, the existing approach provided no continuous monitoring or centralised data logging capability. This limited the ability to identify trends, recurring leaks, or developing hazards over time, and introduced an ongoing maintenance burden associated with managing multiple portable devices.

Together these factors represented a clear gap in the refinery's safety provision and highlighted the need for a fixed SO₂ detection system capable of continuous monitoring, automated alarm response, and integration with the existing plant control infrastructure.

1.3 Project Aim

The aim of this project is to design, install, test, and commission a fixed intrinsically safe SO₂ detection and alarm monitoring system within the activation kiln process areas at Vale Clydach Nickel Refinery, integrated with the existing Foxboro I/A Series Distributed Control System to provide continuous gas monitoring, automated alarm response, and evaluation of system performance.

1.4 Objectives

To achieve this aim, the following objectives were defined:

1. To analyse the limitations of portable gas detection within the activation-kiln area and identify associated safety risks.
2. To design a fixed intrinsically safe SO₂ detection system suitable for operation within a Zone 2 hazardous environment.
3. To develop and verify intrinsically safe 4–20 mA detection loops, including entity parameter verification and supporting documentation.
4. To integrate the detection system with the existing Foxboro I/A Distributed Control System (DCS) for continuous monitoring and alarm handling.
5. To develop a Human Machine Interface (HMI) for real-time gas concentration display, alarm indication, and trend monitoring.
6. To install, test, and commission the system, including signal simulation, gas response verification, and alarm validation.
7. To evaluate system performance against the previous portable detection approach, assessing improvements in safety, reliability, and monitoring capability.

1.5 Project Scope

This project encompasses the full engineering lifecycle of a fixed SO₂ detection system across both activation kiln areas at the refinery. The scope includes the design, procurement, installation, testing, and commissioning of five detection points distributed across Kiln 1 and Kiln 2, with detector positioning informed by process knowledge and the physical behaviour of SO₂ as a dense gas.

The system consists of intrinsically safe, loop-powered 4–20 mA detection circuits integrated into the existing Foxboro I/A Distributed Control System (DCS), enabling continuous monitoring, alarm handling, and operator interaction via the plant HMI. The scope also includes the development of control system logic, alarm configuration, and the integration of the detection system with the plant's existing evacuation alarm infrastructure.

This project covers all aspects of system delivery from initial design through to commissioning and handover. However, it does not include modification of the core process systems, expansion beyond the defined activation kiln areas, or long-term operational performance monitoring beyond initial commissioning and validation.

1.6 Structure of the Report

This report is structured as follows:

- Chapter 2 presents the literature review, covering SO₂ hazards, hazardous-area classification, gas detection technologies, intrinsically safe barrier selection, and DCS integration.
- Chapter 3 outlines the design methodology, including the design process, applicable standards, and commissioning approach.
- Chapter 4 presents the system design and implementation, including equipment selection, intrinsically safe loop design, DCS configuration, HMI development, installation, and project costing.
- Chapter 5 documents the principal engineering deliverables produced during the project, including drawings, compliance records, and commissioning documentation.
- Chapter 6 presents commissioning results and system performance evaluation, including signal injection testing, bump-gas verification, alarm validation, and discussion of project outcomes.
- Chapter 7 presents project conclusions and recommendations for future system development.
- Chapter 8 provides a reflection on the technical and professional competencies developed throughout the project.

2 Literature Review

This chapter reviews the standards, technologies, and engineering considerations that informed the system design.

2.1 Sulphur Dioxide as an Industrial Hazard

Sulphur dioxide is a toxic and corrosive gas with a UK Workplace Exposure Limit of 0.5 ppm TWA and 1 ppm STEL under EH40/2005 [3]. The distinction between TWA and STEL is significant for system design, as TWA represents the average exposure over an eight-hour working period, whereas STEL defines the maximum permissible short-term exposure over a fifteen-minute interval. This places particular importance on rapid detection and alarm response to prevent acute exposure events. Exposure above these limits causes respiratory irritation, bronchoconstriction, and, at higher concentrations, serious harm to personnel [2].

COSHH [5], COMAH [4], and DSEAR [6] collectively require the assessment, control, and monitoring of hazardous gas exposure within industrial environments. Within the activation-kiln area, these regulations directly influenced the selection of hazardous-area protection methods and support the implementation of fixed SO₂ detection as an engineered safety control.

The activation-kiln area at Vale Clydach presents a particular challenge in this regard. SO₂ is introduced deliberately as part of the Mond carbonyl process [1], meaning its presence is a routine operational condition rather than an incidental hazard. This places greater emphasis on continuous and reliable detection at the point of use rather than periodic or personnel-dependent monitoring.

2.2 Hazardous Area Classification and Protection Method Selection

The activation-kiln area at Vale Clydach carries a Zone 2 hazardous area classification, as shown in Figure 2.1. Under IEC 60079-10-1, Zone 2 is defined as an area in which an explosive atmosphere is not likely to occur in normal operation but, if it does occur, will persist for only a short period [7]. This classification arises from the presence of nickel carbonyl and associated process gases within the kiln area during normal operations.

Hazardous Area Classification Identification:

Hydrogen @ 150mm H₂O creating 0.5m IC Gas zone 2 classified area indicated thus:

Seal Gas Liner @ 2psi creating 0.5m IC Gas zone 2 classified area indicated thus:

End Elevation

Elevation on arrow 'A'

End Elevation

N

UP

UP

'A'

Activation Kiln X102

Kiln Line 1

HIGH PRESSURE CO COMPRESSOR PLANT

VALE EUROPE LTD. CLYDACH, SWANSEA.	REV	DESCRIPTION	DATE

PLANT	Kiln Plant	TITLE	DSEAR Risk Assessments RAGOP Area 'A67' Activation Kiln Inlet & Outlet Heads
EQUIPMENT	Kiln Line 1	SCALE	AS SHOWN

DATE	JUN 2018	DRG. No.	128A-000-181
BRANCH	NIS		

This classification directly determines the selection of suitable protection methods for all electrical and instrumentation equipment installed within the area. Under the requirements of DSEAR [6] and IEC 60079-14 [7], equipment must be selected in accordance with the appropriate Equipment Protection Level and installed in compliance with the relevant construction and installation standards. Several explosion protection methods were evaluated for suitability within this application. Table 2.1 summarises the principal protection concepts applicable to Zone 2 instrumentation and the rationale for the final selection.

Table 2.1: Comparison of explosion protection methods considered for Zone 2 instrumentation.

Protection Method	Standard	Permitted Zone	Suitability for IS Loop Instrumentation	Reason Accepted / Rejected
Intrinsic safety (Ex ia)	IEC 60079-11 [10]	Zone 0, 1 and 2	Ideal, designed for low-power instrumentation loops	Selected: Highest protection level, permits live maintenance, industry standard for 4–20 mA signal loops.
Flameproof (Ex d)	IEC 60079-1	Zone 1 and 2	Poor, heavy certified enclosures required per device	Rejected: High installation cost, no live maintenance, impractical for retrofit field instrumentation.
Increase safety (Ex e)	IEC 60079-7	Zone 1 and 2	Limited, applicable to terminal boxes and junction boxes only, not active sensing instruments	Rejected: Not applicable to transmitter devices.
Non-sparking (Ex nA)	IEC 60079-15	Zone 2 only	Possible, lower protection level than Ex ia	Rejected: Lower safety integrity, does not permit live maintenance.

Intrinsic safety (Ex ia) was selected for the field instrumentation as it provides a high level of protection and is well suited to low-power 4–20 mA instrumentation loops [10]. It also supports live maintenance of field circuits without requiring gas-clear permits, improving maintainability and reducing operational downtime compared with alternative protection methods.

2.3 Fixed Versus Portable Gas Detection

Both fixed and portable gas detection approaches were evaluated for this application. Research indicates that fixed detection systems provide continuous, area-wide monitoring independent of personnel presence, enable automated alarm outputs, and generate a continuous data record suitable for regulatory compliance and trend analysis [8], [9]. In contrast, portable detectors, whilst providing personal protection for individual workers, are inherently reactive and only alarm once the wearer has entered a contaminated atmosphere, offering no advance warning of a release in an unoccupied area [8].

Literature identifies fixed gas detection as more suitable for continuous area monitoring due to reduced dependence on operator behaviour and improved integration with alarm and logging systems [8], [9]. Whilst portable detectors remain essential for personal protection, they do not provide automatic area monitoring or alarm response in unoccupied locations [18]. Table 2.2 provides a comparison of both approaches across the most relevant operational criteria.

Table 2.2: Comparative evaluation of fixed and portable gas detection approaches.

Criteria	Fixed Detection	Portable Detection
Continuous monitoring	Yes	No
Detection in unoccupied areas	Yes	No
Integration with plant systems	Yes	No
Continuous data logging	Yes	Limited (device specific).
Dependency on human behaviour	Low	High (Requires correct use and carriage).
Maintenance	Low (Scheduled Servicing)	High (Battery, calibration, Sensor replacement).
Alarm Response	Automatic (System Triggered)	User Dependent
Regulatory compliance record	Yes	No

2.4 Sensor Technology and Detector Selection

Electrochemical sensors are widely recognised as the most suitable technology for sub-ppm toxic gas detection in industrial safety applications, offering high sensitivity, linear output, ambient temperature operation, and low power consumption [13]. These characteristics make electrochemical sensing directly compatible with the 4–20 mA loop-powered intrinsically safe (IS) circuit adopted in this project.

Alternative technologies including metal oxide semiconductor and infrared sensing were evaluated but rejected due to intrinsic safety limitations and insufficient low-level sensitivity for sub-ppm SO₂ detection [13]. Electrochemical sensing therefore provided the most suitable balance of sensitivity, power consumption, and compatibility with the proposed intrinsically safe 4–20 mA loop design.

Four fixed electrochemical detector products were evaluated during the selection process. The comparative specification review is presented in Figure 2.2.

	Crowcon Xgard (Type 1)	MSA X5000	Honeywell XCD	Teledyne OLCT 100 XP
				
Monitor Type:	Fixed Gas Detector	Fixed Gas Detector	Fixed Gas Detector	Fixed Gas Detector
Size:	156 x 166 x 111 mm	150 x 145 mm	Not Specified	179 x 138 x 84 mm
Weight:	Nylon: 0.5kg, alloy: 1kg, 316 S/S: 3.1kg	4kg	Aluminium: 4.4 lbs, stainless steel: 11 lbs	1.1kg
Enclosure Material:	ATEX: Glass nylon or 316 S/S	316 Stainless Steel	Aluminium or stainless steal	Aluminium or stainless steal
IP Rating:	IP65	IP66	IP66	IP66
Cable Entries:	1 x M20, 1/2 "NPT or 3/4 NPT" on right	3-wire shielded (single sensor)	UL/cUL: 2 x 3/4" NPT, ATEX: 2 x M20	M20 or 3/4 NPT
Terminations:	0.5 to 2.5mm ²	Internal terminal blocks	Internal terminal blocks	Internal terminal blocks
Sensor Type:	Varied	Varied	Varied	Varied
Operating Temp:	Varied	Varied	-40°C to +65°C (-40°F to +149°F)	40°C to +65°C
Humidity:	0-90% RH non-condensing	Varied	10% to 95% RH (non-condensing)	10% to 95% RH (non-condensing)
Response Time:	<15s Oxygen, <30s to 120s Toxic*	Varied	Varied	Varied
Operating Voltage:	8- 30V dc	11-30 VDC, 3-wire	12-32 VDC (nominal 24 VDC)	11-32 VDC
Power Requirements:	24mA maximum	Varied	Varied	Varied
Electrical Output:	2-wire 4-20mA (current sink)	Dual 4-20 mA	Varied	Varied
ATEX:	✓	✓	✓	✓
IECEx:	✓	✓	✓	✓

Figure 2.2: Comparative specification overview of fixed electrochemical SO₂ detectors evaluated during selection [17].

The Crowcon Xgard Type 1 was selected based on several key factors. The device is a two-wire, loop-powered transmitter, eliminating the requirement for a separate power supply cable to each detector and significantly reducing installation complexity and associated cable costs. In addition, Vale Clydach maintains an existing service and calibration contract with Crowcon for hydrogen detection systems already installed on site. This established service relationship, along with existing calibration equipment, spare parts availability, and engineer familiarity, made the selection of Crowcon a low-risk and operationally efficient extension of current site practice.

Following consultation with the manufacturer, it was confirmed that the Xgard Type 1, fitted with the appropriate SO₂ electrochemical sensor cartridge, provides validated performance across the required 0–10 ppm detection range and carries the necessary ATEX and IECEx certification for installation within the Zone 2 hazardous area [12].

The Crowcon XgardIQ model, initially proposed during procurement, was evaluated but ultimately rejected. The device requires a three-wire configuration, which is incompatible with the loop-powered intrinsically safe architecture adopted in this design. Furthermore, the manufacturer confirmed that it's SO₂ sensing capability was not optimised for sub-ppm detection, making it unsuitable for compliance with the exposure limits defined for this application.

2.5 Intrinsically Safe Barrier Selection

The selection of an appropriate intrinsically safe (IS) barrier is critical to maintaining intrinsic safety integrity across the complete detection loop. Two barrier types were evaluated during the design process: passive Zener barriers and active galvanic isolators.

Zener barriers were rejected due to their dependence on a high-integrity safety earth connection [10]. Galvanic isolators provide full electrical separation between hazardous and safe area circuits, offering improved fault tolerance for safety-critical instrumentation applications.

The Pepperl+Fuchs KFD0-CS-Ex1.50P was selected following a review of available galvanic isolator products. Its loop-powered operation eliminated the requirement for an additional 24 V DC supply, reducing panel complexity and installation requirements while remaining compatible with the proposed intrinsically safe 4–20 mA loop design.

The KFD0-CS-Ex1.50P carries IECEx certification (IECEx BAS 05.0004X Issue 6) [14], confirming its suitability for use within the proposed intrinsically safe system. Full entity parameter verification, demonstrating compliance with IEC 60079-11 [10], is presented in Chapter 4.

2.6 Distributed Control System Selection

Research indicates that integrating gas detection instrumentation within an existing plant Distributed Control System provides significant advantages over the use of standalone gas detection controllers in process safety applications [15]. DCS integration enables alarm management, historical data logging, and operator interface functions to be consolidated within a single platform, reducing fragmentation of safety-critical information and providing control room operators with a unified view of both process and safety conditions [15], [16]. Where a DCS is already established as the primary site control system, integration with that platform is the preferred approach, allowing the project to leverage existing operator familiarity, maintenance competency, and support infrastructure [15]. Where a DCS is already established as the primary site control system, integration with that platform avoids the introduction of additional standalone systems requiring separate training, configuration, and lifecycle management [15]. This also allows existing operator familiarity, maintenance competency, and plant infrastructure to be retained.

On this basis, integration with the existing Foxboro I/A Series DCS was identified as the most appropriate control architecture for this project. Integration with the existing Foxboro I/A Series DCS ensured compatibility with existing plant infrastructure while supporting alarm management, evacuation system integration, historical trending, and unified operator monitoring.

2.7 Summary

This chapter has established the regulatory and technical context for the design decisions made in this project. DSEAR [6], COSHH [5], and COMAH [4] collectively highlight the need for effective monitoring and control of SO₂ exposure within the Zone 2 activation-kiln area. The evaluations presented confirm that a fixed gas detection system provides the most suitable approach for this application. The selected solution, based on electrochemical detection integrated with the existing Foxboro I/A Distributed Control System, was chosen due to its reliability, compatibility with site infrastructure, and alignment with regulatory requirements. The detailed design and implementation of this system are presented in Chapter 4.

3 Design Methodology

This chapter outlines the methodology adopted for the design, implementation, and validation of the SO₂ detection and alarm monitoring system within a live industrial environment. The approach combined engineering design, system integration, and experimental validation while ensuring compliance with relevant safety standards and existing plant infrastructure.

3.1 Methodological Approach

The project follows a combined development-based and experimental methodology, supported by an industrial case study approach. The development element focuses on the design and installation of a fixed gas detection system, while the experimental element involves testing and validating system performance against defined criteria. This approach is appropriate for projects implemented within operational industrial facilities, where real-world constraints including hazardous area classifications, existing infrastructure, and site safety procedures directly influence design decisions [8].

3.2 System Design and Development Process

The design process began with identifying the safety deficiencies associated with reliance on portable gas detection within the activation-kiln area. A risk-based approach was adopted to determine suitable detector locations, focusing on areas where gas releases were most probable, including flanged connections, valves, and process connection points. Detector positioning was informed by SO₂ gas behaviour characteristics and consultation with the site process chemistry specialist.

Equipment selection was based on technical performance, hazardous-area compliance, and compatibility with existing plant infrastructure. Electrochemical detectors were selected for their suitability for low-level SO₂ detection and compatibility with 4–20 mA signal transmission. Site-standard equipment and loop-powered intrinsically safe barriers were prioritised to simplify installation and maintain consistency with existing maintenance arrangements.

The system architecture and signal flow are illustrated in Figure 3.1. The project was managed against the lifecycle plan developed at proposal stage, with installation activities completed under approved Risk Assessments and Method Statements in accordance with site safety procedures. Supporting documentation is provided in Appendix G.

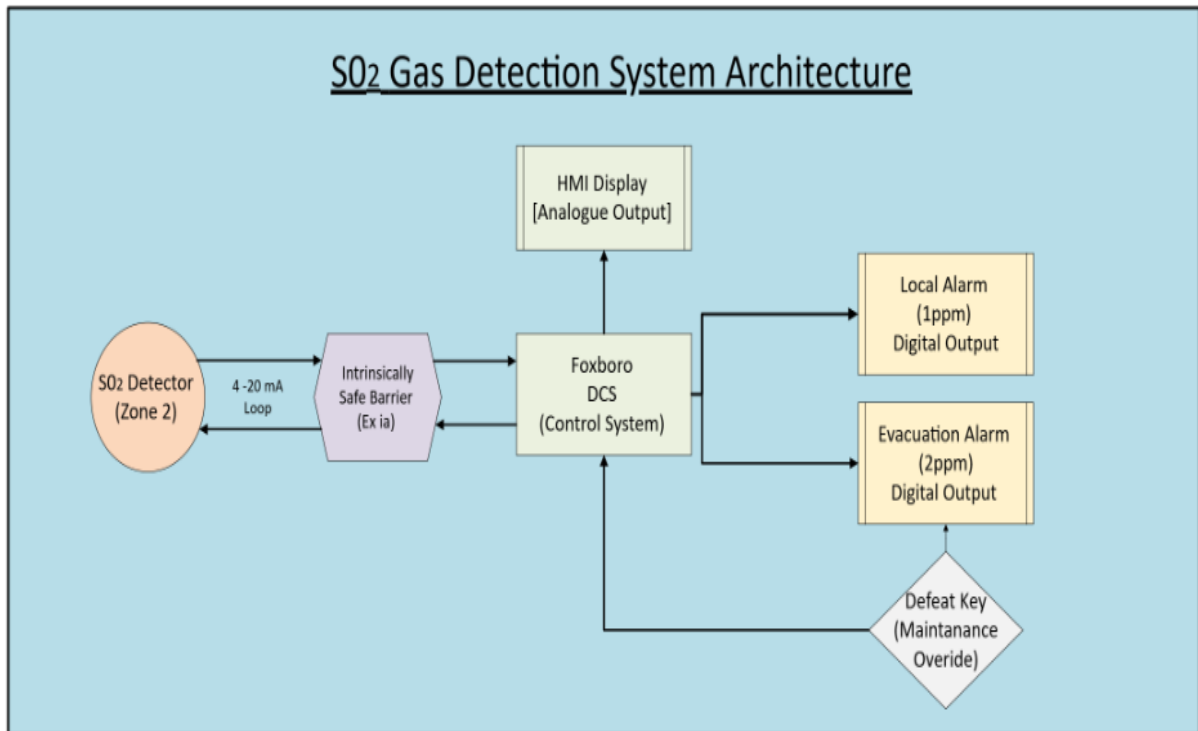


Figure 3.1: SO₂ gas detection system architecture showing signal path from hazardous area detector through IS barrier to Foxboro DCS, alarm outputs, and evacuation tie-in.

The full project lifecycle is illustrated in Figure 3.2 below.

L.Lloyd Independent Project Gantt

Display Week 1

Display Week 1

Task					2023					2024					2025					2026					2027					2028					2029					2030					2031					2032					2033					2034					2035					2036					2037					2038					2039					2040					2041					2042					2043					2044					2045					2046					2047					2048					2049					2050					2051					2052					2053					2054					2055					2056					2057					2058					2059					2060					2061					2062					2063					2064					2065					2066					2067					2068					2069					2070					2071					2072					2073					2074					2075					2076					2077					2078					2079					2080					2081					2082					2083					2084					2085					2086					2087					2088					2089					2090					2091					2092					2093					2094					2095					2096					2097					2098					2099					2100					2101					2102					2103					2104					2105					2106					2107					2108					2109					2110					2111					2112					2113					2114					2115					2116					2117					2118					2119					2120					2121					2122					2123					2124					2125					2126					2127					2128					2129					2130					2131					2132					2133					2134					2135					2136					2137					2138					2139					2140					2141					2142					2143					2144					2145					2146					2147					2148					2149					2150					2151					2152					2153					2154					2155					2156					2157					2158					2159					2160					2161					2162					2163					2164					2165					2166					2167					2168					2169					2170					2171					2172					2173					2174					2175					2176					2177					2178					2179					2180					2181					2182					2183					2184					2185					2186					2187					2188					2189					2190					2191					2192					2193					2194					2195					2196					2197					2198					2199					2200					2201					2202					2203					2204					2205					2206					2207					2208					2209					2210					2211					2212					2213					2214					2215					2216					2217					2218					2219					2220					2221					2222					2223					2224					2225					2226					2227					2228					2229					2230					2231					2232					2233					2234					2235					2236					2237					2238					2239					2240					2241					2242					2243					2244					2245					2246					2247					2248					2249					2250					2251					2252					2253					2254					2255					2256					2257					2258					2259					2260					2261					2262					2263					2264					2265					2266					2267					2268					2269					2270					2271					2272					2273					2274					2275					2276					2277					2278					2279					2280					2281					2282					2283					2284					2285					2286					2287					2288					2289					2290					2291					2292					2293					2294					2295					2296					2297					2298					2299					2300					2301					2302					2303					2304					2305					2306					2307					2308					2309					2310					2311					2312					2313					2314					2315					2316					2317					2318					2319					2320					2321					2322					2323					2324					2325					2326					2327					2328					2329					2330					2331					2332					2333					2334					2335					2336					2337					2338					2339					2340					2341					2342					2343					2344					2345					2346					2347					2348					2349					2350					2351					2352					2353					2354					2355					2356					2357					2358					2359					2360					2361					2362				
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Figure 3.2: Project lifecycle Gantt chart showing planned milestones from project initiation through to final submission, SO₂ Detection Monitoring System, OCU Group Vale Clydach Refinery.

3.3 System Implementation

The implementation phase involved physical installation of field instrumentation, cable routing, IS panel wiring, and termination of all circuits between field devices and the DCS. Cable installation followed IEC 60079-14 [7], with appropriate segregation maintained between intrinsically safe and non-intrinsically safe circuits throughout. DCS configuration was carried out by the project engineer with technical support from a Schneider Electric Foxboro systems engineer, in accordance with Vale's management of change process for live system modifications [16]. A dedicated HMI display was developed to present real-time gas concentration readings, alarm status, and historical trends, consistent with existing plant control standards.

3.4 Testing and Commissioning

Testing and commissioning were completed in accordance with BS EN 60079-17 [11], progressing from point-to-point loop checks through signal injection testing and bump-gas verification. Signal injection testing verified correct 4–20 mA scaling and alarm functionality across all five detection loops, while bump-gas commissioning confirmed detector response using calibrated SO₂ mimic gas. A formal DSEAR inspection was completed following installation. Full commissioning results are presented in Chapter 6.

3.5 Data Collection and Evaluation Criteria

System performance was evaluated using controlled test data and real-time DCS monitoring. Key evaluation criteria are summarised in Table 3.1. Commissioning records, calibration certificates, and DSEAR inspection documentation were retained as formal project deliverables and are provided in the appendices.

Table 3.1: Key Evaluation Data of the effectiveness and reliability of the system.

Criteria	Description
Signal accuracy	Verification of correct 4–20 mA scaling and representation within the DCS
System responsiveness	Ability of the system to respond to simulated gas conditions
Alarm functionality	Correct activation of alarm thresholds at 1 ppm and 2 ppm
Integration reliability	Stability and consistency of signal integration within the DCS
Operational stability	Consistency of readings over extended operating periods

3.6 Constraints and Limitations

The project was implemented within a live industrial environment, requiring compliance with Vale’s management of change procedures and site safety systems [16]. Operational constraints limited full evacuation testing during normal production; therefore, verification was completed during a planned period of reduced site activity. All works were undertaken in accordance with approved Risk Assessments and Method Statements [19].

3.7 Ethical and Environmental Considerations

The implementation of a fixed gas detection system improves personnel safety by reducing potential exposure to hazardous SO₂ concentrations, consistent with the professional responsibilities of engineers to protect human life [20]. Training documentation was issued to all operational staff to ensure consistent access to system information. Environmental considerations relating to end-of-life disposal of electronic equipment should follow recognised environmental management practices [21].

3.8 Summary

This chapter has outlined the combined development and experimental methodology adopted for the design, implementation, and validation of the SO₂ detection system. The methodology ensured that the system was designed to relevant standards, safely integrated with existing plant infrastructure, and thoroughly validated under controlled conditions. The detailed design and implementation are presented in Chapter 4, with commissioning results and evaluation presented in Chapter 6.

4 System Design, Development and Implementation

This chapter presents the design and implementation of the fixed SO₂ gas detection system at Vale Clydach Refinery, including system architecture, equipment selection, intrinsically safe loop design, DCS integration, alarm logic, HMI development, and physical installation.

The system was developed to address the safety deficiencies identified in Chapter 1 while ensuring compliance with hazardous-area requirements and compatibility with existing plant infrastructure.

4.1 System Overview

The SO₂ detection system comprises five fixed electrochemical transmitters installed within the activation-kiln hazardous areas, each connected via a dedicated 4–20 mA intrinsically safe loop through a certified galvanic isolator to the Foxboro I/A Distributed Control System (DCS) located within the safe-area IA computer room. The DCS processes the analogue input signals, applies alarm logic, drives local sounder/beacon outputs, and provides integration with the plant's main evacuation alarm system. The implemented system architecture is illustrated in Figure 4.1.

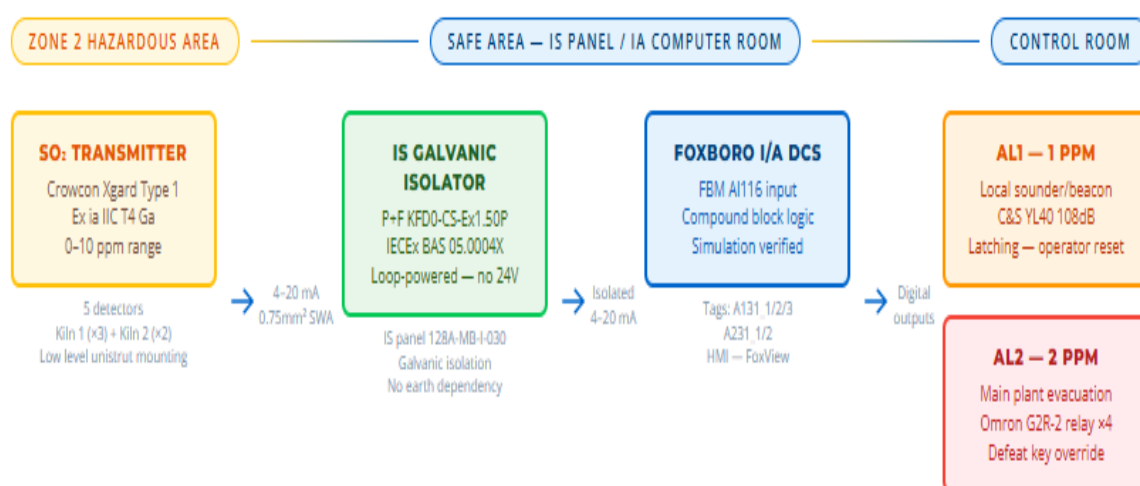


Figure 4.1: Detailed SO₂ gas detection system architecture showing hazardous area instrumentation, intrinsically safe signal transmission, DCS integration, and alarm outputs

Each Crowcon Xgard Type 1 transmitter installed within the Zone 2 hazardous area generates a 4–20 mA signal proportional to SO₂ concentration across a 0–10 ppm range. The signal is transmitted through a Pepperl+Fuchs KFD0-CS-Ex1.50P galvanic isolator to the Foxboro FBM AI211 analogue input module, where it is scaled to engineering units and processed using DCS alarm logic. Alarm outputs are then generated to drive local sounder/beacon units and the evacuation alarm relay circuit.

Table 4.1: SO₂ detector locations and tag references.

Tag	Area	Location Description	Positioning Rationale
A131_1	Kiln 1	Control valve area	High-traffic personnel walkthrough zone
A131_2	Kiln 1	Flow transmitter area	High-traffic personnel walkthrough zone
A131_3	Kiln 1	SO ₂ inlet manifold	Highest concentration of potential leak sources
A231_1	Kiln 2	Control valve area	High-traffic personnel walkthrough zone
A231_2	Kiln 2	Flow transmitter area	High-traffic personnel walkthrough zone

Detector locations were determined through consultation with the site process chemistry specialist and experienced kiln operators, supported by a risk-based assessment of likely SO₂ release points. Due to limited historical leak data, positioning focused on areas of highest potential risk, including process flanges, valves, and manifold connections. Additional consideration was given to personnel exposure, with detectors installed in key access and walkway areas where operators are most likely to be present. The SO₂ inlet manifold, although not continuously manned, was identified as a critical location due to the high concentration of potential leak sources.

The number of detectors installed was influenced by both risk prioritisation and project budget constraints. Five detectors were selected to provide coverage of the highest risk areas within the activation-kiln process. While additional detectors could further improve coverage, the implemented system represents a targeted and cost-effective solution within the approved capital expenditure, with potential for future expansion if required.

4.2 Equipment Selection

Equipment selection was carried out based on the comparative evaluation presented in Chapter 2. This section details the selected components, their key technical characteristics, and the justification for their use within the SO₂ detection system.

4.2.1 Crowcon Xgard Type 1 SO₂ Transmitter

The Crowcon Xgard Type 1 was selected as the field transmitter for all five detection loops. It is a two-wire, loop-powered electrochemical transmitter certified to Ex ia IIC T4 Ga under ATEX certificate Baseefa04ATEX0115X Issue 7 [12], confirming its suitability for installation in Zone 0, 1, and 2 hazardous areas.

The device provides a 4–20 mA output signal proportional to SO₂ concentration and operates directly from the loop supply, eliminating the requirement for a separate

power cable. This significantly simplified field wiring and reduced installation complexity within the hazardous area.

Vale Clydach maintains an existing service and calibration contract with Crowcon for hydrogen detection systems on site. The selection of the Xgard Type 1 extended this arrangement, ensuring that maintenance personnel, calibration equipment, and spare parts availability were already established, reducing long-term operational risk.

The Crowcon XgardIQ model was initially quoted but rejected following technical evaluation and manufacturer consultation for the following reasons: it requires a three-wire configuration, making it incompatible with the loop-powered intrinsically safe design adopted for this project; the SO₂ electrochemical sensor was confirmed by the manufacturer as not optimised for the 0–10 ppm detection range required; the integrated local display was not considered beneficial given that detectors are installed at low level in restricted locations and all monitoring is conducted remotely from the control room HMI; and the significantly higher unit cost of the XgardIQ would have placed the project at risk of exceeding the approved capital expenditure budget. The Xgard Type 1 therefore represented the technically and commercially appropriate solution for this application. The Xgard product selection diagram is presented in Figure 4.2.

The Xgard range offers a comprehensive selection of fixed point gas detectors that meet the diverse requirements for flammable and toxic gas detection and oxygen monitoring in industries throughout the world. This diagram is designed to help you choose the correct Xgard detector to suit your needs.



Figure 4.2: Crowcon Xgard product selection diagram highlighting the intrinsically safe electrochemical variant used for SO₂ detection [12].

4.2.2 Pepperl+Fuchs KFD0-CS-Ex1.50P Galvanic Isolator

The KFD0-CS-Ex1.50P was selected as the intrinsically safe interface device for each detection loop. This unit is a transformer-isolated, loop-powered current separator certified to IECEx BAS 05.0004X Issue 6 [14], providing galvanic isolation between the hazardous area field circuit and the safe-area DCS input.

Following a review of available intrinsically safe barrier options, the KFD0-CS-Ex1.50P was identified as the only loop-powered galvanic isolator capable of meeting the application requirements. Alternative devices required an additional 24 V DC supply, which would have increased panel complexity, wiring requirements, and installation effort. The use of a loop-powered isolator removed the need for a separate power supply within the intrinsically safe panel, simplifying the system design and reducing overall installation cost.

4.2.3 Clifford and Snell YL40 Sounder/Beacon

The Clifford and Snell YL40 sounder/beacon combination unit was selected for local alarm indication. The YL40 provides a maximum sound output of 108 dB(A) at 1 metre and is rated IP65, suitable for the industrial environment of the activation-kiln area. Two units were installed, one for the Kiln 1 activation area and one for Kiln 2, positioned to provide clear audible and visual alarm indication to personnel. The units are located outside the Zone 2 boundary and are activated via digital outputs from the Foxboro DCS.

Table 4.2: Summary of principal equipment selected for the SO₂ detection system.

Item	Manufacturer	Model	Certification	Quantity
SO ₂ transmitter	Crowcon	Xgard Type 1	Ex ia IIC T4 Ga — Baseefa04ATEX0115X [12]	5
IS galvanic isolator	Pepperl+Fuchs	KFD0-CS-Ex1.50P	IECEx BAS 05.0004X [14]	6 (1 spare)
Sounder/ Beacon	Clifford & Snell	YL40	IP65, BS EN 54-3	2
I/O Module	Schneider Electric	Foxboro FBM	Site standard	Existing utilised
Evacuation relay	Omron	G2R-2 24VDC	BS EN 54-3	4

Full technical specifications for selected equipment are provided in Appendix E.

The sounder tone was configured via DIP switch setting 00010 to produce a distinguishable audible alarm signal in accordance with the requirements of BS EN 61310-1 [23], ensuring the SO₂ alarm is clearly differentiated from other audible warnings within the kiln area.

4.3 Intrinsically Safe Loop Design and Verification

The intrinsically safe (IS) loop design was completed in accordance with IEC 60079-11 [10] and IEC 60079-14 [7]. Entity parameter verification was carried out for each of the five detection loops to confirm compliance with intrinsic safety requirements. As all loops utilise identical equipment and cable specifications, the verification presented for loop A131_1 is representative of the complete system.

4.3.1 Entity Parameter Verification

Entity verification requires that the output parameters of the safe-area associated apparatus do not exceed the input parameters of the hazardous area field device. The following conditions must all be satisfied:

- $U_o \leq U_i$: Barrier output voltage must not exceed detector maximum input voltage
- $I_o \leq I_i$: Barrier output current must not exceed detector maximum input current
- $P_o \leq P_i$: Barrier output power must not exceed detector maximum input power
- $C_c + C_i \leq C_o$: Total cable plus device capacitance must not exceed barrier certified output capacitance
- $L_c + L_i \leq L_o$: Total cable plus device inductance must not exceed barrier certified output inductance

The verified parameters for loop A131_1 are presented in Table 4.3.

Table 4.3: Entity parameter verification Loop A131_1 (representative of all five loops).

Parameter	Barrier Output	Cable	Device Input	Combined	Limit	Result
Voltage (V)	$U_o = 25.2$	—	$U_i = 28$	—	$U_o \leq U_i$	PASS
Current (mA)	$I_o = 93$	—	$I_i = 300$	—	$I_o \leq I_i$	PASS
Power (W)	$P_o = 0.585$	—	$P_i = 1.2$	—	$P_o \leq P_i$	PASS
Capacitance (μF)	$C_o = 0.107$	$C_c = 0.005$	$C_i = 0.0144$	0.0194	$\leq C_o$ 0.107	PASS
Inductance(mH)	$L_o = 4.3$	$L_c = 0.013$	$L_i = 0.028$	0.041	$\leq L_o$ 4.3	PASS

All five entity verification conditions are satisfied. The system is confirmed as compliant with IEC 60079-11 [10] for Group IIC, Temperature Class T4 applications.

A representative intrinsically safe loop calculation sheet is shown in Figure 4.3, with the full calculation provided in Appendix A.

 VALE VALE EUROPE LTD CLYDACH, SWANSEA Tel : 01792 842501	Compatibility sketch for a system comprising :- Pepperl + Fuchs Barrier Field IS Barria panel Marshalling Box S02 Detector		Name	Date	Checked										
	Drawn By LL		07.08.2025												
	Rev 1														
	Rev 2														
Rev 3															
Plant Ref No: 128A		Instrument Loop No : A131_1 (K1346)		Plant Area UNIT: Activation K1											
Loop Description :															
Ref Drg: 128A-000-A131_1 KILN 1 REF: S02 DETECTION															
System suitable for :		EEx ia IIC		Temperature Rating : T4											
Barrier/Isolator detail Manufacturer: PEPPERL + FUCHS Model: TYPE KFD0-CS-EX*,5 Certification Code: IEEEx ia) IIC Certificate Number: IECEX BAS 05.0004X		KFD0-CS-Ex1.50P Analogue Input ENCL: 128A-MB-I-030		Gas/Dust: II (1) GD Gas Group: IIC <table border="1"> <tr> <th>Uo V</th> <th>Io mA</th> <th>Po W</th> <th>C μf</th> <th>L mH</th> </tr> <tr> <td>25.2</td> <td>93</td> <td>0.585</td> <td>0.107</td> <td>4.3</td> </tr> </table>		Uo V	Io mA	Po W	C μf	L mH	25.2	93	0.585	0.107	4.3
Uo V	Io mA	Po W	C μf	L mH											
25.2	93	0.585	0.107	4.3											
Cable Parameters Length, metres: 20 Capacitance, μf/m: 0.00025 Inductance, mH/m: 0.000663				Total 0.005 μf 0.01326 mH											
Cable Parameters Length, metres: 0 Capacitance, μf/m: 0 Inductance, mH/m: 0				Total 0 μf 0 mH											
Cable Parameters Length, metres: 0 Capacitance, μf/m: 0 Inductance, mH/m: 0				Total 0 μf 0 mH											
Field Equipment Detail Manufacturer: Crowcon Model: Xguard-Type1 Certification Code: Ex ia IIC T4 Certificate Number: Baseefa 04ATEX0115X		A131-1 S02 DETECTOR (H1346)		<table border="1"> <tr> <th>Uo V</th> <th>Io mA</th> <th>Po W</th> <th>Ci μf</th> <th>Li mH</th> </tr> <tr> <td>28</td> <td>300</td> <td>1.2</td> <td>0.0144</td> <td>0.028</td> </tr> </table> Gas/Dust: IIC 0.0194 0.04126 FIT FIT FIT 'OK' 'OK'		Uo V	Io mA	Po W	Ci μf	Li mH	28	300	1.2	0.0144	0.028
Uo V	Io mA	Po W	Ci μf	Li mH											
28	300	1.2	0.0144	0.028											
COMMENTS 24 vdc supply (loop powered) 4-20mA															
Form Ref No : ---		128A-A131-1													

Figure 4.3: IS loop entity parameter verification calculation sheet Loop A131_1, document ref 128A-A131-

4.3.2 Voltage Drop Calculation

A voltage drop calculation was carried out to confirm that adequate supply voltage was available at the detector terminals under worst-case full-scale current conditions. The loop cable for each detector run is approximately 20 metres in length using 0.75mm² two-core screened SWA cable. The total loop resistance is calculated as follows:

$$R = (2 \times L \times \rho) / A$$

Where:

L = cable length = 20m

ρ = resistivity of copper = 0.0168 $\Omega \cdot \text{mm}^2/\text{m}$

A = conductor cross-sectional area = 0.75mm²

$$R = (2 \times 20 \times 0.0168) / 0.75 = \mathbf{0.896 \Omega}$$

At the maximum loop current of 20 mA, the cable voltage drop is:

$$\text{Voltage drop} = I \times R$$

$$\text{Voltage drop} = 0.020 \times 0.896 = \mathbf{0.018 \text{ V}}$$

The calculated cable voltage drop of 0.018 V is negligible relative to the overall loop voltage. In a loop-powered intrinsically safe system, the available voltage at the detector is influenced by voltage drops across the intrinsically safe barrier and associated wiring. Manufacturer data and consultation confirmed that sufficient voltage remains available at the detector terminals to meet the Crowcon minimum operating requirement of 13 V, validating the suitability of the selected loop-powered configuration.

4.4 Signal Transmission and 4–20 mA Loop Configuration

The system was designed using the 4–20 mA analogue current loop standard for signal transmission between the field detectors and the Distributed Control System. This method provides robust signal transmission with noise immunity and supports loop-powered field devices without requiring a separate power supply. Each loop is scaled as follows:

- 4 mA = 0 ppm SO₂: Live zero, confirms loop continuity
- 20 mA = 10 ppm SO₂: Full-scale measurement range
- Below 4 mA: FAULT condition, open circuit or loss of power detected

This scaling provides a measurement resolution of 0.625 ppm per milliamp, which is sufficient to detect concentrations approaching the 0.5 ppm Time-Weighted Average (TWA) Workplace Exposure Limit (WEL) and to reliably trigger the 1 ppm alarm setpoint.

The live-zero characteristic of the 4mA signal is a critical safety feature. A signal below 4mA indicates a fault condition, such as cable disconnection or loss of detector power, and is configured within the DCS to generate a FAULT alarm. This ensures that system failures are clearly distinguished from a valid zero gas reading, preventing unsafe conditions from being misinterpreted.

Table 4.4: 4–20 mA loop signal scaling for SO₂ concentration.

SO ₂ Concentration (ppm)	Loop Current (mA)	Signal Status	Action
0	4	Live zero normal operation	Normal operation
1	5.6	ALM 1 threshold	Initiate Local Sounder / Beacon
2	7.2	ALM 2 threshold	Activate main evacuation alarm
5	12	Mid-scale reference	Mid-Range
10	20	Full scale	Max Range
Below 4	<4.00	FAULT Open circuit or loss of power	IO Bad Fault Alarm on HMI

Loop drawings were produced using AutoCAD Electrical, defining the complete signal path from detector through intrinsically safe barrier to DCS termination for each of the five circuits, Full loop Drawings found in appendix B. These drawings followed Vale's plant instrumentation tagging and numbering conventions and were reviewed and approved prior to installation. The AutoCAD loop drawing for circuit A131_1 is presented in Figure 4.4. The diagram also illustrates the segregation between hazardous and safe area circuits, which is a key requirement for intrinsically safe system design in accordance with IEC 60079-14 [7].

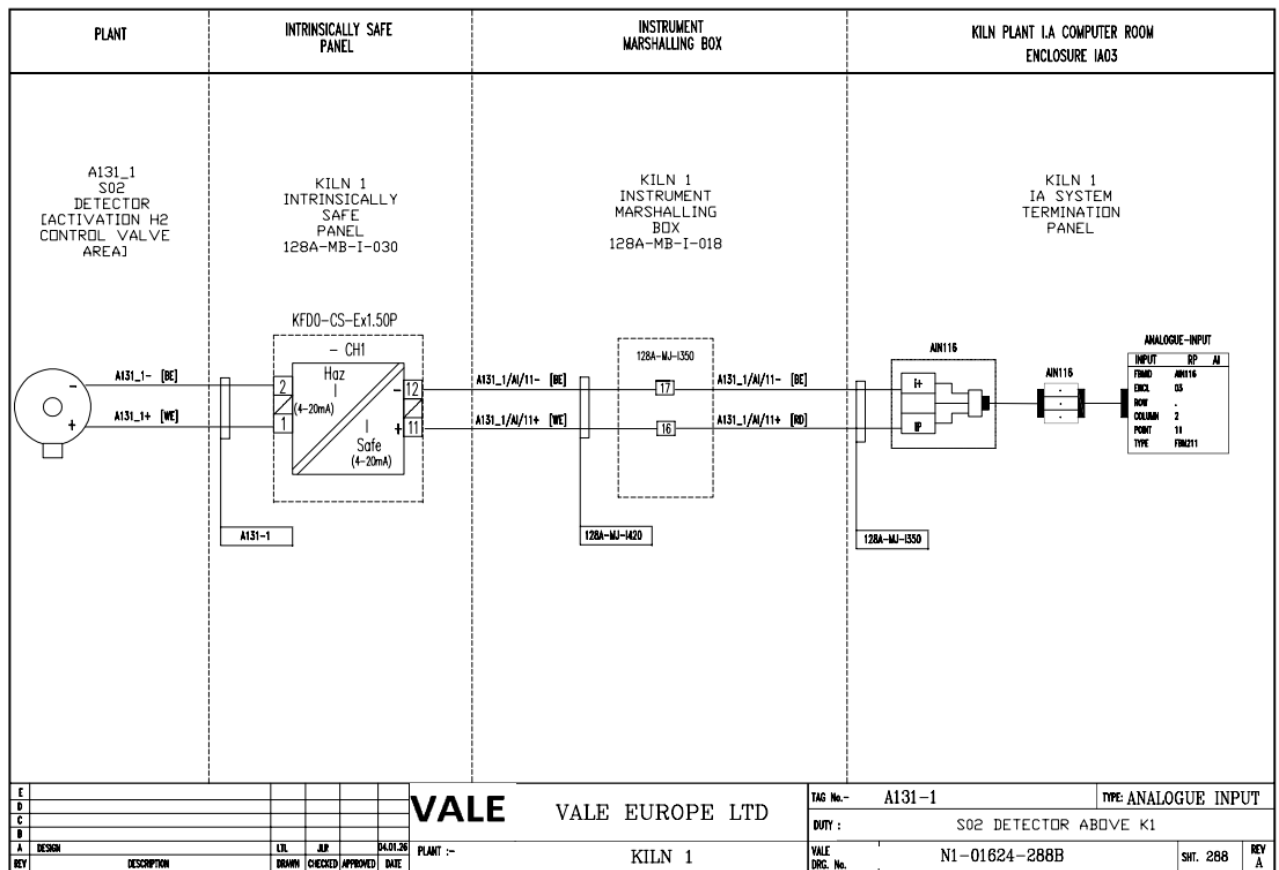


Figure 4.4: AutoCAD loop drawing A131_1 showing SO₂ detector, intrinsically safe barrier, marshalling interface, and DCS analogue input termination across hazardous and safe area boundaries.

4.5 DCS Integration and Alarm Logic Configuration

The Foxboro I/A Distributed Control System (DCS) was configured to receive, process, and act upon the 4–20 mA signals from all five SO₂ detection loops. Configuration was carried out within the Foxboro simulation environment prior to implementation on the live plant system, in accordance with the Kiln Plant SO₂ Detection System I/A Configuration Specification (MoFC1747), included in Appendix I. A Schneider Electric Foxboro engineer present on site during the implementation period provided technical guidance where required.

4.5.1 Analogue Input Block Configuration

Each detection loop was assigned to an Analogue Input (AIN) compound block on the Foxboro FBM211 module. The configuration defined the IOM identifier, point number, engineering unit scaling, and alarm thresholds in accordance with standard industrial distributed control system configuration practices [16]. Analogue input assignments are summarised in Table 4.5.

Table 4.5: Analogue Input Assignments.

DCS Compound Tag	Description	IOM ID	Point No	Range	AL1	AL2
A2_2_ACT MS:A131_1_AI	K1 SO ₂ Detector Control Valve	AIN116	11	0–10 ppm	1 ppm	2 ppm
A2_2_ACT MS:A131_2_AI	K1 SO ₂ Detector Flow Transmitter	AIN116	12	0–10 ppm	1 ppm	2 ppm
A2_2_ACT MS:A131_3_AI	SO ₂ Detector SO ₂ Manifold	AIN116	13	0–10 ppm	1 ppm	2 ppm
A2_2_ACT MS:A231_1_AI	K2 SO ₂ Detector Control Valve	AIN216	11	0–10 ppm	1 ppm	2 ppm
A2_2_ACT MS:A231_2_AI	K2 SO ₂ Detector Flow Transmitter	AIN216	12	0–10 ppm	1 ppm	2 ppm

The implemented AIN block configuration is shown in Figure 4.5, confirming module assignment, scan period, and linear scaling of the 4–20 mA signal to engineering units.

BLOCK ALARM SUMMARY

CNTRL

ALARM TEXT

ALARMS

TREND

CONFIG

PREV DISP

SO₂ DETECT K1 ACT
CNTRL VLV AREA
A2_2_ACT_MS
A131_1_AI

A

MEAS 0.1172

PNT PPM 0.1172

A131

CONFIGURATION

LOCKID:

TYPE : AIN

PERIOD: 2 sec

PHASE : 1

INITMA: 1

INHIB : N

INHOPT: 1

MANALM: 0

HHAOPT: HH

HLOP : H

ORAO : N

FLOP : 0

FTIM : 0.000

MA : 1

IOMOPT: 1

SCI : 3

PNT_NO: 11

IOM_ID: AIN116

XREFOP: N

DEV_ID: 001252

PROPT : N

KSCALE: 1.00

BAD : N

BSCALE: 0.0000

BAO : N

BADOPT: 3

LASTGV: Y

ACK

CLOSE OVL

SOURCE

TOGGLE

LOCK

A/M

Figure 4.5: Foxboro DCS AIN compound block configuration for SO₂ detection loop A131_1 showing module assignment, scan period, and scaling parameters.

4.5.2 Alarm Threshold Configuration

Alarm thresholds were defined in accordance with UK workplace exposure limits (EH40/2005) [3]. The AL1 High alarm at 1 ppm provides early warning aligned with the short-term exposure limit (STEL), while the AL2 High-High alarm at 2 ppm represents a significant exceedance requiring immediate evacuation. The configured alarm setpoints are shown in Figure 4.6, confirming High (MEASHL) and High-High (HHALIM) limits with latching behaviour enabled.

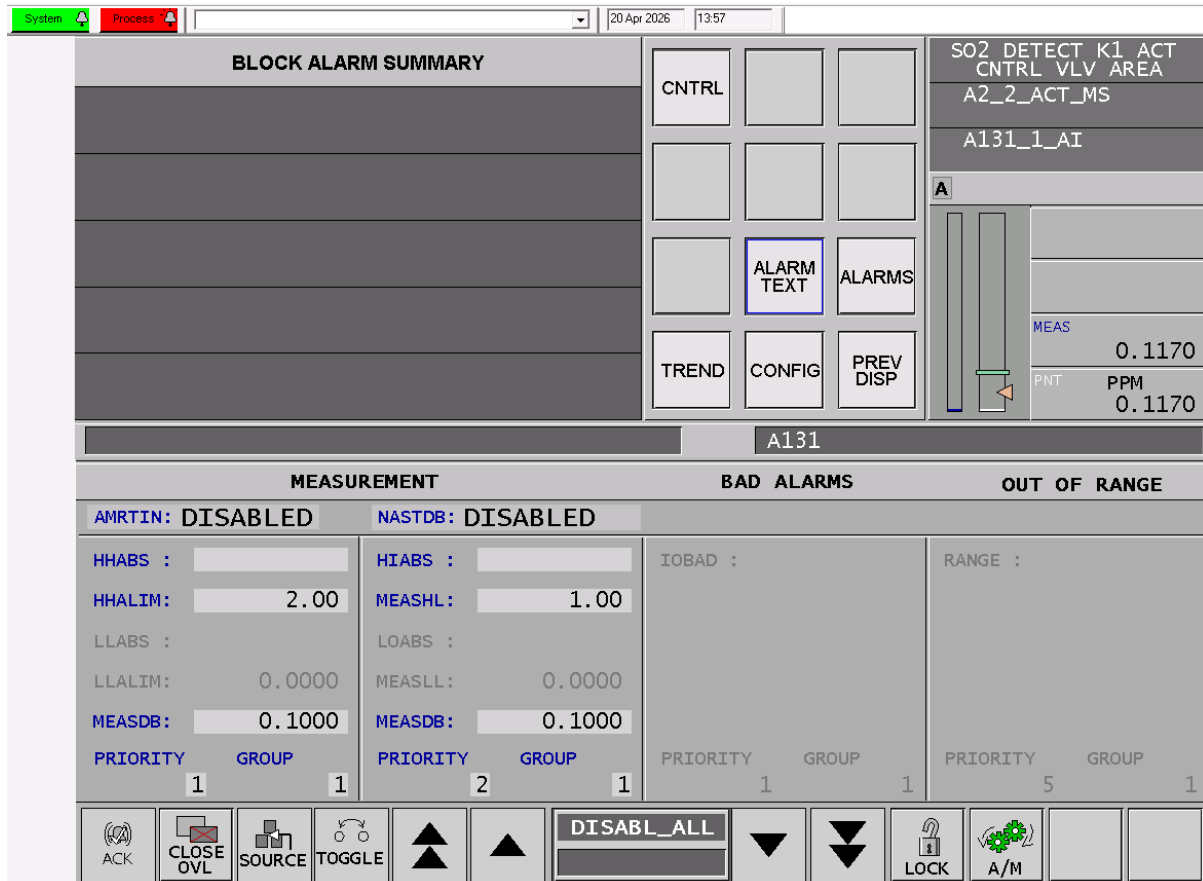


Figure 4.6: Foxboro DCS alarm configuration for SO₂ detection loop A131_1 showing AL1 (1 ppm) and AL2 (2 ppm) thresholds.

4.5.3 Digital Input and Output Configuration

Digital output and input blocks were configured to drive the physical alarm devices and monitor the evacuation defeat key status for each kiln system. The Kiln 1 block assignments are summarised in Table 4.6.

Table 4.6: Foxboro DCS digital output and input block assignments, Kiln 1 SO₂ detection system.

DCS Compound Tag	Description	IOM ID	Point No	Function
A2_2_ACT_MS:A131_1_DO	Kiln 1 SO ₂ Alarm Beacon	COO101	14	Beacon output closes on any High alarm
A2_2_ACT_MS:A131_2_DO	Kiln 1 SO ₂ Alarm Sounder	COO101	15	Sounder output closes on High, opens on acknowledge
A2_2_ACT_MS:A131_3_DO	Kiln 1 SO ₂ Evacuation	COO101	16	Evacuation output normally closed, opens on High-High
A2_2_ACT_MS:HS_A131_1_DI	Kiln 1 Evacuation Defeat	CIN110	14	Defeat key status monitor

The evacuation output is configured as a normally closed contact, which opens on an AL2 High-High condition to initiate the evacuation alarm. This fail-safe arrangement ensures that loss of power or signal also results in an evacuation condition, maintaining system integrity.

4.5.4 Alarm Logic Implementation

The Foxboro DCS compound block processes the 4–20 mA signal from each Crowcon Xgard Type 1 transmitter via the P+F KFD0-CS-Ex1.50P galvanic isolator. A signal below 4 mA is interpreted as an IO Bad fault condition, generating a FAULT alarm on the HMI to alert operators to a loop or instrument failure. Signals at or above 4 mA are linearly scaled to engineering units and evaluated against the configured alarm thresholds.

The overall alarm logic structure implemented within the system is illustrated in Figure 4.7.

DCS Alarm Logic Flow Diagram

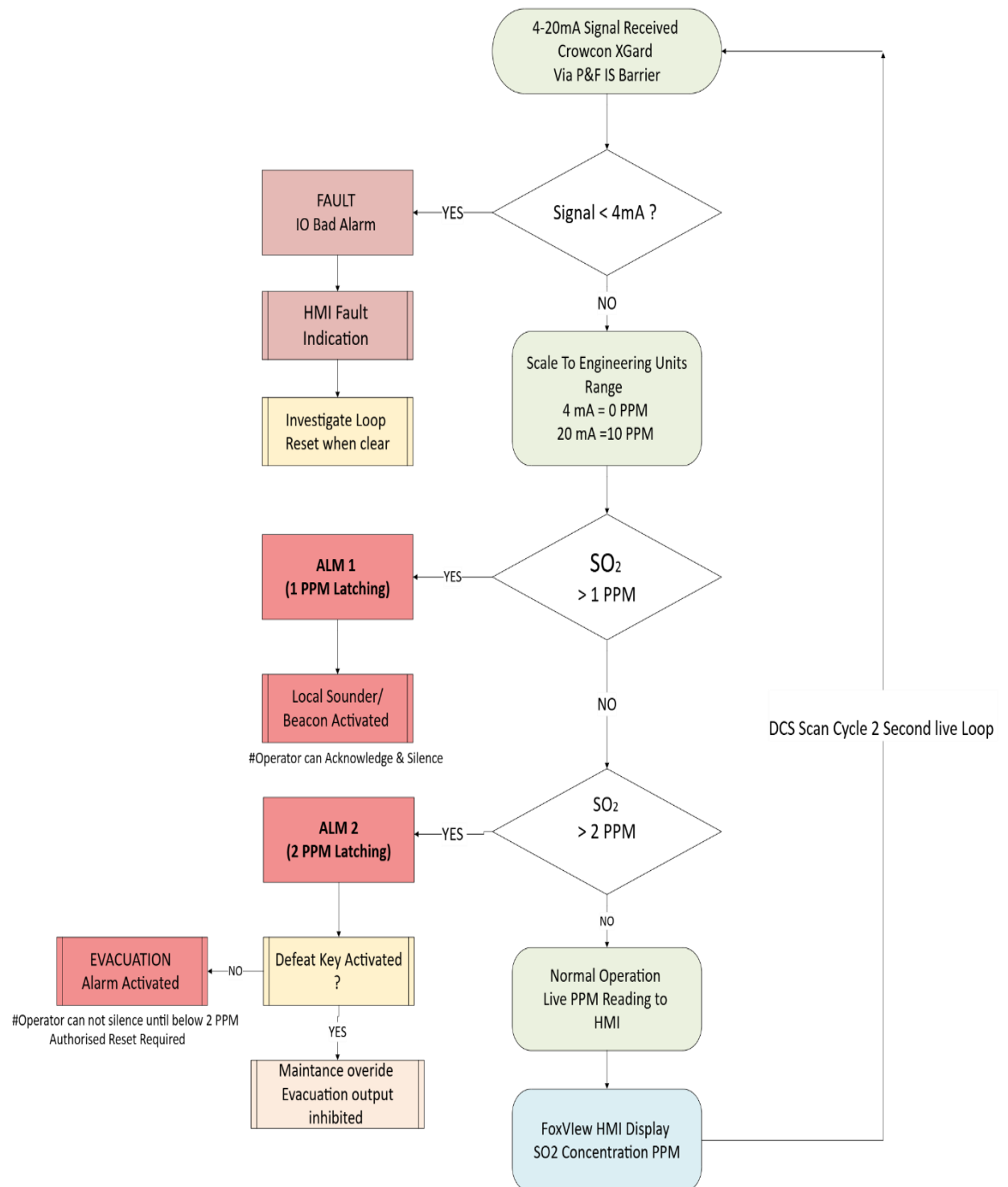


Figure 4.7: SO₂ detection system alarm logic flow diagram showing signal processing, fault detection, alarm thresholds, and system response.

When SO₂ concentration reaches or exceeds 1 ppm, the DCS generates a digital output to activate the local sounder and beacon in the affected kiln area. This AL1 alarm latches on activation and can be acknowledged and silenced by the operator whilst remaining displayed on the HMI until the concentration falls below 1 ppm and a manual reset is carried out. When SO₂ concentration reaches or exceeds 2 ppm, the DCS opens the normally closed evacuation relay contact, initiating the main plant evacuation alarm. This AL2 alarm latches and cannot be silenced until the SO₂ concentration falls below 2 ppm and is acknowledged by authorised personnel. Where a defeat key is active at the gas detection defeat panel, the associated Omron relay is de-energised, isolating the SO₂ evacuation output from the main evacuation circuit for that kiln area without affecting other evacuation triggers.

The alarm logic was implemented within the Foxboro Integrated Control Configurator (ICC) using structured logic blocks to combine multiple detector inputs and generate unified alarm outputs. Boolean OR logic is used to determine if one or more detectors are in a high alarm state, ensuring that any single detector entering alarm will activate the local warning system. Additional logic paths process unacknowledged alarm conditions to maintain sounder activation until operator acknowledgement is completed. Inhibit signals are incorporated to allow detectors to be safely isolated during maintenance without affecting overall system operation. The implemented ICC logic is shown in Figure 4.8.



Figure 4.8: Foxboro ICC logic block A131_LG showing implementation of SO₂ alarm logic using Boolean operations to combine multiple detector alarm states, including high alarm, unacknowledged, and inhibit conditions.

The alarm logic is summarised in Table 4.7.

Table 4.7: DCS alarm logic configuration SO₂ detection system.

Condition	Threshold (ppm)	Signal (mA)	DCS Response	Operator Action
Normal operation	0–1	4.0–5.6	No alarm	None
AL1- High	≥ 1	5.6	Sounder/beacon (latching)	Acknowledge & reset
AL2- High-High	≥ 2	7.2	Evacuation alarm (latching)	Cannot silence until safe
FAULT	Loop fault	< 4.0	IO Bad — FAULT alarm	Investigate and reset

The two-tier alarm threshold configuration, with latching behaviour at both levels, is consistent with established alarm management principles for industrial process control systems [22].

4.5.5 System Monitoring and Validation

The live AIN faceplate display for detector A131_1 is shown in Figure 4.9, confirming correct system operation under normal plant conditions. The display shows real-time SO₂ concentration in ppm, alongside raw signal and scaling parameters, verifying correct signal conversion and stable measurement performance.

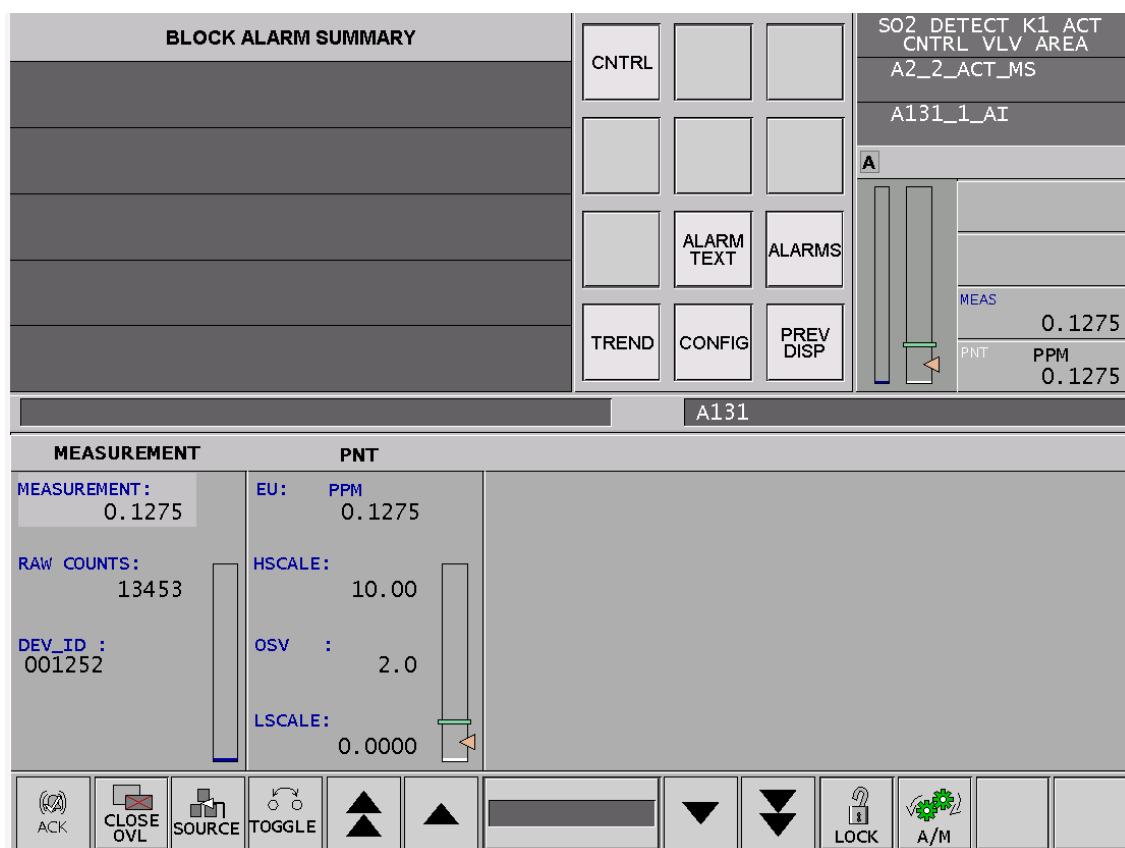


Figure 4.9: Foxboro DCS AIN faceplate display for SO₂ detection loop A131_1 showing live measurement and scaling in engineering units.

4.6 Evacuation Alarm Tie-In

Integration of the SO₂ detection system with the plant evacuation alarm was achieved through modification of the existing Gas Detection Evacuation Defeat Panel, located outside the control room on the Kiln 1 side. The panel was already established on site as part of the existing gas detection infrastructure, allowing the new SO₂ system to utilise the existing plant-wide alarm architecture without the need for additional standalone equipment.

When an AL2 High-High condition of 2 ppm is reached on any detector, the DCS generates a digital output which drives Omron G2R-2 24VDC interface relays within the defeat panel, one assigned to Kiln 1 and one to Kiln 2. The relays are configured as normally closed contacts in a fail-safe arrangement. The contact opens on an AL2 condition to initiate the plant evacuation alarm. Any loss of power, wiring fault, or relay failure also opens the circuit and triggers the alarm, rather than leaving the system in a silent fault condition. This approach is consistent with good engineering practice for safety-critical alarm systems within COMAH-regulated environments [4].

The relay contacts were integrated into the existing evacuation alarm circuit in a series configuration. The complete defeat panel external connections, including the SO₂ defeat relay coils, evacuation relay contacts, and DCS monitoring signals, are shown in Figure 4.10.

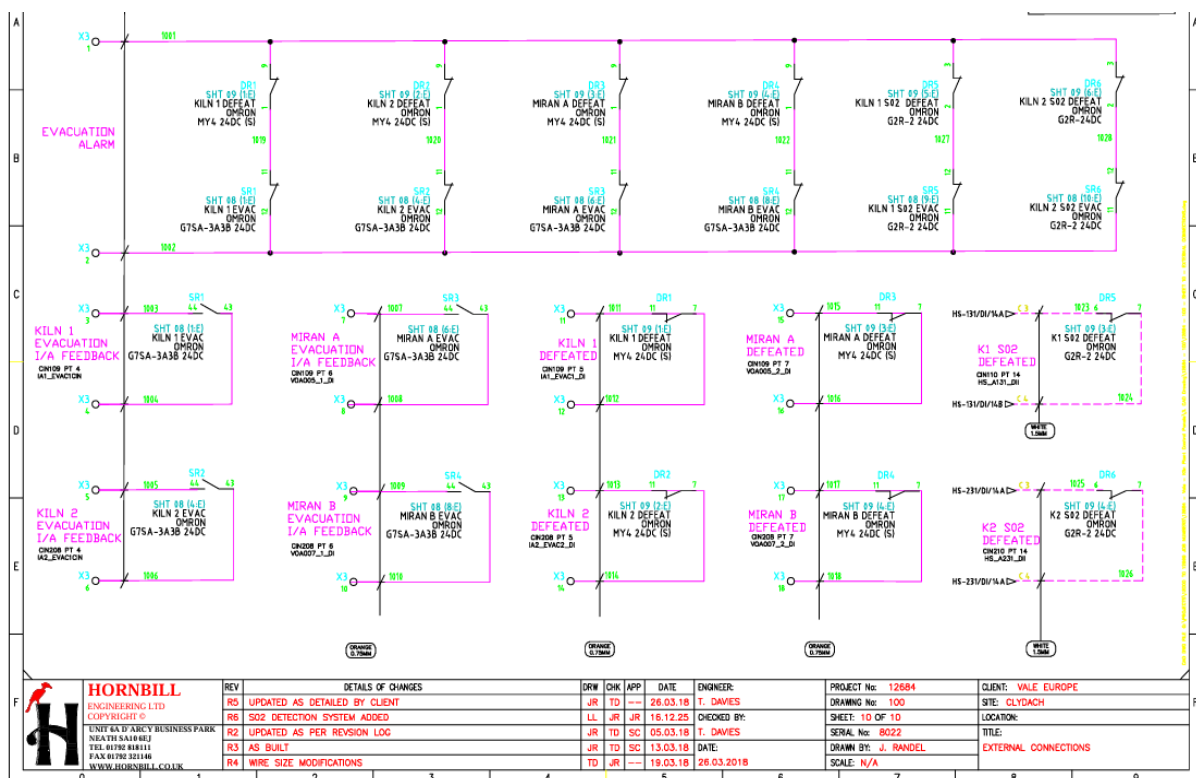


Figure 4.10: Evacuation defeat panel external connections drawing showing SO₂ defeat and evacuation relay integration with the existing plant evacuation alarm circuit, drawing (128A-000-19496).

Two spare key switch positions within the existing panel were utilised for the SO₂ defeat function, one for each kiln system. These allow the evacuation output to be isolated during planned maintenance or calibration without affecting other evacuation circuits. Defeat key status is monitored by the DCS and displayed on the HMI, ensuring operator awareness of any active override condition. Full wiring drawings for the evacuation relay interface are provided in Appendix J.

4.7 HMI Development

The Human Machine Interface (HMI) for the SO₂ detection system was developed using the Foxboro FoxView platform and integrated into the existing kiln plant graphical environment. This approach ensured consistency with established operator interfaces and avoided the introduction of standalone or unfamiliar displays.

A dedicated SO₂ detection overview screen was developed to provide operators with real-time gas concentration readings, detector status, and alarm indication across both Kiln 1 and Kiln 2 areas, as shown in Figure 4.11. Colour coded alarm indication was implemented to support rapid identification of abnormal conditions within the plant environment.

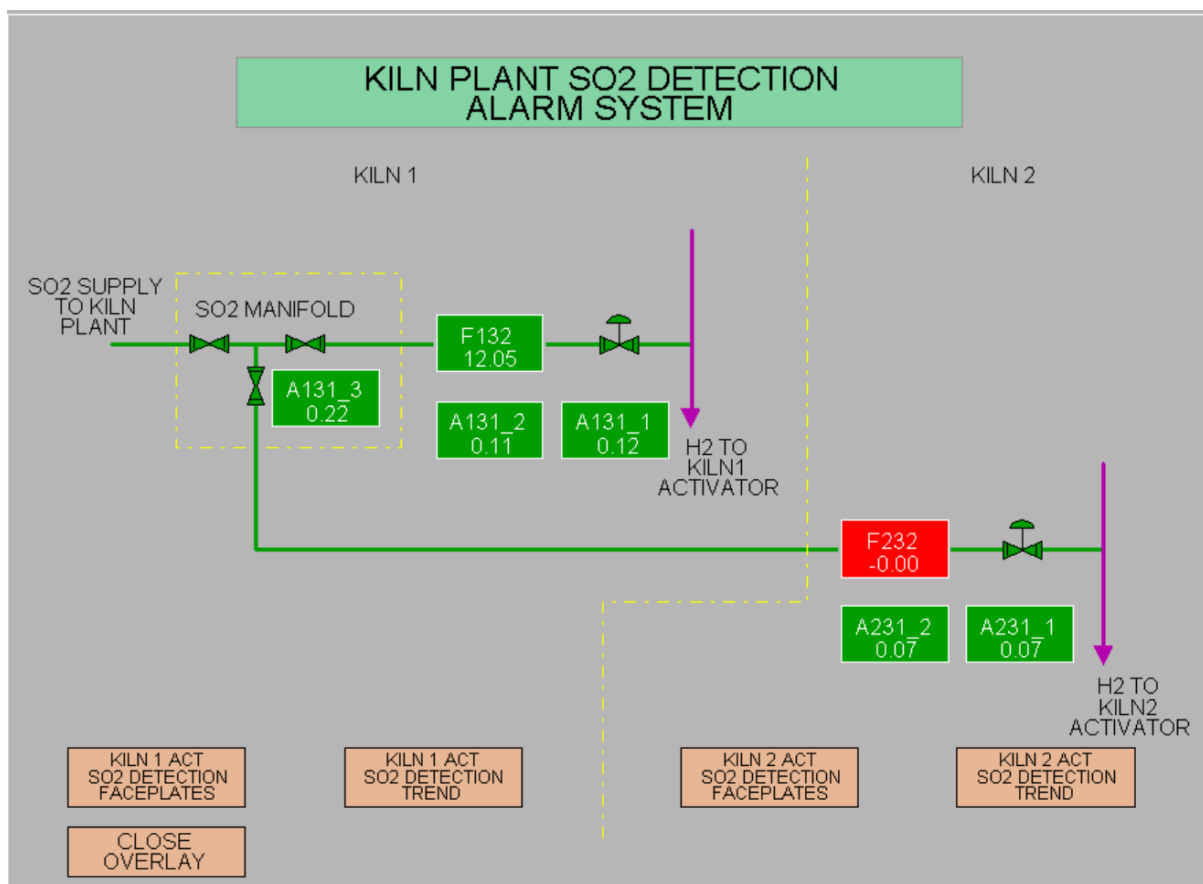


Figure 4.11: FoxView HMI overview screen for SO₂ detection system showing detector locations and live SO₂ concentration readings.

From the overview display, operators can navigate to dedicated faceplate and trend screens for each kiln system. The faceplate display, shown in Figure 4.12, provides detailed information for each detection loop, including real time measurement, alarm

status, and scaling parameters, while maintaining standard Foxboro operator functionality.

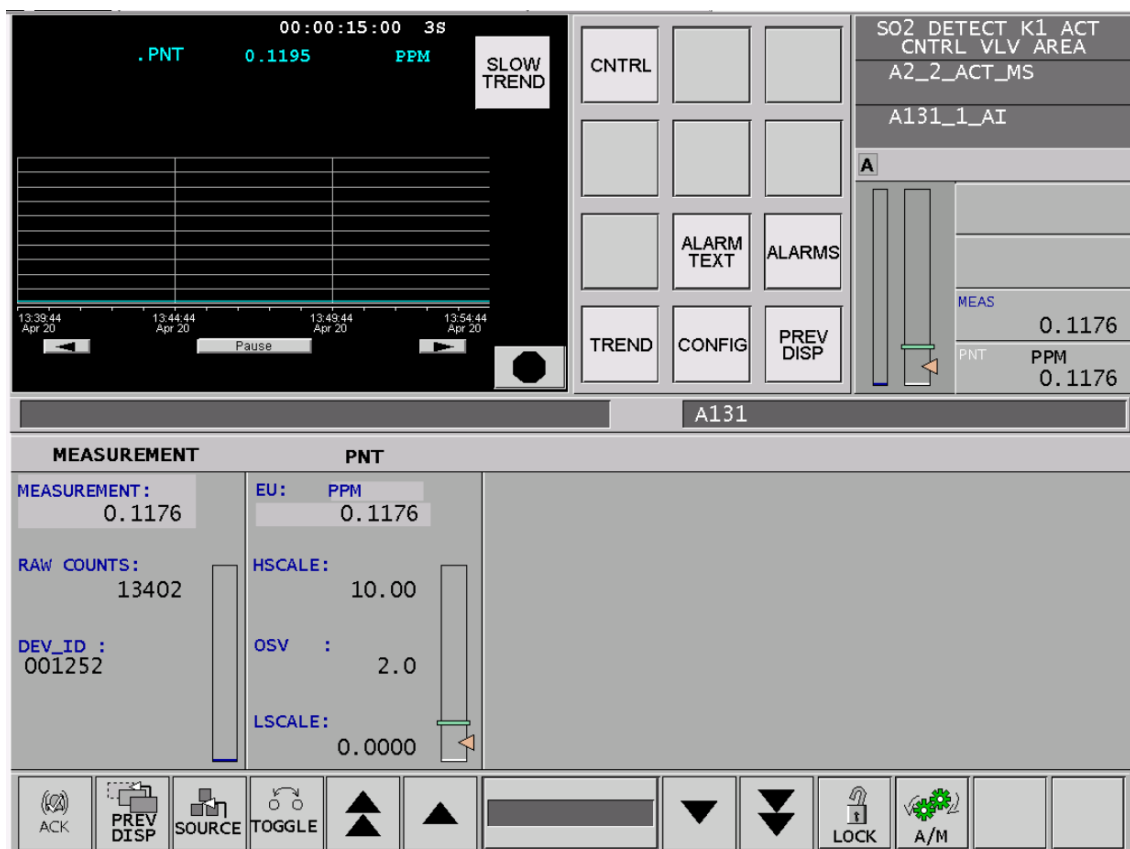


Figure 4.12: FoxView HMI faceplate display for SO₂ detection loop showing real-time measurement and alarm status.

Trend displays were implemented to support operational monitoring and post-event analysis of SO₂ concentration data, as shown in Figure 4.13.

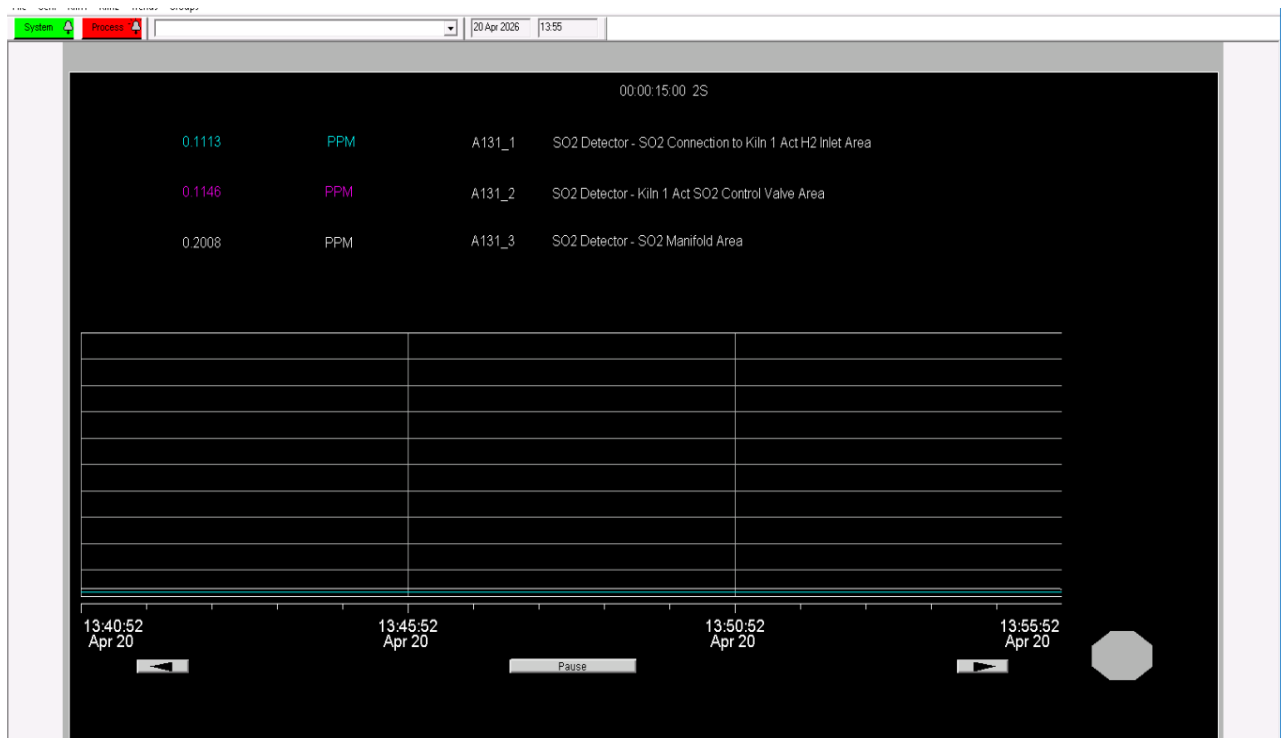


Figure 4.13: FoxView HMI trend display for SO₂ detection system showing time-based variation in SO₂ concentration.

Alarm annunciation was integrated within the DCS in accordance with existing plant alarm management practices [22], with separate indication for AL1 and AL2 conditions and operator acknowledgement functionality.

The HMI also provides indication of system status, including detector faults and evacuation defeat conditions, ensuring that operators remain aware of any inhibited or abnormal system states.

The HMI design was developed in alignment with existing plant graphical standards to maintain operator familiarity and minimise training requirements. Operator training was undertaken to support system introduction, with supporting documentation provided to explain system functionality, navigation, and alarm behaviour.

Additional HMI screens developed to support operator familiarisation and system training are included in Appendix K.

4.8 Physical Installation Overview

All installation works were completed under Vale's permit-to-work system in accordance with approved Risk Assessments and Method Statements [19]. Following installation, a formal DSEAR detailed inspection was completed in accordance with BS EN 60079-17 [11], with all inspection results recorded as satisfactory.

All five detectors were installed on Unistrut fixings at low level, positioned directly below or adjacent to flange, manifold, and valve body locations identified as the most probable SO₂ release points. This positioning reflects the physical behaviour of SO₂ as a gas denser than air, which tends to accumulate at low levels, ensuring effective detection of potential releases. A representative installation is shown in Figure 4.14.



Figure 4.14: Crowcon Xgard Type 1 SO₂ detector installed at low level on Unistrut fixing adjacent to process flange, Kiln 1 activation area.

Two intrinsically safe marshalling panels were installed within the kiln areas to house galvanic isolators and associated wiring terminations. All intrinsically safe circuits were segregated from non-IS wiring in accordance with IEC 60079-14 [7]. The installed IS panel is shown in Figure 4.15.

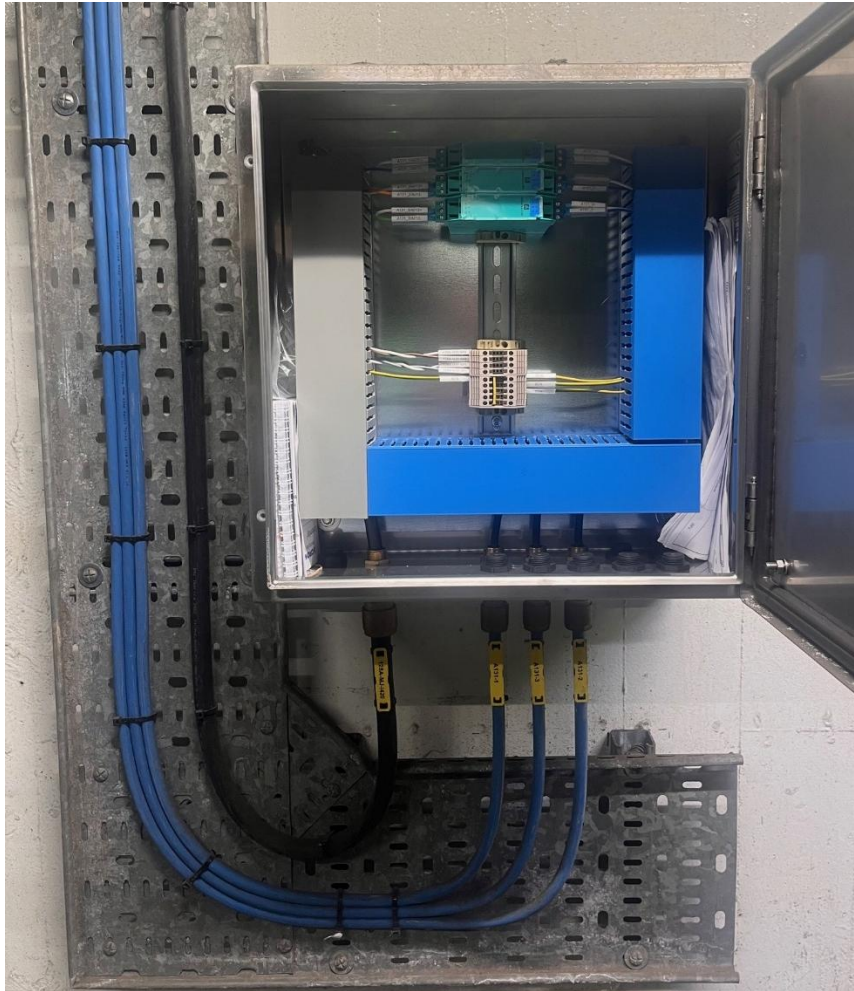


Figure 4.15: IS panel 128A-MB-I-030 showing installed Pepperl+Fuchs KFD0-CS-Ex1.50P galvanic isolators and intrinsically safe wiring, Kiln 1 hazardous area.

Clifford and Snell YL40 sounder/beacon units were installed outside the Zone 2 boundary at each kiln area, providing audible and visual alarm indication in response to elevated SO₂ concentrations. The installed sounder/beacon is shown in Figure 4.16.



Figure 4.16: Clifford and Snell YL40 sounder/beacon installed outside Zone 2 boundary, Kiln 1 activation area.

Cable installation utilised existing cable tray and containment routes where possible, with additional Unistrut supports installed where required. Hazardous area cable glands of the Hawke 501/453 type were used for all cable entries into hazardous area equipment, with Hawke 153/RAC glands applied in safe area locations, in accordance with DSEAR requirements [6]. Full installation photography and the Kiln 1 cable block diagram are provided in Appendix H, K.

4.9 Operator Training

Operator training was undertaken to support the introduction of the SO₂ detection system and ensure effective use within the plant environment. Training was delivered across all shift groups over a two-week period, covering approximately 30 personnel.

The training programme included both control room and field-based elements. Operators were provided with demonstrations of the HMI graphics, including system functionality, expected operating values, and alarm response procedures. In addition, physical plant walkthroughs were conducted to familiarise personnel with detector locations and system layout within the kiln areas.

A structured training aid incorporating detector locations, tag references, and alarm response instructions was developed and issued to operators, as shown in Figure 4.17. This documentation was designed to support both initial training and ongoing reference during normal plant operation.

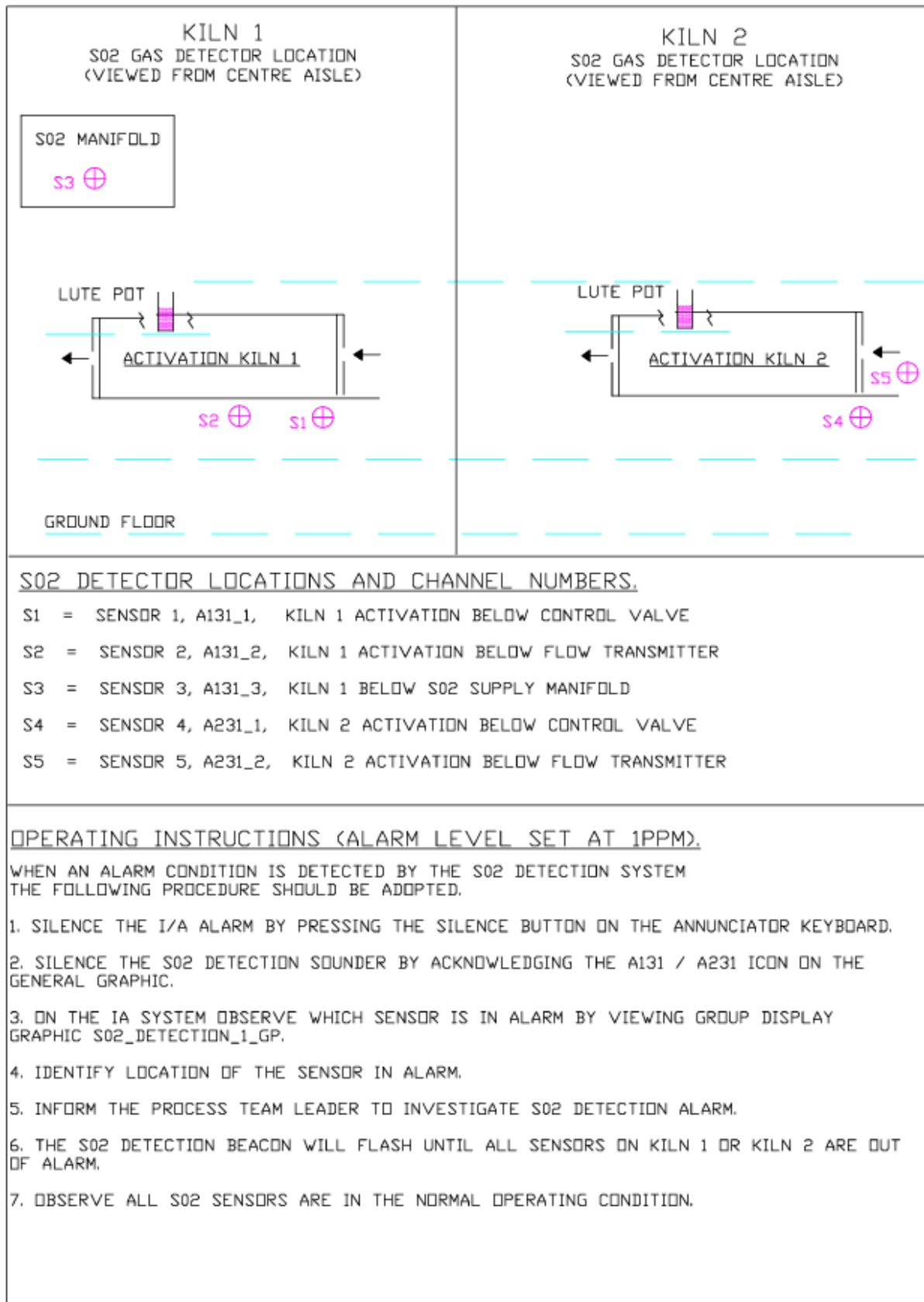


Figure 4.17: Operator training document showing SO₂ detector locations, channel identification, and alarm response procedure for kiln areas.

Supporting documentation, including annotated HMI graphics and additional guidance material, is provided in Appendix K.

4.10 Project Costing

The project was approved under a capital expenditure budget of approximately £10,000, sanctioned as a safety-critical improvement project. Table 4.8 presents the estimated and actual costs for all principal project elements.

Table 4.8: Project cost summary, SO₂ detection system.

Item	Supplier	Reference	Estimated Cost (£)	Actual Cost (£)
Pepperl+Fuchs KFD0-CS-Ex1.50P IS barriers x6	R&M Electrical Group Ltd	Quote 0016/1606534 4	1,350	1348
Crowcon Xgard Type 1 SO ₂ detectors x5	Crowcon Detection Instruments	/19934 (XG1 SO2)	6165	4465
Crowcon commissioning and calibration visit	Crowcon Detection Instruments	Call SETW 065476	810	990
OCU Group installation/ Materials (cable/ glands/ Panels)	OCU Group	Internal	3000	3150
Schneider Electric DCS Support	Schneider Electric	Existing Site service contract	Included	Included
Total			11325	9953
CAPEX budget			10,000	

The project was delivered within the approved CAPEX budget of £10,000, with a final actual cost of £9,953. Three principal cost savings contributed to this outcome. The selection of the Crowcon Xgard Type 1 in place of the initially evaluated XgardIQ model, quoted at £6,995 ex VAT, represented a significant reduction in detector procurement cost while still meeting the functional requirements of the application.

Further cost savings were achieved through utilisation of spare analogue capacity within the existing Foxboro modules, eliminating the need for additional DCS hardware. In addition, the selection of a loop-powered galvanic isolator barrier removed the requirement for a separate 24VDC instrument supply circuit, reducing both material and cable installation costs.

Installation labour costs were further minimised through the direct involvement of inhouse engineering resources, with elements of the design, configuration, and commissioning activities undertaken internally under the existing site engineering contract. Supporting procurement documentation is provided in Appendix L.

4.11 Summary

This chapter has presented the design and implementation of the SO₂ detection system, including field instrumentation selection, intrinsically safe circuit design, control system integration, and HMI development. The physical installation of the system within a live plant environment has been demonstrated, supported by inspection and verification in accordance with relevant hazardous-area standards.

In addition, practical aspects of deployment have been addressed, including operator training and system familiarisation to ensure effective use within the plant. Project costing has also been considered, demonstrating that the system was delivered within the approved CAPEX budget through appropriate equipment selection and utilisation of existing control system infrastructure.

The resulting system provides continuous monitoring of SO₂ concentrations within the activation kiln area, with integrated alarm and evacuation functionality to support personnel safety. The engineering documentation, verification records, and commissioning evidence associated with the implemented system are presented in Chapter 5.

5 Engineering Documentation and System Verification

5.1 Introduction

This chapter documents the principal engineering deliverables produced throughout the project. The outputs span engineering design documentation, hazardous-area compliance records, control system configuration, commissioning, and supporting operational documentation generated during implementation of the SO₂ detection system.

5.2 Engineering and Design Documentation

The following engineering design documents were produced prior to installation and retained within the project file:

- IS Loop Drawings AutoCAD Electrical ×5
One drawing per detection circuit defining the complete signal path from detector terminal through intrinsically safe barrier, marshalling interface, and DCS termination. Drawings were produced to Vale instrumentation draughting standards and reviewed prior to installation.
- Cable Block Diagram
Defining cable routing, containment strategy, cable types, and termination references for both Kiln 1 and Kiln 2 systems.
- SO₂ Detector Location Drawing
Identifying the installed detector positions across both kiln hazardous areas.
- IS Entity Parameter Verification Calculations x5
Completed for all five detection loops to confirm compliance with IEC 60079-11 [10] prior to energisation. A representative calculation for loop A131_1 is presented in Chapter 4.
- Intrinsically safe Marshalling box Panels
Defining barrier allocation, terminal arrangements, and cable segregation within the intrinsically safe panel in accordance with IEC 60079-14 [7].
- Defeat Relay Modification Drawing
Produced to document relay installation and wiring modifications to the existing gas detection evacuation defeat panel.

Representative engineering drawings and calculations are provided in Appendix B.

5.3 DSEAR Compliance Dossier

The following documents were compiled as part of the hazardous-area compliance dossier for the installation:

- Site area classification drawing confirming Zone 2 designation
- ATEX and IECEx certificates of conformity for all installed hazardous-area equipment
- DSD entity parameter verification calculation sheets ×5
- Intrinsically safe loop drawings as installed
- DSEAR detailed inspection schedule completed in accordance with BS EN 60079-17 [11]

Five DSEAR detailed inspections were completed following installation, one per detection loop, by the project engineer holding COMPEX qualifications Ex01, Ex04, and Ex14. All inspections were recorded as satisfactory with no remedial actions raised.

The completed DSEAR inspection schedule is included in Appendix C.

HORNBILL ENGINEERING LIMITED		Ex'ia'	
Inspection Schedule for Ex'ia' Installations in accordance to BS EN 60079-17 Table 2			
DSEAR Tag	K1346	Item Identity	NA
Field Device	SO2 DETECTOR	Manufacturer	CROWCON
ATEX Description	Ex ia IIC T4 Ga	Field Junction Box	128A-MB-I-030
ATEX Certificate No.	BASEEFA04ATEX0115X	Cable 1	A131-1
Type Number	XGARD TYPE 1	Cable 2	NA
Serial Number	W369319-004	Non-Conform Rating	SATISFACTORY
Model Number	NA	Safe Area Interface	PEPPERL+FUCHS KFD0-CS-Ex1.50P
Site Name	VALE	Grade of Inspection	Detailed
Area of Plant	KILN 1		
APPARATUS			
A1	Apparatus is appropriate to area classification		OK
A2	Apparatus installed is that specified in the documentation - Fixed apparatus only		OK
A3	Circuit and/or equipment category and group is correct		OK
A5	Equipment temperature class is correct		OK
A6	Ambient temperature range of the apparatus is correct for the installation		OK
A8	Installation is Clearly Labelled		OK
A9	Enclosure, glass to metal sealing gaskets and/or compounds are satisfactory		OK
A10P	Physical Check - Cables, glands and blanking elements are correct, complete and tight		OK
A11	There are no unauthorised modifications		OK
A13	Barrier units or other safe area associated equipment in accordance with certification		OK
A14	Condition of enclosure gaskets is satisfactory		OK
A15	Electrical connections are tight		OK
A16	Printed circuit boards are clean and undamaged		OK
A17	The Maximum voltage Um of associated apparatus is not exceeded		OK
INSTALLATION			
B1	Type of cable is appropriate		OK
B2	Cable screens are earthed in accordance with drawings		OK
B3	There is no obvious damage to cable		OK
B4	Sealing of trunking, ducts, pipes and/or conduits is satisfactory		NA
B5	Point to point connections are all correct		OK
B6	Earth continuity is satisfactory (e.g. connections are tight and conductors are of sufficient cross-section)		OK
B7	Earth connections maintain the integrity of type of protection		OK
B8	The intrinsically safe circuit is isolated from earth or earthed at one point only (refer to documentation)		OK
B9	Insulation resistance is satisfactory		NA
B10	Separation is maintained between intrinsically safe and non-intrinsically safe circuits in common marshalling boxes		OK
B11	As applicable, short circuit protection of the power supply is in accordance with documentation		NA
B12	Special conditions of use (if applicable) are complied with		OK
B13	Cables not in use are correctly terminated		OK
ENVIRONMENT			
C1	Apparatus is adequately protected against corrosion, weather, vibration and other adverse factors		OK
C2	No undue accumulation of dust and dirt		OK
COMMENTS		CLIENT PROJECT REFERENCE PROJECT DESCRIPTION AREA CLASSIFICATION	VALE 23.ME.897 ATEX Inspection 2/Gc

Figure 5.1: DSEAR detailed inspection certificate confirming satisfactory result in accordance with BS EN 60079-17 [11].

5.4 Control System Configuration

Control system configuration was carried out within the Foxboro I/A Distributed Control System (DCS) in accordance with the Kiln Plant SO₂ Detection System I/A Configuration Specification, reference MoFC1747.

Analogue input blocks were configured for all five detection loops, defining signal allocation, engineering unit scaling from 4–20 mA to 0–10 ppm, alarm threshold parameters, and historical trending functionality. Digital output and digital input blocks were additionally configured to drive field alarm devices and monitor evacuation defeat key status.

Prior to live deployment, logic verification and alarm testing were undertaken within an offline engineering environment using simulated 4–20 mA signal injection. This allowed signal scaling, alarm annunciation, latching behaviour, and evacuation logic to be verified without impact to live plant operations.

HMI graphics were developed in accordance with existing kiln plant display standards to provide operators with real-time gas concentration indication, alarm annunciation, trend displays, and defeat key status monitoring across both kiln systems.

Representative control system configuration records are provided in Appendix I.

5.5 Commissioning Records

System commissioning was completed across two phases.

The first phase comprised 4–20 mA signal injection testing using a calibrated loop calibrator, verifying correct signal scaling, alarm activation at AL1 and AL2 thresholds, FAULT alarm generation on sub-4 mA signals, and correct latching and reset behaviour across all five detection loops.

The second phase involved bump-gas commissioning completed by a Crowcon Detection Instruments field service engineer using calibrated SO₂ mimic gas. Mimic gas was used in preference to live SO₂ to avoid introducing a toxic substance into the working environment unnecessarily during commissioning activities.

The system performed correctly during commissioning with no remedial actions identified. The Crowcon calibration and commissioning report is included in Appendix D.

KILN PLANT 1+2

Call no. SEW 065476

Order no. _____

Customer VALE EUROPE LTD
Site address CLYDACH REFINERY
CLYDACH
SWANSEA
WEST GLAMORGAN Postcode: SA6 5QR

Site contact JONATHAN ROBERTS
Tel no. _____
Mobile _____

Type of call:

- ☒ Contract
☐ Service
☐ Non-contract
☒ Commissioning
☐ Fault call
☐ Warranty
☐ Other
☐ Installation

Equipment details

Model: XCARD

S/N: SEE BELOW

Ancillary equipment: A/U + OUTPUT TO SITE
PLC - 7 EVAC ALARM

Chnl.	Prior zero	Calibration			Alarms			Range/Gas	Calibration Gas	Comments
		PRE-Cal	Max	Final	A1	A2	A3			
1	0	10.2	10+	10	1	2	10	0-10ppm SO2	10ppm SO2	W369319-001 A231-2
2	0	10.2	10+	10	1	2	10			W369319-002 A231-1
3	0	10.0	10+	10	1	2	10			W369319-003 A131-2
4	0	10.2	10+	10	1	2	10			W369319-004 A131-1
5	0	9.48	10+	10	1	2	10			W369319-005 A131-3
6										
7										
8										
9										
10	* ALL SENSORS DATE CODE 083									
11										
12										
13										
14										
15										
16										

Figure 5.2: Crowcon calibration and commissioning report for Kiln Plant 1 and 2 SO₂ detection system.

5.6 Summary of Project Deliverables

Table 5.1: Principal development and verification records.

Record / Document	Purpose	Status
IS loop drawings ×5	Intrinsically safe installation reference	Complete
Cable block diagram	Cable routing and termination reference	Complete
Detector location drawing	Detector installation reference	Complete
IS entity parameter calculations	Verification of IS loop compatibility	Complete
DSEAR detailed inspection schedule	Hazardous-area compliance verification	Complete
ATEX / IECEx certification records	Equipment certification verification	Complete
Configuration specification	DCS modification control	Complete
4–20 mA signal injection test records	Verification of analogue scaling and alarms	Complete
Crowcon commissioning report	Detector calibration and commissioning verification	Complete
Operator training documentation	Operational familiarisation and alarm response guidance	Complete

The chapter has documented the principal engineering deliverables produced throughout the project, including design documentation, hazardous-area compliance records, control system configuration, and commissioning records. Together, these outputs form a complete auditable record of the implemented SO₂ detection system and support its ongoing operation, maintenance, and verification.

System performance and evaluation against the original project objectives are presented in Chapter 6.

6 Results and Discussion

6.1 Introduction

This chapter presents the results obtained during commissioning and initial operation of the SO₂ detection and alarm monitoring system installed within the activation kiln areas at Vale Clydach Nickel Refinery. The results are evaluated against the original project objectives defined in Chapter 1, with discussion of system performance, commissioning activities, operational challenges, and areas identified for potential future improvement.

6.2 Signal Injection Test Results

Prior to bump-gas commissioning, 4–20 mA signal injection testing was carried out across all five detection loops using a calibrated Fluke loop calibrator. Signals were injected at five points across the full measurement range and verified against the DCS engineering display within an offline simulation environment, ensuring that live plant operations were not affected during testing. The results for all five loops are presented in Table 6.1.

Table 6.1: 4–20 mA signal injection test results all five SO₂ detection loops.

Loop	Location	4 mA	8 mA	12 mA	16 mA	20 mA	Result
A131_1	K1 Control Valve	0	2.5	5	7.5	10	PASS
A131_2	K1 Flow TX	0	2.5	5	7.5	10	PASS
A131_3	K1 SO ₂ Manifold	0	2.5	5	7.5	10	PASS
A231_1	K2 Control Valve	0	2.5	5	7.5	10	PASS
A231_2	K2 Flow TX	0	2.5	5	7.5	10	PASS

All values shown in ppm. Expected values based on linear scaling of 4 mA = 0 ppm and 20 mA = 10 ppm.

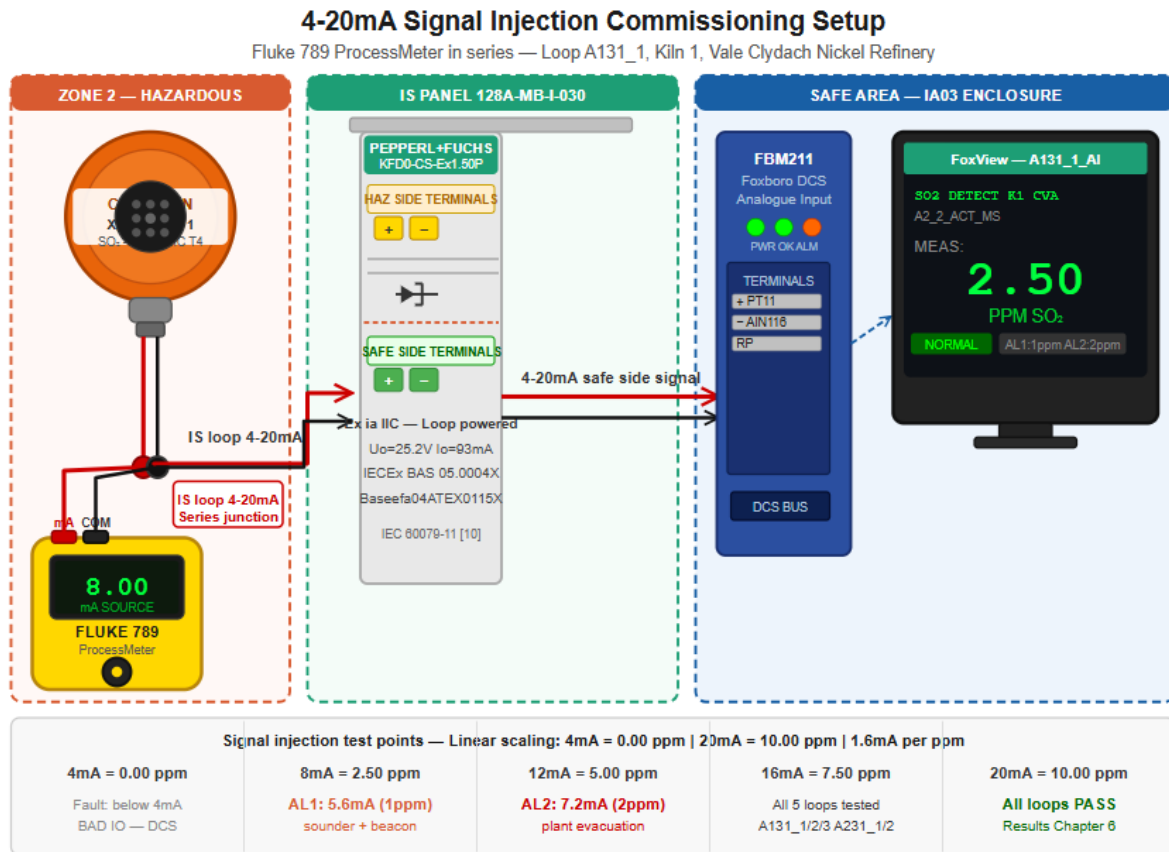


Figure 6.1: 4–20 mA signal injection testing using a calibrated Fluke loop calibrator during commissioning of SO₂ detection.

All five loops demonstrated correct linear scaling across the full measurement range, with DCS readings corresponding to expected engineering unit values at each injection point. Minor variations between expected and observed readings during commissioning were considered acceptable and consistent with normal instrumentation tolerance.

AL1 alarm activation was confirmed at 1 ppm on all loops, initiating local sounder and beacon outputs. AL2 alarm activation was confirmed at 2 ppm on all loops, initiating the evacuation alarm output. Based on the configured 0–10 ppm scaling range, alarm activation occurred at approximately 5.6 mA for AL1 and 7.2 mA for AL2.

Fault alarm generation was verified by simulating an open-circuit condition below 4 mA, producing a BAD IO indication on the DCS faceplate. Correct alarm latching and reset behaviour was confirmed during testing, with operator acknowledgement required before alarms cleared.

Individual loop calibration certificates are provided in Appendix M.

6.3 Bump Gas Commissioning Results

Following successful signal injection testing, bump-gas commissioning was carried out by a Crowcon Detection Instruments field service engineer using calibrated 10 ppm SO₂ mimic gas. Mimic gas was used in preference to live SO₂ to avoid introducing a toxic substance into the working environment unnecessarily during commissioning activities. The results of the final calibration phase are presented in Table 6.2

Table 6.2: Bump gas commissioning results final calibration phase.

Loop	Location	0 ppm Reading	5 ppm Reading	10 ppm Reading	Result
A131_1	K1 Control Valve	0.08 ppm	5.08 ppm	10.09 ppm	PASS
A131_2	K1 Flow TX	0.06 ppm	5.07 ppm	10.08 ppm	PASS
A131_3	K1 SO ₂ Manifold	0.06 ppm	5.07 ppm	10.08 ppm	PASS
A231_1	K2 Control Valve	0.07 ppm	5.08 ppm	10.07 ppm	PASS
A231_2	K2 Flow TX	0.00 ppm	5.08 ppm	10.09 ppm	PASS

Job Card No. 202301714847-20		Location No. KILN 2		Reference No. .		
Loop / Inst No: A231_1						
Type: S02 Detector [K2 Activation Control Valve Area]				Service: Activation S02 Mon		
Manufacturer: CROWCON				Serial No: W369319-04		
Model No: Xguard type 1						
Initial Calibration	Measurement	Instrument Input	Instrument Output	% Error	I/A Reading	STA Reading
		4mA	0 %		0 PPM	
		8mA	25 %		2.5 PPM	
		12mA	50 %		5.0 PPM	
		16mA	75 %		7.5 PPM	
		20mA	100 %		10.0 PPM	
Final Calibration	Measurement	Instrument Input	Instrument Output	% Error	Panel/Screen Reading	% Error
		0 PPM	40.1 mV		0.07 PPM	
		5 PPM	120.1 mV		5.08 PPM	
		10 PPM	199.9 mV		10.07 PPM	
IA04 FBM211 AIN216- PT11 Remarks: <u>Initial Calibration</u> 4-20mA for 0 – 10ppm Trip @ 1ppm Critical Alarm @ 2ppm Sounder Beacon Alarm operational <u>Final Calibration</u> Crowcon Engineer Calibration Gas of 10 PPM SO2 in nitrogen. S02 detector calibrated ok Signal checked back to DCS Loop Commissioned ok						
Calibration Checked by: J. Roberts / L. Lloyd				Date:		

Figure 6.2: Extract from calibration and commissioning certificate showing analogue scaling verification and alarm setpoints for loop A231_2.

All detectors demonstrated correct response to calibration gas, with displayed readings remaining within acceptable tolerance of expected values across the full operating range. Detector response following gas application was effectively immediate, with no abnormal drift or unstable readings observed during testing.

The Crowcon commissioning report, signed by both the Crowcon field service engineer and the project engineer, is provided in Appendix D.

6.4 Alarm Activation Results

Alarm activation was verified during signal injection testing and confirmed during bump-gas commissioning. Table 6.3 summarises the alarm verification results across both kiln systems.

Table 6.3: Alarm activation verification results.

Alarm	Threshold	Trigger Condition	Output	Result
AL1 High	1 ppm	Any loop exceeds 1 ppm.	Local sounder and beacon activated.	PASS
AL2 High-High	2 ppm	Any loop exceeds 2 ppm.	Plant evacuation alarm initiated.	PASS
Fault	Below 4mA	Open circuit or loop failure.	BAD IO displayed on DCS.	PASS
Defeat Key	Key Switch	Defeat key switch active.	HMI defeat indication active.	PASS

The sounder and beacon outputs were confirmed operational during AL1 activation, providing audible and visual indication within the kiln areas. Alarm latching behaviour was confirmed on all loops, requiring operator acknowledgement at the DCS before alarms cleared.

Operation of the evacuation defeat key system was also verified during testing. Correct indication of defeat status was confirmed at the HMI by operating the physical key switch located at the Gas Detection Evacuation Defeat Panel.

6.5 Evacuation Alarm Test

Verification of the plant evacuation alarm interface represented the most operationally significant commissioning activity completed during the project. Due to the potential impact of an unplanned evacuation on plant operations and personnel, the test was conducted during a weekend period of reduced site activity.

All relevant personnel were informed in advance, and the test was carried out in a controlled manner with plant operations and senior engineering staff in attendance. The DCS evacuation output was activated by simulating an AL2 condition, confirming correct operation of the main plant evacuation alarm.

The evacuation defeat key system was additionally verified during testing, confirming that the evacuation output could be safely isolated during maintenance activities without initiating the live plant alarm. The test was completed successfully with no operational issues encountered.

The controlled weekend testing approach adopted during this activity proved effective and would be recommended for similar future plant-wide alarm integration work on COMAH-regulated sites [19].

6.6 DSEAR Inspection Results

Five DSEAR detailed inspections were completed following installation, one per detection loop, in accordance with BS EN 60079-17 [11]. Inspection activities verified correct hazardous-area installation practices, equipment certification, cable segregation, and intrinsically safe wiring arrangements.

All five inspections were recorded as satisfactory with no remedial actions raised. Completed inspection schedules are provided in Appendix C.

6.7 System Performance

Following commissioning, the SO₂ detection system has operated continuously without significant fault or interruption. No SO₂ release events have been recorded since commissioning and the system has remained operational throughout this period, providing continuous monitoring capability across all five detector locations.

Historical trend data has remained stable during normal operation, with no evidence of nuisance alarms, signal instability, or abnormal detector drift observed during the initial operational period.

The system provides continuous 24-hour monitoring of key activation kiln process areas, with live gas concentration data available to operators through the FoxView HMI. Operator feedback following training and familiarisation activities has been positive, with no additional guidance requests or operational concerns raised by plant personnel.

The evacuation defeat key system has also functioned as intended, allowing maintenance activities to be completed without triggering unnecessary evacuation events.

6.8 Discussion

The commissioning and operational results demonstrate that the SO₂ detection and alarm monitoring system was implemented successfully and performs in accordance with the original design intent. Signal injection testing confirmed correct analogue scaling across all five detection loops, while bump-gas commissioning verified detector sensitivity and alarm functionality throughout the full operating range.

The completed system directly addresses the problem identified in Chapter 1. Prior to installation, SO₂ releases within the activation kiln area could only be identified through operator presence, olfactory detection, or activation of personal portable monitors. The implemented system now provides continuous fixed monitoring with a graduated alarm response, consisting of local sounder and beacon activation at 1 ppm and automatic plant evacuation initiation at 2 ppm.

Although the installed detector arrangement provides coverage of the highest-risk process areas, detector placement was influenced by project budget constraints and existing plant infrastructure. Additional detection points could further improve

monitoring coverage in less accessible areas and provide greater redundancy within the system.

The decision to select the Crowcon Xgard Type 1 detector over the initially evaluated XgardIQ model was validated during commissioning. The selected detector performed reliably within the loop-powered intrinsically safe design and achieved successful calibration and alarm verification without remedial modification.

The principal commissioning challenge arose during procurement when the initially supplied XgardIQ equipment was identified as incompatible with the intended loop-powered intrinsically safe design. The revised solution using the Pepperl+Fuchs KFD0-CS-Ex1.50P barrier was implemented successfully, although the issue resulted in a programme delay. This highlighted the importance of verifying equipment compatibility and loop architecture during the early stages of hazardous-area instrumentation projects.

The evacuation alarm tie-in test presented an additional operational challenge due to the risk of unintended plant evacuation during live testing. Conducting testing during a planned weekend period of reduced occupancy minimised operational disruption and provided a controlled environment for verification of the evacuation interface. This approach proved effective and demonstrated the importance of operational planning when integrating safety systems within live COMAH-regulated process facilities.

From a commercial perspective, the project was delivered within the approved CAPEX budget of £10,000, with a final installed cost of approximately £9,953. Cost savings achieved through appropriate equipment selection, utilisation of spare DCS infrastructure, and implementation of a loop-powered intrinsically safe design demonstrated that meaningful safety improvements can be delivered without excessive capital expenditure.

Two areas for potential future development were identified during the project. The first would involve implementation of an automatic SO₂ isolation valve interlock configured to close the incoming SO₂ supply on confirmed alarm activation. The second would involve expansion of detector coverage into adjacent kiln process areas to further improve overall monitoring capability.

6.9 Summary

The commissioning and operational results presented in this chapter confirm that the SO₂ detection and alarm monitoring system performs in accordance with the original design objectives across all five detection loops. Signal scaling, alarm activation, fault detection, and bump-gas response were all verified successfully during commissioning.

The completed system now provides continuous fixed monitoring of the activation kiln areas, representing a significant improvement in personnel safety and operational awareness within the SO₂ handling process areas at Vale Clydach Nickel Refinery.

7 Conclusions and Recommendations

7.1 Project Conclusions

The aim of this project was to design, implement, and commission a fixed SO₂ detection and alarm monitoring system for the activation kiln areas at Vale Clydach Nickel Refinery. Prior to implementation, detection of SO₂ releases within the kiln areas relied primarily on operator presence and portable gas monitoring equipment, creating the potential for delayed identification of hazardous gas release events.

The completed system successfully achieved the original project objectives defined in Chapter 1. Five fixed SO₂ detectors were installed across the Kiln 1 and Kiln 2 activation areas and integrated into the existing Foxboro I/A Distributed Control System using intrinsically safe 4–20 mA analogue input loops. The system now provides continuous monitoring of key process locations, with live concentration indication, alarm annunciation, historical trending, and evacuation alarm integration available through the FoxView HMI.

Commissioning activities confirmed correct signal scaling, alarm activation, fault detection, and evacuation alarm operation across all five detection loops. The implemented alarm philosophy operated as intended, with local sounder and beacon activation at 1 ppm and automatic plant evacuation alarm initiation at 2 ppm. Hazardous-area inspection activities additionally confirmed compliance with relevant DSEAR and intrinsically safe installation requirements.

The project also demonstrated that meaningful improvements in plant safety can be achieved through effective use of existing infrastructure and carefully selected equipment. By utilising spare DCS analogue input capacity and implementing a loop-powered intrinsically safe design, the completed system was delivered within the approved CAPEX budget while still meeting operational and safety requirements.

Although the installed detector arrangement provides coverage of the highest-risk process areas, detector placement was influenced by project budget constraints and existing plant infrastructure. Additional detection points could further improve monitoring coverage in less accessible areas and provide greater redundancy within the system.

Several challenges were encountered throughout the project, particularly during procurement and commissioning phases. The initial delivery of incompatible detector equipment highlighted the importance of equipment compatibility verification during specification and procurement activities. Integration and testing within a live COMAH-regulated process environment additionally required careful planning and coordination with plant operations to ensure commissioning activities could be completed safely without unnecessary operational disruption [19].

The project additionally demonstrated the importance of practical engineering problem-solving within a live industrial environment. Identifying a compatible loop-powered intrinsically safe barrier solution for the proposed 4–20 mA architecture proved particularly challenging and required consultation with specialist manufacturers during the design phase. Successful integration of the system with the existing Foxboro DCS and plant evacuation infrastructure also highlighted the importance of planning, commissioning strategy, and coordination with operations personnel when implementing safety systems within a live process facility.

Despite these challenges, the project was completed successfully and has provided a permanent fixed monitoring solution for SO₂ detection within the activation kiln areas. The system has improved operator awareness, reduced reliance on personnel-based gas detection, and introduced continuous monitoring and historical alarm trending capability within the process area. The project also demonstrated that meaningful improvements in industrial safety can be achieved through practical engineering design, effective use of existing infrastructure, and close coordination between engineering and operations teams.

7.2 Recommendations and Development

Although the implemented system achieved the original project objectives, several opportunities for future development were identified during commissioning and initial operation.

The first recommendation would involve implementation of an automatic SO₂ isolation interlock configured to close the incoming SO₂ supply valve following confirmed elevated gas detection. This would provide an additional layer of protection by isolating the source of a release rather than relying solely on alarm annunciation and operator intervention, particularly during periods of reduced plant occupancy.

A second recommendation would involve expansion of detector coverage into adjacent kiln process areas. Whilst the current installation provides monitoring at the highest-risk release locations, additional detectors could further improve overall monitoring capability and system redundancy within the wider process environment.

As additional operational trend data becomes available over time, future analysis of detector history may also assist in identifying recurring low-level release conditions, process faults, or maintenance issues within the SO₂ distribution system.

Periodic proof testing, calibration verification, and continued operator familiarisation should remain part of the long-term maintenance strategy to ensure continued system reliability and compliance with hazardous-area and plant safety requirements.

7.3 Final Project Outcome

This project successfully delivered a fully operational fixed SO₂ detection and alarm monitoring system integrated within a live industrial process environment. The project involved the complete engineering lifecycle, including design, hazardous-area verification, installation, DCS integration, commissioning, and operator training.

The completed system now provides continuous monitoring and improved protection for personnel working within the activation kiln areas at Vale Clydach Nickel Refinery, while also demonstrating the practical application of hazardous-area instrumentation, process safety engineering, and industrial control system integration within a real plant environment.

8 Reflection

8.1 Introduction

This project represented the most comprehensive engineering undertaking completed to date in a professional capacity. Whilst the project did not represent a first exposure to industrial engineering practice, it involved a significantly greater level of responsibility for complete project delivery than previously experienced. The project required management of the full engineering lifecycle within a live COMAH-regulated process environment, from initial concept and CAPEX justification through design, procurement, installation, commissioning, regulatory inspection, documentation, and operator training.

The experience developed both technical and professional competencies across multiple engineering disciplines and provided practical exposure to the responsibilities associated with leading a safety-critical project within a live industrial environment.

8.2 Technical and Professional Development

The project significantly developed my understanding of intrinsically safe system design and hazardous-area engineering. The IS loop design and entity parameter verification process required detailed understanding of the relationship between barrier parameters, field device certification limits, cable characteristics, and hazardous-area installation requirements. Producing and verifying the entity parameter calculations as the responsible engineer, rather than relying on third-party verification, represented a significant development in technical competency and engineering confidence.

One of the most valuable technical learning experiences involved identifying a compatible loop-powered intrinsically safe barrier solution for the proposed 4–20 mA architecture. Resolving the issue required consultation with specialist manufacturers and highlighted the importance of practical problem-solving and technical verification during hazardous-area system design.

Working directly to the requirements of DSEAR [6], COSHH [5], and COMAH [4] throughout the project also developed a broader understanding of how legislation and engineering design interact within a live industrial process environment. Rather than existing purely as compliance documentation, these requirements became active design considerations influencing equipment selection, installation methods, testing arrangements, and commissioning activities.

The project additionally provided practical application of existing COMPEX competencies through completion of DSEAR detailed inspections following installation. Carrying out the inspections as the competent person reinforced the importance of installation quality, documentation accuracy, and regulatory compliance within hazardous-area instrumentation projects.

Beyond the technical aspects, the project developed broader project engineering skills. Coordination of installation contractors, communication with the Crowcon commissioning engineer and Schneider Electric systems support, scheduling

commissioning activities around plant operational constraints, and delivering operator training across multiple shift groups all required planning, communication, and organisation in addition to technical engineering capability. Presenting the completed system and HMI functionality directly to plant operators also developed confidence in communicating technical information within an operational environment.

The project also improved confidence in producing formal engineering documentation. Translating practical engineering work into structured technical reports, commissioning records, drawings, and training documentation proved more challenging than the physical installation activities themselves. Developing the documentation required clear communication of technical information to both specialist and non-specialist personnel and reinforced the importance of accurate engineering records within safety-critical projects.

8.3 Challenges and Lessons Learned

Several challenges encountered throughout the project provided valuable learning opportunities. One of the principal issues arose during procurement when the initially supplied Crowcon XgardIQ detectors were identified as incompatible with the intended loop-powered intrinsically safe design. Following detailed technical review and manufacturer consultation, the detectors were returned and replaced with the Xgard Type 1, which proved suitable for the final installation.

Although the issue was resolved successfully, the experience highlighted the importance of detailed equipment compatibility verification during specification and procurement stages, particularly where intrinsically safe systems are involved. Identifying the issue before final installation prevented significantly greater cost and programme impact later in the project lifecycle.

A further challenge involved commissioning and integration of the plant evacuation alarm interface within a live operating plant. The potential consequences of incorrect wiring or unintended evacuation created additional pressure during final tie-in and commissioning activities. Careful planning, use of offline simulation testing, and controlled weekend commissioning arrangements proved essential in reducing operational risk during this stage of the project.

Carrying out live testing of the evacuation alarm interface within an operational plant environment also reinforced the importance of commissioning strategy and risk control. The requirement to coordinate testing during a low-occupancy weekend period demonstrated the operational challenges associated with modifying safety-critical systems within live process facilities.

The project also reinforced the importance of early coordination between all stakeholders involved in a project. Managing the installation programme around plant operational requirements, contractor availability, commissioning schedules, and live process constraints demonstrated that successful project delivery depends as much on planning and communication as technical design itself. The use of a structured project programme and Gantt scheduling approach proved particularly valuable in coordinating activities and maintaining progress during installation and commissioning phases.

8.4 Future Professional Development

This project strengthened confidence in managing multidisciplinary engineering work within a live industrial environment and reinforced an interest in project engineering within the process and hazardous-area industries. The experience of leading a project from initial concept through to operational handover provided practical understanding of the responsibilities associated with engineering decision-making, particularly where personnel safety and plant operation are directly affected.

The project also identified areas for continued professional development. Greater familiarity with Foxboro DCS compound block configuration and graphics development at the outset would have improved efficiency during the control system implementation phase. Continued development within industrial control systems and process safety engineering would therefore be beneficial for future projects of a similar nature.

Successfully delivering a fully operational SO₂ detection system from concept through to commissioning significantly strengthened both technical confidence and professional capability within industrial project engineering.

9 References

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10 Appendices

The appendices provide supporting documentation for the project, including calculations, technical drawings, system data, and additional materials referenced throughout the report. These documents support the design, implementation, and validation of the SO₂ detection system and are included separately to maintain clarity within the main body of the report.

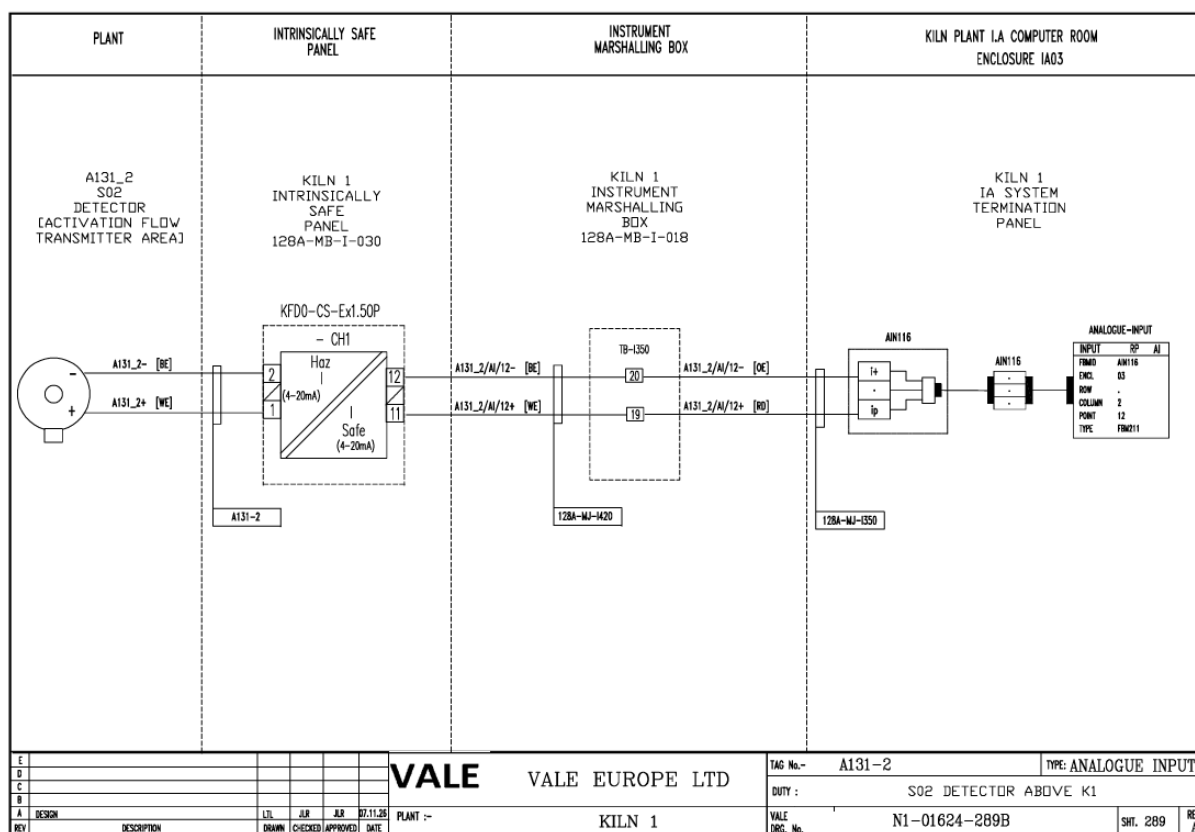
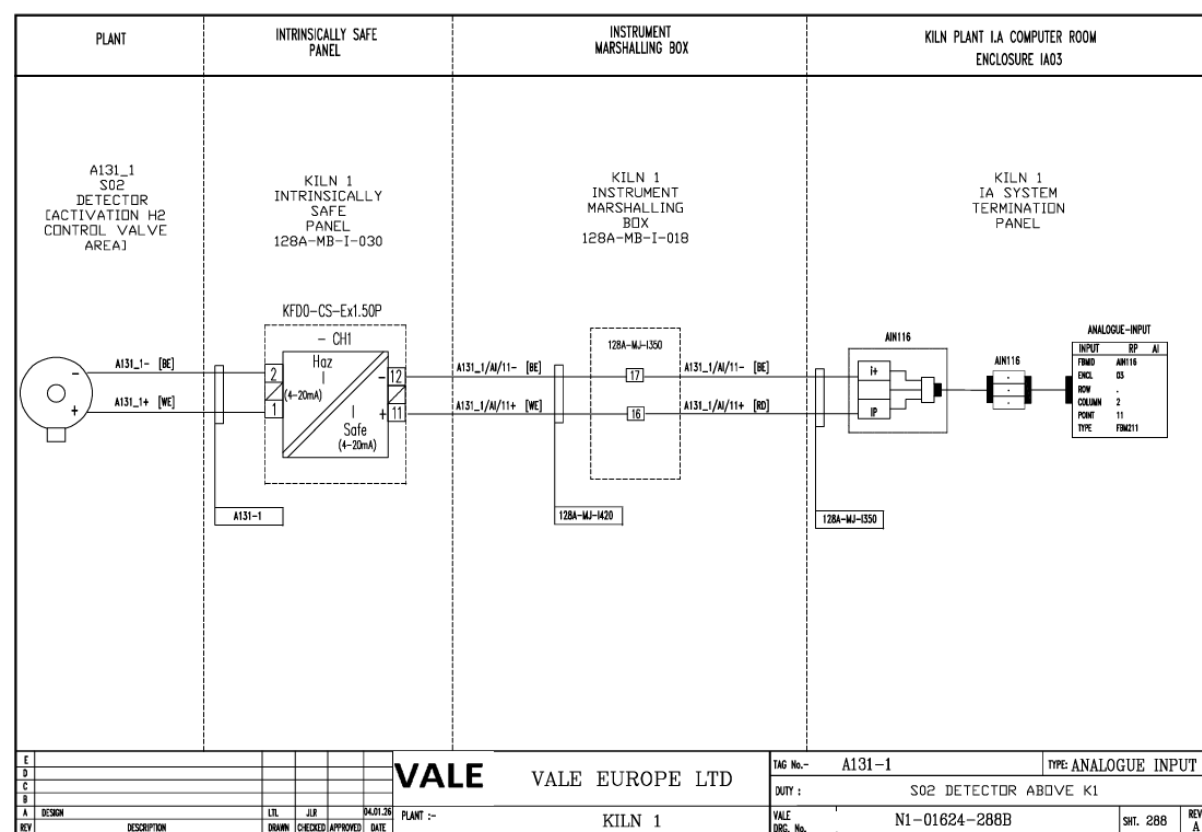
APPENDIX A: Intrinsically Safe Loop Calculations

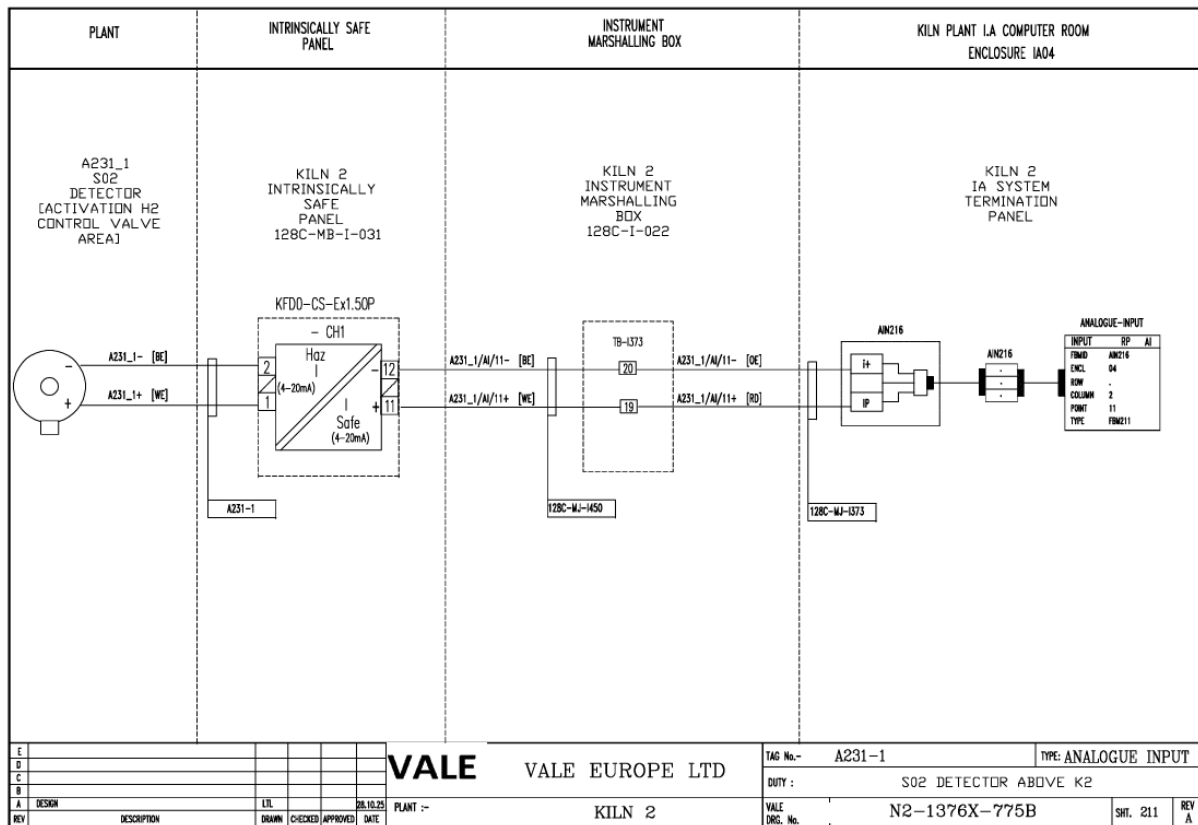
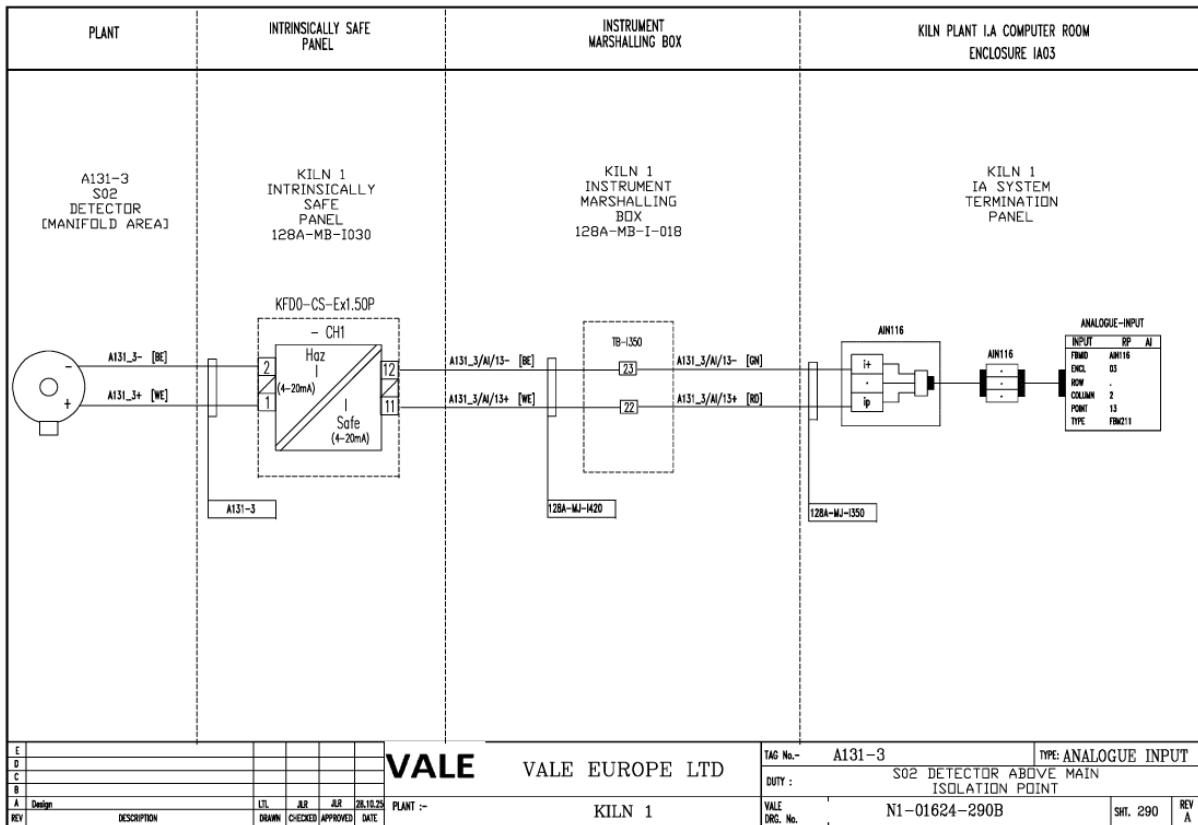
 VALE VALE EUROPE LTD CLYDACH, SWANSEA Tel : 01792 842501		Compatibility sketch for a system comprising :- Pepperl + Fuchs Barrier Field IS Barria panel Marshalling Box S02 Detector		Name Drawn By: LL Date: 07.08.2025 Rev 1 Rev 2 Rev 3	Checked										
Plant Ref No: 128A		Instrument Loop No : A131_1 (K1346)		Plant Area UNIT: Activation K1											
Loop Description : Ref Drg: 128A-000-A131_1 KILN 1 REF: S02 DETECTION															
System suitable for :		EEx ia IIC		Temperature Rating : T4											
Barrier/Isolator detail Manufacturer: PEPPERL + FUCHS Model: TYPE KFD0-CS-EX*5 Certification Code: IEEx ia IIC Certificate Number: IECEX BAS 05.0004X		KFD0-CS-EX1.50P Analogue Input ENCL: 128A-MB-I-030		Gas/Dust: II (1) GD Gas Group: IIC <table border="1"> <tr> <th>Uo V</th> <th>Io mA</th> <th>Po W</th> <th>C μf</th> <th>L mH</th> </tr> <tr> <td>25.2</td> <td>93</td> <td>0.585</td> <td>0.107</td> <td>4.3</td> </tr> </table>		Uo V	Io mA	Po W	C μ f	L mH	25.2	93	0.585	0.107	4.3
Uo V	Io mA	Po W	C μ f	L mH											
25.2	93	0.585	0.107	4.3											
Cable Parameters Length, metres: 20 Capacitance, μ f/m: 0.00025 Inductance, mH/m: 0.000663				Total 0.005 μ f 0.01326 mH											
Cable Parameters Length, metres: 0 Capacitance, μ f/m: 0 Inductance, mH/m: 0				Total 0 μ f 0 mH											
Cable Parameters Length, metres: 0 Capacitance, μ f/m: 0 Inductance, mH/m: 0				Total 0 μ f 0 mH											
Field Equipment Detail Manufacturer: Crowcon Model: Xguard-Type1 Certification Code: Ex ia IIC T4 Certificate Number: Baseefa 04ATEX0115X		A131-1 S02 DETECTOR (H1346)		<table border="1"> <tr> <th>Uo V</th> <th>Io mA</th> <th>Po W</th> <th>Ci μf</th> <th>Li mH</th> </tr> <tr> <td>28</td> <td>300</td> <td>1.2</td> <td>0.0144</td> <td>0.028</td> </tr> </table> Gas/Dust: IIC 0.0194 0.04126 FIT FIT FIT 'OK' 'OK'		Uo V	Io mA	Po W	Ci μ f	Li mH	28	300	1.2	0.0144	0.028
Uo V	Io mA	Po W	Ci μ f	Li mH											
28	300	1.2	0.0144	0.028											
COMMENTS 24 vdc supply (loop powered) 4-20mA															
Form Ref No : ---		128A-A131-1													

 VALE VALE EUROPE LTD CLYDACH, SWANSEA Tel : 01792 842501	Compatibility sketch for a system comprising :- Pepperl + Fuchs Barrier Field IS Barria panel Marshalling Box S02 Detector		Name	Date	Checked										
	Drawn By	LL	07.08.2025												
	Rev 1														
	Rev 2														
Plant Ref No: 128A	Instrument Loop No: A131_2 (K1347)		Plant Area UNIT: Activation K1												
Loop Description : Ref Drg: 128A-000-A131_2 KILN 1 REF: S02 DETCTION															
System suitable for :			EEx ia IIC		Temperature Rating: T4										
Barrier/Isolator detail Manufacturer: PEPPERL + FUCHS Model: TYPE KFD0-CS-EX*5 Certification Code: IECEx ia IIC Certificate Number: IECEx BAS 05.0004X			KFD0-CS-Ex I.50 P Analogue Input ENCL: 128A-MB-I-030 Gas/Dust: II(1) GD Gas Group: IIC <table border="1"> <thead> <tr> <th>Uo/V</th> <th>Io mA</th> <th>Po/W</th> <th>C μf</th> <th>L mH</th> </tr> </thead> <tbody> <tr> <td>25.2</td> <td>93</td> <td>0.585</td> <td>0.107</td> <td>4.3</td> </tr> </tbody> </table>			Uo/V	Io mA	Po/W	C μf	L mH	25.2	93	0.585	0.107	4.3
Uo/V	Io mA	Po/W	C μf	L mH											
25.2	93	0.585	0.107	4.3											
Cable Parameters Length, metres: 25 Capacitance, μf/m: 0.00025 Inductance, mH/m: 0.000663			Total 0.00625 μf 0.01658 mH												
Cable Parameters Length, metres: 0 Capacitance, μf/m: 0 Inductance, mH/m: 0			Total 0 μf 0 mH												
Cable Parameters Length, metres: 0 Capacitance, μf/m: 0 Inductance, mH/m: 0			Total 0 μf 0 mH												
Field Equipment Detail Manufacturer: Crowcon Model: Xguard-Type1 Certification Code: Exia IIC T4 Certificate Number: Baseefa 04ATEX0115X			A131-2 S02 DETECTOR (H1347) <table border="1"> <thead> <tr> <th>UI/V</th> <th>II mA</th> <th>PI/W</th> <th>CI μf</th> <th>LI mH</th> </tr> </thead> <tbody> <tr> <td>28</td> <td>300</td> <td>1.2</td> <td>0.0144</td> <td>0.028</td> </tr> </tbody> </table> Gas/Dust: IIC 0.02086 0.044676 FIT FIT FIT OK OK			UI/V	II mA	PI/W	CI μf	LI mH	28	300	1.2	0.0144	0.028
UI/V	II mA	PI/W	CI μf	LI mH											
28	300	1.2	0.0144	0.028											
COMMENTS 24 vdc supply [loop powered] 4-20mA															

Form Ref No : ---	128A-A131-2
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 VALE VALE EUROPE LTD CLYDACH, SWANSEA Tel : 01792 842501	Compatibility sketch for a system comprising :- Pepperl + Fuchs Barrier Field IS Baria panel Marshalling Box S02 Detector		Name	Date	Checked										
			Drawn By	LL	08.08.2025										
			Rev 1												
			Rev 2												
			Rev 3												
Plant Ref No: 128C Loop Description : Ref Drg: 128C-000-A231_1		Instrument Loop No : A231_1 (K2284) KILN 1 REF: S02 DETECTION		Plant Area UNIT: K2 ACTIVATION											
System suitable for : EEx ia IIC Temperature Rating : T4															
Barrier/Isolator detail Manufacturer: PEPPERL + FUCHS Model: TYPE KFD0-CS-EX*5 Certification Code: [EEx ia] IIC Certificate Number: IECEX BAS 05.0004X			KFD0-CS-Ex L60 P Analogue Input ENCL : 128C-MB4-031 Gas/Dust: II (1) GD Gas Group: IIC <table border="1"> <thead> <tr> <th>U_b V</th> <th>I_o mA</th> <th>P_o W</th> <th>C_u μF</th> <th>L_u mH</th> </tr> </thead> <tbody> <tr> <td>25.2</td> <td>93</td> <td>0.585</td> <td>0.107</td> <td>4.3</td> </tr> </tbody> </table>			U _b V	I _o mA	P _o W	C _u μ F	L _u mH	25.2	93	0.585	0.107	4.3
U _b V	I _o mA	P _o W	C _u μ F	L _u mH											
25.2	93	0.585	0.107	4.3											
Cable Parameters Length, metres: 20 Capacitance, μ F/m: 0.00025 Inductance, mH/m: 0.000863			Total 0.005 μ F 0.01326 mH												
Cable Parameters Length, metres: 0 Capacitance, μ F/m: 0 Inductance, mH/m: 0			Total 0 μ F 0 mH												
Cable Parameters Length, metres: 0 Capacitance, μ F/m: 0 Inductance, mH/m: 0			Total 0 μ F 0 mH												
Field Equipment Detail Manufacturer: Crowcon Model: Xguard-Type1 Certification Code: Ex ia IIC T4 Certificate Number: Bascofa 04ATBX0115K			A231-1 S02 DETECTOR (K2284) <table border="1"> <thead> <tr> <th>U_b V</th> <th>I_o mA</th> <th>P_o W</th> <th>C_u μF</th> <th>L_u mH</th> </tr> </thead> <tbody> <tr> <td>28</td> <td>300</td> <td>1.2</td> <td>0.0144</td> <td>0.026</td> </tr> </tbody> </table> Gas/Dust: IIC FIT FIT FIT 0.0184 0.04126 'OK' 'OK'			U _b V	I _o mA	P _o W	C _u μ F	L _u mH	28	300	1.2	0.0144	0.026
U _b V	I _o mA	P _o W	C _u μ F	L _u mH											
28	300	1.2	0.0144	0.026											
COMMENTS 24 vdc supply [loop powered] 4-20mA															
Form Ref No : --- 128C-A231-1															







APPENDIX C: DSEAR Inspection Schedule

HORNBILL ENGINEERING LIMITED Ex'ia' Inspection Schedule for Ex'ia' Installations in accordance to BS EN 60079-17 Table 2			
DSEAR Tag	K1346	Item Identity	NA
Field Device	SO2 DETECTOR	Manufacturer	CROWCON
ATEX Description	Ex ia IIC T4 Ga	Field Junction Box	128A-MB-I-030
ATEX Certificate No.	BASEEFA04ATEX0115X	Cable 1	A131-1
Type Number	XGARD TYPE 1	Cable 2	NA
Serial Number	W369319-004	Non-Conform Rating	SATISFACTORY
Model Number	NA	Safe Area Interface	PEPPERL+FUCHS
Site Name	VALE	Grade of Inspection	KFD0-CS-Ex1.50P
Area of Plant	KILN 1		Detailed
APPARATUS			
A1	Apparatus is appropriate to area classification		☒ OK
A2	Apparatus installed is that specified in the documentation - Fixed apparatus only		☒ OK
A3	Circuit and/or equipment category and group is correct		☒ OK
A5	Equipment temperature class is correct		☒ OK
A6	Ambient temperature range of the apparatus is correct for the installation		☒ OK
A8	Installation is Clearly Labelled		☒ OK
A9	Enclosure, glass to metal sealing gaskets and/or compounds are satisfactory		☒ OK
A10P	Physical Check - Cables, glands and blanking elements are correct, complete and tight		☒ OK
A11	There are no unauthorised modifications		☒ OK
A13	Barrier units or other safe area associated equipment in accordance with certification		☒ OK
A14	Condition of enclosure gaskets is satisfactory		☒ OK
A15	Electrical connections are tight		☒ OK
A16	Printed circuit boards are clean and undamaged		☒ OK
A17	The Maximum voltage Um of associated apparatus is not exceeded		☒ OK
INSTALLATION			
B1	Type of cable is appropriate		☒ OK
B2	Cable screens are earthed in accordance with drawings		☒ OK
B3	There is no obvious damage to cable		☒ OK
B4	Sealing of trunking, ducts, pipes and/or conduits is satisfactory		☐ NA
B5	Point to point connections are all correct		☒ OK
B6	Earth continuity is satisfactory (e.g. connections are tight and conductors are of sufficient cross-section)		☒ OK
B7	Earth connections maintain the integrity of type of protection		☒ OK
B8	The intrinsically safe circuit is isolated from earth or earthed at one point only (refer to documentation)		☒ OK
B9	Insulation resistance is satisfactory		☐ NA
B10	Separation is maintained between intrinsically safe and non-intrinsically safe circuits in common marshalling boxes		☒ OK
B11	As applicable, short circuit protection of the power supply is in accordance with documentation		☐ NA
B12	Special conditions of use (if applicable) are complied with		☒ OK
B13	Cables not in use are correctly terminated		☒ OK
ENVIRONMENT			
C1	Apparatus is adequately protected against corrosion, weather, vibration and other adverse factors		☒ OK
C2	No undue accumulation of dust and dirt		☒ OK
COMMENTS		CLIENT PROJECT REFERENCE PROJECT DESCRIPTION AREA CLASSIFICATION	VALE 23.ME.897 ATEX Inspection 2/Gc

HORNBILL ENGINEERING LIMITED Ex'ia'

Inspection Schedule for Ex'ia' Installations in accordance to BS EN 60079-17 Table 2



DSEAR Tag	K1347	Item Identity	NA
Field Device	SO2 DETECTOR	Manufacturer	CROWCON
ATEX Description	Ex ia IIC T4 Ga	Field Junction Box	128A-MB-I-030
ATEX Certificate No.	BASEEFA04ATEX0115X	Cable 1	A131-2
Type Number	XGARD TYPE 1	Cable 2	NA
Serial Number	W369319-003	Non-Conform Rating	SATISFACTORY
Model Number	NA	Safe Area Interface	PEPPERL+FUCHS KFD0-CS-Ex1.50P
Site Name	VALE	Grade of Inspection	Detailed
Area of Plant	KILN 1		

APPARATUS	A1	Apparatus is appropriate to area classification	OK
	A2	Apparatus installed is that specified in the documentation - Fixed apparatus only	OK
	A3	Circuit and/or equipment category and group is correct	OK
	A5	Equipment temperature class is correct	OK
	A6	Ambient temperature range of the apparatus is correct for the installation	OK
	A8	Installation is Clearly Labelled	OK
	A9	Enclosure, glass to metal sealing gaskets and/or compounds are satisfactory	OK
	A10P	Physical Check - Cables, glands and blanking elements are correct, complete and tight	OK
	A11	There are no unauthorised modifications	OK
	A13	Barrier units or other safe area associated equipment in accordance with certification	OK
	A14	Condition of enclosure gaskets is satisfactory	OK
	A15	Electrical connections are tight	OK
	A16	Printed circuit boards are clean and undamaged	OK
	A17	The Maximum voltage Um of associated apparatus is not exceeded	OK

INSTALLATION	B1	Type of cable is appropriate	OK
	B2	Cable screens are earthed in accordance with drawings	OK
	B3	There is no obvious damage to cable	OK
	B4	Sealing of trunking, ducts, pipes and/or conduits is satisfactory	NA
	B5	Point to point connections are all correct	OK
	B6	Earth continuity is satisfactory (e.g. connections are tight and conductors are of sufficient cross-section)	OK
	B7	Earth connections maintain the integrity of type of protection	OK
	B8	The intrinsically safe circuit is isolated from earth or earthed at one point only (refer to documentation)	OK
	B9	Insulation resistance is satisfactory	NA
	B10	Seperation is maintained between intrinsically safe and non-intrinsically safe circuits in common marshalling boxes	OK
	B11	As applicable, short circuit protection of the power supply is in accordance with documentation	NA
	B12	Special conditions of use (if applicable) are complied with	OK
	B13	Cables not in use are correctly terminated	OK

ENVIRONMENT	C1	Apparatus is adequately protected against corrosion, weather, vibration and other adverse factors	OK
	C2	No undue accumulation of dust and dirt	OK

COMMENTS	CLIENT	VALE
	PROJECT REFERENCE	23.ME.897
	PROJECT DESCRIPTION	ATEX Inspection
	AREA CLASSIFICATION	2/Gc

HORNBILL ENGINEERING LIMITED

Ex'ia'

Inspection Schedule for Ex'ia' Installations in accordance to BS EN 60079-17 Table 2



DSEAR Tag	K1348	Item Identity	NA
Field Device	SO2 DETECTOR	Manufacturer	CROWCON
ATEX Description	Ex ia IIC T4 Ga	Field Junction Box	128A-MB-I-030
ATEX Certificate No.	BASEEFA04ATEX0115X	Cable 1	A131-3
Type Number	XGARD TYPE 1	Cable 2	NA
Serial Number	W369319-005	Non-Conform Rating	SATISFACTORY
Model Number	NA	Safe Area Interface	PEPPERL+FUCHS KFD0-CS-Ex1.50P
Site Name	VALE	Grade of Inspection	Detailed
Area of Plant	KILN 1		

APPARATUS			
A1	Apparatus is appropriate to area classification		OK
A2	Apparatus installed is that specified in the documentation - Fixed apparatus only		OK
A3	Circuit and/or equipment category and group is correct		OK
A5	Equipment temperature class is correct		OK
A6	Ambient temperature range of the apparatus is correct for the installation		OK
A8	Installation is Clearly Labelled		OK
A9	Enclosure, glass to metal sealing gaskets and/or compounds are satisfactory		OK
A10P	Physical Check - Cables, glands and blanking elements are correct, complete and tight		OK
A11	There are no unauthorised modifications		OK
A13	Barrier units or other safe area associated equipment in accordance with certification		OK
A14	Condition of enclosure gaskets is satisfactory		OK
A15	Electrical connections are tight		OK
A16	Printed circuit boards are clean and undamaged		OK
A17	The Maximum voltage Um of associated apparatus is not exceeded		OK
INSTALLATION			
B1	Type of cable is appropriate		OK
B2	Cable screens are earthed in accordance with drawings		OK
B3	There is no obvious damage to cable		OK
B4	Sealing of trunking, ducts, pipes and/or conduits is satisfactory		NA
B5	Point to point connections are all correct		OK
B6	Earth continuity is satisfactory (e.g. connections are tight and conductors are of sufficient cross-section)		OK
B7	Earth connections maintain the integrity of type of protection		OK
B8	The intrinsically safe circuit is isolated from earth or earthed at one point only (refer to documentation)		OK
B9	Insulation resistance is satisfactory		NA
B10	Separation is maintained between intrinsically safe and non-intrinsically safe circuits in common marshalling boxes		OK
B11	As applicable, short circuit protection of the power supply is in accordance with documentation		NA
B12	Special conditions of use (if applicable) are complied with		OK
B13	Cables not in use are correctly terminated		OK
ENVIRONMENT			
C1	Apparatus is adequately protected against corrosion, weather, vibration and other adverse factors		OK
C2	No undue accumulation of dust and dirt		OK
COMMENTS		CLIENT PROJECT REFERENCE PROJECT DESCRIPTION AREA CLASSIFICATION	VALE 23.ME.897 ATEX Inspection 2/Gc

HORNBILL ENGINEERING LIMITED

Ex'ia'

Inspection Schedule for Ex'ia' Installations in accordance to BS EN 60079-17 Table 2



DSEAR Tag	K2284	Item Identity	NA
Field Device	SO2 DETECTOR	Manufacturer	CROWCON
ATEX Description	Ex ia IIC T4 Ga	Field Junction Box	128C-MB-I-031
ATEX Certificate No.	BASEEFA04ATEX0115X	Cable 1	A231-1
Type Number	XGARD TYPE 1	Cable 2	NA
Serial Number	W369319-002	Non-Conform Rating	SATISFACTORY
Model Number	NA	Safe Area Interface	PEPPERL+FUCHS KFD0-CS-Ex1.50P
Site Name	VALE	Grade of Inspection	Detailed
Area of Plant	KILN 2		

APPARATUS	A1	Apparatus is appropriate to area classification	OK
	A2	Apparatus installed is that specified in the documentation - Fixed apparatus only	OK
	A3	Circuit and/or equipment category and group is correct	OK
	A5	Equipment temperature class is correct	OK
	A6	Ambient temperature range of the apparatus is correct for the installation	OK
	A8	Installation is Clearly Labelled	OK
	A9	Enclosure, glass to metal sealing gaskets and/or compounds are satisfactory	OK
	A10P	Physical Check - Cables, glands and blanking elements are correct, complete and tight	OK
	A11	There are no unauthorised modifications	OK
	A13	Barrier units or other safe area associated equipment in accordance with certification	OK
	A14	Condition of enclosure gaskets is satisfactory	OK
	A15	Electrical connections are tight	OK
	A16	Printed circuit boards are clean and undamaged	OK
	A17	The Maximum voltage Um of associated apparatus is not exceeded	OK

INSTALLATION	B1	Type of cable is appropriate	OK
	B2	Cable screens are earthed in accordance with drawings	OK
	B3	There is no obvious damage to cable	OK
	B4	Sealing of trunking, ducts, pipes and/or conduits is satisfactory	NA
	B5	Point to point connections are all correct	OK
	B6	Earth continuity is satisfactory (e.g. connections are tight and conductors are of sufficient cross-section)	OK
	B7	Earth connections maintain the integrity of type of protection	OK
	B8	The intrinsically safe circuit is isolated from earth or earthed at one point only (refer to documentation)	OK
	B9	Insulation resistance is satisfactory	NA
	B10	Separation is maintained between intrinsically safe and non-intrinsically safe circuits in common marshalling boxes	OK
	B11	As applicable, short circuit protection of the power supply is in accordance with documentation	NA
	B12	Special conditions of use (if applicable) are complied with	OK
	B13	Cables not in use are correctly terminated	OK

ENVIRONMENT	C1	Apparatus is adequately protected against corrosion, weather, vibration and other adverse factors	OK
	C2	No undue accumulation of dust and dirt	OK

COMMENTS	CLIENT	VALE
	PROJECT REFERENCE	23.ME.897
	PROJECT DESCRIPTION	ATEX Inspection
	AREA CLASSIFICATION	2/Gc

HORNBILL ENGINEERING LIMITED Ex'ia'

Inspection Schedule for Ex'ia' Installations in accordance to BS EN 60079-17 Table 2



DSEAR Tag	K2285	Item Identity	NA
Field Device	SO2 DETECTOR	Manufacturer	CROWCON
ATEX Description	Ex Ia IIC T4 Ga	Field Junction Box	128C-MB-I-031
ATEX Certificate No.	BASEEFA04ATEX0115X	Cable 1	A231-2
Type Number	XGARD TYPE 1	Cable 2	NA
Serial Number	W369319-001	Non-Conform Rating	SATISFACTORY
Model Number	NA	Safe Area Interface	PEPPERL+FUCHS KFD0-CS-Ex1.50P
Site Name	VALE	Grade of Inspection	Detailed
Area of Plant	KILN 2		

APPARATUS		
A1	Apparatus is appropriate to area classification	OK
A2	Apparatus installed is that specified in the documentation - Fixed apparatus only	OK
A3	Circuit and/or equipment category and group is correct	OK
A5	Equipment temperature class is correct	OK
A6	Ambient temperature range of the apparatus is correct for the installation	OK
A8	Installation is Clearly Labelled	OK
A9	Enclosure, glass to metal sealing gaskets and/or compounds are satisfactory	OK
A10P	Physical Check - Cables, glands and blanking elements are correct, complete and tight	OK
A11	There are no unauthorised modifications	OK
A13	Barrier units or other safe area associated equipment in accordance with certification	OK
A14	Condition of enclosure gaskets is satisfactory	OK
A15	Electrical connections are tight	OK
A16	Printed circuit boards are clean and undamaged	OK
A17	The Maximum voltage Um of associated apparatus is not exceeded	OK

INSTALLATION		
B1	Type of cable is appropriate	OK
B2	Cable screens are earthed in accordance with drawings	OK
B3	There is no obvious damage to cable	OK
B4	Sealing of trunking, ducts, pipes and/or conduits is satisfactory	NA
B5	Point to point connections are all correct	OK
B6	Earth continuity is satisfactory (e.g. connections are tight and conductors are of sufficient cross-section)	OK
B7	Earth connections maintain the integrity of type of protection	OK
B8	The intrinsically safe circuit is isolated from earth or earthed at one point only (refer to documentation)	OK
B9	Insulation resistance is satisfactory	NA
B10	Seperation is maintained between intrinsically safe and non-intrinsically safe circuits in common marshalling boxes	OK
B11	As applicable, short circuit protection of the power supply is in accordance with documentation	NA
B12	Special conditions of use (if applicable) are complied with	OK
B13	Cables not in use are correctly terminated	OK

ENVIRONMENT		
C1	Apparatus is adequately protected against corrosion, weather, vibration and other adverse factors	OK
C2	No undue accumulation of dust and dirt	OK

COMMENTS	CLIENT	VALE
	PROJECT REFERENCE	23.ME.897
	PROJECT DESCRIPTION	ATEX Inspection
	AREA CLASSIFICATION	2/Gc

APPENDIX D: Crowcon Calibration and Test Report

CROWCON Detecting Gas Saving Lives		CALIBRATION/TEST REPORT								
Crowcon Detection Instruments Ltd, 172 Brook Drive, Milton Park, Abingdon OX14 4SD, UK										
FIELD SERVICE: Tel: +44 (0) 1235 557721 Fax: +44 (0) 1235 557769										
KILN PLANT 1+2										
Call no.	SETW 065476	Order no.								
Customer	VALE EUROPE LTD	Site contact	JONATHAN ROBERTS							
Site address	CLYDACH REFINERY	Tel no.								
	CLYDACH	Mobile								
	SWANSEA									
	WOT GRAMS									
	Postcode: SA6 5QR									
Type of call: ☒ Contract ☐ Service ☐ Non-contract ☒ Commissioning ☐ Fault call ☐ Warranty ☐ Other ☐ Installation										
Equipment details										
Model:	XCARD	S/N:	SEE BELOW							
		Ancillary equipment:	A/U + OUTPUT TO SITE PLC -> EVAC ALARM							
Chnl.	Prior zero	Calibration			Alarms			Range/Gas	Calibration Gas	Comments
		PRE-Cal	Max	Final	A1	A2	A3			
1	0	10.2	10+	10	1	2	10	0-10 ppm SO2	10 ppm SO2	W369319-001 A231-2
2	0	10.2	10+	10	1	2	10			W369319-002 A231-1
3	0	10.0	10+	10	1	2	10			W369319-003 A131-2
4	0	10.2	10+	10	1	2	10			W369319-004 A131-1
5	0	9.48	10+	10	1	2	10			W369319-005 A131-3
6										
7										
8										
9										
10	* ALL SENSORS DATE CODE 083									
11										
12										
13										
14										
15										
16										

APPENDIX E: Equipment Datasheets



Repeater KFD0-CS-Ex1.50P

- 1-channel isolated barrier
- 24 V DC supply (loop powered)
- Current input/output 4 mA ... 20 mA
- transmitter power supply
- Accuracy 0.1 %
- Reverse polarity protection
- Up to SIL 2 (SC 3) acc. to IEC/EN 61508



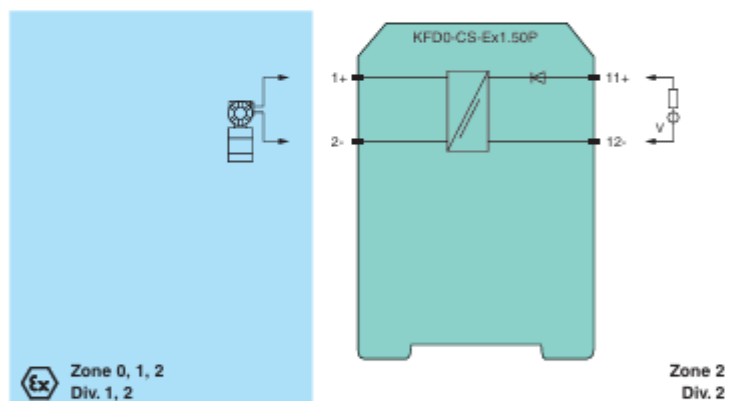
SIL 2



Function

This isolated barrier is used for intrinsic safety applications.
The device can be used as a repeater or transmitter power supply for 2-wire transmitters.
This device is loop powered. No additional power supply has to be connected.
Use the technical data to verify that proper voltage is available to the field devices.

Connection



Technical Data

General specifications		
Signal type	Analog input/analog output	
Functional safety related parameters		
Safety Integrity Level (SIL)	SIL 2	
Systematic capability (SC)		SC 3
Supply		
Rated voltage	U _r	5 ... 35 V DC , loop powered
Control circuit		
Connection		terminals 12-, 11+
Voltage	5 ... 35 V DC	
Current	4 ... 20 mA	

Refer to "General Notes Relating to Pepperl+Fuchs Product Information".

Pepperl+Fuchs Group
www.pepperl-fuchs.com

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pa-info@us.pepperl-fuchs.com

Germany: +49 621 776 2222
pa-info@de.pepperl-fuchs.com

Singapore: +65 6779 9091
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1

Technical Data

Power dissipation	at 20 mA and $U_n < 24.3 \text{ V}$: < 250 mW per channel at 20 mA and $U_n > 24.3 \text{ V}$: < 500 mW per channel
Field circuit	
Connection	terminals 1+, 2-
Voltage	for $5 \text{ V} < U_n < 24.3 \text{ V}$: $\geq 0.9 \times U_n - (0.37 \times \text{current in mA}) - 1.0$ for $U_n > 24.3 \text{ V}$: $\geq 21 \text{ V} - (0.36 \times \text{current in mA})$
Short-circuit current	at $U_n > 24.3 \text{ V}$: $\leq 65 \text{ mA}$
Transfer current	$\leq 40 \text{ mA}$
Transfer characteristics	
Accuracy	0.1 %
Deviation	
After calibration	$\leq \pm 20 \mu\text{A}$; incl. calibration, linearity, hysteresis and load fluctuations at the field side up to a load of $1 \text{ k}\Omega$ at 20°C (68°F)
Influence of ambient temperature	$\leq \pm 2 \mu\text{A/K}$ at $U_n \leq 20 \text{ V}$; $\leq \pm 5 \mu\text{A/K}$ at $U_n > 20 \text{ V}$
Rise time	$\leq 5 \text{ ms}$ at bounce from 4 ... 20 mA and $U_n < 24 \text{ V}$
Galvanic isolation	
Field circuit/control circuit	safe electrical isolation acc. to IEC/EN 60079-11, voltage peak value 375 V
Indicators/settings	
Labeling	space for labeling at the front
Directive conformity	
Electromagnetic compatibility	
Directive 2014/30/EU	EN 61326-1:2013 (industrial locations)
Conformity	
Electromagnetic compatibility	NE 21:2012 EN 61326-3-2:2008
Degree of protection	IEC 60529:2001
Protection against electrical shock	UL 61010-1:2012
Ambient conditions	
Ambient temperature	$-20 \dots 70^\circ\text{C}$ ($-4 \dots 158^\circ\text{F}$)
Mechanical specifications	
Degree of protection	IP20
Connection	screw terminals
Mass	approx. 100 g
Dimensions	$20 \times 107 \times 115 \text{ mm}$ ($0.8 \times 4.2 \times 4.5 \text{ inch}$) (W x H x D), housing type B1
Mounting	on 35 mm DIN mounting rail acc. to EN 60715:2001
Data for application in connection with hazardous areas	
EU-type examination certificate	BAS 98 ATEX 7343 X
Marking	Ⓒ II (1)G [Ex ia Ga] IIC Ⓒ II (1)D [Ex ia Da] IIIC Ⓒ I (M1) [Ex ia Ma] I
Voltage	U_n 25.2 V
Current	I_n 93 mA
Power	P_n 585 mW
Control circuit	
Maximum safe voltage	U_m 250 V _{eff} (Attention! The rated voltage can be lower.)
Field circuit	
Maximum safe voltage	U_m 250 V _{eff} (Attention! The rated voltage can be lower.)
Certificate	FIDI 22 ATEX 0001X
Marking	Ⓒ II 3G Ex ec IIC T4 Gc
Galvanic isolation	
Field circuit/control circuit	safe electrical isolation acc. to IEC/EN 60079-11, voltage peak value 375 V
Directive conformity	
Directive 2014/34/EU	EN IEC 60079-0:2018, EN 60079-11:2012, EN IEC 60079-7:2015+A1:2018
International approvals	
FM approval	

Refer to "General Notes Relating to Pepperl+Fuchs Product Information".

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 **PEPPERL+FUCHS**

Xgard

Fixed Gas Detector

Choosing the gas detector for your needs

Xgard offers three different sensor concepts so you can choose exactly what you need for your site. Xgard is available in flameproof, intrinsically safe, or safe area formats for use in all environments, whatever the classification.

Features

Low cost of ownership	Xgard detectors are designed for easy installation and maintenance to keep costs down. The three junction box options are all designed to make replacement of sensors and sinters extremely simple. Spare sensors simply plug-in. Many spare parts are common to all Xgard models, which keeps spares holding requirements to a minimum.
Wide range of sensors	Poison resistant pellistors, for all flammable detection needs including hydrocarbons, hydrogen, ammonia, jet fuel, leaded petrol and vapours containing halogens. Electrochemical sensors are used to detect a vast range of toxic gases and oxygen. Thermal conductivity sensors are available to monitor % volume concentrations of gases.
Flexible installation options	Xgard is designed for either wall or ceiling mounting without the need for additional brackets. Xgard can accommodate M20, 1/2" NPT or 3/4" NPT cable glands to suit all site requirements. High temperature models are available for hot environments (up to 150°C). Accessories are available for duct mounting and sampling applications as well as remote gassing for simple sensor checking.
Rugged and reliable	Xgard is manufactured using a choice of three materials: glass reinforced nylon, highly durable aluminium with a tough polyester coating, or 316 stainless steel for ultimate corrosion resistance. All versions are designed to operate even in the harshest conditions. Spray deflectors and weatherproof caps are available for use in areas subject to regular wash-downs, or offshore environments. All models have been validated to the functional safety standard IEC 61508 (SIL 1 to SIL 3).

The Xgard range offers a comprehensive selection of fixed point gas detectors that meet the diverse requirements for flammable and toxic gas detection and oxygen monitoring in industries throughout the world. This diagram is designed to help you choose the correct Xgard detector to suit your needs.



Gases and ranges

Gas	LTEL (ppm) LEL (% Vol)	STEL UEL (% vol)	Range available: Type 1	Range available: Type 2	Range available: Type 3, 4, 5 & Xsafe	Range available: Type 6
Acetylene (C ₂ H ₂)	2.3	100	-	-	0-100%* LEL	-
Ammonia (NH ₃)	25 15	35 33.6	50, 100, 250, 500, 1000 ppm	-	0-25%* LEL	-
Argon (Ar)	-	-	-	-	-	Contact Crowcon
Arsine (AsH ₃)	0.05	-	1 ppm	-	-	-
Bromine (Br ₂)	0.1	0.2	3 ppm	-	-	-
Butane (C ₄ H ₁₀)	1.4	9.3	-	-	0-100%* LEL*	-
Carbon dioxide (CO ₂)	5000 (0.5% Vol)	5000 (1.5% Vol)	-	-	-	Contact Crowcon
Carbon monoxide (CO)	30	200	50, 100, 200, 250, 500, 1000, 2000 ppm	50, 100, 200, 250, 500, 1000, 2000 ppm	-	-
Chlorine (Cl ₂)	-	0.5	3, 5, 10, 20, 50, 100 ppm	-	-	-
Chlorine Dioxide (ClO ₂)	0.1	0.3	1 ppm	-	-	-
Diborane (B ₂ H ₆)	0.1	-	1 ppm	-	-	-
Ethane (C ₂ H ₆)	2.4	15.5	-	-	0-100%* LEL	-
Ethylene (C ₂ H ₄)	2.3	36	-	-	0-100%* LEL	-
Ethylene oxide (C ₂ H ₄ O)	5	-	10, 50, 100 ppm	-	-	-
Fluorine (F ₂)	1	1	1 ppm	-	-	-
Germane (GeH ₄)	0.2	0.6	2 ppm	-	-	-
Helium (He)	-	-	-	-	-	Contact Crowcon
Hydrogen (H ₂)	4	77	200, 2000 ppm	200, 2000 ppm 100% LEL	0- 100%* LEL 50% LEL, 100% LEL	0-5%, 10%, 50% vv (in air) 0-20%, 25%, 30%, 50% vv (H ₂ in N ₂)
Hydrogen chloride (HCl)	1	5	10, 25 ppm	-	-	-
Hydrogen cyanide (HCN)	-	10	25 ppm	-	-	-
Hydrogen fluoride (HF)	1.8	3	10 ppm	-	-	-
Hydrogen sulphide (H ₂ S)	5	10	5, 10, 20, 25, 50, 100, 200, 250, 300, 1000 ppm	5, 10, 20, 25, 50, 100, 200 ppm	-	-
LPG	2	10	-	-	0- 100% LEL	-
Methane (CH ₄)	4.4	17	-	-	0- 100% LEL	-
Nitric Oxide (NO)	5*1	5*1	25, 50, 100 ppm	-	-	-
Nitrogen dioxide (NO ₂)	1*1	1*1	10, 50, 100 ppm	-	-	-
Ozone (O ₃)	-	0.2	1 ppm	-	-	-
Oxygen (O ₂)	-	-	25% Vol	25% Vol	-	-
Pentane (C ₅ H ₁₂)	1.1 600 ppm	8.7 1800 ppm	-	-	0- 100%* LEL	-
Petrol vapour	1.4	6	-	-	0- 100%* LEL	-
Phosgene (COCl ₂)	0.02	0.06	1 ppm	-	-	-
Phosphine (PH ₃)	0.1	0.2	1 ppm	-	-	-
Propane (C ₃ H ₈)	1.7	10.9	-	-	0- 100%* LEL	-
Silane (SiH ₄)	0.5	1	1 ppm	-	-	-
Sulphur Dioxide (SO ₂)	1*1	1*1	10, 20, 50, 100, 250 ppm	-	-	-
Vinyl chloride (VCM) (CH ₂ =CHCl)	3.6 3	33 -	-	-	0- 100%* LEL	-
Volatile organics (VO)*2	-	-	0-100 ppm *2	-	-	-



Clifford & Snell

Yodalight YL40

Multi-purpose Audible & Visual
Signalling Device designed for use in
Commercial, Light Industrial & Marine
applications

PRODUCT FEATURES

- Max sound output 108 dB(A) @ 1m
- IP65 rated as standard
- Beacon options include:
 - 5 Joule Xenon Strobe
 - 2.5 Joule Xenon Strobe (optional)
 - High brightness LED (optional)
- 32 selectable tones meeting international regulations
- Flame retardant ABS enclosure
- Robust, reliable and simple to install
- Stainless steel fixings
- 2 stage alarm
- Independently selectable second stage (optional)
- Low current consumption
- Lens available in 8 colours

Product Approvals



Marine Equipment Directive MED
Compliant



Compliant



Merchant Shipping (Marine Equipment)
Regulations EN 54-3:2014 incl. A1:2019,
IEC 60092-504:2016 IEC 60533:2015
Module B (BSI/UK/3.53/738807)
Module D (BSI/MED/UK/738808)



BS EN 54-3 : 2001 + A1:2002 + A2:2006
Type B



BS EN 54-3 : 2001 + A1:2002 + A2:2006
Type B



Compliant

UK +44 (0) 121 446 5322 FR +33 (0) 170 721 271

uksales@moflash.co.uk

exportsales@moflash.co.uk

KM-europ@moflash.com

www.moflash.com

Issue 1

TECHNICAL DATA

Electrical Data		
Operating Voltage	Current Draw	
	5J Xenon	LED
24VDC ---	345mA	70mA
48VDC ---	190mA	NA
115VAC ~	130mA	NA
230VAC ~	95mA	NA

Ambient Conditions	
Operating Temperatures	
Standard General	-35 °C to +70 °C
EN54 Pt:3 Fire	-25 °C to +55 °C
Storage Temperature	-40 °C to +70 °C
Max. Relative Humidity	93% ± 3 at 40 °C

Mounting / Installation
For ease of installation the Sounder and Beacons are supplied loose from the mounting back box. The back box must be mounted with the two cable entries either at the top or the bottom. The back box should be mounted to a suitable flat wall, bulkhead or conduit box avoiding areas of undue vibration and using the internal fixing point options in the back box. Always use the mounting gasket supplied. The recommended fixing screws are 4.5mm Dia x 20mm long. To maintain the IP rating of the enclosure the cable entries must be fitted with a suitably rated cable gland (Not Supplied). Max cable termination 2.5mm ² .

Mechanical Data	
Enclosure Material	ABS FR UL94 5VB
Lens Material	PC FR UV Stable UL94 HB
External Fixings	Stainless Steel
Degree of Protection	IP65 (IEC60529)

Acoustic Data	
Maximum Volume Output	108dB (A)
Volume Control Adjustment	-18 dB (A)
2 Stage Alarm with predetermined second stage as standard.	
Selectable second stage option available (DC units only) (2)	

Luminous Characteristics	
Xenon Tube	5J Output (2.5J Option Available)
Flash Rate	60 FPM
Lens Colour	Effective Candela (cd) (5J Xenon)
Clear	72.10
Red	8.92
Amber	25.52
Blue	14.09
Green	29.70
Opal	65.78

Line integrity on DC systems

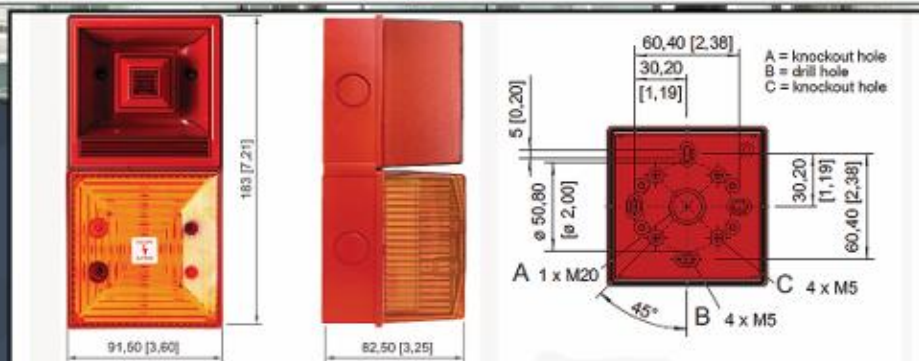
- For 3 wire 2 stage alarm system, monitor via reverse polarity.
- For 2 wire 2 stage alarm system, monitor via threshold, (applied voltage < 1v) an end-of-line (E.O.L) resistor is required for line monitoring and should have a minimum resistance of 3k3 Ohms and 0.5 Watts, wire-wound or metal film type.

Multi-Stage Alarm Options

Standard units offer a 2 stage alarm system with a predetermined second stage (see tone table on the installation sheet for details). A selectable second stage option is available for DC units only with the (2) prefix code in the selection table on page 3.

Dimensional Drawing

We reserve the right to make alterations to the technical data, dimensions, weights, designs and products available without notice. The illustrations cannot be considered binding. All Dimensions in mm [inches] - Subject to alterations



APPENDIX F: ATEX and IECEx Certificates

1 EU - TYPE EXAMINATION CERTIFICATE

**2 Equipment or Protective System Intended for use in Potentially Explosive Atmospheres
Directive 2014/34/EU**

3 EU - Type Examination Certificate Number: **Baseefa04ATEX0115X – Issue 7**

3.1 In accordance with Article 41 of Directive 2014/34/EU, EC-Type Examination Certificates referring to 94/9/EC that were in existence prior to the date of application of 2014/34/EU (20 April 2016) may be referenced as if they were issued in accordance with Directive 2014/34/EU. Supplementary Certificates to such EC-Type Examination Certificates, and new issues of such certificates, may continue to bear the original certificate number issued prior to 20 April 2016.

4 Product: **Xgard Gas Detector**

5 Manufacturer: **Crowcon detection instruments Limited**

6 Address: **172 Brook Drive, Milton Park, Abingdon, Oxfordshire, OX14 4SD**

7 This re-issued certificate extends EC Type Examination Certificate No. Baseefa04ATEX0115X to apply to product designed and constructed in accordance with the specification set out in the Schedule of the said certificate but having any variations specified in the Schedule attached to this certificate and the documents therein referred to.

8 SGS Baseefa, Notified Body number 1180, in accordance with Article 17 of Directive 2014/34/EU of the European Parliament and of the Council, dated 26 February 2014, certifies that this product has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of products intended for use in potentially explosive atmospheres given in Annex II to the Directive.

The examination and test results are recorded in confidential Report No. **GB/BAS/ExTR16.0340/00**

9 Compliance with the Essential Health and Safety Requirements has been assured by compliance with:

EN60079-0: 2012 + A11: 2013 EN60079-11: 2012

except in respect of those requirements listed at item 18 of the Schedule.

10 If the sign "X" is placed after the certificate number, it indicates that the product is subject to the Specific Conditions of Use specified in the schedule to this certificate.

11 This EU - TYPE EXAMINATION CERTIFICATE relates only to the design and construction of the specified product. Further requirements of the Directive apply to the manufacturing process and supply of this product. These are not covered by this certificate.

12 The marking of the product shall include the following :

Ⓔ II 1 G Ex ia IIC T4 Ga (-40°C ≤ Ta ≤ +55°C)

SGS Baseefa Customer Reference No. **0249**

Project File No. **16/0384**

This document is issued by the Company subject to its General Conditions for Certification Services accessible at <http://www.sgs.com/en/Terms-and-Conditions.aspx> and the Supplementary Terms and Conditions accessible at <http://www.sgs.com/SGSBaseefa/Terms-and-Conditions.aspx>. Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any holder of this document is advised that information contained herein reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. It does not necessarily indicate that the equipment may be used in particular industries or circumstances. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents. This document cannot be reproduced except in full, schedule included, without prior written approval of the Company. Any unauthorized alteration, forgery or falsification of the content or appearance of this document is unlawful and offenders may be prosecuted to the fullest extent of the law.

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Registered in England No. 4305578.

Registered address: Rossmore Business Park, Ellesmere Port, Cheshire, CH65 3EN

PP. R S Sinclair

R S SINCLAIR

TECHNICAL MANAGER

On behalf of SGS Baseefa Limited

ABELLMAN
Certification
Manager

13 **Schedule**

14 **Certificate Number Baseefa04ATEX0115X – Issue 7**

15 **Description of Product**

The Xgard Gas Detector is a loop-powered gas detector which can be used to detect Toxic gases or Oxygen depending upon the circuitry and electrochemical cell used and provide a 4-20mA output signal. It comprises an electrochemical cell (and accompanying sensor PCB) and an amplifier PCB mounted within a stainless steel or glass filled nylon enclosure.

Electrical connections to the amplifier PCB are made to a terminal block with cable access to the enclosure being provided by a threaded entry hole. Access to the terminal block and PCB is gained by a removable threaded lid with an O-ring seal.

Toxic Detector, Terminals + and –

$U_i = 28V$

$I_i = 300mA$ $C_i = 14.4nF$

$P_i = 1.2W$ $L_i = 28\mu H$

Oxygen Detector, Terminals + and –

$U_i = 28V$

$I_i = 300mA$ $C_i = 13.2nF$

$P_i = 1.2W$ $L_i = 0$

16 **Report Number**

GB/BAS/ExTR16.0340/00

17 **Specific Conditions of Use**

1. The apparatus has a plastic enclosure (introduced in Issue 2) that constitutes a potential electrostatic hazard. The enclosure must be cleaned only with a damp cloth.

NOTE: This condition does not apply to the stainless steel enclosure version.

18 **Essential Health and Safety Requirements**

In addition to the Essential Health and Safety Requirements (EHSRs) covered by the standards listed at item 9, the following are considered relevant to this product, and conformity is demonstrated in the report:

Clause	Subject
1.4.1	External effects
1.4.2	Aggressive substances, etc.



IECEx Certificate of Conformity

INTERNATIONAL ELECTROTECHNICAL COMMISSION IEC Certification Scheme for Explosive Atmospheres

for rules and details of the IECEx Scheme visit www.iecex.com

Certificate No.: IECEx BAS 05.0042X

Issue No: 7

Certificate history:

Status: Current

Page 1 of 4

Issue No. 7 (2018-04-12)
Issue No. 6 (2014-08-06)
Issue No. 5 (2012-12-06)
Issue No. 4 (2011-04-15)
Issue No. 3 (2011-02-17)
Issue No. 2 (2007-11-12)
Issue No. 1 (2006-10-20)

Date of Issue: 2018-04-12

Applicant: Crowcon Detection Instruments Ltd
172 Brook Drive
Milton Park
Abingdon
Oxfordshire
OX14 4SD
United Kingdom

Equipment: Xgard Gas Detector

Optional accessory:

Type of Protection: Intrinsic Safety

Marking:

Ex ia IIC T4 Ga (-40°C ≤ Ta ≤ +55°C)

Approved for issue on behalf of the IECEx
Certification Body:

R S Sinclair

ABELLMAN
Certification
Manager

Position:

Technical Manager

Signature:
(for printed version)

Date:

PP.
13th April 2018

1. This certificate and schedule may only be reproduced in full.
2. This certificate is not transferable and remains the property of the issuing body.
3. The Status and authenticity of this certificate may be verified by visiting the Official IECEx Website.

Certificate issued by:

SGS Baseefa Limited
Rockhead Business Park
Staden Lane
Buxton, Derbyshire, SK17 9RZ
United Kingdom





for rules and details of the IECEx Scheme visit www.iecex.com

Marking: [Ex Ia Ga] IIC
[Ex Ia Da] IIIC
[Ex Ia Ma] I
(-20°C ≤ Ta ≤ +60°C / +70°C)

Date:
(for printed version)

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Rockhead Business Park
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United Kingdom

SGS

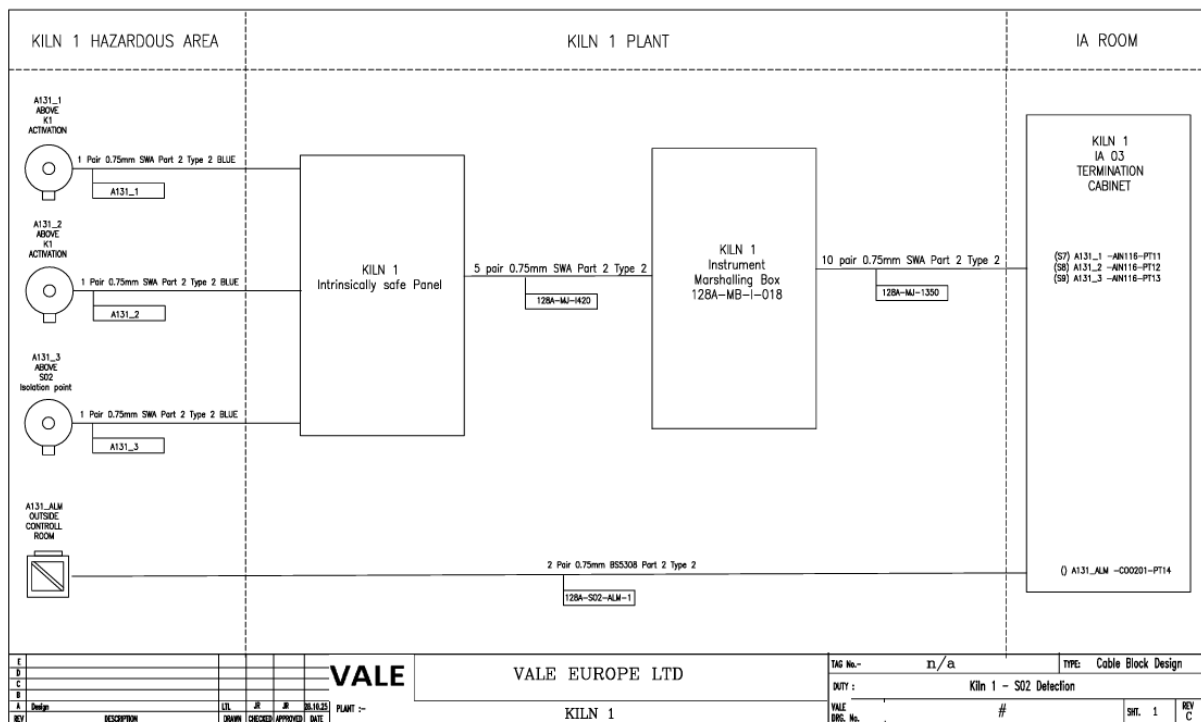
APPENDIX G: Risk Assessment and Method Statement

VALE		Clydach Refinery Occupational Risk Assessment Record Form				SAFE PRODUCTION		RAP06/ W101/SF04 (v4) Nov 2015				
Department / Location:	ENGINEERING/KILN				Likelihood	Rare	Unlikely	Occasional	Likely	Frequent	Risk Levels	
Description of Subject / job / task to be assessed:	Kiln Plant - Installation of SO2 Detection System				Impact Severity							
					Catastrophic (E)	10	50	100	150	200	250	300
					Critical (D)	10	20	40	60	80	100	120
					Severe (C)	5	10	20	30	40	50	60
Reference No:	RA-202301714847	Work Order No:	202301714847	Moderate (B)	5	10	20	30	40	50	75 - 100	
Version No:	1	Task No:	-20	Minor (A)	2	5	10	15	20	25	25 - 50	
Date of this assessment:	03/10/2025	ORA Team Leader:	L. Loyd	ORA Team Members:								
Next scheduled review:	02/10/2028	Approved By:	J.Roberts	L.Loyd, J. Roberts								
Activity / Step / Area / component	Hazard	Hazardous Event and Impact	Potential Risk (assuming no controls in place)	Existing Control Measures		Residual Risk (Taking into account existing controls and their effectiveness)		Further Actions				
No:	Subject broken down into manageable components, sections or steps	What has the potential to cause harm?	How could it go wrong? What would be the likely impacts?	Impact	Like'd	Risk	Describe the existing control measures relevant to each hazard		Impact	Like'd	Risk	
Consider if there is a risk of exposure to asbestos (mandatory field)												
LINK TO ASBESTOS REGISTERS												
A1	The moving of the panels and the installation of containment, cables and pipework.	There is potential to disturbed asbestos containing materials	Possible Asbestos discovery during installation. Exposure to asbestos particles.	32	5	160	The asbestos register has been checked and it has identified that the floor tiles install on the floor in the electrical room (Bandstand) between the Kiln control room and the IA Room contain asbestos. Whilst working in the area personnel must ensure that the floor tiles are not damaged, if any damage does occur that the work is stopped immediately, the area contained to stop anyone entering the area and report the damage to your supervisor and vale personnel immediately.		16	2	32	
Consider the risk of the environmental impact of the job (mandatory field)												
E1	The installation of equipment, containment, cables and pipework	Waste Generation	Uncontrolled disposal of waste	4	3	12	Technicians to follow site protocol for waste disposal		4	2	8	
Consider the manual handling risks associated with the task (Mandatory Field)												
M2	Transportation of materials and tools to site and installation	Twisting	Muscular Problem, Back Problem	8	5	40	Ensure personnel present have undergone manual handling training and adhere to good manual handling practices/procedures.		8	2	16	
M3	The installation of equipment, containment, cables and pipework	Stretching	Muscular Problem, Back Problem	8	5	40	No over stretching, ensure enough personnel present when installing supply cable. SLAM to be carried out prior to the start of work.		8	2	16	
Consider the work at height risks associated with the task (Mandatory Field) NB: EMERGENCY ARRANGEMENTS MUST BE IN PLACE BEFORE WORK AT HEIGHT COMMENCES												
H1	Working at height	Hit by falling object	People working below or above another person in the same area. Incorrect use of hand tools. Due care and attention.	16	5	80	Ensure nobody is working directly below or above when working at heights. Kickboards if working on scaffold. Barriers must be installed below work area if using MEWP.		16	2	32	
H4	Working from a step ladder	Fall from Height	Fall from height/impact injury	16	5	80	Any working from height should be conducted from approved step ladders. Carry out visual inspection to ensure ladders are in a good condition. Tagged to show it has a current up to date inspection record. Ensure the ladder is placed on firm even ground and always maintain 3 points of contact with the ladder. Ladders should only be used for short duration work.		16	2	32	
H5	Working in floor void	Fall from Height	Fall from height/impact injury	16	5	80	Where there is a requirement to lift floor plates or create voids for cable ways introducing a fall hazard, ensure area is cordoned off according to Vale procedures with a fixed barrier, and signage is put up to ensure personnel safety, at least 2 men working at all times, 1 man to be standby watchman. Floor plates to be reinstated at the end of the day.		16	2	32	

Activity / Step / Area / component		Hazard	Hazardous Event and Impact	Potential Risk (assuming no controls in place)			Existing Control Measures	Residual Risk (Taking into account existing controls and their effectiveness)			Further Actions
No.	Subject broken down into manageable components, sections or steps	What has the potential to cause harm?	How could it go wrong? What would be the likely impacts?	Impact	Like'd	Risk	Describe the existing control measures relevant to each hazard	Impact	Like'd	Risk	Number and transfer to Action tab
Consider the risk of exposure to hazardous substances (mandatory field) - Please inform Safety & Hygiene Coordinator of all tasks with significant hazardous substance risks											
S1	Working with the kiln building	Exposure to gases	Breathing in of gases on site could cause a range of symptoms from mild irritation through to asphyxiation	32	5	160	Team Leader will determine if area requires gas testing and monitoring prior to the start of work. Correct P.P.E and personal CO monitors to be worn and also ensuring monitors are bump tested as required. Ensure whilst working in the kiln IA room the fire suppression system is put in manual at all times, once all work has been completed and all working parties have left the area ensure the system is put back into auto.	32	2	64	
S2	Working with the kiln building	Exposure to Dust	Exposure to general dust and/or nickel powder can cause symptoms with respiratory system	8	5	40	If any work is being carried out in an area where there is a potential to disturb surface dust an approved Vaisala half face masks to be worn. All personnel must have been fitted for half face mask by the Occupational Health Department prior to use.	8	2	16	
	Carrying out any hot works as part of the project i.e Drilling, Grinding and cutting.	Hazardous Areas	Risk of Explosion	32	5	160	Hot Work Permit to be obtained from plant team leader prior to any hot works being carried out. Ensure all areas of hot work are indicated to the team leader before they issue HWP. Continuous gas monitoring to be in place. All combustible material to be removed and fire extinguisher in place. Fire blankets to be used to capture grinding sparks. Fire watcher in place at all times and to remain in place for at least the following completion of work. Appropriate fire retardant PPE to be worn whilst performing hot work.	32	2	64	
	Working with the refinery including the kiln building	Failure to adhere to site safety standards and control procedures	No or incorrect PPE. Slips, trips, fall, Contact with road traffic/ Buildings/Structures/ Equipment	8	3	24	Compliance with: Refinery safety standards. Adhere to Permit to Work procedures Induction training. Correct PPE worn for the task. Minimum, Hard Hat, Safety Boots, Safety glasses, Ear Protection, Gloves, goggles, Overalls. Awareness of access egress routes in case of emergency.	4	2	8	
	The installation of equipment, containment, cables and pipework	Site left in an unsafe and untidy condition	Injury from Slips, trips and falls	4	5	20	Housekeeping Clean tidy work space at all times. Caution & Awareness. Ensure guards are fitted to moving machinery in the work area. SLAM procedure to be carried out by contractor.	4	2	8	
	The installation of equipment, containment, cables and pipework	Hand tools	Cuts and bruising to hands. Possible broken fingers.	8	5	40	All tools are to be used as the manufacturer intended, shall be in good condition and visually inspected before use. Competent trained personnel to follow correct working procedures ensuring correct tool for specific job.	8	2	16	
	Delivery of materials and equipment to site/ Daily ingress and egress to plant	Road traffic	Contact with: Refinery Pedestrians, Other Road Traffic or Buildings/Structures/ Equipment	8	5	40	Compliance with: Refinery Access Control Procedures, Refinery traffic control measures, Designated access route to work area. Refinery speed limits and road signs. Approved parking locations	8	2	16	
	The installation of equipment, containment, cables and pipework	Electricity	Due care and attention and incorrect working procedures. Electric shock. Live Cables on traywork.	16	5	80	Qualified electricians to follow correct working procedures. Awareness of live cables on existing traywork and ducting Competent and experienced electricians. SLAM procedure to be carried out by contractor. Safe isolation procedure to be carried out.	16	2	32	
	The installation of equipment, containment, cables and pipework	Noise	Temporary or permanent damage to hearing	8	5	40	Hearing protection is mandatory in most areas of the plant. These areas are clearly marked.	8	2	16	
	The installation of equipment, containment, cables and pipework	Air borne debris	Eye injury	8	3	24	Ensure correct PPE is used for the task. Safety Glasses must be worn at all times and goggles to be worn whilst drilling, grinding or any other task which may create air borne debris.	8	2	16	

Activity / Step / Area / component		Hazard	Hazardous Event and Impact	Potential Risk (assuming no controls in place)			Existing Control Measures	Residual Risk (Taking into account existing controls and their effectiveness)			Further Actions
No:	Subject broken down into manageable components, sections or steps	What has the potential to cause harm?	How could it go wrong? What would be the likely impacts?	Impact	Like'd	Risk	Describe the existing control measures relevant to each hazard	Impact	Like'd	Risk	Number and transfer to Action tab
	The installation of equipment, containment, cables and pipework	Portable Tools	Misuse of tools could cause broken bones, lacerations, possible electric shock.	8	5	40	All tools are to be used as the manufacturer intended, shall be in good condition and visually inspected before use. Personnel have served relevant apprenticeships. All tools shall be Portable Appliance Tested and be 55-0-55V or battery powered.	8	2	16	
	The installation of equipment, containment, cables and pipework	Sharp corners	Cuts and grazes	4	5	20	Wear gloves and associated PPE to cover bare skin and carry out SLAM prior to work to identify any possible hazards.	4	2	8	
	General maintenance and work area	Adequacy of guards/Protection from moving parts	Jamming hands on equipment	3	2	6	Ensure when working near online equipment that all guards are in place and not damaged. Guards are inspected as part of refinery planned maintenance, if any defects are noticed stop work and inform plant team leader.	3	1	3	
	Working with the refinery including the kiln building	Plant Emergencies	Unaware of Plant Emergency situations and procedures	8	3	24	Alarm systems including Plant Evacuation alarms.	8	2	16	
	The installation of containment, cables and pipework	Unintentional Production plant equipment isolation	Loss of production	2	2	4	Care must be taken when working in panels and around online plant Co-ordination with production staff is essential	2	2	4	
NOTE - This risk assessment is a dynamic document based on how the work is envisaged at the time of production. Things can change and this ORA should be reviewed in light of any changes. It is important that all stakeholders cooperate and work with on-going risk management in mind. Please use our SafeProduction tools (such as SLAM, interactive discussion and coaching), our Behavioural Standards and maintain situational awareness to identify changes and unforeseen hazards and risks, to challenge unsafe practices and to stop work and report issues to ensure continued risk control.											

APPENDIX H: Cable Block Diagram



APPENDIX I: DCS Configuration Specification

Kiln 1 SO2 Detection System Configuration Requirements

The following is a detail specification for the Kiln Plant SO2 Detection System.

- Configure analogue input blocks as detailed in the following table:
The inputs will be 4-20 mA input signal and high alarm facility is required:

Name	DESCRP	Loopid	Loop_id	Pnt.No	Range	Hi Al	Hi Al
A2_2_ACT_MS-A131_1_AI	SO2 DETECTOR_KILN 1 ACT SO2 CONTROL VALVE AREA	A131_1_AI	AIN116	11	0-10 PPM	1 PPM	2 PPM
A2_2_ACT_MS-A131_2_AI	SO2 DETECTOR_KILN 1 ACT SO2 FLOW TRANSMITTER AREA	A131_2_AI	AIN116	12	0-10 PPM	1 PPM	2 PPM
A2_2_ACT_MS-A131_3_AI	SO2 DETECTOR_SO2 MANIFOLD AREA	A131_3_AI	AIN116	13	0-10 PPM	1 PPM	2 PPM

- Configure digital output blocks as detailed in the following table:

Name	DESCRP	Loopid	Loop_id	Pnt.No
A2_2_ACT_MS-A131_1_DO	KILN 1 SO2 DETECTION SYSTEM ALARM BEACON	A131_1_DO	COO101	14
A2_2_ACT_MS-A131_2_DO	KILN 1 SO2 DETECTION SYSTEM ALARM SOUNDER	A131_2_DO	COO101	15
A2_2_ACT_MS-A131_3_DO	KILN 1 SO2 DETECTION SYSTEM EVAC	A131_3_DO	COO101	16

- Configure digital input block as detailed in the following table:

Name	DESCRP	Loopid	Loop_id	Pnt.No
A2_2_ACT_MS-HS_A131_1_DI	KILN 1 SO2 DETECTION SYSTEM EVAC ALARM DEFEAT	HS_A131_DI	CTN110	14

- Configure the digital output A2_2_ACT_MS:A131_2_DO to close contact COO101 point 15 when any of the kiln 1 SO2 detection system analogue inputs initiate a high alarm. The contact will open when the silence button is pressed and the alarm is acknowledged.
- Configure the digital output A2_2_ACT_MS:A131_1_DO to close contact COO101 point 14 when any of the kiln 1 SO2 detection system analogue inputs initiate a high alarm. The contact will open when all the kiln 1 SO2 detection system analogue inputs are not in alarm.

ENQUIRY REF : MoFC1747 I/A
KILN PLANT SO2 DETECTION SYSTEM
I/A CONFIGURATION

- Configure the digital output A2_2_ACT_MS:A131_3_DO to open contact COO101 point 16 when any of the Kiln 1 SO2 detection system analogue inputs initiate a high high alarm. The contact will close when all the kiln 1 SO2 detection system analogue inputs are not in high high alarm.
- Configure a Kiln Plant SO2 Detection System Evacuation Defeat Button on the Kiln 1 defeat Graphic to turn red to indicate defeat key has been switched. The icon will turn back to its original colour when the kiln 1 SO2 detection system defeat has been turned back manually at the panel.
- Configure a Kiln Plant SO2 Detection System Overlay Button on the Kiln 1 Activator Graphic to turn red and sound the existing kiln alarm when any of the kiln 1 SO2 detection system analogue inputs initiate a high alarm. The icon will turn back to its original colour when all the kiln 1 SO2 detection system analogue inputs are not in alarm.
- Create a new Kiln Plant SO2 Detection System Overlay as per drawing supplied.
- Configure pattern alarm blocks as required.
- Create a new faceplate graphic as per existing kiln graphic to display Kiln 1 SO2 Detection System analogue inputs points 1 to 3.
- Create a new trend graphic as per existing kiln trend graphic to trend Kiln 1 SO2 Detection System analogue inputs points 1 to 3.
- Create a new enable/disable overlay graphic.

Kiln 2 SO2 Detection System Configuration Requirements

The following is a detail specification for the Kiln Plant SO2 Detection System.

- Configure analogue input blocks as detailed in the following table:
The inputs will be 4-20 mA input signal and high alarm facility is required:

Name	DESCRP	Loonid	Iom_id	Pnt.No	Range	Hi Al	Hi Hi Al
BV_4_ACT_MS-A231_1_AI	SO2 DETECTOR_KILN 2 ACT SO2 CONTROL VALVE AREA	A231_1_AI	AIN216	11	0-10 PPM	1 PPM	2 PPM
BV_4_ACT_MS-A231_2_AI	SO2 DETECTOR_KILN 2 ACT SO2 FLOW TRANSMITTER AREA	A231_2_AI	AIN216	12	0-10 PPM	1 PPM	2 PPM

- Configure digital output blocks as detailed in the following table:

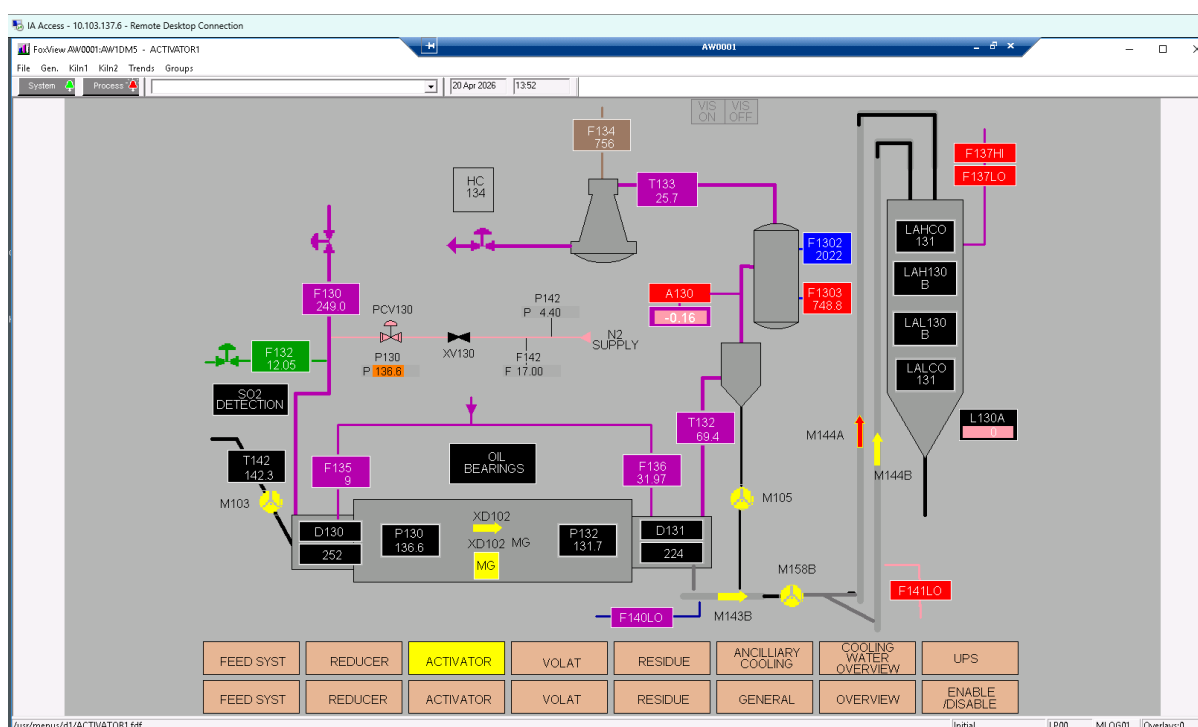
Name	DESCRP	Loonid	Iom_id	Pnt.No
BV_4_ACT_MS-A231_1_DO	KILN 2 SO2 DETECTION SYSTEM ALARM BEACON	A231_1_DO	COO201	14
BV_4_ACT_MS-A231_2_DO	KILN 2 SO2 DETECTION SYSTEM ALARM SOUNDER	A231_2_DO	COO201	15
BV_4_ACT_MS-A231_3_DO	KILN 2 SO2 DETECTION SYSTEM EVAC	A231_3_DO	COO201	16

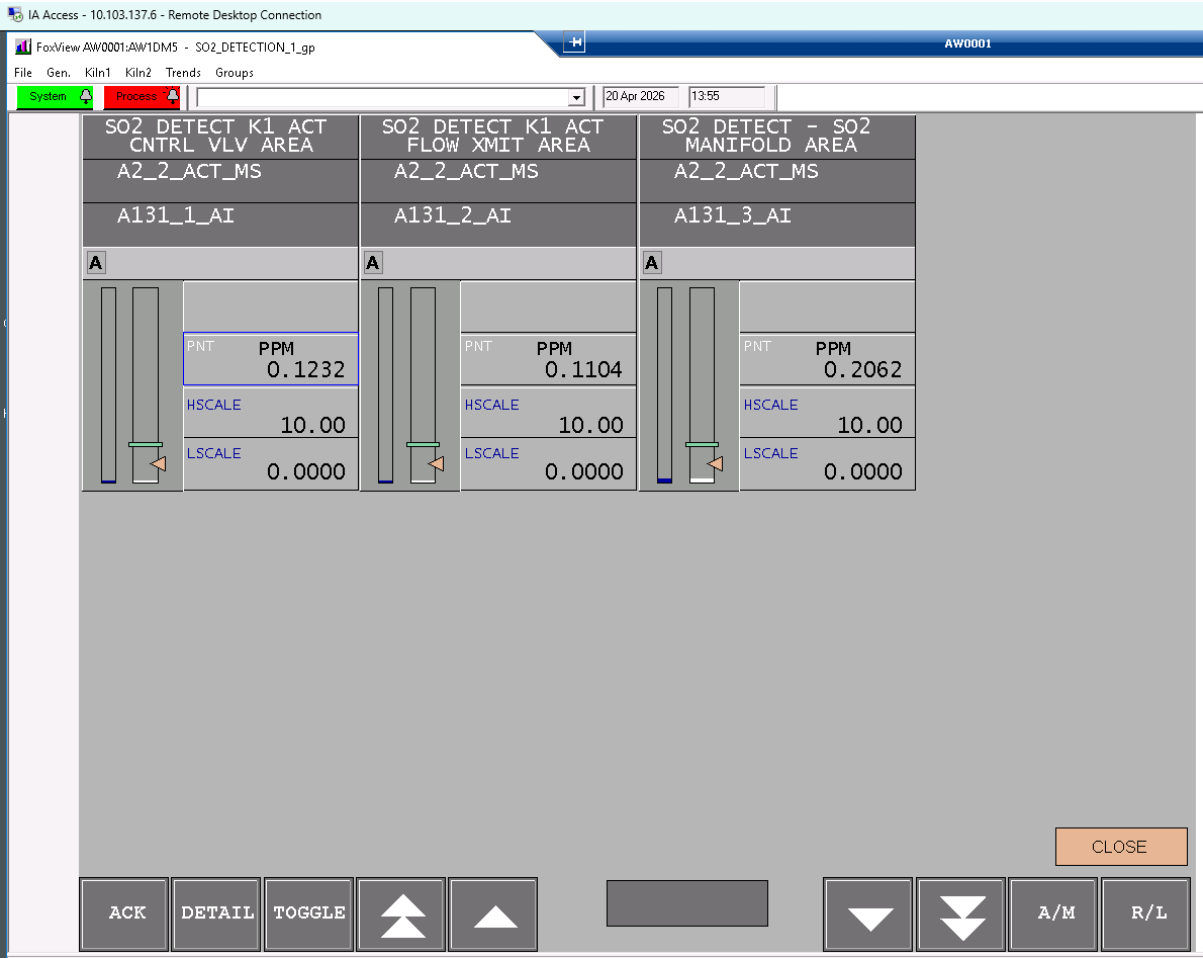
- Configure digital input blocks as detailed in the following table:

Name	DESCRP	Loonid	Iom_id	Pnt.No
BV_4_ACT_MS-HS_A231_1_DI	KILN 2 SO2 DETECTION SYSTEM EVACUATION DEFEAT	HS_A231_DI	CIN210	14

- Configure the digital output BV_4_ACT_MS:A231_2_DO to close contact COO201 point 15 when any of the kiln 2 SO2 detection system analogue inputs initiate a high alarm. The contact will open when the silence button is pressed and the alarm is acknowledged.

- Configure the digital output BV_4_ACT_MS:A231_1_DQ to close contact COO201 point 14 when any of the kiln 2 SO2 detection system analogue inputs initiate a high alarm. The contact will open when all the kiln 2 SO2 detection system analogue inputs are not in alarm.
- Configure the digital output BV_4_ACT_MS:A231_3_DQ to open contact COO201 point 16 when any of the Kiln 2 SO2 detection system analogue inputs initiate a high alarm. The contact will close when all the Kiln 2 SO2 detection system analogue inputs are not in high alarm.
- Configure a Kiln Plant SO2 Detection System Evacuation Defeat Button on the Kiln 2 defeat Graphic to turn red to indicate defeat key has been switched. The icon will turn back to its original colour when the kiln 2 SO2 detection system defeat has been turned back manually at the panel.
- Configure a Kiln Plant SO2 Detection System Overlay Button on the Kiln 2 Activator Graphic to turn red and sound the existing kiln alarm when any of the kiln 2 SO2 detection system analogue inputs initiate a high alarm. The icon will turn back to its original colour when all the kiln 2 SO2 detection system analogue inputs are not in alarm.
- Create a new Kiln Plant SO2 Detection System Overlay as per drawing supplied.
- Configure pattern alarm blocks as required.
- Create a new faceplate graphic as per existing kiln graphic to display Kiln 2 SO2 Detection System analogue inputs points 1 to 2.
- Create a new trend graphic as per existing kiln trend graphic to trend Kiln 2 SO2 Detection System analogue inputs points 1 to 2.
- Create a new enable/disable overlay graphic.





IA Access - 10.103.137.6 - Remote Desktop Connection

FoxView AW0001:AW1DM5 - AIN AW0001

File View Trips Config Disp Kilns SftMnt

System Process 20 Apr 2026 13:57

BLOCK ALARM SUMMARY

CNTRL

TREND

CONFIG

PREV DISP

SO2 DETECT K1 ACT
CNTRL VLV AREA
A2_2_ACT_MS
A131_1_AI

A

MEAS

0.1170

PNT

PPM

0.1170

A131

MEASUREMENT

BAD ALARMS

OUT OF RANGE

AMRTIN: DISABLED

NASTDB: DISABLED

HHABS :
HHALIM: 2.00
LLABS :
LLALIM: 0.0000
MEASDB: 0.1000
PRIORITY 1
GROUP 1

HIABS :
MEASHL: 1.00
LOABS :
MEASLL: 0.0000
MEASDB: 0.1000
PRIORITY 2
GROUP 1

IOBAD :

PRIORITY 1
GROUP 1

RANGE :

PRIORITY 5
GROUP 1

ACK

CLOSE OVL

SOURCE

TOGGLE

▲

▲

DISABL_ALL

▼

▼

LOCK

A/M

IA Access - 10.103.137.6 - Remote Desktop Connection
FoxView AW0001:AW1DM5 - AIN
AW0001
File View Trips Config Disp Kilns SftMnt
System Process 20 Apr 2026 13:59

BLOCK ALARM SUMMARY

CNTRL

ALARM TEXT

ALARMS

TREND

CONFIG

PREV DISP

SO2 DETECT K1 ACT
CNTRL VLV AREA
A2_2_ACT_MS
A131_1_AI
A
MEAS
0.1172
PNT PPM
0.1172

A131

CONFIGURATION

OWNER

LOCKID:
TYPE : AIN
PERIOD: 2 sec
INITMA: 1
INHIB : N
INHOPT: 1
MANALM: 0
HHAOPT: HH
HLOP : H
ORAO : N

FLOP : 0
FTIM : 0.000
MA : 1

IOMOPT: 1
SCI : 3
PNT_NO: 11
IOM_ID: AIN116
XREFOP: N
DEV_ID: 001252
PROPT : N
BAD : N
BAO : N
BADOPT: 3
LASTGV: Y

KSCALE: 1.00
BSCALE: 0.0000

ACK

CLOSE OVL

SOURCE

TOGGLE

▲

▲

▼

▼

LOCK

A/M

FOXBORO: Integrated Control Configurator

HELP
SHOW
FBM
PRINT
NEW
CHECKPOINT
MAINT
BUFFER
EXIT

Integrated Control Configurator
Active
STA = CP0001 @AW0001

A2_2_ACT_MS
A111_6_AI
A111_7_AI
A130_AI
A130_DI
P142_AI
F142_AI
HS_A131_1_DI
A131_1_AI
A131_2_AI
A131_3_AI
A131_LG
A131_1_DO
A131_2_DO
A131_3_LG
A131_3_DO
Z130_AI
Z130_AO
FS1309_DI
XV1310_LG
XV1310_GDEV
XV1311_LG

Block Definition:
Name: A131_1_AI
Type: AIN
DESCRP S02 DETECT K1 ACT CNTRL VLV AREA
PERIOD 3
PHASE 1
LOOPID A131
IOMOPT 1
IOM_ID AIN116
PNT_NO 11
SCI 3
HSC01 10.0
LSC01 0.0
DELTO1 1.0
E01 PPM
OSV 2.0
EXTBLK 0
MA 0
INITMA 1
BADOPT 3
LASTGV 1
INHOPT 1

Done
Cancel

FOXBORO: Integrated Control Configurator

HELP
SHOW
FBM
PRINT
NEW
CHECKPOINT
MAINT
BUFFER
EXIT

Integrated Control Configurator
Active
STA = CP0001 @AW0001

A2_2_ACT_MS	Block Definition:
A111_6_AI	Name: A131_1_AI
A111_7_AI	Type: AIN
A130_AI	ANM S02 TO KILN 1 ACT H2 INLET
A130_DI	HAL 1.0
P142_AI	HAT HIGH S02
F142_AI	LAL 0.0
HS_A131_1_DI	LAT
A131_1_AI	HLDB 0.1
A131_2_AI	HLPR 2
A131_3_AI	HLGP 1
A131_LG	HHAOPT 2
A131_1_DO	HHALIM 2.0
A131_2_DO	HHATXT HI HI S02 LEVEL
A131_3_LG	LLALIM 0.0
A131_3_DO	LLATXT
Z130_AI	HHAPRI 1
Z130_AO	HHAGRP 1
FS1309_DI	PROPT 0
XV1310_LG	MEAS 0.0
XV1310_GDEV	AMRTIN 0
XV1311_LG	NASTDB 0

Done
Cancel

FOXBORO: Integrated Control Configurator

HELP
SHOW
FBM
PRINT
NEW
CHECKPOINT
MAINT
BUFFER
EXIT

Integrated Control Configurator
Active
STA = CP0001 @AW0001

A2_2_ACT_MS
A111_6_AI
A111_7_AI
A130_AI
A130_DI
P142_AI
F142_AI
HS_A131_1_DI
A131_1_AI
A131_2_AI
A131_3_AI
A131_LG
A131_1_DO
A131_2_DO
A131_3_LG
A131_3_DO
Z130_AI
Z130_A0
FS1309_DI
XV1310_LG
XV1310_GDEV
XV1311_LG

Block Definition:
Name: A131_LG
Type: LOGIC
DESCRP DRIVE KILN 1 S02 BEACON SOUNDER
PERIOD 3
PHASE 1
LOOPID
BI01 :A131_1_AI.HAI
BI02 :A131_2_AI.HAI
BI03 :A131_3_AI.HAI
BI04 0
BI05 :A131_1_AI.UNACK
BI06 :A131_2_AI.UNACK
BI07 :A131_3_AI.UNACK
BI08 0
BI09 :A131_1_AI.INHIB
BI10 :A131_2_AI.INHIB
BI11 :A131_3_AI.INHIB
BI12 0
BI13 0
BI14 0
BI15 0

Done Cancel

FOXBORO: Integrated Control Configurator

HELP
SHOW
FBM
PRINT
NEW
CHECKPOINT
MAINT
BUFFER
EXIT

Integrated Control Configurator
Active
STA = CP0001 @AW0001

A2_2_ACT_MS
A111_6_AI
A111_7_AI
A130_AI
A130_DI
P142_AI
F142_AI
HS_A131_1_DI
A131_1_AI
A131_2_AI
A131_3_AI
A131_LG
A131_1_DO
A131_2_DO
A131_3_LG
A131_3_DO
Z130_AI
Z130_AO
FS1309_DI
XV1310_LG
XV1310_GDEV
XV1311_LG

Block Definition:
Name: A131_2_DO
Type: COUT
DESCRP ILN 1 S02 DETECTR ALARM SOUNDER
PERIOD 2
PHASE 1
LOOPID A131
IOMOPT 1
IOM_ID C00101
PNT_NO 15
IN : A131_LG.B002
PROPT 0
EROPT 0
PLSOPT 0
WIDTH 0.0
INVCO 0
MA 0
INITMA 1
MANFS 0
INHOPT 0
INHIB 0
BAO 0

Done
Cancel

FOXBORO: Integrated Control Configurator

HELP
SHOW
FBM
PRINT
NEW
CHECKPOINT
MAINT
BUFFER
EXIT

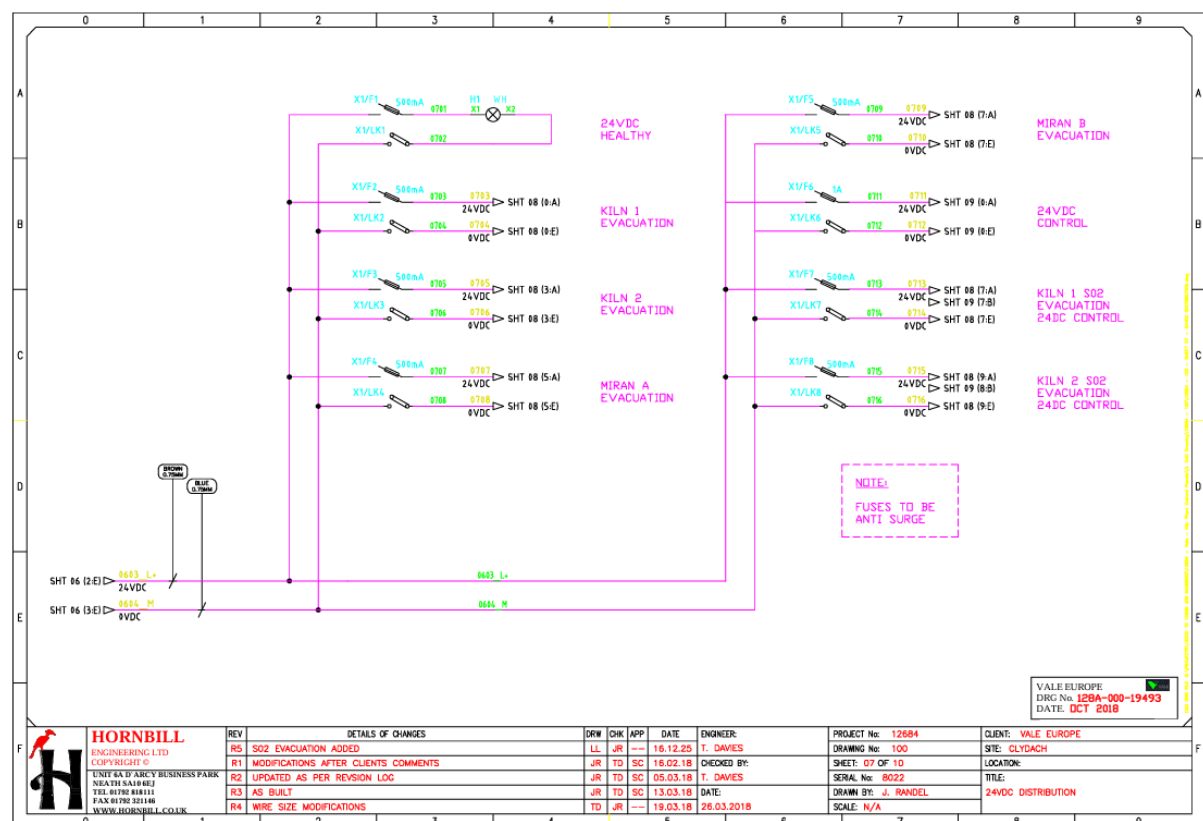
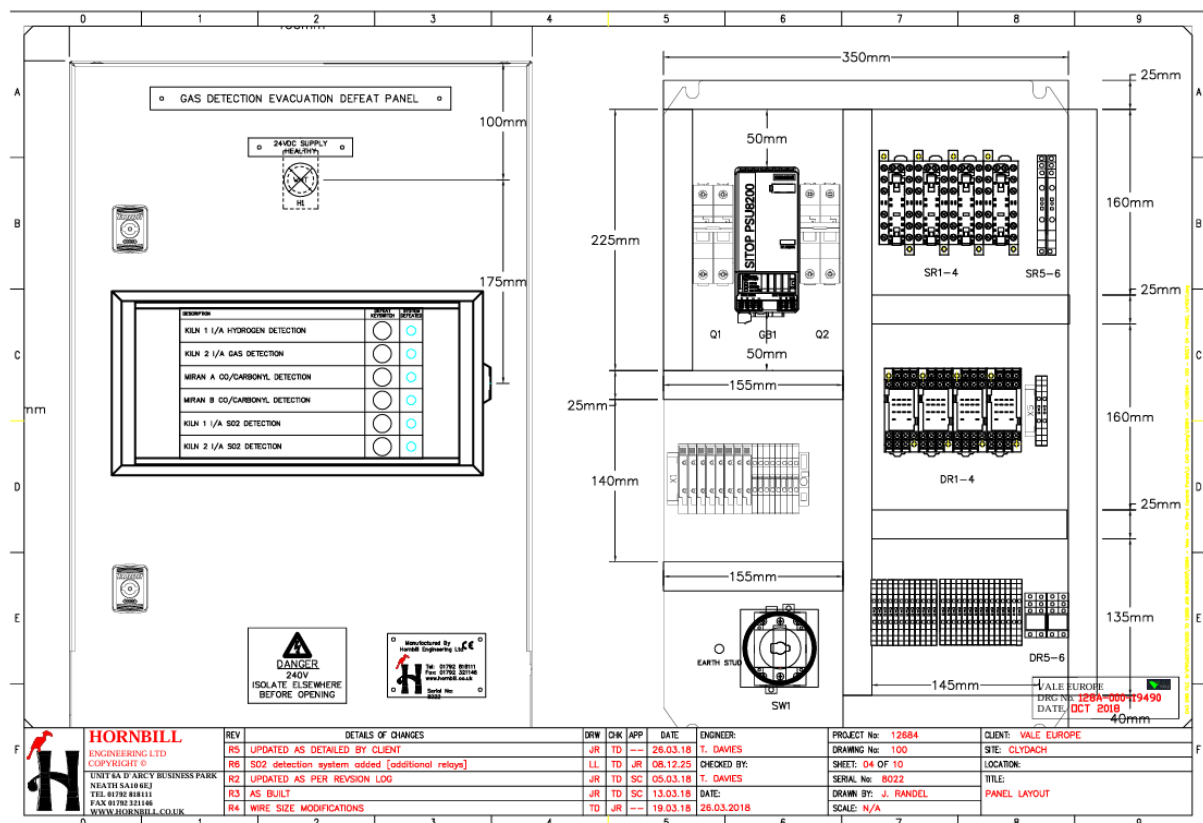
Integrated Control Configurator
Active
STA = CP0001 @AW0001

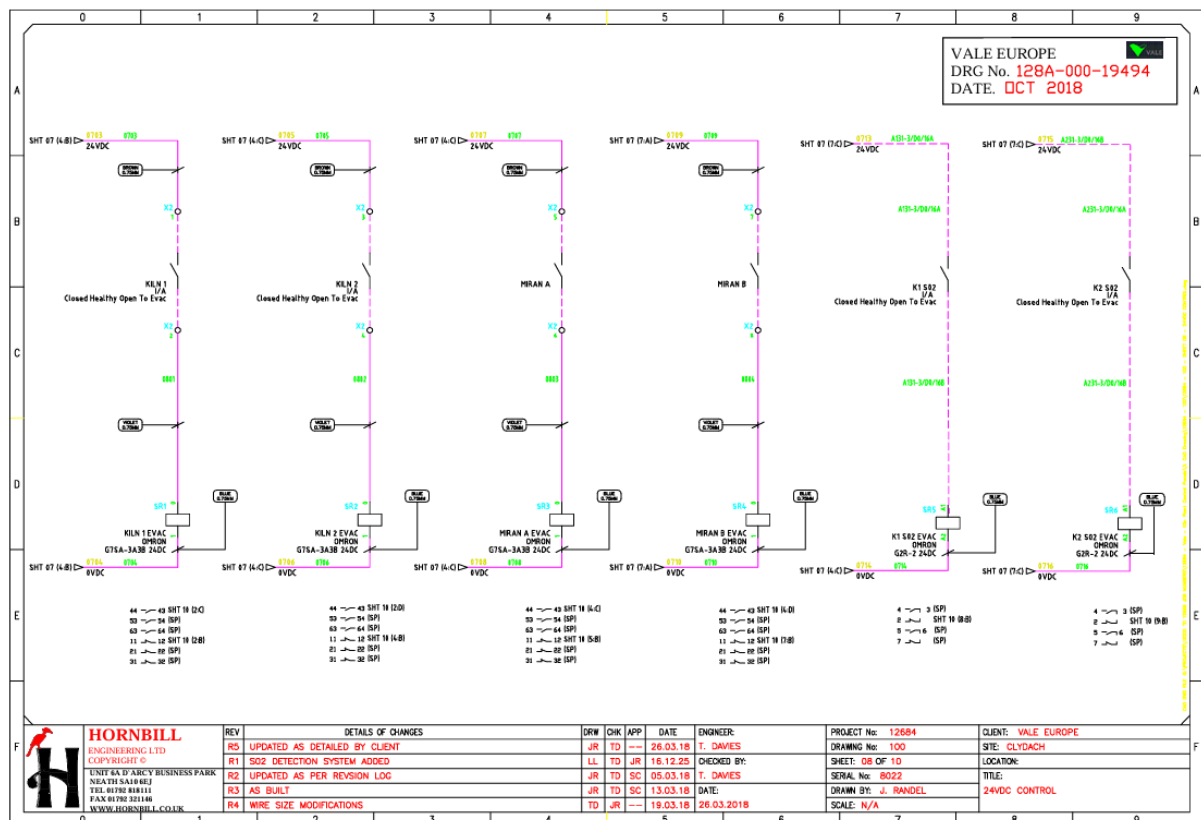
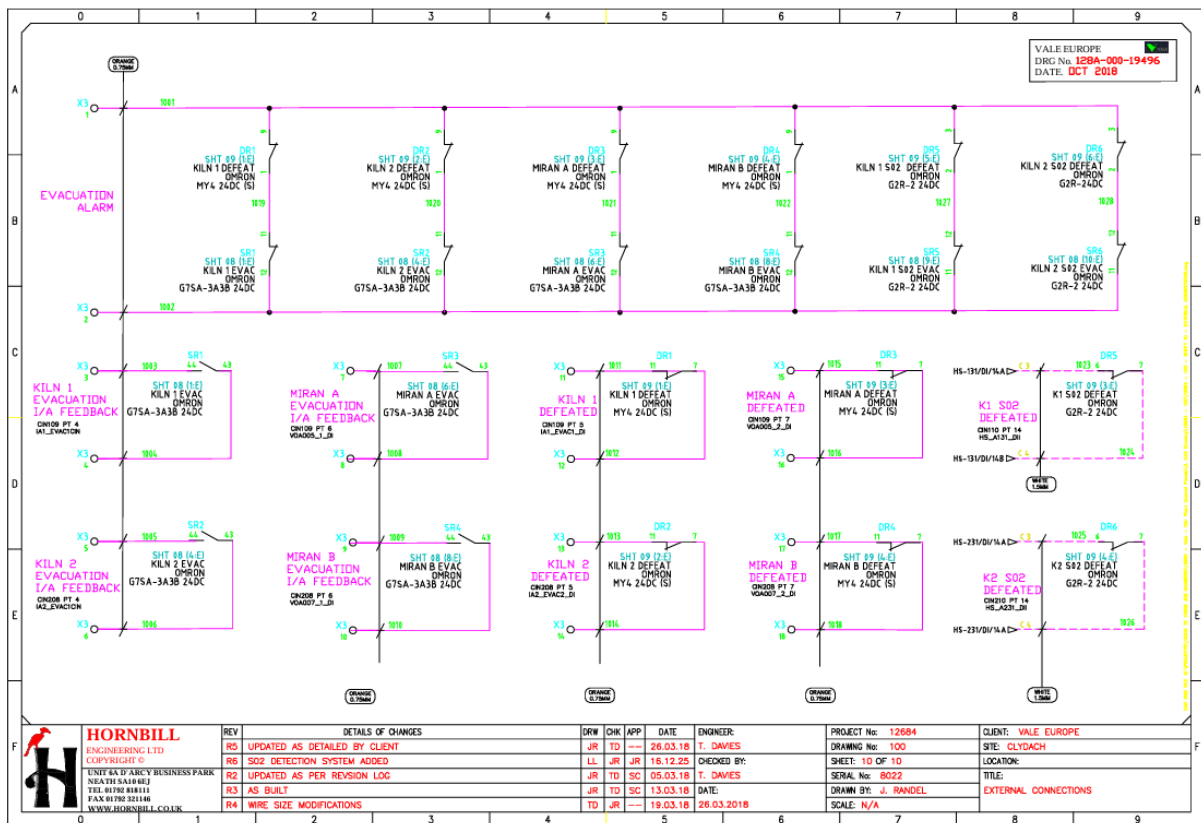
A2_2_ACT_MS
A111_6_AI
A111_7_AI
A130_AI
A130_DI
P142_AI
F142_AI
HS_A131_1_DI
A131_1_AI
A131_2_AI
A131_3_AI
A131_LG
A131_1_DO
A131_2_DO
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Z130_AI
Z130_AO
FS1309_DI
XV1310_LG
XV1310_GDEV
XV1311_LG

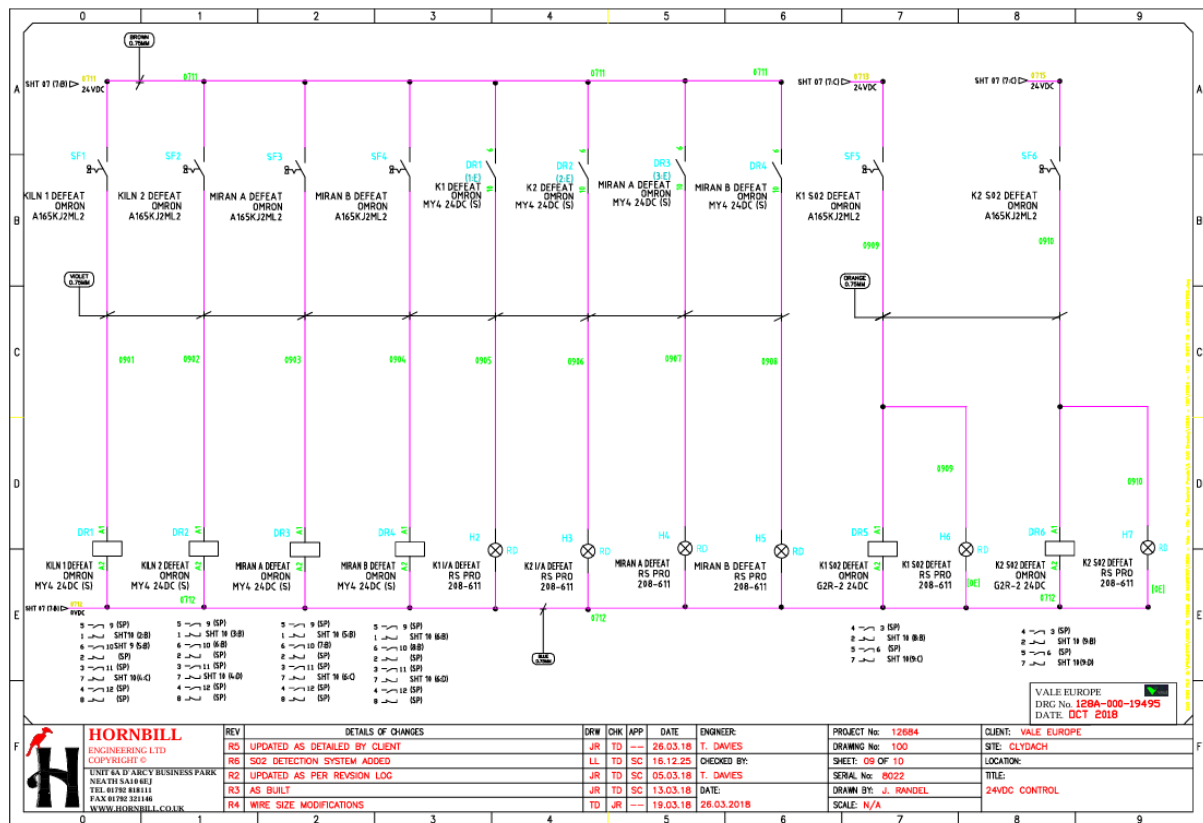
Block Definition:
Name: HS_A131_1_DI
Type: CIN
DESCRP ☒ ILN 1 S02 EVAC ALARM DEFEAT
PERIOD 3
PHASE 0
LOOPID
IOMOPT 1
IOM_ID CIN110
PNT_NO 14
ANM INPUT
NM0 RETURN TO SERVICE
NM1 DEFEATED
IVO 0
MA 1
INITMA 1
INHOPT 0
INHIB 1
INHALM 0x0
INVALM 0
MANALM 0
SAO 1

Done Cancel

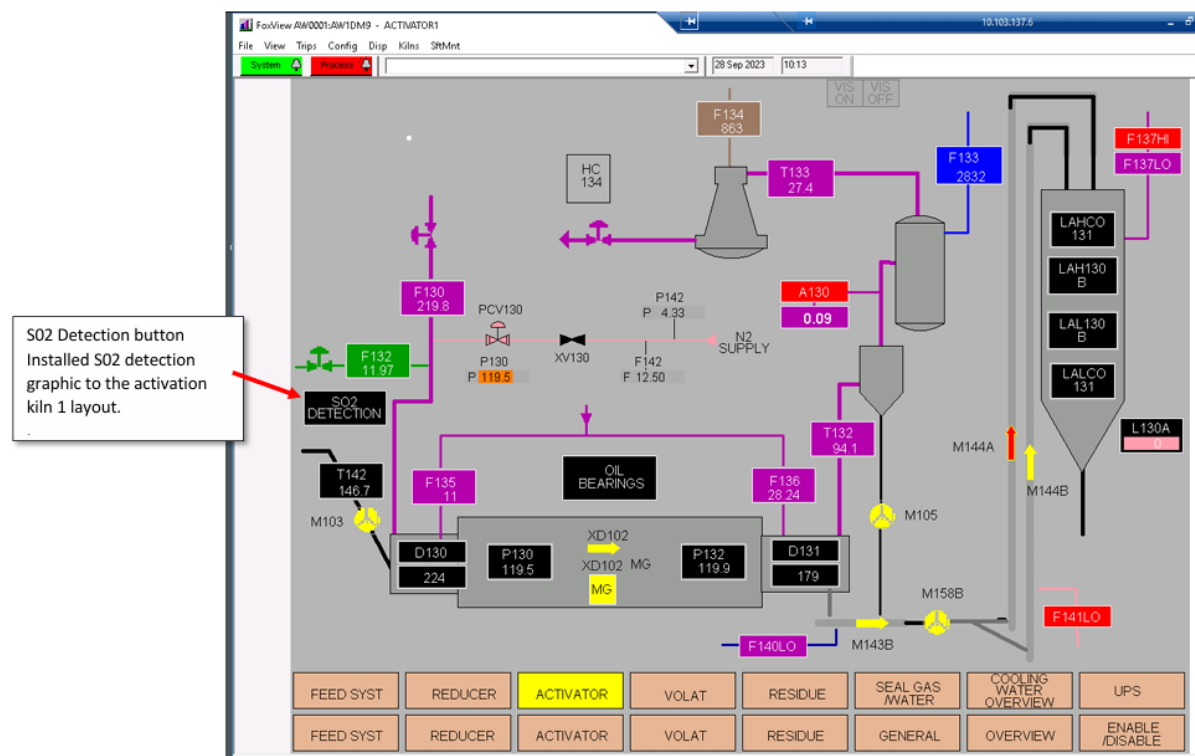
APPENDIX J: Evacuation Defeat Panel Drawings



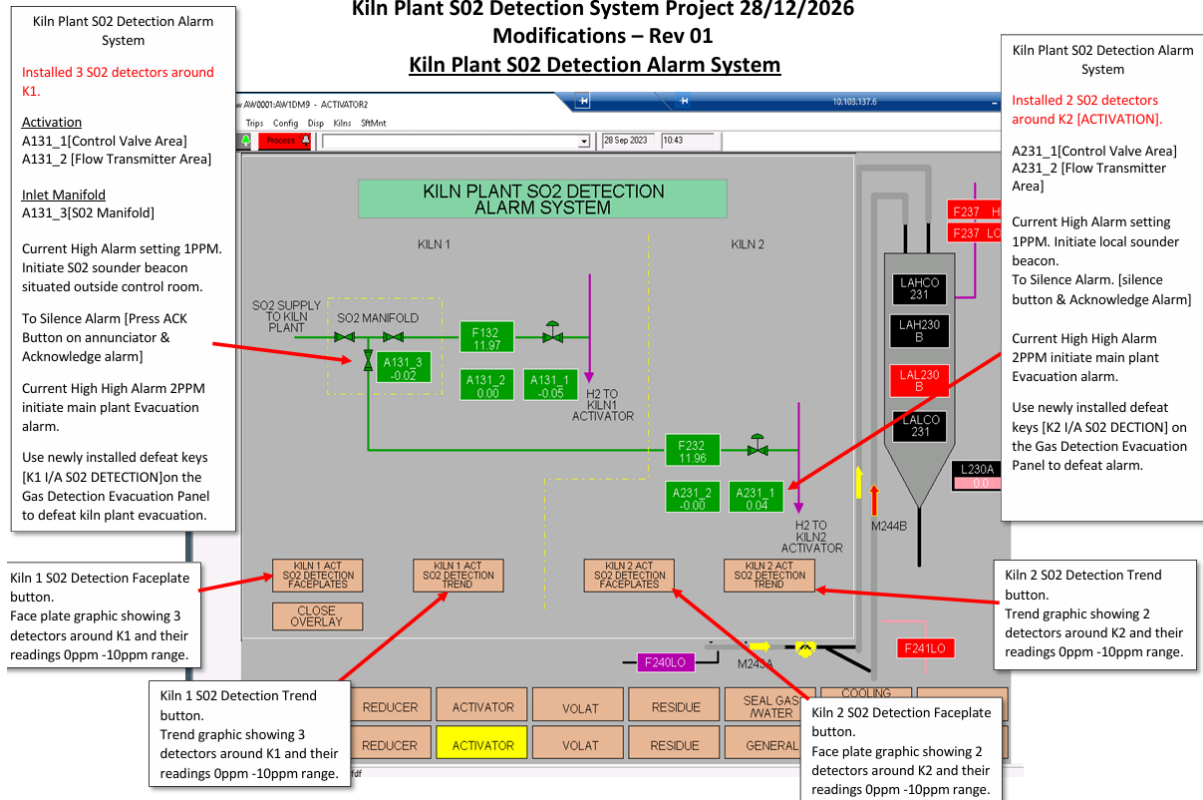




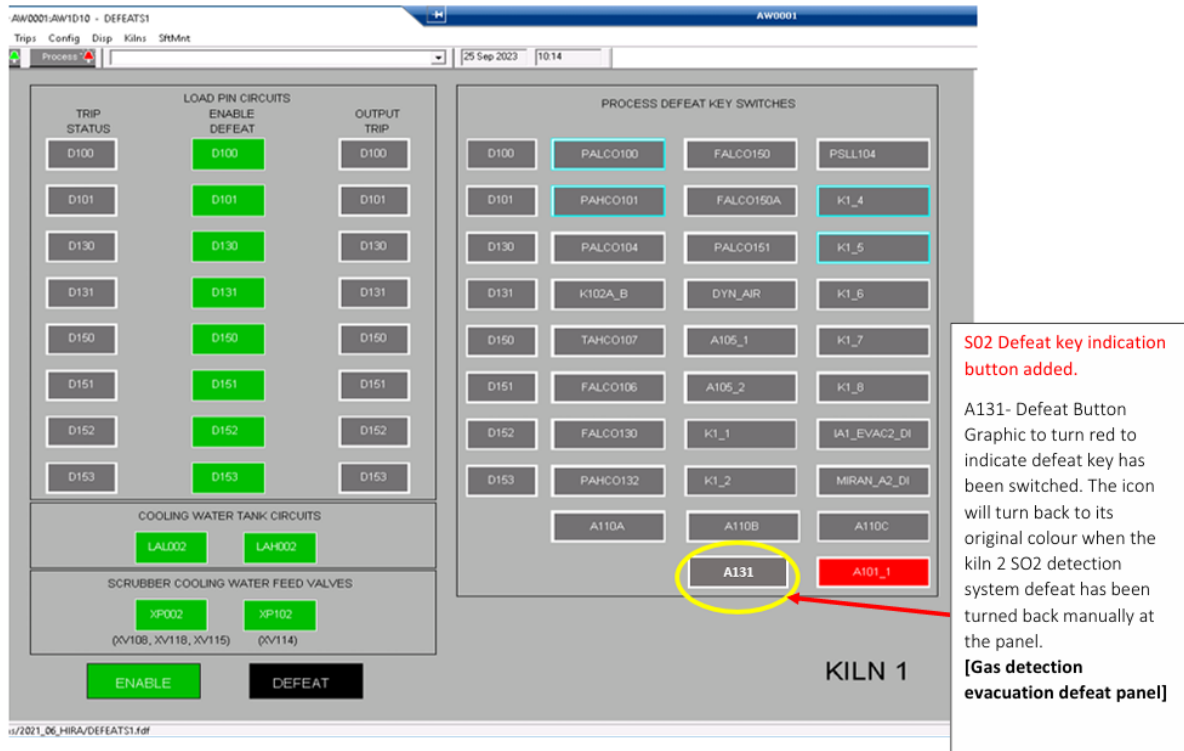
APPENDIX K: Operator Training Materials / HMI Graphics



Kiln Plant SO2 Detection System Project 28/12/2026 Modifications – Rev 01 Kiln Plant SO2 Detection Alarm System



DEFEATS1 GRAPHIC MODIFICATIONS



APPENDIX L: Procurement Quotations

Quotation
Crowcon Detection Instruments Ltd. 172 Brook Drive, Milton Park, Abingdon, Oxfordshire, OX14 4SD, United Kingdom Tel +44 (0) 1235 557700 Email: quotes@crowcon.com
Quote Ref No: QUO-16611-N6S6

 CROWCON Detecting Gas Saving Lives
Account No: [REDACTED]
Date: [REDACTED]
Payment Terms: 30 days end of month

Customer	Vale Europe Limited
Contact Name	Luis Lloyd
E-mail	[REDACTED]
Tel Number	[REDACTED]
Your Reference	Fixed - SO2

DETAIL LINES

Part Number	Description	Qty	List Price	Discount %	Line Amount
XIQ-ZZ-S1-011-Z-Z-A	XIQ SSteel M20 ATEX/IECEx ENG	5.00	£1,057.00	20.00	£4,228.00
XIQ-AJ	XGARDIQ Sensor Module, SO2, 0-10PPM	5.00	£358.00	20.00	£1,432.00
S012340	XGARDIQ COLLECTOR CONE ASSEMBLY	5.00	£105.00	4.00	£525.00
COMM	Commission(CLIENT TO INSTALL,TERMINATE/ID CABLES)	1.00	£810.00		£810.00
Sub Total					£6,995.00
Shipping Costs					£0.00
Total (Excluding VAT)					£6,995.00

Currency	Pound Sterling
Estimated Lead Time	2-3 weeks
Freight Terms	CPT

Quotation

Quote reference number: [REDACTED]

Crowcon Detection Instruments Ltd.
172 Brook Drive, Milton Park,
Abingdon, Oxfordshire, OX14 4SD,
United Kingdom
Tel. +44 (0) 1235 557700
Email: quotes@crowcon.com



Account No.: [REDACTED]
Date: [REDACTED] 2025
Payment Terms: 30 days end of month

Customer: Vale Europe Ltd
Contact Name: Luis Lloyd
Your Reference: XG1 SO2

Currency: GBP
Freight Terms: CPT
Lead Time: 7-10 Working Days

No.	Description	Quantity	Unit Price	Discount %	Line Amount
XG1-N1-01-SQ	XG1 GRNylon M20 ATEX/IECEx SO2-10ppm	5	893.00	0.00	4,465.00
COMM	Commission(CLIENT TO INSTALL,TERMINATE/ID CABLES)	1	990.00	0.00	990.00
Z-UKDELCH2	Crowcon UK Orders 1-10K	1	50.00		50.00
Total GBP Excl. VAT					5,505.00

This quotation is subject to acceptance by 30 days of the above date and is subject to our standard Terms and Conditions. Please click the link below to view our Terms and Conditions.
[Terms and Conditions](#)

Quotation

Quotation No

Quotation prepared for:-
VALE EUROPE LIMITED
[REDACTED]
MOND WORKS, CLYDACH
SWANSEA
SA6 5QR

Prepared by:-
R & M Electrical Group Ltd
Swansea Branch
Units 4 & 5, Charnwood Court
Viking Way, Winch Wen
Swansea
SA1 7DA

Account	Processed by	Date	Time	Order Number
██████████	██████████	██████████	16:██	16065344
Your Contact	Customer Order No	Quote expiry date		
		██████████		

Item Code	Description	Quantity	Price	Discount	Total V
1 S/635578	RFUCHS KF80-CS-EXL-50P	6 EA	224.66 EA		1347.96 S

Please note this is
not a VAT invoice

Total Goods Ex VAT : 1347.96

Currency : Sterling

ITEM	DESCRIPTION	UNIT OF MEASURE	COST TO VALE	TOTAL COST
Line	DIRECT LABOUR RATES			
1	Management / Supervision-Standard Cost	1	£313.52	313.52
1	Productive Labour-Standard Cost	1	£1,803.38	1,803.38
	SUB-TOTAL 1			£2,116.90
Line	DIRECT LABOUR OVERTIME RATES			
1	Management / Supervision- Premium Cost	1	0.00	-
1	Productive Labour- Premium Cost	1	0.00	-
	SUB-TOTAL 2			£0.00
	Total Labour Cost			£2,116.90
	MAJOR EQUIPMENT HIRE (Add / Delete as Req).			
2	MEWP	1	-	-
2		1	-	-
2		1	-	-
2		1	-	-
2		1	-	-
	SUB-TOTAL EQUIPMENT COSTS			£0.00
Line	DIRECT MATERIAL (inc Mark up)			
3	Consumables	1	-	-
3	Material 1	1	880.00	880.00
3	Material 2	1	209.00	209.00
3	Material 3	1	-	-
3	Material 4	1	-	-
3		1	-	-
	SUB-TOTAL MATERIAL			£1,089.00
Line	Miscellaneous Expenses (Add / Delete as Req)			
4	QA	1	-	-
4	Design	1	-	-
4		1	-	-
4		1	-	-
4		1	-	-
	SUB-TOTAL MISCELLANEOUS COSTS			£0.00
D	TOTAL COST (£)			£3,205.90
COMMENTS RELATING TO QUOTATION				

APPENDIX M: Individual Loop Calibration Certificates



VALE INCO

CLYDACH NICKEL REFINERY

SF07A/02	Page 1 of 1	Issue Status: 1
Title: Calibration Certificate		Date: JAN 2026

Job Card No. 202601714847-20		Location No. KILN 1		Reference No.		
Loop / Inst No: A131_1						
Type: S02 Detector [K1 Activation Flow TX Area]				Service: Activation S02 Mon		
Manufacturer: CROWCON				Serial No: W369319-02		
Model No: Xguard type 1						
Initial Calibration	Measurement	Instrument Input	Instrument Output	% Error	I/A Reading	STA Reading
		4mA	0 %		0 PPM	
		8mA	25 %		2.5 PPM	
		12mA	50 %		5.0 PPM	
		16mA	75 %		7.5 PPM	
		20mA	100 %		10.0 PPM	
Final Calibration	Measurement	Instrument Input	Instrument Output	% Error	Panel/Screen Reading	% Error
		0 PPM	40.2 mV		0.06 PPM	
		5 PPM	120.2 mV		5.07 PPM	
		10 PPM	200.2mV		10.08 PPM	
IA03 FBM211 AIN116- PT12 Remarks: Initial Calibration 4-20mA for 0 – 10ppm Trip @ 1ppm Critical Alarm @ 2ppm Sounder Beacon Alarm operational Final Calibration Crowcon Engineer Calibration Gas of 10 PPM SO2 in nitrogen. S02 detector calibrated ok Signal checked back to DCS Loop Commissioned ok						
Calibration Checked by: J. Roberts / L. Lloyd				Date: 05-01-26		



VALE INCO

CLYDACH NICKEL REFINERY

SF07A/02	Page 1 of 1	Issue Status : 1
Title : Calibration Certificate		Date : - JAN 2026

Job Card No. 202601714847-20		Location No. KILN 1		Reference No. .		
Loop / Inst No: A131_2						
Type: S02 Detector [K1 Activation Flow TX Area]				Service: Activation S02 Mon		
Manufacturer: CROWCON				Serial No: W369319-02		
Model No: Xguard type 1						
Initial Calibration	Measurement	Instrument Input	Instrument Output	% Error	I/A Reading	STA Reading
		4mA	0 %		0 PPM	
		8mA	25 %		2.5 PPM	
		12mA	50 %		5.0 PPM	
		16mA	75 %		7.5 PPM	
		20mA	100 %		10.0 PPM	
Final Calibration	Measurement	Instrument Input	Instrument Output	% Error	Panel/Screen Reading	% Error
		0 PPM	40.2 mV		0.06 PPM	
		5 PPM	120.2 mV		5.07 PPM	
		10 PPM	200.2mV		10.08 PPM	
IA03 FBM211 AIN116- PT12 Remarks: <u>Initial Calibration</u> 4-20mA for 0 – 10ppm Trip @ 1ppm Critical Alarm @ 2ppm Sounder Beacon Alarm operational <u>Final Calibration</u> Crowcon Engineer Calibration Gas of 10 PPM SO2 in nitrogen. S02 detector calibrated ok Signal checked back to DCS Loop Commissioned ok						
Calibration Checked by: J. Roberts / L. Lloyd					Date: 05-01-26	



VALE INCO

CLYDACH NICKEL REFINERY

SF07A/02	Page 1 of 1	Issue Status : 1
Title : Calibration Certificate		Date :- Jan 2026

Job Card No. 202301714847-20		Location No. KILN 1		Reference No. .		
Loop / Inst No: A131 3						
Type: S02 Detector [S02 Manifold]				Service: Manifold S02 Mon		
Manufacturer: CROWCON				Serial No: W369319-03		
Model No: Xguard type 1						
Initial Calibration	Measurement	Instrument Input	Instrument Output	% Error	I/A Reading	STA Reading
		4mA	0 %		0 PPM	
		8mA	25 %		2.5 PPM	
		12mA	50 %		5.0 PPM	
		16mA	75 %		7.5 PPM	
		20mA	100 %		10.0 PPM	
Final Calibration	Measurement	Instrument Input	Instrument Output	% Error	Panel/Screen Reading	% Error
		0 PPM	40.4mV		0.06 PPM	
		5 PPM	120.1mV		5.07 PPM	
		10 PPM	200.1mV		10.08 PPM	
IA03 FBM211 AIN116- PT13 Remarks: <u>Initial Calibration</u> 4-20mA for 0 – 10ppm Trip @ 1ppm Critical Alarm @ 2ppm Sounder Beacon Alarm operational <u>Final Calibration</u> Crowcon Engineer Calibration Gas of 10 PPM SO2 in nitrogen. S02 detector calibrated ok Signal checked back to DCS Loop Commissioned ok						
Calibration Checked by: J. Roberts / L. Lloyd				Date: 06-01-26		



VALE INCO

CLYDACH NICKEL REFINERY

SF07A/02		Page 1 of 1		Issue Status : 1		
Title : Calibration Certificate				Date :- Jan 2026		
Job Card No. 202301714847-20		Location No. KILN 2		Reference No. .		
Loop / Inst No: A231_1						
Type: S02 Detector [K2 Activation Control Valve Area]				Service: Activation S02 Mon		
Manufacturer: CROWCON				Serial No: W369319-04		
Model No: Xguard type 1						
Initial Calibration	Measurement	Instrument Input	Instrument Output	% Error	I/A Reading	STA Reading
		4mA	0 %		0 PPM	
		8mA	25 %		2.5 PPM	
		12mA	50 %		5.0 PPM	
		16mA	75 %		7.5 PPM	
		20mA	100 %		10.0 PPM	
Final Calibration	Measurement	Instrument Input	Instrument Output	% Error	Panel/Screen Reading	% Error
		0 PPM	40.1 mV		0.07 PPM	
		5 PPM	120.1 mV		5.08 PPM	
		10 PPM	199.9 mV		10.07 PPM	
IA04 FBM211 AIN216- PT11 Remarks: <u>Initial Calibration</u> 4-20mA for 0 – 10ppm Trip @ 1ppm Critical Alarm @ 2ppm Sounder Beacon Alarm operational <u>Final Calibration</u> Crowcon Engineer Calibration Gas of 10 PPM SO2 in nitrogen. S02 detector calibrated ok Signal checked back to DCS Loop Commissioned ok						
Calibration Checked by: J. Roberts / L. Lloyd				Date: 06-01-26		



VALE INCO

CLYDACH NICKEL REFINERY

SF07A/02	Page 1 of 1	Issue Status : 1
Title : Calibration Certificate		Date : - Jan 2026

Job Card No. 202301714847-20	Location No. KILN 2	Reference No.
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Loop / Inst No: A231_2						
Type: S02 Detector [K2 Activation flow Tx Area]				Service: Activation S02 Mon		
Manufacturer: CROWCON				Serial No: W369319-05		
Model No: Xguard type 1						
Initial Calibration	Measurement	Instrument Input	Instrument Output	% Error	I/A Reading	STA Reading
		4mA	0 %		0 PPM	
		8mA	25 %		2.5 PPM	
		12mA	50 %		5.0 PPM	
		16mA	75 %		7.5 PPM	
		20mA	100 %		10.0 PPM	
Final Calibration	Measurement	Instrument Input	Instrument Output	% Error	Panel/Screen Reading	% Error
		0 PPM	40mV		0 PPM	
		5 PPM	120mV		5.08 PPM	
		10 PPM	200mV		10.09 PPM	

IA04
FBM211
AIN216- PT12

Remarks:
Initial Calibration
 4-20mA for 0 – 10ppm
 Trip @ 1ppm
 Critical Alarm @ 2ppm
 Sounder Beacon Alarm operational

Final Calibration
 Crowcon Engineer Calibration Gas of 10 PPM SO2 in nitrogen.
 S02 detector calibrated ok
 Signal checked back to DCS
 Loop Commissioned ok

Calibration Checked by: J. Roberts / L. Lloyd	Date: 06-01-26
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APPENDIX N: Installation Photographs

