final draft major report

by Joshua Davies

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PSDE6019 – Major Project

Lute Pot Automatic Level Control

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Abstract

This project is the design and implementation of an automatic level control system for an existing 'Lute Pot' liquid seal pressure relief system to control refinery waste gas pressure to the incinerators within the Incinerator plant at Vale Europe Limited. The existing system relied on process operators periodically checking the level within the vessel and adjusting via a manual valve to keep a certain level to maintain a desired pressure of waste gas.

The purpose of this project is to implement automatic level control for the lute pot to maintain a desired pressure for the waste gas incinerators that ensure efficient operation of the waste gas burners to incinerate the excess carbon monoxide produced on site limiting the use of the back up natural gas burners to emergency only.

The automatic level control system was designed, functionally tested within the workshop and implemented on plant and partially tested with only the automatic control tuning parameters still requiring implementation when the plant is available.

repetition

Acknowledgements

I would like to thank Mr. Mark Baynham (Engineering Manager) for trusting me to lead this project. I would like to thank Mr. Neil Hopkins (Electrical Manager) and Mr. Darren Paddison (Instrument Engineer) for their support throughout the project for without their guidance and consultation, the project wouldn't have been completed.

I would like to show personal gratitude to Aled Rees (Electrical Maintenance Supervisor) and the maintenance department for ordering of components, support in configuration of components in the workshop and to help test the new system on plant.

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Good

Well structured

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1. Introduction

The aim of this project is to design and implement automatic control of the level of water within the Refinery Waste Gas (RWG) Lute pot situated at the base of the refinery stack for better control of RWG pressure to the Incinerators Burner Management System (BMS).

The Pellet plants existing manual control operation being judged as insufficient and an opportunity has arisen to design and implement an automatic control loop to modernize and increase the efficiency of the RWG Lute pot system.

Automatic control of the level within the lute pot will eliminate manual interaction of the level where the use of a level sensor will measure the level and feedback a control signal to a control valve to control the process medium entering the vessel.

To reach the overall aim of the project, objectives were set where completion of each objective will build towards the final aim of the project. These objectives are:

- Conduct background research and literature review to understand how the existing system operates and reason for why the system requires upgrading.
- Investigate three different solutions that can solve the existing problem within a given budget justifying chosen solution.
- Design the solution to a given specification.
- Implement the solution on plant.
- Test the solution to evaluate that the specification has been met.

Clear statements of objectives

Vale Europe Limited

Punctuation Error

Vale Europe limited is a Nickel Refinery based in Clydach that is a part of Vales base metals division. The refinery receives nickel ore 'Furnace Mat Wales' (FMW) from Vales' Copper Cliff mine in Sudbury, Ontario and 'Tokyo Nickel Oxide' (TNOS) from Aisian mines. The Refinery consists of 7 individual plants that each play a vital role in refining the raw material using the Ludwig Mond process into nickel pellets, chips and powders. These plants are, Process Gas Plant (PGP), Kiln Plant, Pellet & Powder Plant (PPP), Water Treatment Plant, Gaseous Treatment Plant, Bulk Handling & shipping warehouse. A block diagram of the refineries operations' shown in Figure 1.

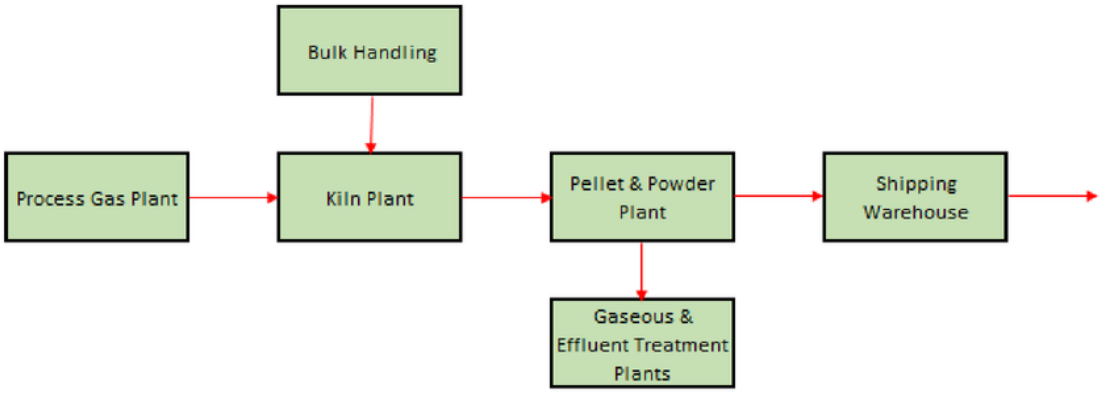


Figure 1 - Flow Diagram of Operation at Clydach Refinery

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The PGP is the beginning of the plants operation, Natural gas is supplied to the plant where it is chemically separated. The plant uses super-heated steam to aid in the separation as the natural gas is fed into the plants' process.

The natural gas is fed firstly into the Benfield absorber that separates the majority of the CO2 (Carbon Dioxide) out of the gas, the remaining CO2 is separated from the natural gas through the following 'DEA' Absorber. The remaining gas is absorbed within the Copper Liquor absorber that separates the CO (Carbon Monoxide) leaving the remaining gas pure Hydrogen. The Benfield, DEA and Copper Liquor process liquids that absorb each gas are processed through individual re-boilers that utilize the super- heated steam to boil off the liquids leaving the respective gases.

The three gases are then contained within individual 'Holders' on site that the Kiln plant use for production.

Citation Needed



Figure 2 - Process Gas Plant

The Kiln Plant consists of two kiln lines, 1 & 2 that are identical to each other. Each line consists of 4 Kilns in series where the raw material is fed into, starting at the Reduction kiln, Activation kiln, Volatilization kiln and finally the Stabilization kiln. Each kiln treats the material with different, temperatures and gases such as Hydrogen, CO, CO2 & Sulphur Dioxide to extract the Nickel from the 'FMW' and 'TNOS' to produce Nickel Carbonyl gas.



Figure 3 - Kiln Plant

you should always refer to and explain your figures in the text of the report

Bulk handling receives the raw material in shipping containers. A crane then places the containers on to the two hydraulic tippers. The Tippers then lifts the containers where the raw materials' transported on a series of conveyor belts to storage silos ready to feed into the kiln plant.



Figure 4 - Bulk Handling Crane & Feed Conveyor to Silos

The extracted Nickel Carbonyl gas from kiln plant is transferred to the PPP through 'Carbonyl Blowers', this gas supplies 19 Pellet Units and 8 Powder decomposers where the carbonyl gas binds on the iron fines that are being circulated through each unit through an elevator. Once the pellets grow to a specified size, they are caught in the sieve of the unit, and will be collected by at a pellet bin at the bottom.

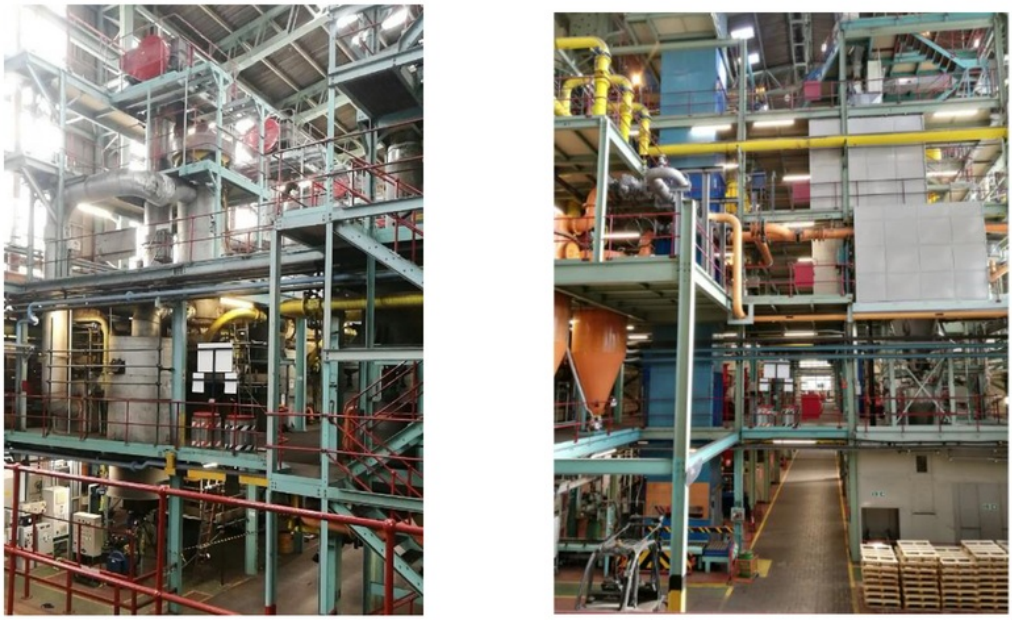


Figure 5 - Pellet Plant (Left) Powder Plant (Right)

Nickel powder is produced through decomposers, each decomposer contains four zones that are controlled through thyristor firing circuits to heat the decomposer. The gas is fed into the decomposer from the top along with Oxygen where the combination between the heat (200-400 degrees), Oxygen and Nickel carbonyl causes the gas to crystalize. The powders' transported through elevators and screw conveyors to be packed into drums.

The shipping warehouse receives the pellets bins from the PPP where the pellets and chips are put through another sieve for segregation. The sieved pellets are put into hoppers to be packed into 1 tonne drums and pallets of 50Kg boxes containing 5 10kg bags ready to be dispatched.



Figure 6 - Shipping Warehouse

All water used on site is treated at the Effluent treatment plant that removes the contamination from the water prior to exporting to the River Tawe.



Figure 7 - Effluent Treament Plant

The Gaseous treatment plant consists of two incinerators that produced heat to incinerate the excess CO produced at the PGP. The incinerators use natural gas and refinery waste gas to fuel each incinerator where incinerated product is vented out to atmosphere via the stack shown in Figure 8



Figure 8 - Gaseous Treatment Plant

This section does set the project in context. However, it should contain citations

2. Background Research and Literature Review

The Lute pot systems' based at the Incinerator plant next to the base of the stack. Where a pipe is teed from the RWG to Incinerator line down into the Lute pot. The Lute consists of the RWG inlet, 40-meter vent outlet, local indication and overflow pot that will take the used water to the WTP.

The existing set-up of the Incinerator Lute Pot systems' shown below in Figure 9

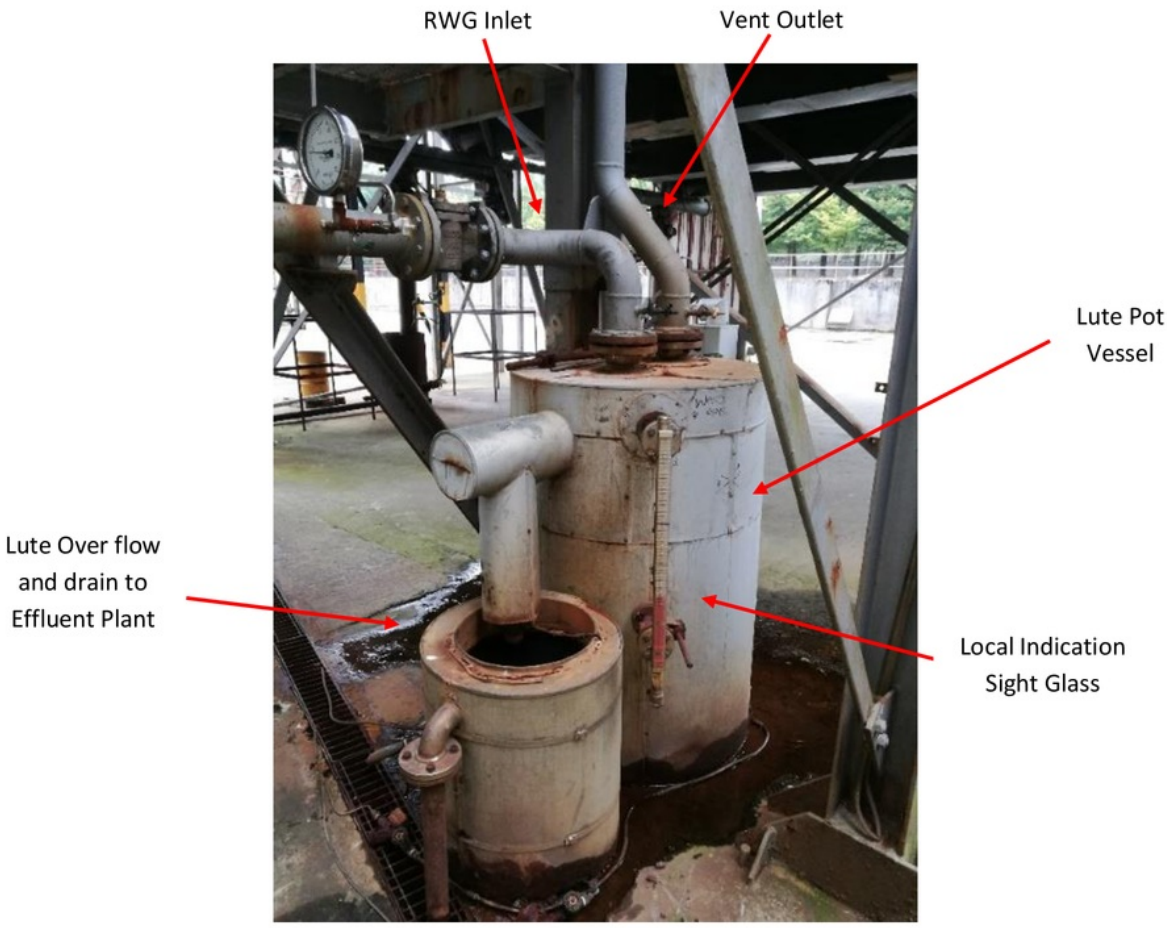


Figure 9 – Existing Configuration

The existing systems' controlled manually through an operator checking periodically through their shift, ensuring the level of the lute pot is within a margin on the local sight glass of the Lute so a sufficient backpressure of the RWG from the Kiln plant is given to incinerators waste gas burners A and B. A Lute pot is a pressure relief system utilizing a liquid seal that will separate relief gases and the burner through a layer of liquid. The waste gas is forced into the liquid of the pot and

bubbles to the top and is then vented to atmosphere thus preventing air or gas returning through liquid. The liquid seal also acts as flame arrestor as it allows gas to pass through but stops a flame from reacting with the gas-preventing explosion. (PetroWiki, 2015)



Figure 10 - Canal Water inlet

Figure 10 shows the valve set up for the canal water inlet to the Lute pot, this is where the operators control the amount of water flowing into the tank by adjusting the bypass ball valve.

RWG mainly consists of Hydrogen; the waste gas is the result of purging of the Reduction Kiln circuit to prevent the material from sticking inside the kiln. As the usage of the purge gas will fluctuate it produces a fluctuation of RWG pressure within the circuit feeding the waste gas burners.

Fluctuations of the pressure in the RWG circuit causes the level within the Lute to fluctuate becoming unstable as the greater the pressure, the bubbles produced from part of the gas being forced into the liquid seal are bigger producing more turbulence. The fluctuations of the level within the lute leads to issues at the waste gas incinerators when the level is too high or too low.

If the level is too low, RWG pressure will drop as the gas will overcome the liquid seal and vent to atmosphere where there will be insufficient gas flow/ pressure sent to the incinerator. The lack of pressure will lead to the waste gas Flow Control Valves operating constantly as a threshold flow is intermittently being met providing a poor supply of gas. If the Lute Pot level is too high, then a new problem occurs where the kiln plant will not be able to purge the Reduction kilns as

Punctuation Error

the purge gas, cant be purged out of the kilns which can result in the RWG leaking onto plant with the possibility of gassing personnel and creating an explosive atmosphere.

With inadequate control of the RWG to the incinerator, this leads to unnecessary use of the back-up natural gas burner thus costing a lot more money.

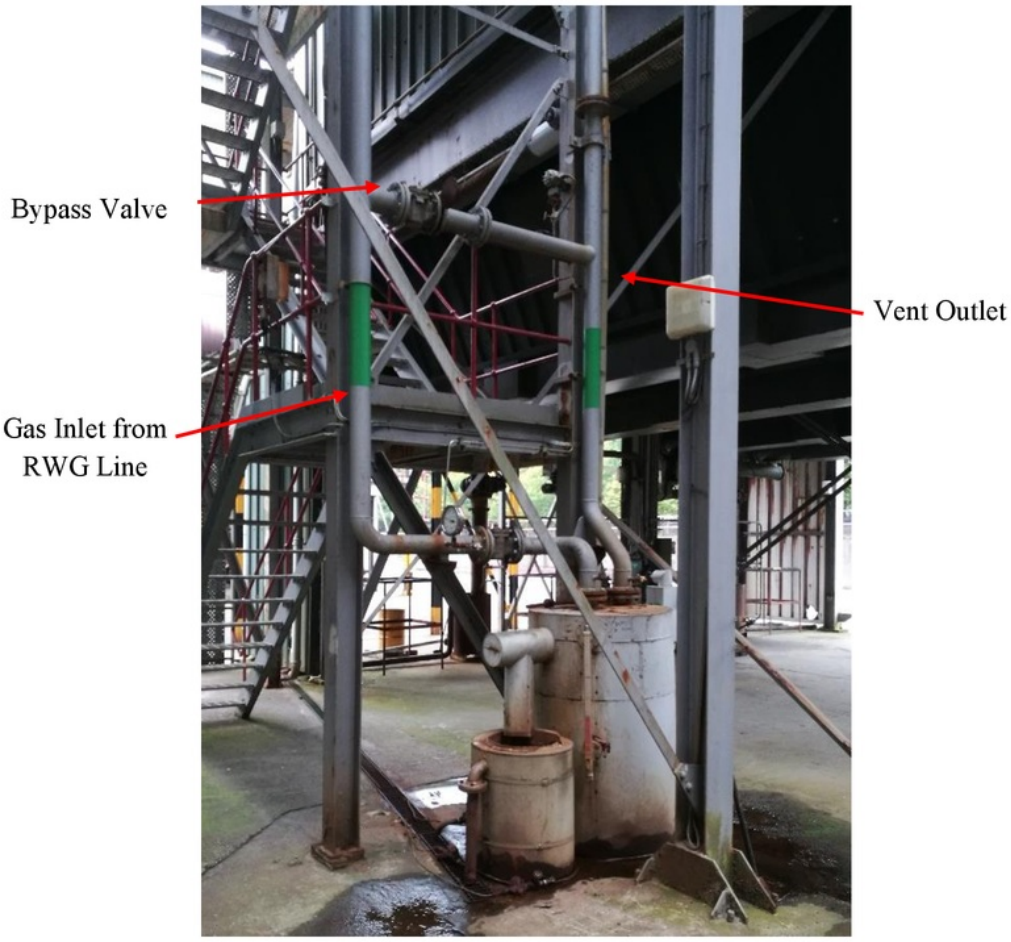


Figure 11 - Lute Pot Gas Inlet & Vent outlet

Figure 11 shows the overview of the gas inlet and vent outlet. There is a bypass route which can be used if there is a problem with the lute.

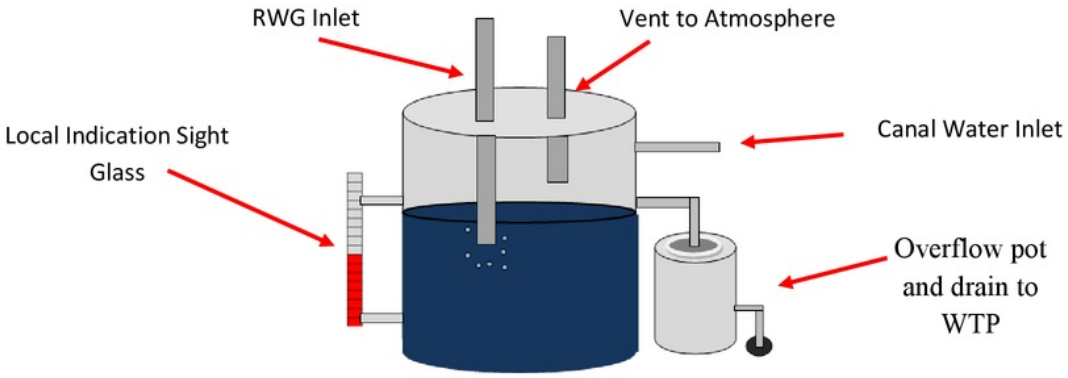


Figure 12 – Inside View of Lute

Figure 12 shows the internal view of the Lute pot. The RWG line connects to the pot through 4" ANSI flange and extends 520mm into the vessel where the canal water forms a liquid seal when the pipe is submerged. The gas from the RWG line is released into the liquid seal where the gas binds with the water and then vents to atmosphere that leads to the loss of level. Canal water is fed through a 1" pipe into the 398 liter vessel at a flow rate of 15 m3/hr.

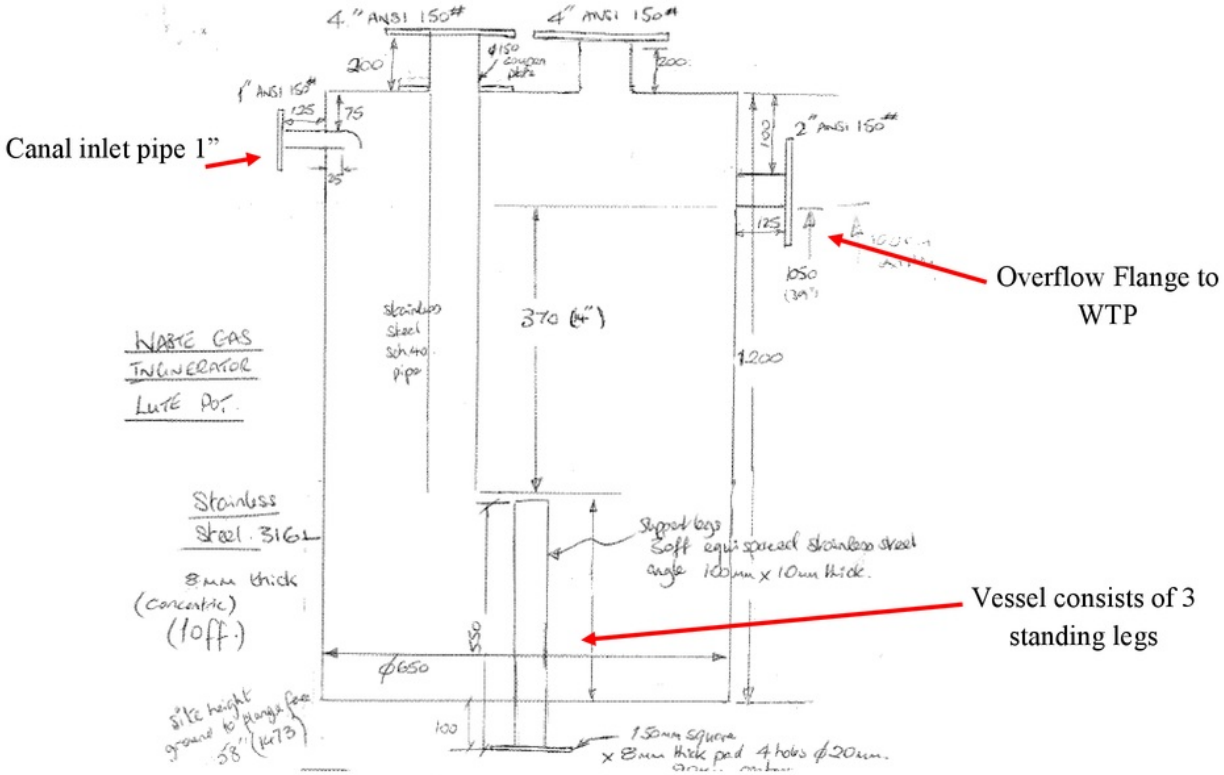


Figure 13 - Schematic Drawing of Lute Vessel

2.1. Dangerous Substances at Explosive Atmospheres Regulations (DSEAR 2002)

From studying the operation of the Lute pot and knowing the process liquids and gases that are involved, as the majority of RWG is hydrogen, the instruments utilized must comply with DSEAR 2002 (Dangerous Substances at Explosive Atmospheres Regulations). As hydrogen is an explosive gas, the design must input counter measures for protection to prevent an explosion occurring.

The DSEAR 2002 regulations puts duties on employers to protect employees and the public from fires, explosions and corrosion of metal in the workplace and those who could be at risk by the work activity. Dangerous substances are found in all workplaces that include flammable gases, solvents, varnishes, paints, liquids, pressurized gases and dusts from machining or foodstuffs. (HSE.GOV, 2018)

DSEAR protection consists of three ATEX (Atmospheres Explosive) classifications that determine the protection that is required. These area classifications are:

- ATEX 1G: A place that an explosive atmosphere is present continuously, long periods or frequently
- ATEX 2G: A place that an explosive atmosphere is likely to occur during operation occasionally.
- ATEX 3G: A Place that an explosive atmosphere is not likely to occur during operation but if it does, persists for a short period only.

G applying to gas, where D applies for dust. (CompEX, 2010)

Table 1 shows types of protection equipment suitable in each respective area classifications.

Table 1 - ATEX Category Protection Types

Protection Tag	Type	Suitable ATEX Categories
Ex ia	Intrinsically safe	1G
Ex ma	Encapsulation	1G
Ex ib	Intrinsically Safe	2G
Ex mb	Encapsulation	2G
Ex d	Flameproof	2G
Ex pxb	Pressurized	2G
Ex pyb	Pressurized	2G
Ex q	Powder Filled	2G
Ex o	Oil Filled	2G
Ex e	Increased Safety	2G
Ex ic	Pressurized	3G
Ex mc	Intrinsically Safe	3G
Ex pzb	Pressurized	3G
Ex nA	Non-Sparking	3G
Ex nR	Restrictive Breathing	3G
Ex nL	Energy Limiting	3G
Ex nC	Enclosed Break	3G

Spelling

ATEX 1 area classification must used equipment suitable for ATEX 1, ATEX 2 area classification must use equipment suitable for ATEX 1 and 2 whereas ATEX 3 area classification can use ATEX 1, 2 and 3 equipment.

(CompEX, 2010)

2.2. DSEAR Area classification

With the majority of RWG made up of hydrogen, the inlet pipe to the Lute pots' classed as ATEX 1 as hydrogen is continuously present. The internal area not submerged in water is classed as ATEX 2 as it is likely that the area will contain hydrogen throughout the process and binding with the water and venting to atmosphere. The area external to the Lute pots' classed as ATEX 3 it is unlikely that hydrogen will be present during operation. Figure 14 shows the area classification diagram of the Lute pot.

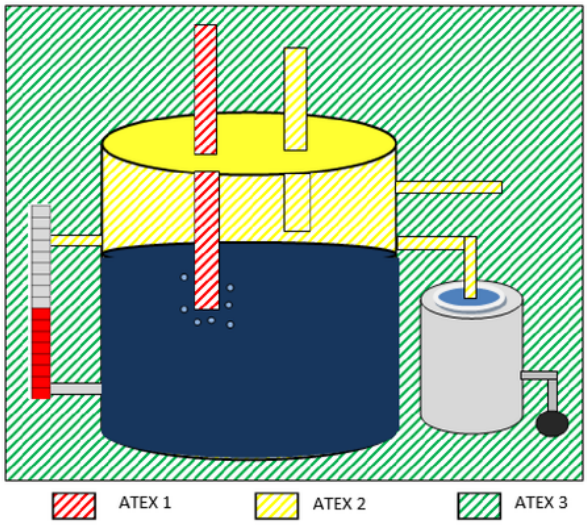


Figure 14 - ATEX area classification of Lute Pot

There are also area equipment groups when selecting the correct protection required. These groups are;

- Group I – Equipment designated for use below ground and area where methane (firedamp) is the flammable gas.
- Group II – Equipment designated for use above ground where any potential flammable gas could be present
- Group III – Equipment designation for use where flammable dusts could be present.

(CompEX, 2010)

Hydrogen's classed in a sub division of IIC with an ignition point of 560°C. Table 2 shows the temperature classification. The temperature class shows the maximum temperature the enclosure can reach.

Table 2 - DSEAR Temperature Classification

Temperature Class	Maximum surface temperature
T1	450°C
T2	300°C
T3	200°C
T4	135°C
T5	100°C
T6	85°C

(CompEX, 2010)

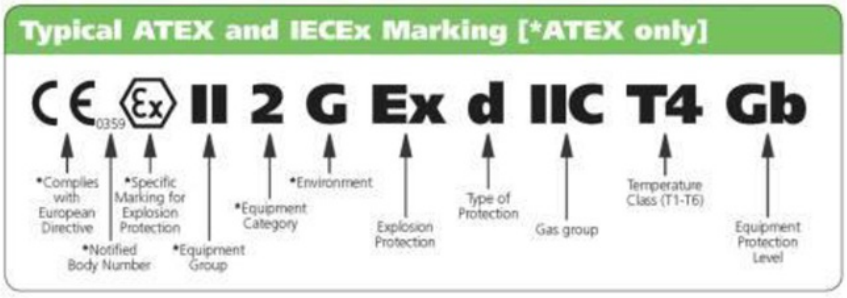


Figure 15 - ATEX Equipment Protection Markings

(intertek.com, 2018)

Figure 15 displays the information stamped upon the equipment showing the rating of the equipment. This is shown on items such as enclosures, instruments, junction boxes and light fittings.

2.3. Process Data

It wasn't possible to use a data logger to monitor the level in the lute pot as the only indication was from the visual sight glass. However, after talking to process operators, it was said that the level in the lute pot is inversely proportional to the flow of gas to the incinerator, the higher the level produces greater backpressure and therefore produces less flow at incinerator head. The lower the level, means that there is less resistance in the liquid seal allowing more volume of gas to be passed through and vented to atmosphere also resulting in not enough gas at the incinerator head.

The following figures represent a daily average of RWG Flow to incinerators in October

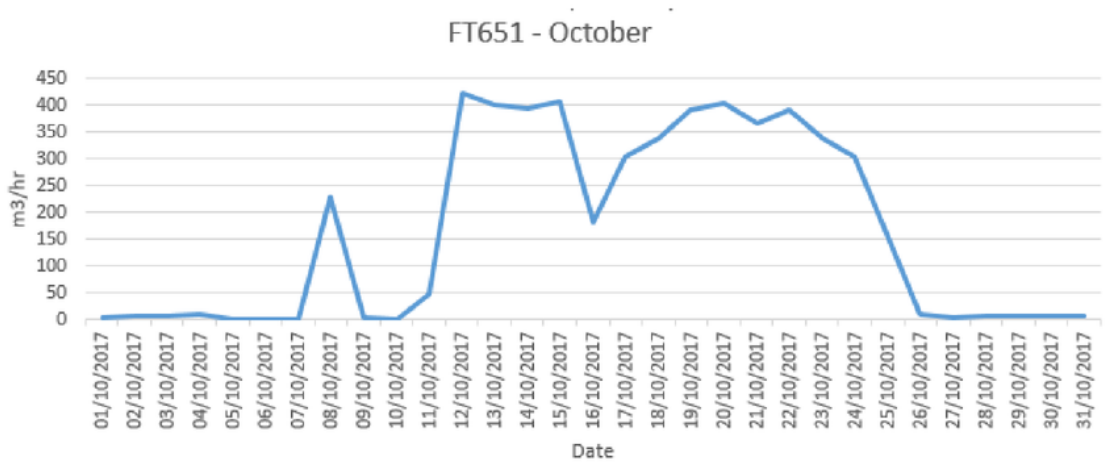


Figure 18 – FT661 Incinerator A RWG Flow November Trend

Figure 18 illustrates the flow of waste gas to incinerator A, the daily average flow rate fluctuates from a low of 200 m3/hr to a high of 500 m3/hr. Figure 18 displays the daily average flow rate for incinerator B, the flow rate also fluctuates with majority flow rate at 400 m3/hr.

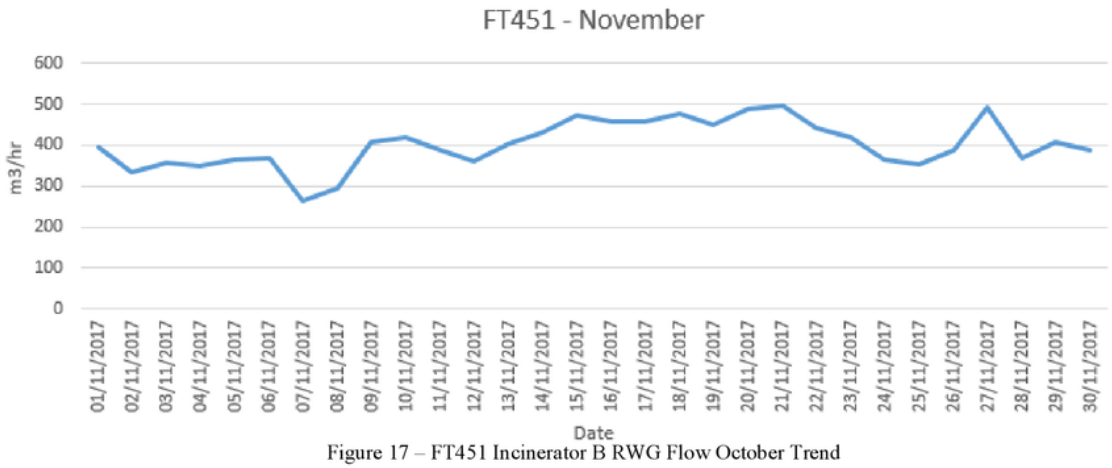


Figure 17 – FT451 Incinerator B RWG Flow October Trend

In October incinerators A and B were swapped over and where the flow rate reads 0 m3/hr, its respective incinerator was offline.

Figure 17 displays the RWG daily average for November with an average flow rate of around 400 m3/hr, it can be seen that the flow rate fluctuates through the month. Manual control tries to control the level within the pot to keep a constant flow to the incinerator.

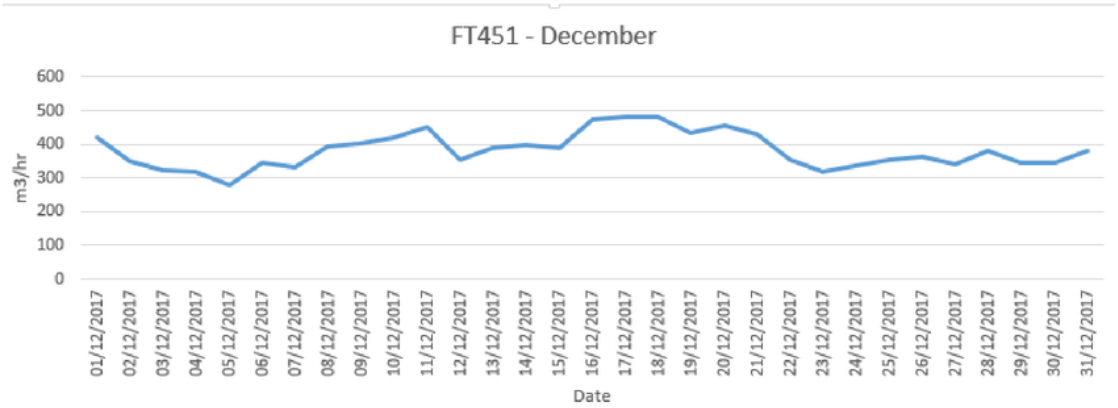


Figure 19 - FT451 Incinerator B RWG Flow December Trend

Shown in Figure 19 is the daily average trend for the month of December, the average flow rate has the least fluctuations out of the three month. This shows the process operators have had better manual control of the level within the lute pot to their desired set point. However, the RWG from the kiln plant isn't constant and fluctuates due to the behavior of the operation of the Kilns reductions circuit that supplies the waste gas.

Under steady operation within the Kiln plant, the RWG flow rate can be controlled easier but if changes on plant to the reduction circuit e.g. plant breakdown or changing operation parameters can cause the exported gas to vary even more thus causing more fluctuation in the RWG flow rate to the incinerators.

The cause in the fluctuations in the flow-rate in October were because of plant changes where Incinerator A struggled to reach the optimal RWG inlet pressure of 20mBar due to the varying RWG pressure to the lute pot and the level failed to control where the incinerator BMS shutdown forcing process to use Incinerator B with the back up burner.

The ideal flow rates of waste gas is to be constant with no fluctuations, however, this isn't possible due to the motorized gas blowers moving the gas and the plant conditions change to suit production.

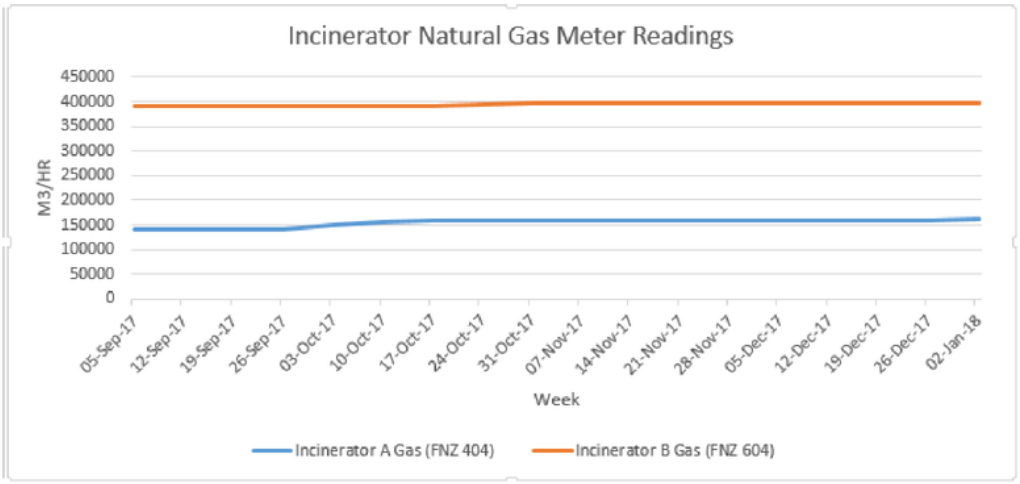


Figure 20 - Incinerator Natural Gas Meter Readings

Figure 20 represents a graph of the natural meter readings from September to December; it shows a slow increment of flow, which is good, as there is less cost. However, if the waste gas burners were to fail, the meter readings will have greater increases as the back-up burners will be online.

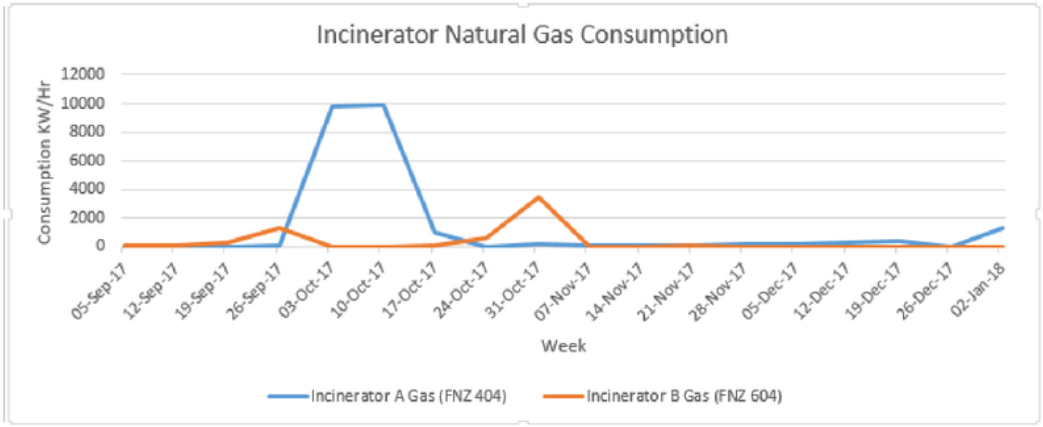


Figure 21 - Incinerator Natural Gas Consumption

Figure 21 shows the consumption of natural gas used by the incinerators. When comparing the graph in Figure 21 to the graphs in Figure 16 and Figure 18, it shows that the back up natural gas burner was online as the waste gas flow to incinerator A was struggling to be controlled in October. t can be seen that incinerator A was shut down and incinerator B was turned online with both natural gas and waste gas burners were online.

Spelling

Table 3 -Natural Gas Consumption

Month	Incinerator Consumption (KW/Hr)		Cost (£)	£ Per KW/Hr
	A	B		
September	62.9486	1806.1406	£1,895.53	1.42
October	20904.98795	4124.34385	£27,586.42	1.62
November	450.3246	112.3706	£648.10	1.76
December	940.59735	2.4211	£945.12	1.87

The natural gas is billed in KW/Hrs as the price of natural gas in m3/hr fluctuates every half hour. This cost table shows that with inadequate control of the waste gas or waste gas incinerator downtime, results in the natural gas burner being used thus using money to maintain incineration of the excess CO.

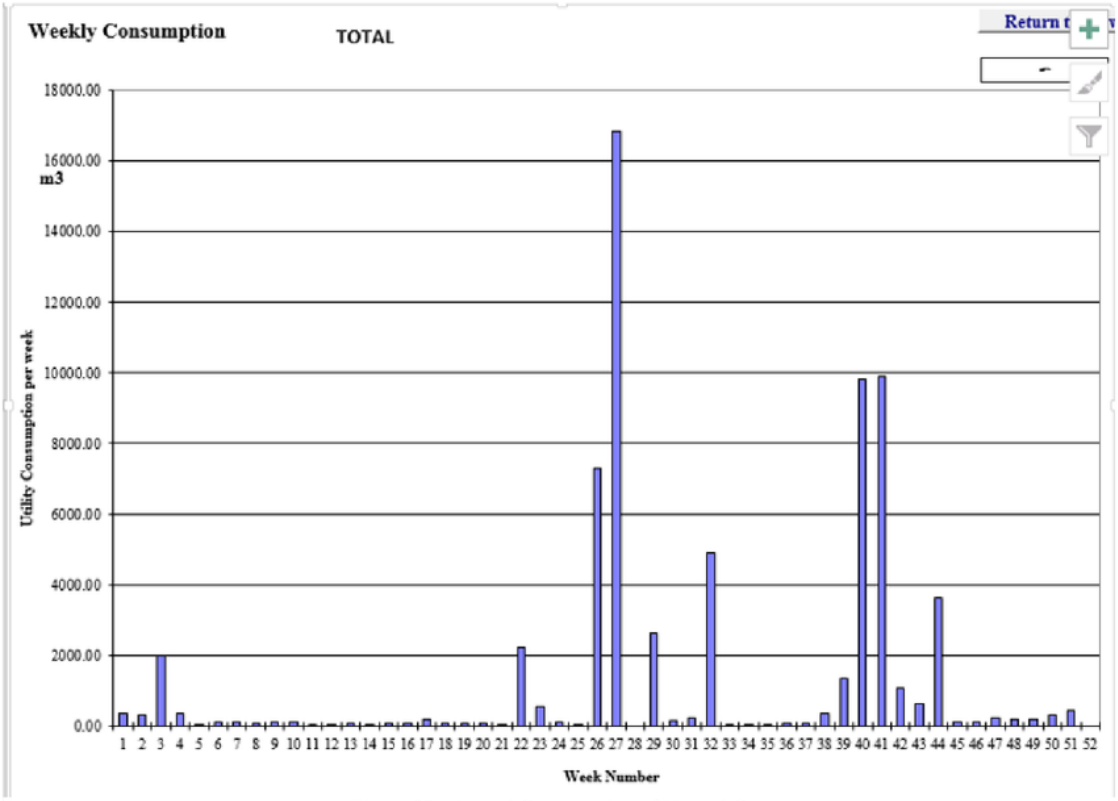


Figure 22 - Annual Consumption of Natural Gas

Figure 22 shows the annual consumption of natural gas at the incinerator. If the waste gas burners were to fail, the cost of running the incinerator would rapidly increase to a huge number. Natural gas is used for the pilots' to light the two incinerators that's why small quantities are shown in some months.

The problem with the existing Lute pot system is that there is no automatic control of the level with the vessel therefore operators are having the check the level and adjust manually. With no automatic control, this leads to level within the lute becoming too high or too low causing not enough RWG reaching the incinerators. With not RWG reaching the incinerators, the excess CO produced at the PGP can't be incinerated correctly.

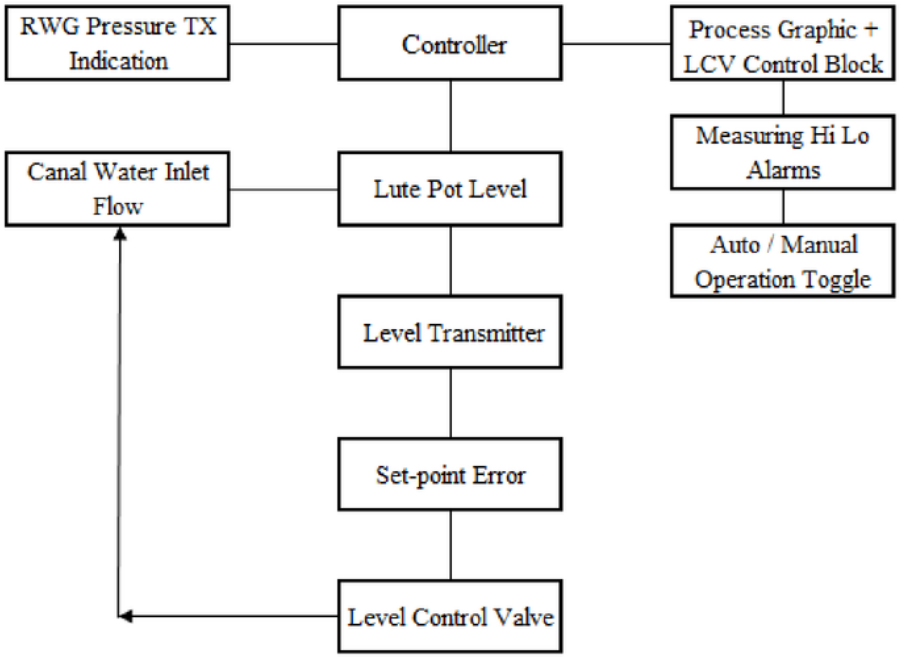


Figure 23 - Operation Block diagram of new system

Figure 23 gives a block diagram overview of the operation of the proposed upgrade of the Lute pot system.

This is a detailed section that puts the project in context but it is very involved and by the end of reading it, it is easy to forget the purpose of it.

A clear statement of what you intend to deliver and therefore research for solutions could have been stated here.

2.4. Solution 1 – Foxboro I/A Series DCS

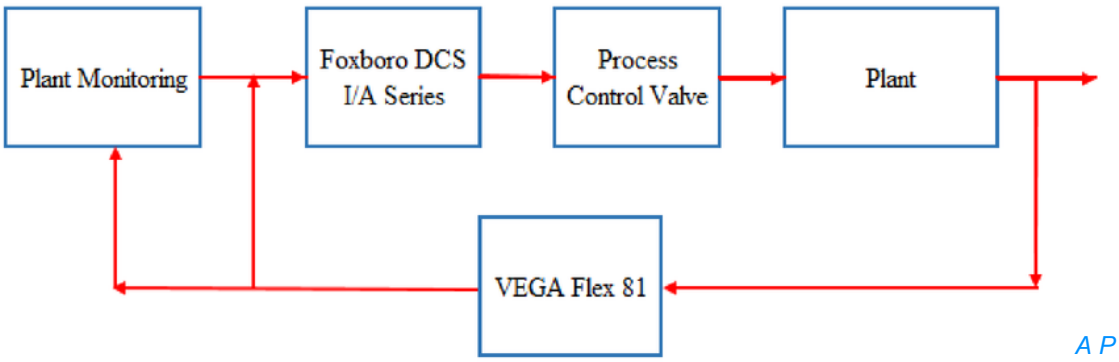


Figure 24 - Solution 1, Foxboro I/A Series DCS Block Diagram

A P & I Diagram would have been helpful

Solution 1 is to utilize Foxboro Intelligent Automation (I/A) Series DCS (Distributed Control System) as the process controller of the Lute pot level that will receive data from the VEGA Flex 81, calculate and output control signal to a field control valve. Whilst also displaying a graphic on screen in the control room of a level reading, valve position and process alarms.

Components Required

You could have focused more on the valve and sensor types particularly knowing that the controller type was fixed by plant standard.

- Intrinsic twisted pair cable
- VEGA Flex 81 instrument Cap + Rod (VEGA, 2017)
- FBM (Field Bus Module) I/O Blocks + CP (Control Processor) (Outlet, 2018) – FBM201 (aotewell.net, 2018) –FBM237 (Outlet, 2018) – FCP270
- Process Control Valve
- Monitor

Table 4 - Solution 1 - Foxboro IA DCS System Cost

Component	Resource	Cost
VegaFlex 81	VEGA Controls LTD	£1,866.00
GX Control Valve	Reliance Control Systems	£3,355.00
Pressure Transmitter	Schneider	£1,104.61
Total		£6,325.61

2.4.1. About the Foxboro I/A DCS Series

The Foxboro I/A Distributed Control System (DCS) is of fault free and readily available control components that combines critical information and operator capabilities to maintain precise control of continuous plant production. (Schneider Electric, 2017)

For years the Foxboro DCS has been able to aid the growth of the industry through changing the methods of its clients work, by improving organizations worldwide plant operations, asset operation and systematic performance. There are several versions of the DCS starting with a node design all the way through to mesh design where all of the developments purposes is to escalate the performance and proficiency for expansion. Figure 25 shows the DCS processor modules that are currently used at Vale Europe Ltd. (Aotewell automation group, 2017).

Field instruments such as pressure, flow and temperature are connected to field bus modules (FBMs) which receive and omit analog and digital signals to the Control processor that executes control calculations from data received and then gives output values to then control the process.

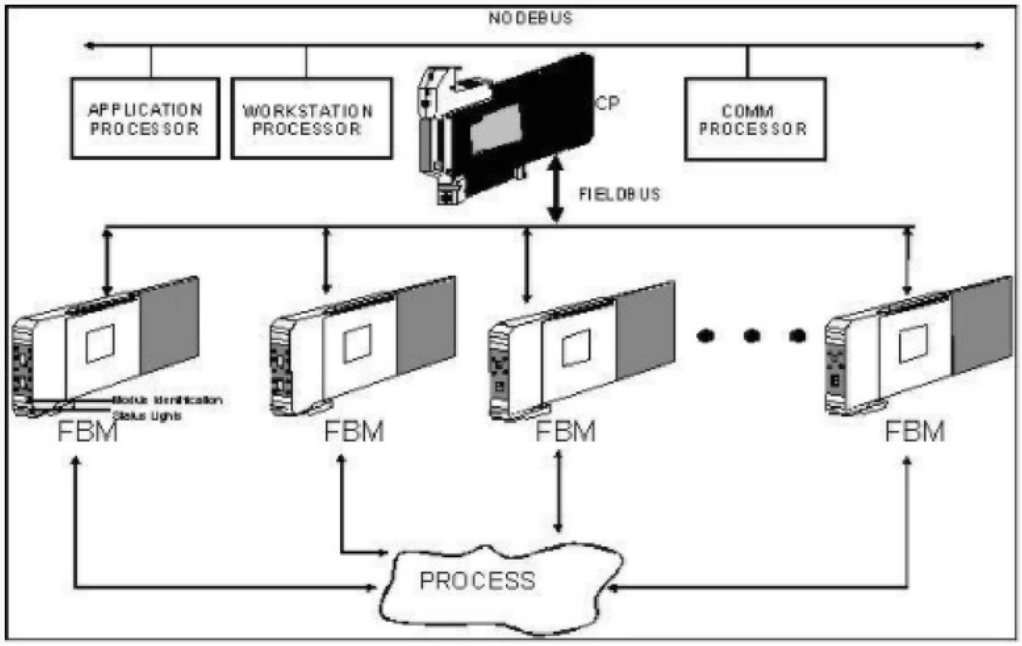


Figure 25 - Foxboro Field Bus Modules

(Aotewell automation group, 2017)

2.5. Solution 2 – Field Programmable Gate Array (FPGA)

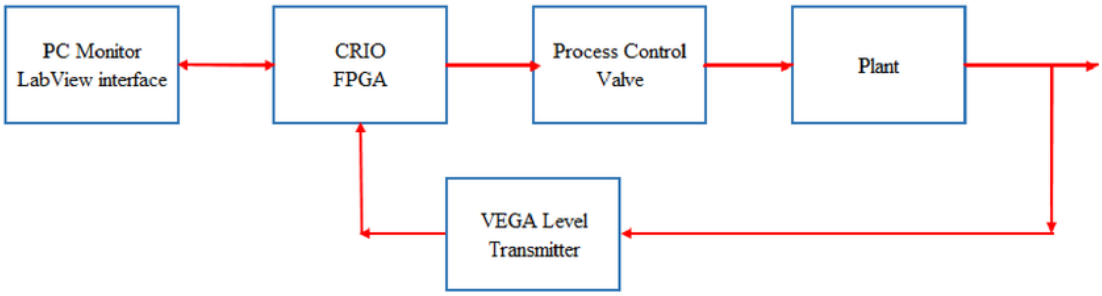


Figure 26 - Solution 2, FPGA Block Diagram

Solution 2 is to use a FPGA controller "NI Compact RIO" to produce automatic control of the level within the lute pot. The FPGA will receive data from the VEGAPULS level transmitter and produce a 4-20mA output signal to operate a process control valve allowing canal water into the lute ensuring that the level remains constant

Components Required

- FPGA + driver circuits (National Instruments, 2014)
- FPGA Labview/ Xilinx Software for programming
- Intrinsic twisted pair cable
- Vega Puls 62 (VEGA, 2017)
- Process Control Valve
- Monitor
- Enclosure

Table 5 - Solution 2, NI Compact RIO system cost

Component	Resource	Cost
VegaPuls	VEGA Controls LTD	£1,442.00
NI Compact RIO-9030	National Instruments	£2,210.00
GX Control Valve	Reliance Control Systems	£3,355.00
Pressure Transmitter	Schneider	£1,104.61
Total		£8,111.00

2.5.1. Field Programmable Gate Arrays (FPGA)

FPGAs are devices containing semiconductors centered around a medium of CLBs (Configurable logic blocks) these are connected through programmable interconnects. FPGAs have the ability to be reprogrammed to new applications or operating desires after manufacturing which contrasts the FPGA from ASICs (Application Specific Integrated Circuits) which are manufactured to suit one design. (Xilinx, 2017) (Gilberto Ochoa-Ruiz, 2017)

2.5.2. FPGA Applications

With the FPGAs programmable nature, they are utilized in various markets that include:

- Defense & Aerospace
- Audio and Communication
- Automotive
- Industrial Automation Engineering
- High Performance Computing and Data Storage

(Xilinx, 2017)



Figure 27 - FPGA Chip

(Diligent//Blog, 2015)



Figure 28 – Xilinx Spartan FPGA Chip on board

(Digilent, 2017)

2.5.3. National Instruments DAQ & RIO

National Instruments have an array of FPGA boards that range from student editions (MyDAQ or MyRIO), more rugged editions (cDAQ or cRIO) where the smaller student editions are cheaper and can be used academically and the CompactDAQ or RIO can be applied in industry. Using LabVIEW software allows customization of how data can be acquired and how it can be represented in a laboratory or in industry.

The CompactDAQ is a portable data acquisition platform that assimilates signal conditioning and connectivity to I/O devices interfacing to a field sensors or signals. (National Instruments, 2017)

CompactRIO is a portable, rugged data acquisition platform that assimilates connectivity and signal conditioning into modular I/O for directly interfacing to any sensor or signal. The CompactRIO is a rugged high-performance embedded controller also utilizing I/O modules to industry standard, industrial communication and HMI abilities (National Instruments, 2017)



Figure 29 – NI MyRIO



Figure 30 – NI MyDAQ

(National Instruments, 2017)



Figure 31 – NI CompactRIO



Figure 32 – NI CompactDAQ

(National Instruments, 2017) (National Instruments, 2017)

2.6. Solution 3 – Allen Bradley PLC

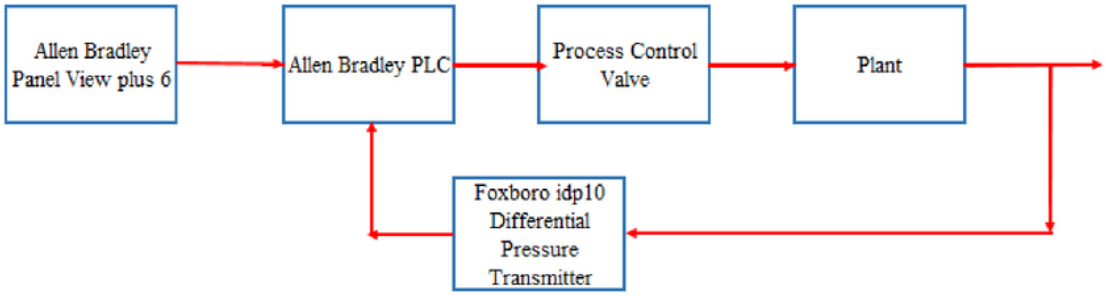


Figure 33 - Solution 3, Allen Bradley PLC Block Diagram

Solution 3 would utilize an Allen Bradley PLC instead of a FPGA or Foxboro I/A Series module. The Allen Bradley PLCs' can be installed locally to the Lute Pot within an enclosure receiving data from the Foxboro IDP10 DP Cell transmitter utilized as a wet leg system to measure level. Control action calculated through control program and then outputting control signal to the process control valve, thus controlling the canal water input to the Lute pot preventing Low and High level.

Components Required

- Allen Bradley PLC
- RS Logix programming software
- Intrinsic twisted pair cable
- IDP10 Transmitter (Schneider-electric.com, 2017)
- Process Control Valve
- Allen Bradley Panel View Plus 6 (rockwellautomation.com, 2017)
- External Enclosure

Table 6 - Solution 3, Allen Bradley SLC 500 PLC system cost

Component	Resource	Cost
Allen Bradley SLC 500 PLC & Accesories	Rockwell Automation	£800.00
Allen Bradley Panelview Plus 6	Rockwell Automation	£650.00
GX Control Valve	Reliance Control Systems	£3,355.00
2 off Pressure Transmitter	Schneider	£2,208.22
Total		£7,013.22

2.6.1. Allen Bradley PLC & Software

Programmable Logic Controllers (PLC) are dedicated computers utilized to controlling industrial machines and processes large or small. They consist of a central processing unit (CPU), memory and software communications just like typical PCs at home. However, a PLC is designed to last within rugged industrial environments whilst carrying out its duty. PLCs' consist of three main areas, Power Supply unit, CPU and Input/ Output Modules for field devices. (plcdev.com, 2017)



Figure 34 - Allen Bradley SLC 500 PLC

(elec-intro.com, 2009)

PLCs are efficient and successful in industry as they replaced the conventional hard-wired relay logic as it is a single unit where input/ output modules replace numerous relays. PLCs are able to carry out numerous tasks within a written program, these include relay switching tasks, counting, calculating, comparison of process analog valves. Ability to modify the control logic when required with minimal downtime and can also link with Human-Machine Interfaces (HMI) for display of process and alarms. (Portal, 2017).

Allen Bradley PLCs use the RSLogix Ladder logic software to write an industrial program declaring the discrete and field inputs and outputs and then to upload the program to the PLC ready to start. Being able to program away from the PLC, it doesn't involve long downtime when applying changes to the control logic. (Rockwell automation, 2017)

2.7. Justification of Chosen Solution

Although the FPGA and PLC would also meet the specification, the chosen solution was the Foxboro I/A DCS Series. The FPGA and PLC systems are more than suitable to solve the problem producing automatic control of the level within the lute. However, in regards to the FPGA, the technology isn't used on site where operators, maintenance technicians and engineers would find it difficult to operate the system at first until they had been trained and familiarized themselves with the new software.

Though technicians can read PLC programs as Allen Bradley PLCs are used on site, learning the new software language for the FPGA (LabView) would be difficult where using familiar technology would make it easier to follow when making alterations or following programs when fault finding.

Table 7 - Comparing the Three Solutions

Solution	Pros	Cons	Total Cost
1 – Foxboro IA	All existing plant instrument loops feedback to the Foxboro IA DCS Process Operators are already familiar with the software	Engineer required when making adjustments to tuning no access for technicians	£6,325.61
2 – FPGA	Can be utilized to produce an automatic control loop	Not used on site New programming technology and language	£8,111.00
3 – SLC PLC	Can be utilized to produce an automatic control loop Technicians familiar with software language and PLC logic systems	Easier to add new control loop to existing DCS.	£7,013.22

The Foxboro I/A DCS series was preferred than the PLC as the Lute pot instruments could be added on to the existing DCS system that the refinery operates on. A modification to the control room graphic can be updated indicating the readings of the level, RWG pressure, valve position and other features such as data trending and alarms. As the process operators are familiar with the

DCS software, no training will be required only a brief overview would be sufficient. The costs for each solution were considered, would it be economically viable to spend more on new technology that could potentially cause more issues implementing as staff are unfamiliar with the system or stick to standardized technology that is tried and tested already on site for less cost.

3. Specification & Testing Planning

3.1. General Specification

1. To produce efficient automatic control of the level within the Lute Pot that will maintain RWG pressure to the Waste gas Incinerator through:

1.1 Continuous level measurement feedback signal 4-20mA to a controller

1.2 Control output signal of 4-20mA from controller to an Intelligent control valve

2. Instrument accuracy of sufficient to ISO:9001 standard. ISO 9001 is an international standard that stipulates the requirements needed for a quality management system. Organizations utilize the standard to validate its capability to produce products that meet customer regulations. Instrumentation on site require routinely calibration checks and calibration certificates to ensure that readings are correct to specification. (ASQ.ORG, 2017)
3. Instrumentation and Control valve must have ATEX protection of II 2G Ex d IIC T6 for protection from hydrogen to meet Dangerous Substances at Explosive Atmosphere Regulations (DSEAR 2002).
4. Lute pot instrumentation readings to display on control room plant monitoring interfaces for operations team.

3.2. Technical and Performance Specification

1. To utilize refinery standard manufacturers for instrumentation and control valve.
2. Control loop to utilize Proportional-Integral control action.
3. Existing 'Process Gases In' plant monitoring graphic to be modified to cater for process line diagrams and instrumentation readings
4. Process alarms of level instrument to be set at:

4.1 High level alarm of 15inH20

4.2 Low Level alarm of 5inH20

5. Process alarms of pressure instrument to be set at:

5.1 High alarm for 14inH20

5.2 Low alarm of 4inH20.

6. Instrumentation failure output for safe control shut down of Lute system to be:

6.1 Level – level probe output to fail high (20mA) to replicate a full tank to prevent lute pot from filling.

6.2 Control Valve – Control valve to be configured as Air-to-open, Spring return closed so in the event of power or air failure, control valve will close, stopping process medium filling tank.

6.3 Pressure – pressure transmitter to fail low (4mA) to replicate that there is no flow of RWG.

7. Level control loop to display control valve output
8. Toggle for automatic or manual operation
9. Instrumentation accuracy of ±5% *Not very accurate*
10. Automatic control response time of 3 minutes
11. Annual calibration checks of new instrumentation to be generated on SAP on completion of project.

3.3. Budget

David Amour, Pellet and Powder Plant Super intendant has allowed £15,000.00 to complete the project.

3.4. Test Plan

Testing tables produced for workshop testing and on plant testing to test the system against the specification. Table 8 shows the workshops functionality test plan whereas Table 9 shows the testing table for on plant commissioning.

Table 8 - Workshop testing table

Test	Expected Outcome	Actual Outcome	Pass/Fail
Three point calibration check of VegaFlex 81	VegaFlex 81 to output 0, 50 and 100% of range		
Three point calibration check of Pressure Transmitter	Pressure Transmitter to output 0, 50 and 100% of range		
Operation check of Fisher GX valve with 4-20mA input	Valve travel to 0% at 4ma, 50% travel at 12mA, 100% travel at 20mA		
Air Failure to Valve	Valve travel to move to closed position		
Power loss to valve	Valve travel to closed position		
System Functionality Testing			

Bypass vessel at 0% full with a setpoint of 12.50	Controller to output 20mA for valve to be fully open when vessel empty		
Bypass vessel at 50% full with a setpoint of 12.50	Controller to reduce mA output to valve to start closing to keep level at set point		
Bypass vessel at 100% full with a setpoint of 12.50	Controller to output 4mA for valve to be fully closed when vessel full		

Table 9 - On plant testing table

Test	Expected Outcome	Actual Outcome	Pass/Fail
Three point calibration check of VegaFlex 81 to DCS	VegaFlex 81 to display 0, 50 and 100% range on DCS to a tolerance of ± 5%		
Level High Alarm	DCS to alarm when level is above alarm threshold		
Level Low Alarm	DCS to alarm when Process variable is below alarm threshold		
Break in feedback loop from VegaFlex	feedback measurement from Vegaflex to show 100%		
Three point calibration check of Pressure Transmitter to DCS	Pressure Transmitter to display 0, 50 and 100% range on DCS to a tolerance of ± 5%		
Pressure High Alarm	DCS to alarm when pressure is above alarm threshold		
Pressure Low Alarm	DCS to alarm when pressure is below alarm threshold		
Break in feedback loop from Pressure Transmitter	feedback measurement from transmitter to show 100%		

Operation check of Fisher GX valve from DCS output block 0, 50 and 100%	Valve travel to be at 0% at 0% output, 50% travel at 50% output, 100% travel at 100% output from DCS		
Automatic/ Manual control toggle	Control to toggle between automatic and manual when toggled on DCS		
Automatic controls' response time within 3 minutes	Measured variable to stabalise on set-point within 3 minutes.		
Introducing a set point change	Level of Lute pot to settle at new set point within 3 minutes.		

4. Safety, Sustainability, Environment, Professionalism, Maintenance and Reliability

4.1. Safety

At Vale, safety is paramount, no work can be carried out unless authorized by a plant team leader after viewing risk assessments and completing a permit-to-work. Everyone is encouraged to complete a 'SLAM' (Stop Look Assess Manange) report prior to performing a task to ensure it is safe to be carried out. Vale employees and Contactors must adhere to rules and regulations of the Health and Safety at Work Act 1974 (HASAWA) whilst working on site.

Notification of work documents are completed by project leaders' and are given to the plant to notify that work is planned to be done. Electrical and Mechanical risk assessments and notification of work documents can be found in the appendix

A HAZOP (Hazard and operational) study was carried out by a team prior to designing the new system. This was to determine the hazards to personnel in the environment of the project, the consequences of a hazard, and the corrective action to be taken place for safety if the Lute pot system' level, temperature or pressure were to go too high or too low. The HAZOP study No. 2015-002 can be found in the appendix.

4.2. Sustainability

Waste produced throughout the projects was to be recycled following Vales' waste control protocol using segregation bins provided around site, contaminated water was treated to environmental standards before being pumped into the River Tawe.

The life span of the sensors were taken into account so that they were fit for purpose. They were purchased from reliable manufacturers with certified life cycles.

4.3. Environmental

Considering the environmental impact from the project, the water used for the liquid seal is extracted from the canal, and used in the lute pot. All drainage is treated at the Water treatment plant ensuring that all contaminated water is returned in accordance with environmental standards ISO:14001 before the water is pumped into the River Tawe. The pH level of the water is monitored at different stages throughout the effluent plants process using water analysis pH 'buffer' probes.

Spelling

ISO:14001 is a group if standards that are related to environmental management that is in place to assist organizations to reduce the impact of any negative effect upon the environment, to comply with the applicable laws, regulations and to continuously improve thus preventing further damage to the environment.

This standard is treated in a similar way to ISO:9001, in that an audit will be carried out on the process where if the process is satisfactory, the organization will be accredited to the ISO:14001 standard.

(Naden, 2015)

4.4. Professionalism

The management of the project was carried out in a professional manner working alongside contractors to adhere to HASAWA. Risk assessments and Permits to work were authorized to allow work to commence. Regulations such as PUWER (Provision and Use of Working Equipment Regulations), LOLER (Lifting Operations and lifting Equipment Regulations), Manual Handling and DSEAR (Dangerous Substances at Explosive Atmospheres Regulations) were adhered to throughout designing and implementation of the project.

The project was authorized after an MOFC (Management of Facilities Change) was completed by plant requesting an upgrade to the existing system. The project was then delegated down from the Engineering Manager. MOFC can be found in appendix.

Regular progression meetings were held with the workplace supervisors to track the timescale of the project, support given on issuing work to contractors and documents that were involved and ordering parts from suppliers. Consulted with mechanical engineers within the design stage as well as the production department to learn about the process operation and what materials could be used.

4.5. Maintenance

Maintenance of the new system has been considered. The design of implementing the level transmitter externally in a bypass vessel provided easier access to the instrument for calibration checks and removal if broken as the vessel can be isolated from the process therefore not interfering with the operation. Annual preventative maintenance job cards have been added to SAP system where the maintenance planner will schedule technicians to perform the calibration checks of the instruments and stroke checking of the valve. Calibration certificates will be produced to capture the test data on record.

4.6. Reliability

Certified instruments, equipment and mechanical fittings were purchased from manufacturers such as Vega Controls LTD, Emerson, and BSS where products were CE certified. Instruments and enclosures were ATEX certified to meet DSEAR standards.

Instrument reliability to be monitored through scheduled maintenance calibration checks to ensure that the instrument readings are accurate for plant operation.

5. Project Design

The Foxboro IA Series DCS (Distribution Control System) was the chosen solution, the new system consists of a closed loop system using a VegaFlex 81 level sensor that measures the level within the Lute pot. The level sensor outputs a 4-20mA signal to the DCS that will generate a 4-20mA control output signal to the Fisher GX control valve to control the level of the Lute pot at the desired set point. A pressure transmitter was added to monitor the RWG pressure at the lute pot.

Process operators are able to monitor the plant instrumentation readings of level, pressure and control valve output with process alarms.

5.1. DSEAR Protection

DSEAR protection is required as hydrogen is present in the process. Following the area classification diagram shown in Figure 14 and DSEAR literature. The VegaFlex 81 and Fisher GX valve are to be installed into the process, the minimum protection that is required is ATEX 2 rated equipment. The instruments and control valve will be rated to **II 2G Ex d IIC T6 Gb** for protection against hydrogen.

The rated protection is because the equipment is at ground level - II, ATEX 2G (gas) area, Ex d flameproof protection, protection of gas subdivision IIC and a maximum surface temperature of 450°C for protection against hydrogen within the process and its ignition temperature of 560°C meeting DSEAR regulations.

Integrity

5.2. Safety Integral Level

Safety Integral Level (SIL) risk reduction assessment was progressed but as the new system has no plant trip action, only control of a process, SIL safety standard wasn't required.

You could have provided a P & I diagram

5.3. VegaFlex81 Application

The VegaFlex 81 is to sit in an external bypass vessel that's mounted on the two existing tapping points of the Lute pot that are currently used for the local level indication. The bypass vessel is fixed vertically on the Lute pot, with isolation valves on both branch legs to isolate the bypass vessel from the process. Spool pieces were used to add the bypass vessel and keep the existing local indication gauge. The bypass vessel applications' shown in Figure 35

(VEGA, 2017)

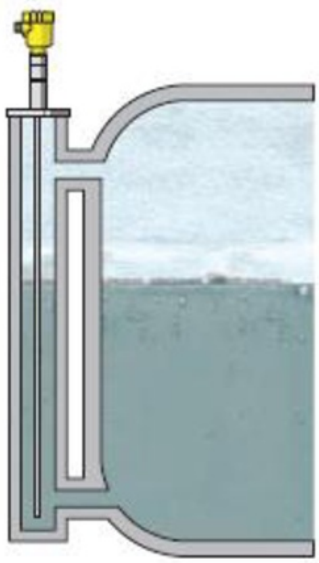


Figure 35 – Bypass Vessel

There was an alternative approach for installing the VegaFlex 81. This was to mount the probe directly on to the top of the Lute pot through a flange connection and the probe to sit internally. However, this approach was decided against in favor of the external bypass vessel as the bypass vessel could be designed, installed and commissioned with minimal disruption to the process.

To mount the probe internally, the Lute pot system would need to be taken out of service, drained, area gas tested for hydrogen and mechanically modified to cater for the level probe. The external bypass vessel also allows for easy maintenance as the vessel can be isolated from the process and test equipment can be attached to check the calibration of the instrument back to the DCS or to replace for new.

The failure mode of the instrument is to fail 'high' replicating a high level within the Lute pot, closing the valve safely preventing the lute pot from over filling.

The VegaFlex 81 is level sensor for continuous level or interface measurement that is appropriate for application in liquid processes. The sensor operates through generated high frequency microwave pulses that are guided along either stainless steel rod or cable. The microwaves will rebound when reaching the process medium where the run time will be evaluated by the instrument that will then output 4-20mA signal of level.

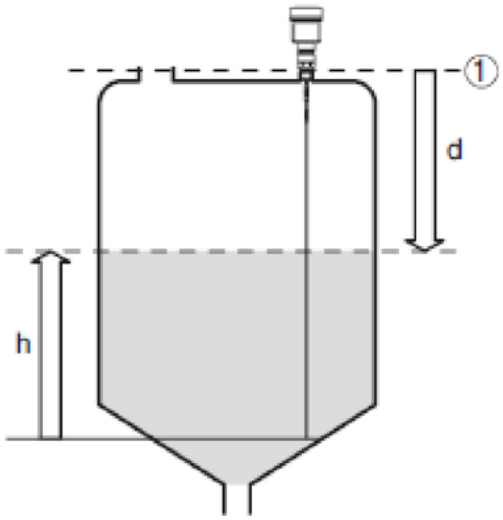


Figure 36 – Vega Flex 81 Operation

Punctuation Error Punctuation Error

Figure 36 shows a diagram of the sensors operation. 1 displays the instruments reference plane, D represents the distance between the liquid and reference plane, H is the height of the medium within the tank.

(VEGA, 2017)

5.4. Bypass Vessel Design

The existing tapping points of the Lute pot were measured at 24". A dead band of 6" was allowed from the flange of the vessel to the top tapping point where a ½" BSP socket was placed between the tapping point and flange for ease of draining the vessel. A dead band was also allowed beneath the bottom tapping point where a 'spacer' was used to ensure the probe didn't touch the side of the vessel to provide faulty signals. Another ½" BSP socket was installed at the capsulated end of the vessel to allow for draining and to attach calibration test equipment.

Consulting with a mechanical project engineer, the material and pipe schedule of the bypass vessel was determined as a pipe schedule of 40 as the process medium contains hydrogen, and that the material of the bypass vessel to be identical to that of the Lute pot, that was stainless steel 316L. A schematic drawing of the bypass vessels' shown in Figure 37

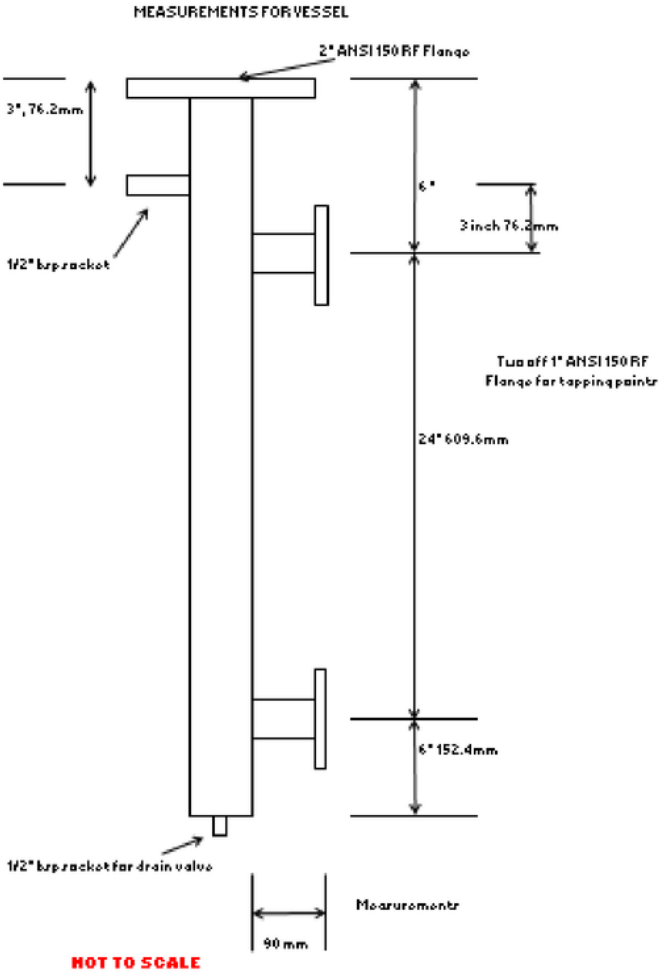


Figure 37 - Mechanical drawing for Bypass Vessel

5.5. Fisher GX Fieldvue DVC2000 Controller

A Fisher GX control valve with a FieldVue DVC2000 actuator was selected for the solutions control valve. The valve required an air supply to operate and receives a 4-20mA control signal from the DCS to control the position of the valve and thus, control the level of water within the Lute pot. The VegaFlex 81 provides constant feedback of the level working as a closed loop system. The Fisher GX Control valves' shown below in Figure 38.



Figure 38 - Fisher GX Control Valve Fieldvue DVC2000 Actuator

(Emerson, 2011)

The control valve has the ability to be set up for 4-20mA loop control, position feedback and two limit switch contacts.

Process variables were determined for selecting correct valve ratings. Table 10 shows the determined variables of the valve.

Table 10 - Valve Design Variables

Variable	Determined
Process medium being controlled	Water
Temperature	Ambient
Viscosity	1
Flow capacity (Min, Max)	0, 13m3/hr
Inlet pressure at valve (Min, Max)	0, 4Bar
Flange connections	1" ANSI 150
Valve body	Balanced Plug & Seat
Control signal	4-20mA
Operation	Air to open, Spring to close
Linearization	Linear

The maximum flow capacity of the canal inlet was determined using an existing pressure transmitters' range of canal water pressure '0 - 4Bar' and using a UK look up table for maximum flow rate of a 1 inch pipe with a pressure of 4 bar. Figure 39 shows the UK gallons per minute look up table for capacity flow rate of pipe diameters at different pressures.

Water Flow (GPM) Capacity Based on ID Size and Pressure

PRESSURE	FLOW IN GPM THROUGH PIPE ID IN INCHES						
PSI	1"	1.25"	1.5"	2"	2.5"	3"	4"
20	26	47	76	161	290	468	997
30	32	58	94	200	360	582	1240
40	38	68	110	234	421	680	1449
50	43	77	124	264	475	767	1635
60	47	85	137	291	524	846	1804
75	53	95	153	329	591	955	2035
100	62	112	180	384	690	1115	2377
125	70	126	203	433	779	1258	2681
150	77	139	224	478	859	1388	2958
200	90	162	262	558	1004	1621	3455

Figure 39 - Water Flow Capacity table

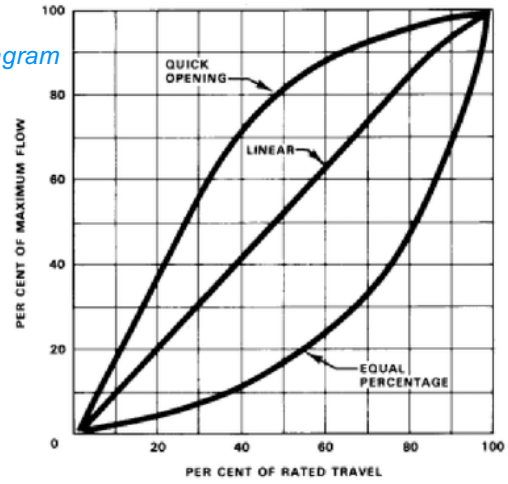
(www.hy-techroofdrains.com, 2017)

Maximum canal water pressure of 4 Bar is equal to 60 PSI. The gallons per minute of a 1" pipe at 4 bar is 47GPM. Converting from GPM to m3/hr using an online calculator providing a result of 13 m3/hr for the valves maximum flow capacity.

Considering safety aspects, it was important that in the event of a failure of the valve such as air supply or electrical failure, the valves failure state allowed safe shut down control of the process. The control valve is to operate as an air-to-open, spring return closed configuration so in the event of a failure, the valve would close preventing the lute from filling where the gas can vent to atmosphere through the outlet.

If an air-to-close, spring return open configuration was selected then flow of water will continue to enter the lute pot uncontrolled, potentially over filling, creating too much back pressure within the RWG line where the purge gas pressure will build up within the kiln and potentially leak onto plant.

This is a helpful diagram



This could have been part of your literature review

Figure 40 - Flow Characteristic Curves

(Fisher, 1977)

Figure 40 shows the flow characteristic curves of different types of valve operation.

You could have explained the other tow first before showing that linear is the best method

Linear flow characteristic was selected for the valve as linear characteristic produce a flow rate that is directly proportional to the amount of travel of the valve e.g. 25% travel will give 25% of maximum flow. Linear characteristics are typically used for liquid level control applications.

Other types of valve linearization include 'Quick opening' valves that are normally in relief applications as it provides maximum change in flow rate at low travel distance with minimal change towards the end of the valve travel.

Equal percentage valves characteristics are ideally equal increments in travel, the change of flow rate can be expressed as a constant percentage in respect to valve travel. The flow rates change in respect to valve travel will be minimal when near the seat of the valve and when its almost fully open. With constant equal percentage flow characteristics, the valve will give precise throttling control within the lower band of travel range and rapidly increase the capacity of flow as the valves plug nears the 'fully open' position. Utilization of Equal percentage valves are mostly within pressure control systems and applications where most of the pressure drop is immersed by the system itself with a small percent available at the control valve.

(Fisher, 1977)

5.6. Foxboro IDP10S Differential Pressure Transmitter

The customer wanted to monitor the pressure of RWG at the Lute pot specifying the range of the transmitter at 0 – 50 inH20. Consulting with Foxboro, there were no IGP10 gauge pressure transmitter available at that pressure range. An IDP10S differential pressure transmitter with the required pressure range was used andconfigured to measure the pressure at the Lute pot.

5.7. Electrical Design

Electrical installation was required to link the instrumentation to the Foxboro IA Series DCS. The instrument loops were connected to DCS through field terminal assemblies, where the signals proceed to the FBMs' (Field Bus Modules) and then into the Control processors. Existing FBM 201 input module and FBM 237 output modules had spare channels at the Incinerator plants DCS FBM cabinets that were used. The electrical designs' scope of work document given to electrical contractors Hornbill Engineering to install the cables and containment is in the appendix Figure 41 shows how the termination assembly connects to the FBM modules.

(Invensys, 2002)

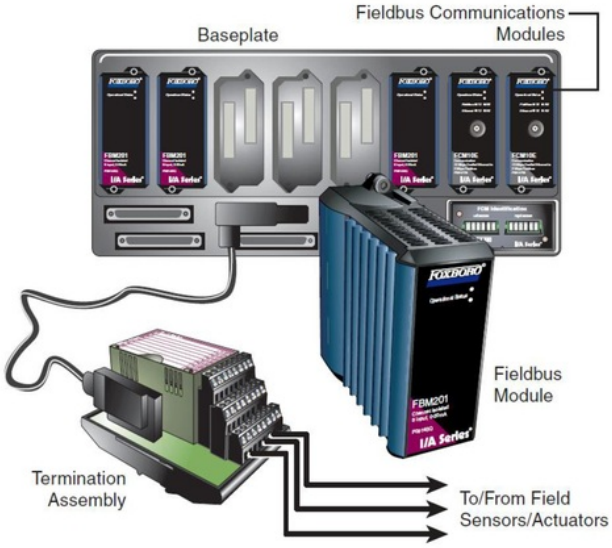


Figure 41 - Field Termination assemblies to FBM

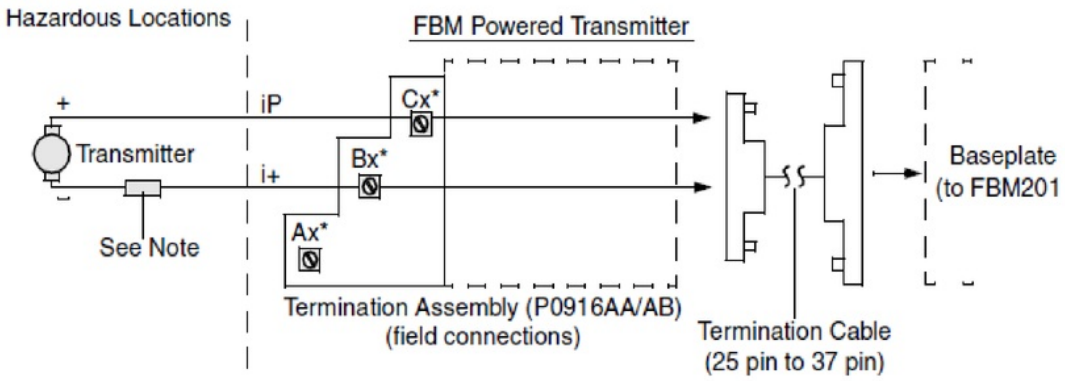


Figure 42 - FBM201 Termination Assembly connections

Figure 42 displays how the instruments were terminated within the assembly of the FBM201 input module using rows C and B. a 250Ω resistor was added in series for communication with the intelligent transmitter and FBM. (Invensys, 2002)

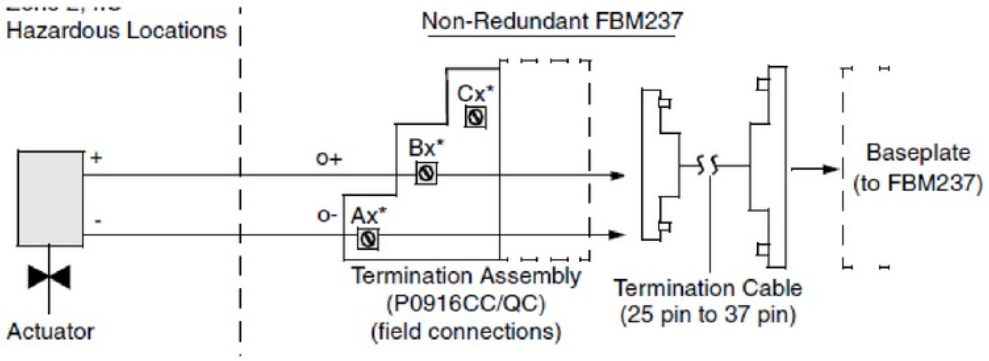


Figure 43 - FBM237 Termination Assembly connections

Figure 43 shows the FBM237 termination assembly output modules connections the control valve used. The output used Rows A and B where no resistor was required. (Invensys, 2002)

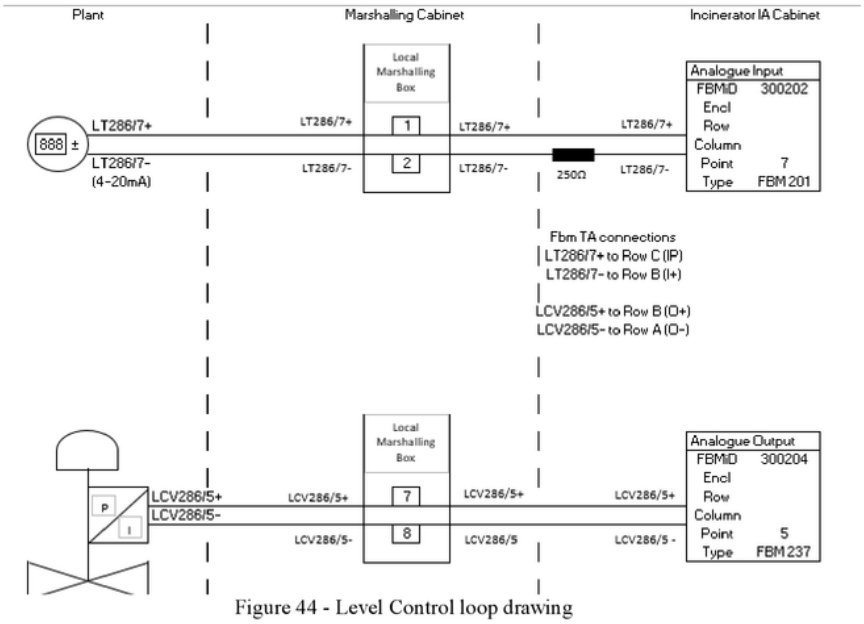


Figure 44 - Level Control loop drawing

Figure 44 shows the loop schematic of the Level transmitter (LT286) and level control valve (LCV286). It declares the areas of the FBMs in DCS Cabinet, Marshalling cabinet at Lute pot and then from the marshalling cabinet to instrument as well as identification.

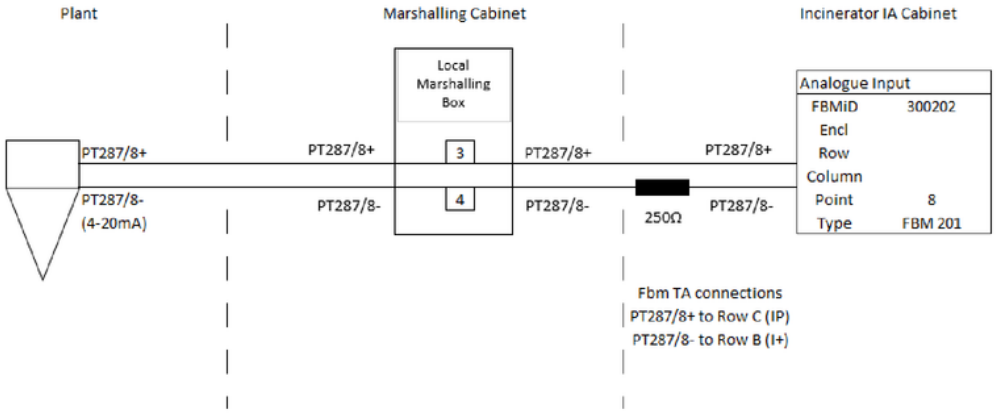


Figure 45 - Pressure Transmitter drawing

Figure 45 shows the loop schematic for the pressure transmitter (PT287). It also consists of the FBM terminations, cable to the local marshalling cabinet and from the cabinet to the instrument.

5.8. Foxboro IA DCS

The existing 'Process Gases In' plant monitoring graphics was modified using 'Fox View' software to include the new instrumentation and process lines of the Lute pot system. Figure 46 shows the existing and Figure 47 showing the modification.

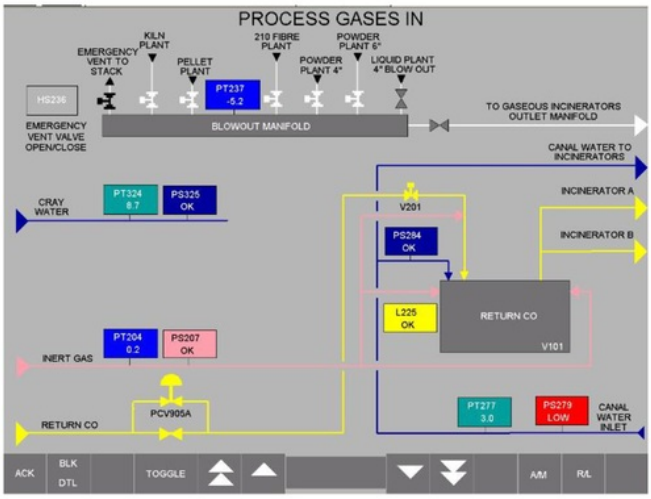


Figure 46 - Process Gases In - Before

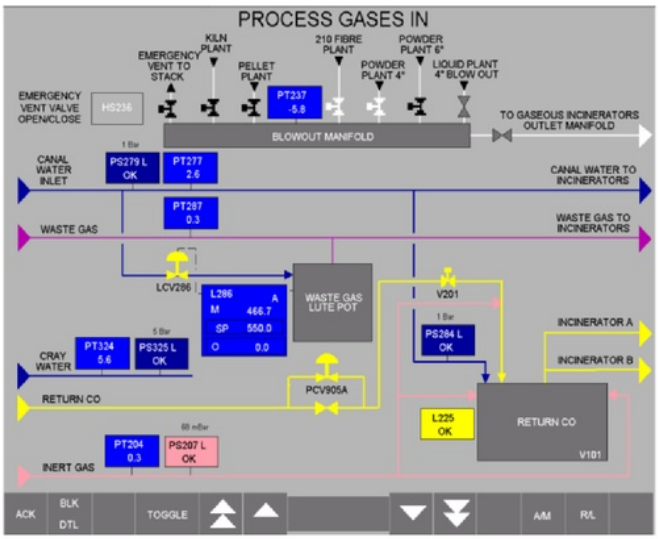


Figure 47 - Process Gases In - After

The modified graphic now shows the waste gas lute pot, Level control valve 'LCV286' now in the canal water inlet to the Lute pot. A control block for Level transmitter 'LT286' is now present that displays the measured variable, set-point and output to the control valve. The pressure transmitter 'PT287' is also added to the RWG line.

6. Project Implementation

6.1. Instrument Configuration

The instruments required configuration to function to the design specification. Configuration software known as 'Pactware' was used through the maintenance departments' netbook allowing access to 'talk' to the instruments for configuration. There were separate Pactware software for talking to Vega and Foxboro instruments where each software package was inside a virtual machine within the netbook.

6.1.1. VegaFlex 81

Shown in Figure 48 is the configuration set up of the Vegaflex 81 level measurement probe. The Vega sensors' placed within the bypass vessel. The sensor was supplied with 24vdc with an inline 250Ω resistor on the positive leg. The 250Ω resistor was required to be able to talk to the sensor through Pactware, two probes of the Vega Connect 4 interface adaptor connected accross the resistor where the sensor could then communicate with the netbook and configuration could then begin.



Figure 48 - VegaFlex 81 configuration set up

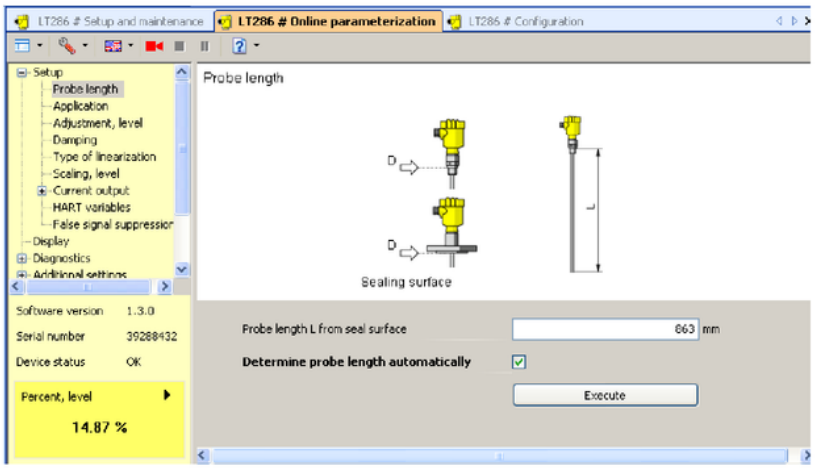


Figure 49 - Configuring Vegaflex 81 probe Pactware

Figure 49 shows the 'probe length' page under the set up menu. The stainless steel rod issued by Vega was 1-meter (39.4" inch) standard size and required cutting to the correct length. With the bypass vessel having a 6" deadband from flange the top tapping point, and then 24" between top and bottom tapping points. The rod must over shoot the bottom tapping point to use a 'spacer' to prevent probe touching the side of the vessel. 5 ½" inch was cut off the rod leaving a remainder of 34" inch (863mm). The automatic probe length detection option was used where the length matched the length measurements.

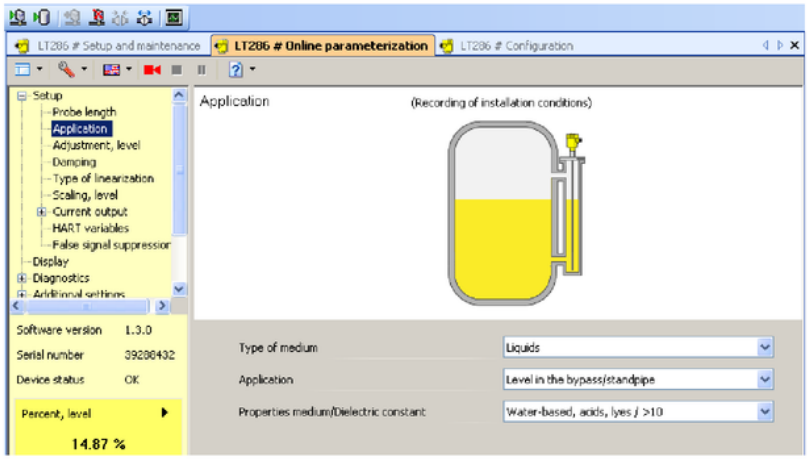


Figure 50 - Configuration of Probes application

On the application section it allowed the option to set what medium, application and properties of the process variable, Water based liquids was selected for type of medium with application in a bypass vessel as shown in Figure 50.

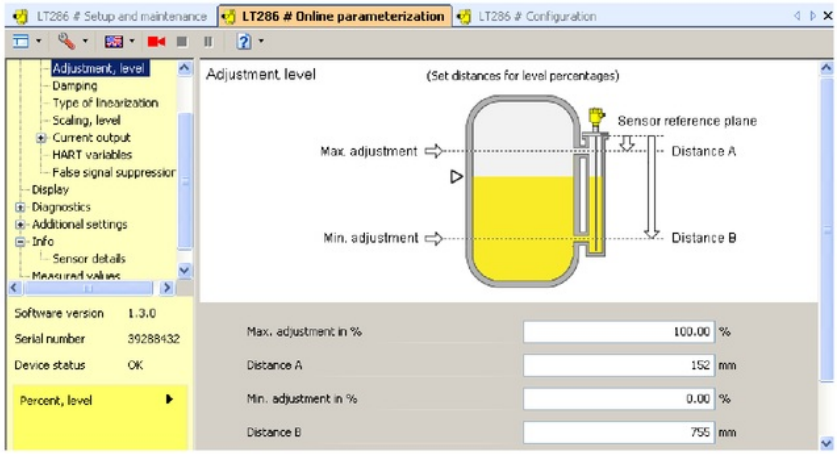


Figure 51 - Setting Probe measurement limits

Figure 51 shows the configuration page of the minimum and maximum percentage adjustment for the sensors scale. Distance A was for maximum 100% which was the distance of the deadband zone from the reference plane to the top tapping point for 100% which was 152mm (6”). Distance B was for Minimum 0% which was to the bottom tapping point measured at 755mm. The over shoot distance of the probe for the spacer is ignored.

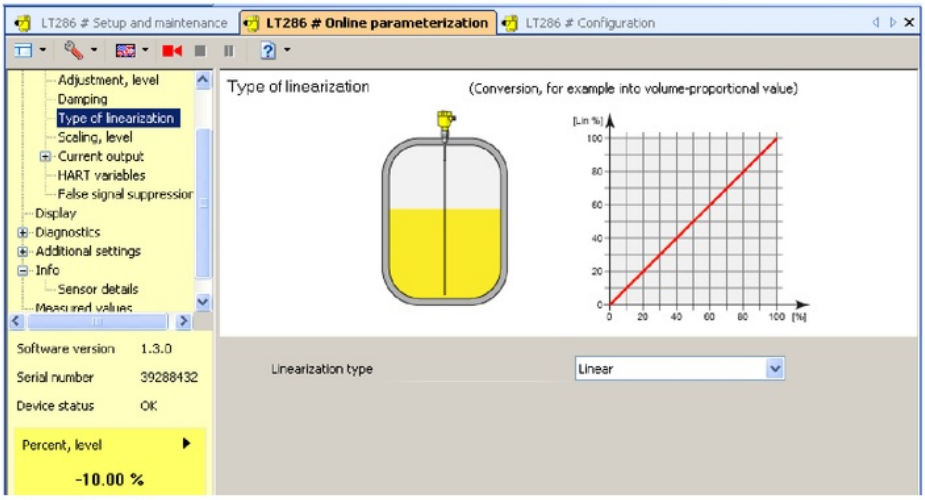


Figure 52 - Linearization Set up

Figure 52 shows the linearization set up page. As the application is to measure the level within the tank, standard linear measurement was selected for even 4-20mA signal.

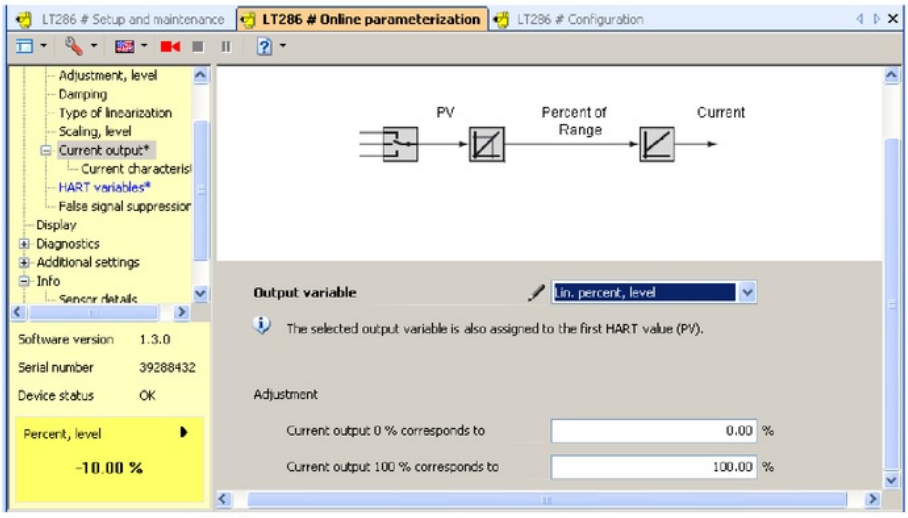


Figure 53 - Configuring Probes Output variables

Figure 53 shows the output variables configuration of the probe. This menu sets the range of the instrument where 0% will generate and output of 4mA and 100% will generate 20mA. The output variable was set to linear percentage.

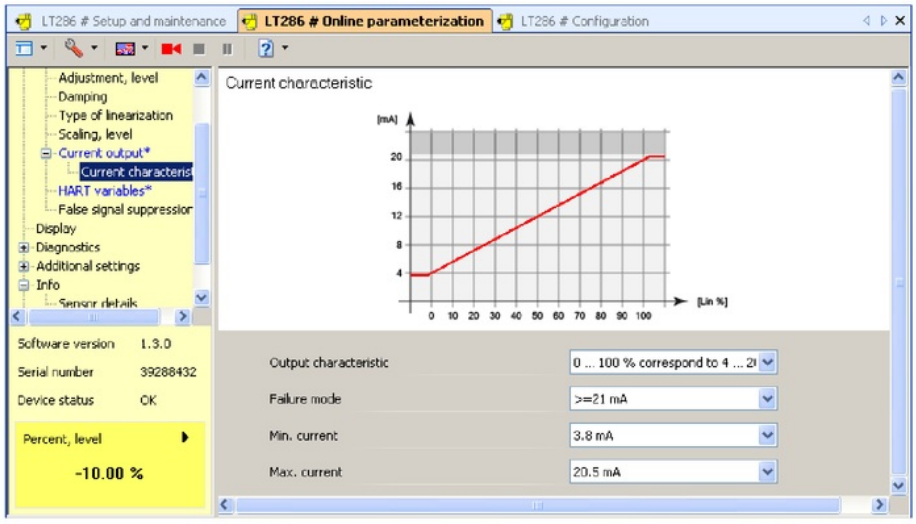


Figure 54 - Configuration of output characteristics

Figure 54 shows the current characteristics page, the output characteristic was set as 0 – 100% corresponds to 4 – 20mA. The failure mode of the instrument >=21mA, the instrument failing high in the event of a fault. A minimum current of 3.8mA and a maximum of 20.5mA.

6.1.2. Fisher GX Control Valve

When valve arrived on site, the valve body direction of flow was incorrect. The valve body was reversed by unbolting the body and turning the direction the correct way. This allowed the valve to be installed correctly with the Fieldvue DVC2000 display facing outward as planned.

Punctuation Error

Figure 55 shows the valves body after reversal.

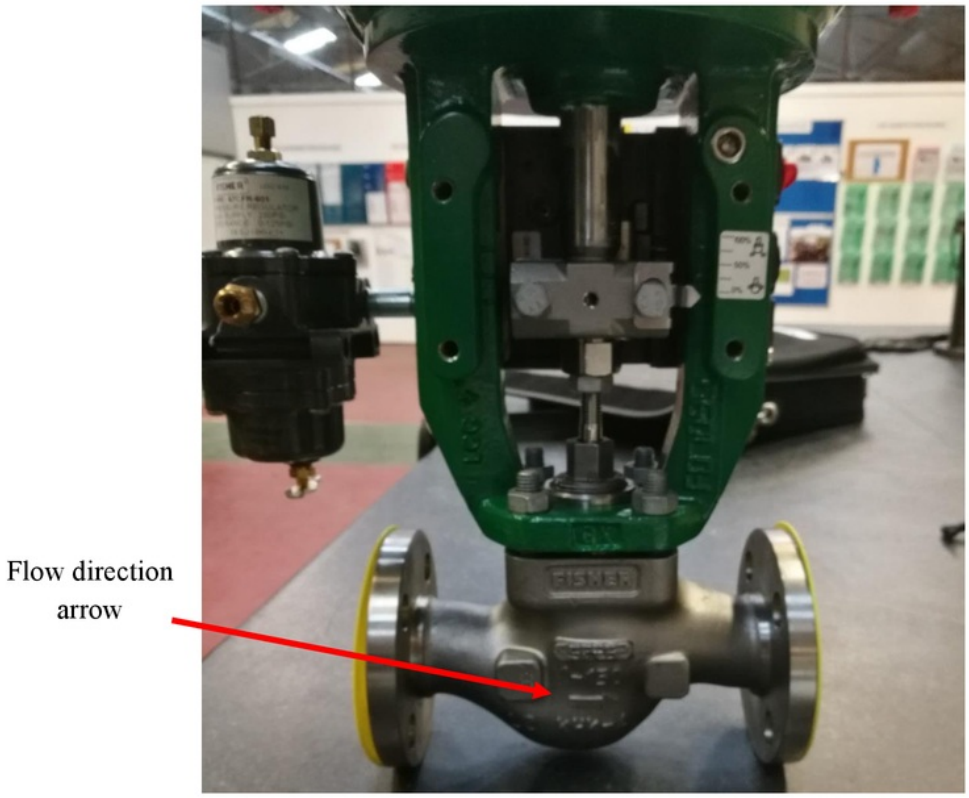


Figure 55 - Valve bodys' direction of flow reversed

6.1.3. Foxboro IDP10S Pressure Transmitter

Shown in Figure 48 is the configuration set up of the Foxboro IDP10S Pressure Transmitter. A 24vdc supply and an inline 250Ω was used to talk to the transmitter to configure using Pactware. A Hart communication dongle was used where probes were placed either side of the resistor to provide communication between netbook and device. The setup is shown in Figure 56

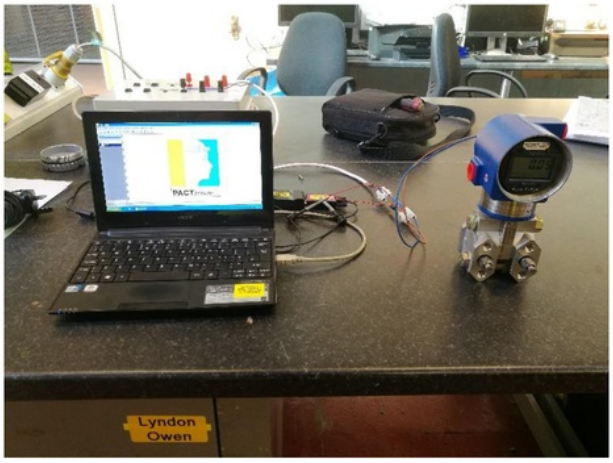


Figure 56 - Pressure transmitter configuration set up

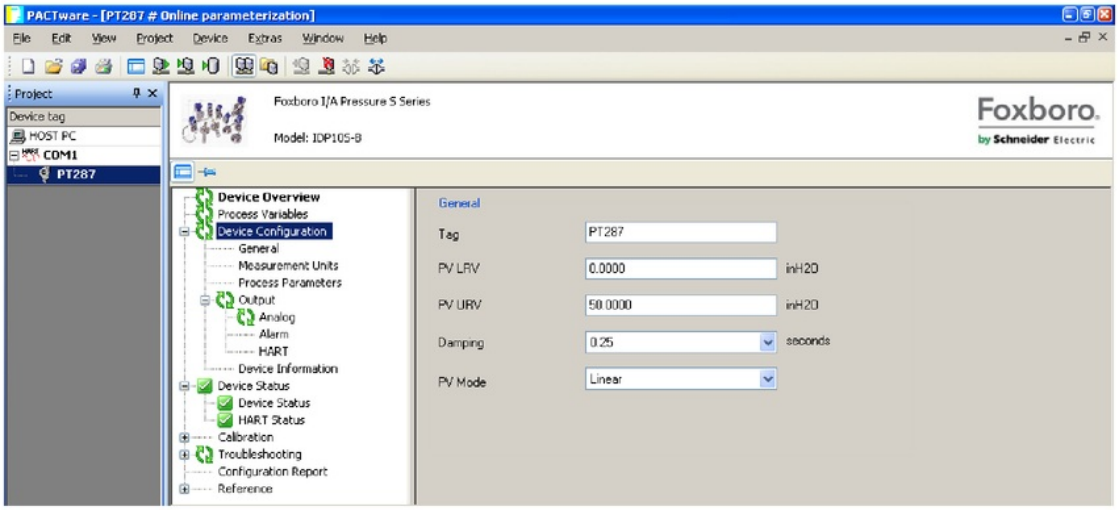


Figure 57 - Configuration of Pressure transmitter

Figure 57 shows the device configuration screen of the Foxboro Pactware once connection established with the transmitter. The asset number for the transmitter PT287 was entered as device tag. The process variable lower range value was set at 0 inH20 with the upper range value set at 50 inH20. Damping of the device was left default at 0.25 seconds and the process variable mode to linear as the device is measuring pressure.

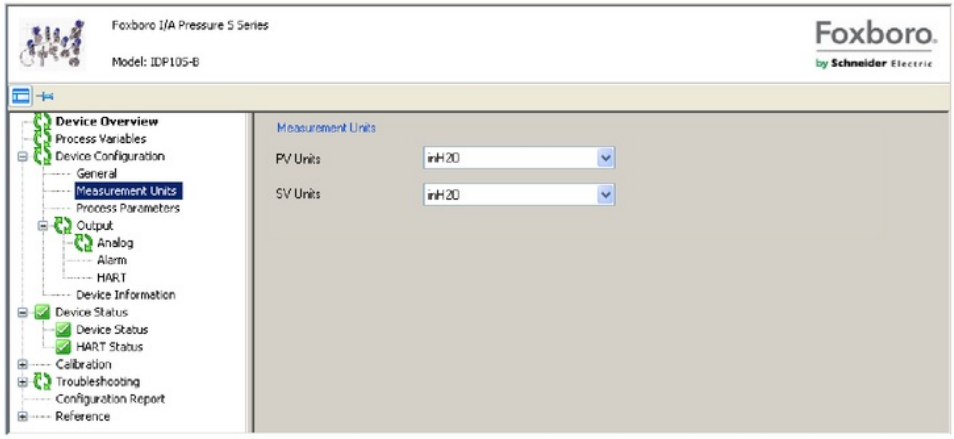


Figure 58 - Entering Measurement Units to Transmitter

Figure 59 shows the measuring units window. This allowed the option to set the process variables unit through a drop down menu. The PV unit was set at inches Water gauge (inH20).

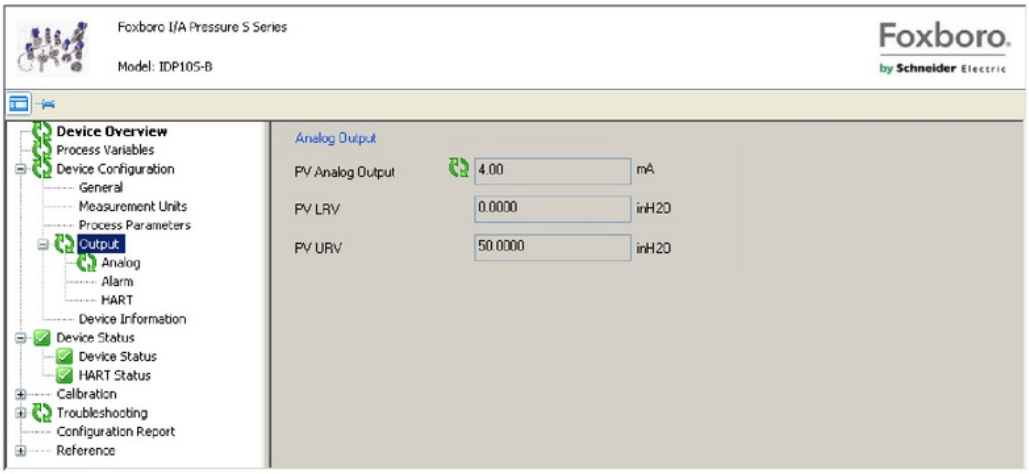


Figure 59 – Live Output Monitoring screen

Figure 59 shows the analog output screen. This can be used to monitor the mA output and process variable upper and lower range values of a transmitter.

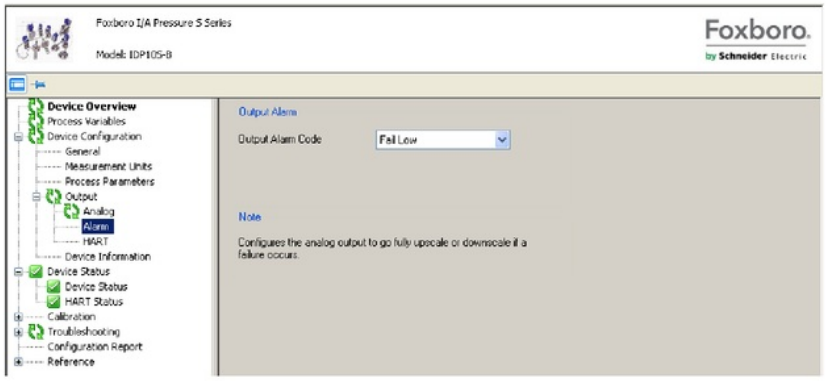


Figure 60 - Configuring Transmitter failure state

Figure 60 shows the output alarm configuration. This was set to 'Fail Low' so that if there was a problem or instrument failure then the output would drop to minimum output current. This will display on that there is no pressure within the pipeline or alarm the operators that there is a fault with the instrument.

6.2. Mechanical & Electrical Implementation

The bypass vessel design given to Skelton & Thomas was fabricated as well as two spool pieces for connecting to the Lute pot and catering for the existing local indication. Figure 61 shows the completed bypass vessel and spool pieces under a pressure test.



Figure 61 - Bypass vessel under Pressure test

The Fisher GX control valve required an air supply to operate, a local instrument air supply manifold was found locally to the lute pot that could be used. However, the airline was dead and disconnected. To reinstate the air supply for the valve, the instrument air supply pipe work was traced so that a modification could be carried out to safely reinstate the airline manifold, modifying existing pipework to the control valve and redundant pipework was to be removed via MEWP (Mobile Elevated Work Platform).



Figure 62 - Reinstating Air supply

Figure 62 shows the reinstating of the existing instrument air supply line. Instrument air pipework was modified by using a t-piece and an isolation valve. The pipework then connects to an existing air supply line to a manifold. A manifold port is used to supply the control valve with air.



Figure 63 - Bypass vessel and VegaFlex 81 installed

Figure 63 shows the bypass vessel and Vegaflex 81 installed on plant with isolation valves and the existing local indication reattached.

The electrical designs' scope of work was discussed with the Hornbill supervisor so that the job was understood. The first stage involved running a 5 pair cable from the Incinerator DCS Cabinet to a local marshalling box at the Lute pot with containment.

The second stage of the electrical installation required the mechanical installation to be complete so that VegaFlex 81, control valve and pressure transmitter were installed and single pair cables from the marshalling box to each instrument can be connected. This includes connecting the instrument loops to the FBM termination assembly.

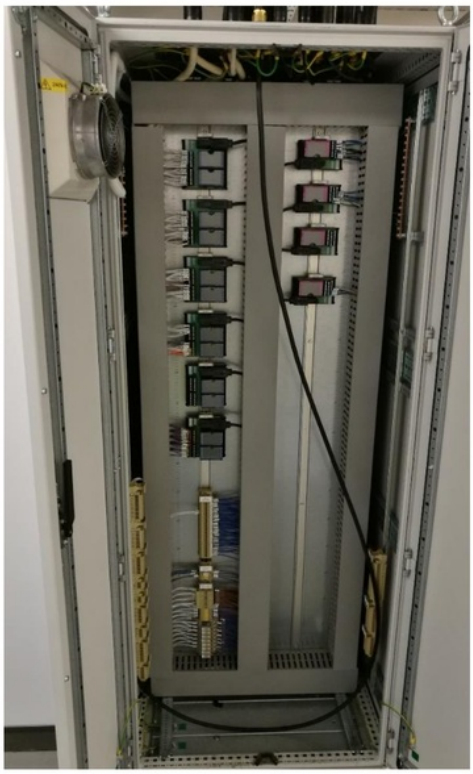


Figure 65 - 5 Pair cable Installed in Incinertor DCS FBM Cabinet



Figure 64 – Instrument loops terminated in termination assemblies

Figure 65 shows the installation of the 5 pair cable to the incinerator DCS FBM termination assembly panel. Figure 66 shows the termination of the loops into the analog input and output termination assemblies.



Figure 66 - Installation of 5 Pair cable and Local marshalling box

Figure 66 shows the installation of the 5 pair cable, local marshalling box and containment.



Figure 67 - Installation of Level control instrumentation on plant

Figure 67 shows the complete installation of the level control instruments on plant.



Figure 68 - Pressure Transmitter Installation

Figure 68 shows the installation of the pressure transmitter on plant. It contains a manifold for isolation and a vent port for test equipment to be attached. Process variable is plumbed in to the high side of transmitter where low is open to atmosphere, this configuration allows gauge pressure measurement.

6.3. Foxboro IA DCS Implementation

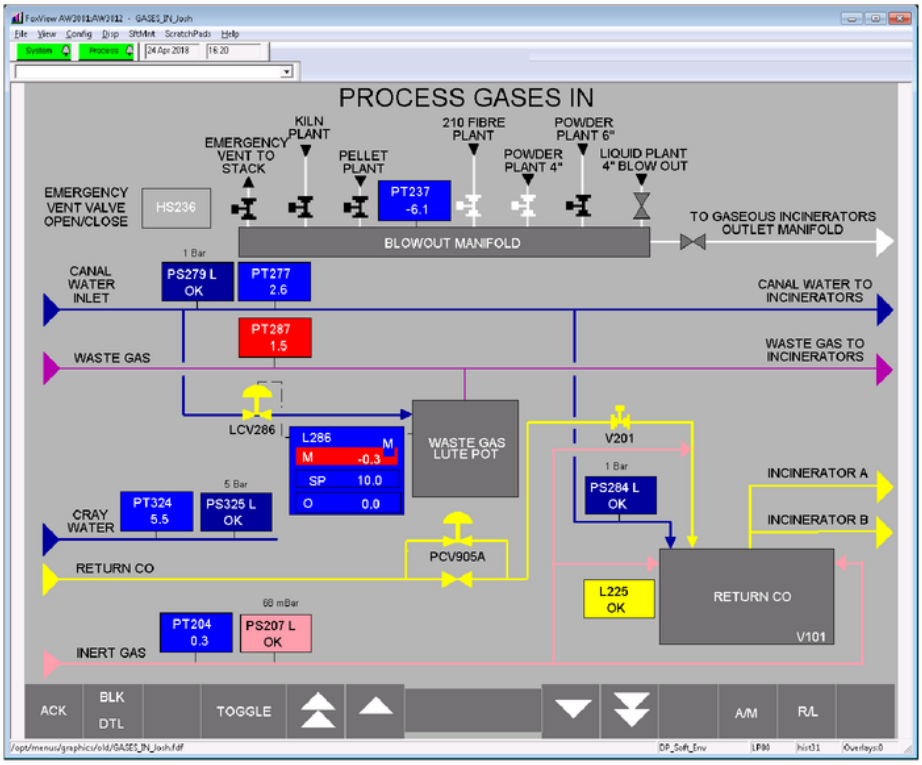


Figure 69 - Modified Plant monitoring graphic

Figure 69 shows the new plant monitoring graphic with online readings after implementation.

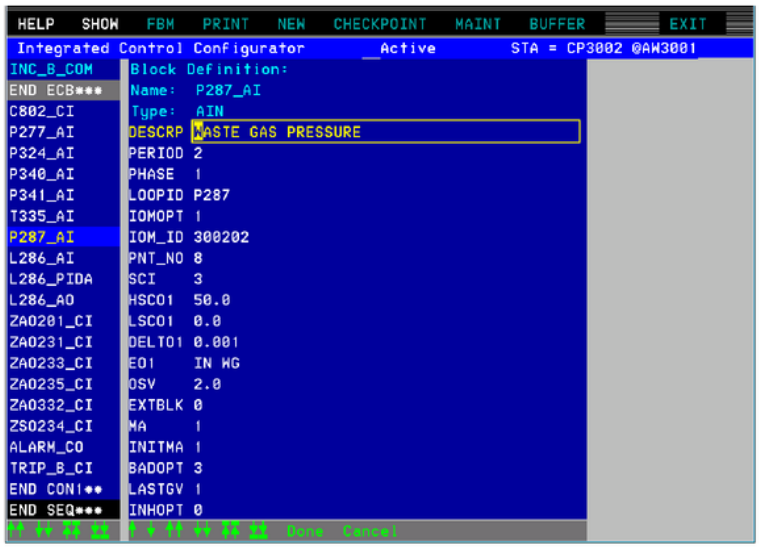


Figure 70 - Analog input control block configuration of Pressure Transmitter

Figure 70 shows the integrated control configurator (ICC) screen of the DCS for the pressure transmitter anologue input block. The parameters were populated to match the design. The block was given the asset name PT287. The loops termination assembly (I/O Module) block was inputted as 300202, channel of termination assembly – 3, high scale of 50, low scale of 0 and unit of inches Water gauge (inH20)

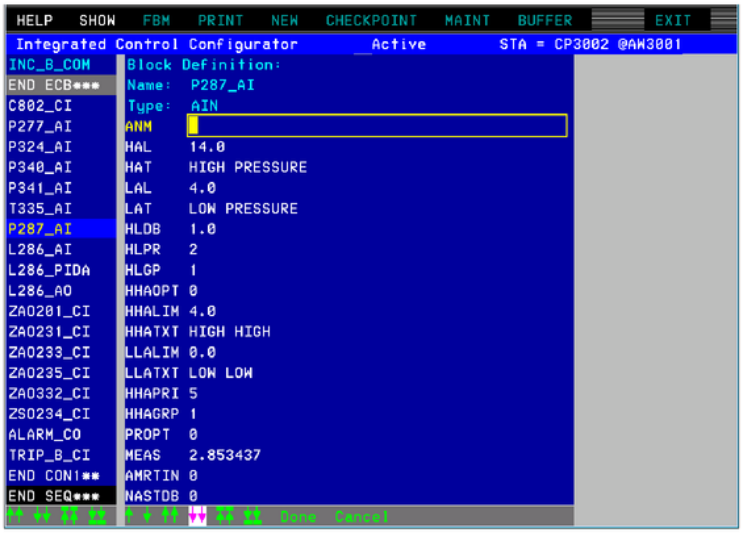


Figure 71 - Analog input control block alarm configuation of pressure transmitter

Figure 71 shows the alarm configuration on the ICC. The high alarm was set at 14inH20 and the low alarm was set at 4inH20. Alarm text was also used for logging.

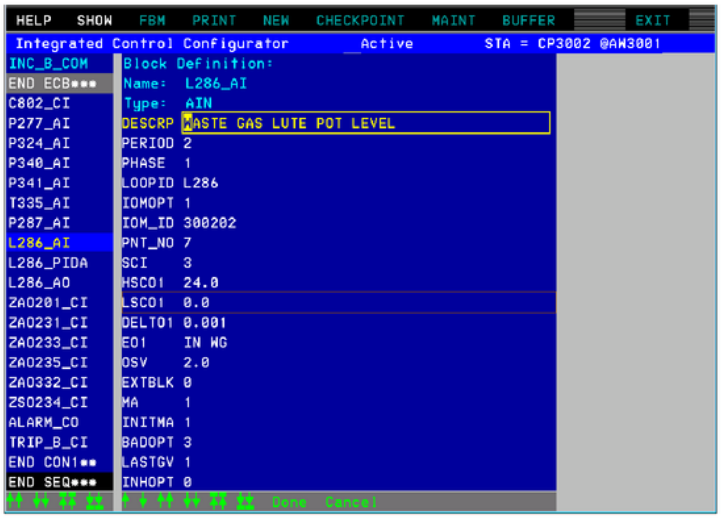


Figure 72 – Analogue input control block configuration of Level transmitter

Figure 72 shows the ICC for the configuration of the analogue input of the VegaFlex 81. The asset number is given to the bloke LT286, IOM was addressed to the input field termination assembly 300202, channel 7, with a high scale of 24 and a low scale of 0 with the unit set as inches water gauge.

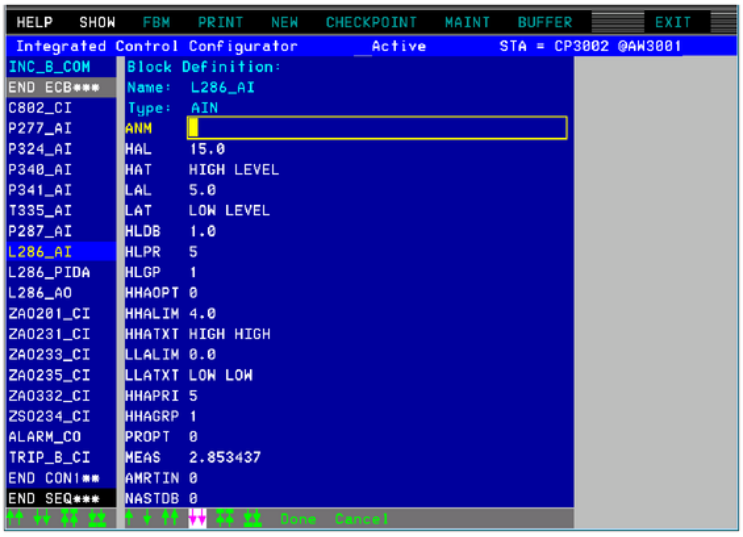


Figure 73 – Analogue input control block alarm configuration for Level transmitter

Figure 73 shows the alarm configuration for the VegaFlex 81 input. A high alarm was set at 15inH20 and a low alarm set at 5inH20.

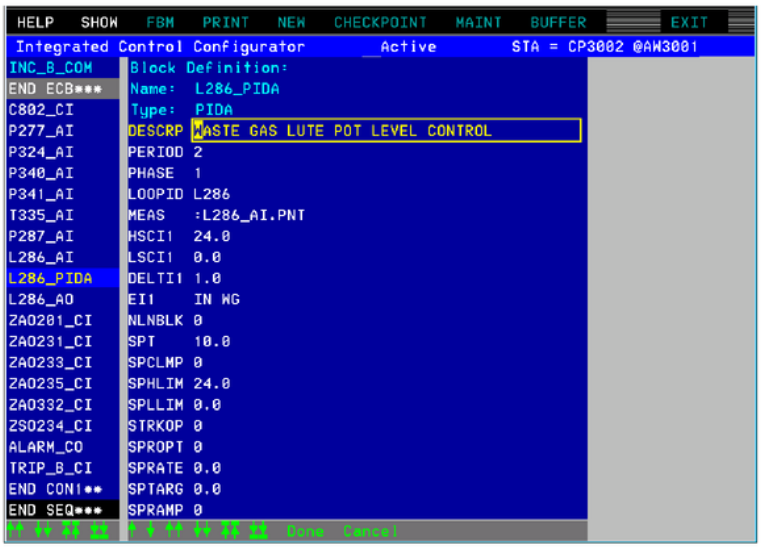


Figure 74 - Level control block for automatic control

Figure 74 shows the ICC for the PIDA control block. The level measurement input is addressed to the measured parameter to use as the feedback reference for control also including the 0-24inH20 scale of the instrument.

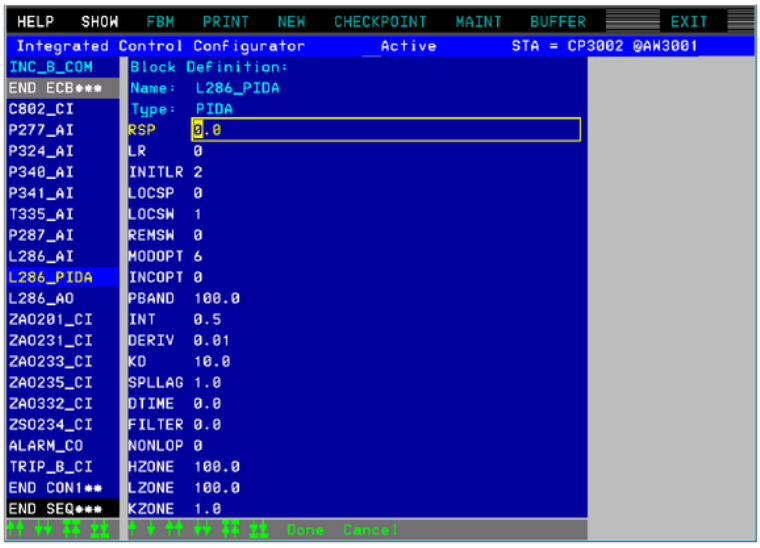


Figure 75 – Level Control block continued

Figure 75 shows the continued page of the level control PIDA block. For automatic control action of the loop. Default parameters are inputted, this is where the Proportional band, integral and derivative control parameters would be entered when implementing automatic control

6.5. Matlab Simulation

A Matlab model of the Lute pot level control system was produced. Using the simulation software allowed the model to be tuned and tested with disturbances without effecting plant before implementing automatic control.

The model was simulated using existing plant variables and time coefficients of the level sensor and control valve. The model consists of a step input, proportional-integral controller, models' for level sensor, control valve and the lute pot with step inputs to simulate plant disturbances. The models' shown in Figure 76

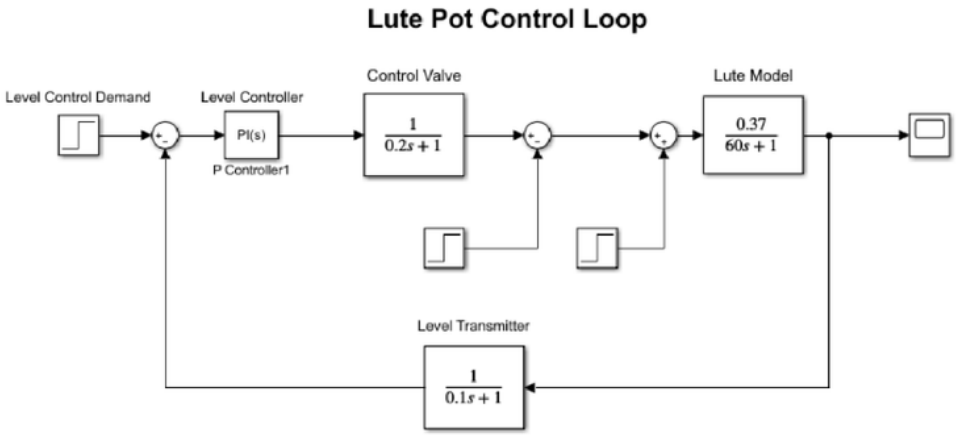


Figure 76 - Matlab Simulation

The Lute model was determined as the distance between the bottom of the RWG inlet pipe to the mechanical overflow pipe 370mm and 1/5th of the time that the vessel takes to fill from empty. Process operators stated from experience that filling the Lute pot from empty took 5 minutes, therefore a 1/5th is 60 seconds.

Models for the level sensor and control valve inputted as 0.1, 0.2 seconds as they are continuously transmitting and receiving data.

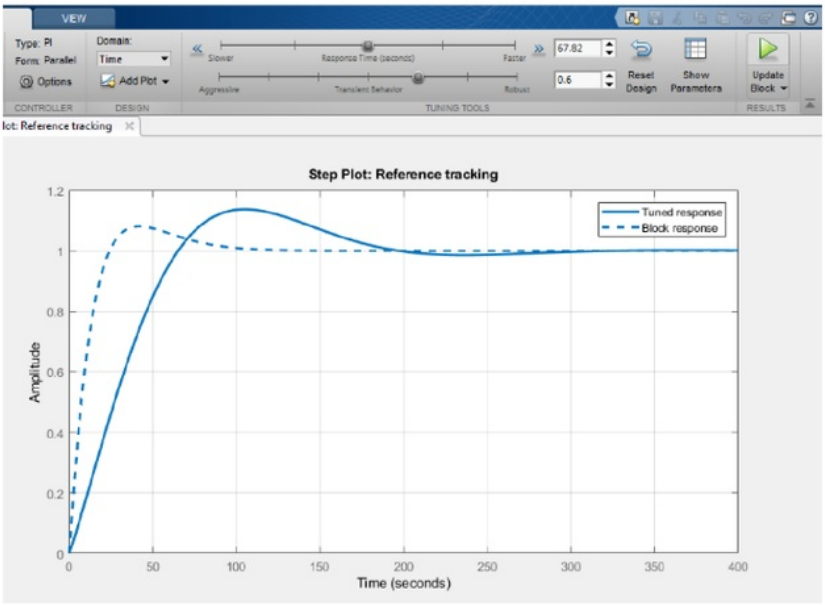


Figure 77 - Matlab Autotune feature

Figure 77 shows the auto-tune window of Matlab. The Auto-tune feature used to achieve optimum process response curve of the model using the 'response time' and 'transient behaviour' dials to alter the speed of the response time and how aggressive or robust the behavior of the control is.

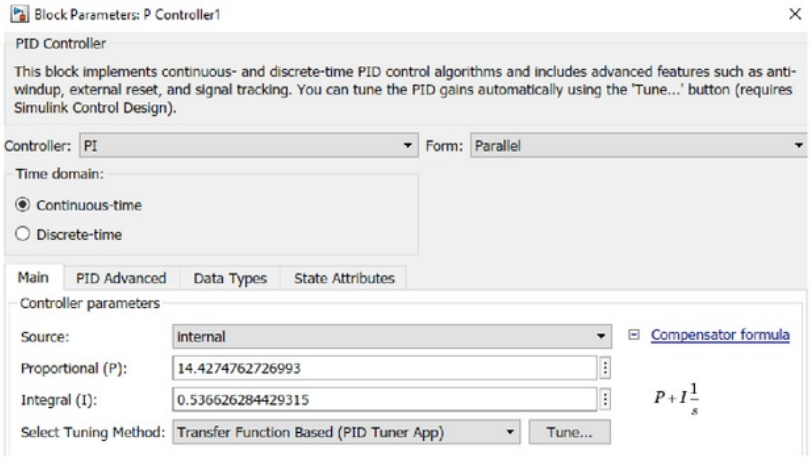


Figure 78 - PI Block parameters

Figure 78 shows the proportional (14.427) and integral gain (0.536) values from the auto-tune process. These parameter values can be a starting point for tuning the control of the new system on plant.

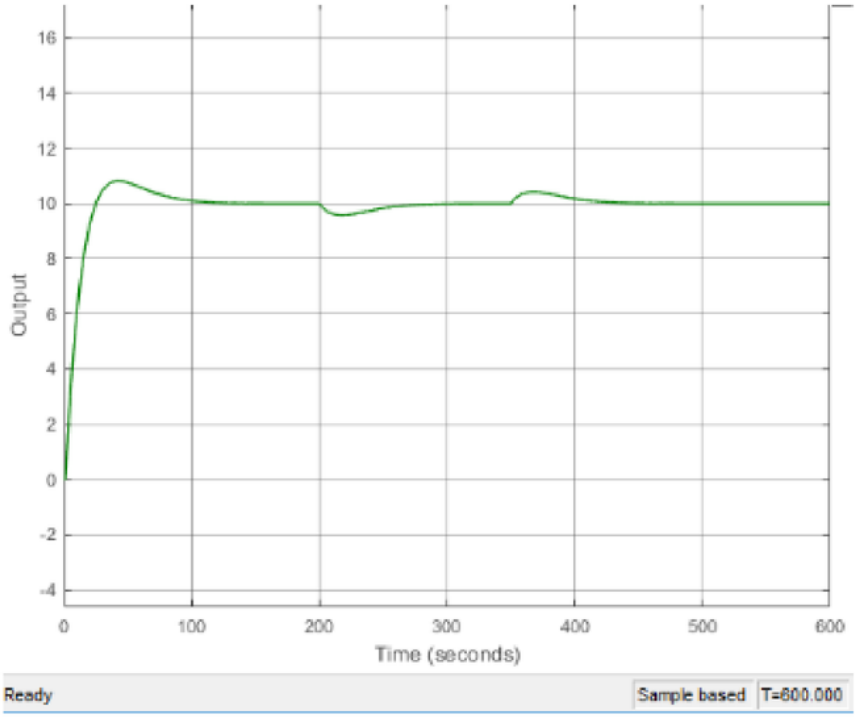


Figure 79 - Matlab model response

Figure 79 shows the response waveform of the model. With a set point of 10 it can be seen that the response rapidly increases and overshoots the set point before the integral action of the controller stabalises the response at the set-point after 2 minutes.

Negative and positive disturbances were set at 200 seconds and 350 seconds to test the models control under a load. It can be seen that the process response deviates from the set point and then corrects the error to stabalises on the set point after 80 seconds. This result shows that the control is stable and the response time meets the specification as it is under specified 3 minutes.

6.6. Implementation Cost

Table 11 - Implementation Cost Report

Task	Resource	Reference No.	Cost
Electrical Install	Hornbill	12605/002	£3,004.02
Vega Flex 81	VEGA	1110382	£1,902.00
IDP10S DP Transmitter	Foxboro	QUK-0118-10039	£1,104.61
Fisher GX Control valve	Reliance Control	4100290741	£3,355.00
Bypass Vessel & Spool pieces	Skelton & Thomas	Q10478	£1,749.42
Modification of instrument airline, Installation of Bypass Vessel and control valve	Skelton & Thomas	Q10857	£1,343.16
Flange Plates & Ball Valve	BSS	29/99330	£141.20
Total Spend			£12,599.41
Remaining Buget			£2,400.59

Table 11 shows the cost report of the implementation on plant. The report shows the cost of each instrument, valve, electrical and mechanical installation including labor.

Of a given budget of £15,000.00, the project accumulated a total spend of £12,599.41 with a remaining budget of £2,400.59

7. Project Testing & Evaluation

7.1. Workshop testing of instruments

Prior to installation of instruments on plant, they were tested in the workshop to prove the calibration. This stage prevents delays in on plant commissioning because the instruments operation will have been proven correct and would require configuration.

7.1.1. VEGA Flex81

The VegaFlex 81 was fixed within the bypass vessel and connected to the netbook to obtain test data. An attachment was added to the bottom entry of the vessel for visual indication of the level within the vessel for comparison between actual and software measurements. Tape applied to the hose to indicate 0%, 50% and 100% where a water pump was used to fill the vessel with water. The test setups shown in Figure 80.



Figure 80 - Workshop test set up for Vega Level probe

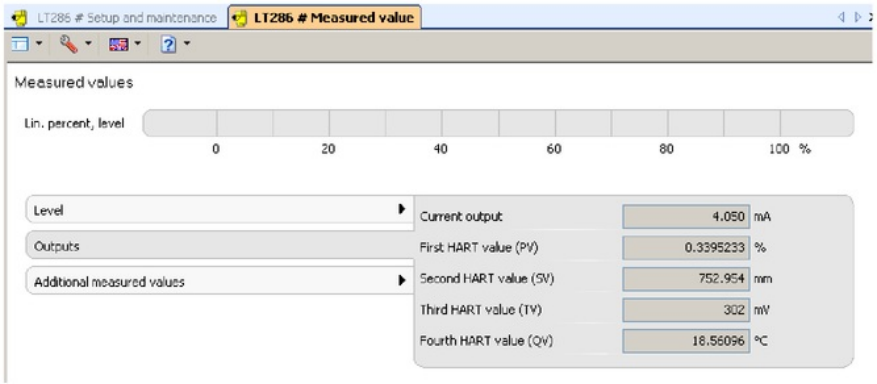


Figure 81 - Vega Pactware at 0%

Figure 81 shows the live data from the probe at 0% full where the water was equal to the bottom marking on the external hose. The Vega probe is outputting 4.05mA at 0.3%

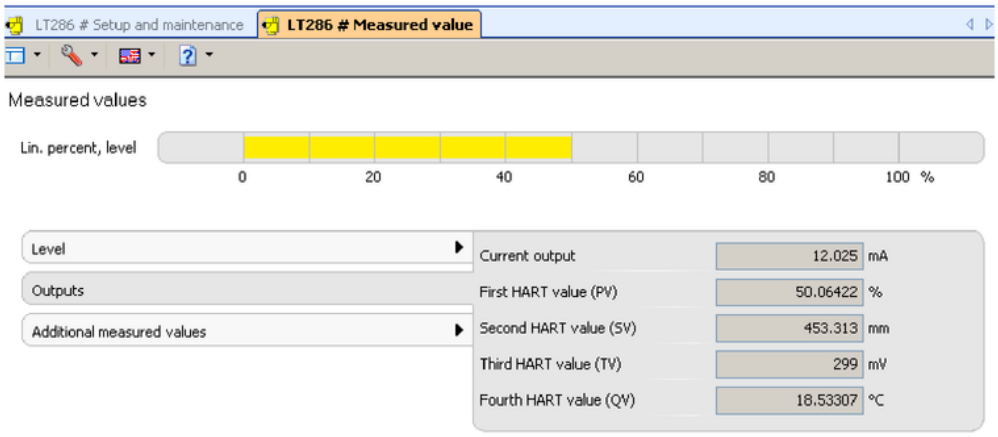


Figure 82 - Vega Pactware at 50%

Figure 82 shows the live data from Pactware when the vessel was filled to 50% on the external hose. The Vega probe is outputting 12.025mA at 50.06% full.

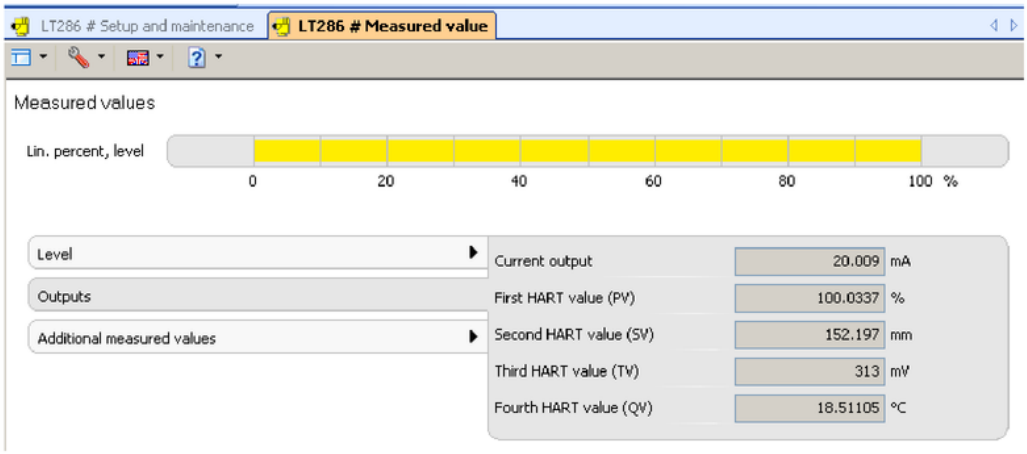


Figure 83 - Vega Pactware at 100%

Figure 83 shows the live data from Pactware when the vessel was filled to 100% on the external hose. The Vega probe is outputting 20.009mA at 100% full.

The results shown on Pactware of the test of the Vegaflex 81 in the workshop proved that the probe is functioning correctly to its set-up giving accurate 4-20mA output signal at 0%, 50% and 100%. The probe is now ready for installation.

7.1.2. Fisher GX Control Valve

Using 5Bar air supply and a 4-20mA loop injector, the control valves operation was tested. This test included a 5 point test, starting at 4mA and incrementing in steps of 4mA to a final value of 20mA to ensure the correct 0 – 100% travel of the valve. Figure 84 to Figure 89 shows the 5 point test at each individual stage with 0% travel representing fully closed and 100% fully open.



Figure 84 – Control valve test set up



Figure 85 – 4ma input signal 0% travel



Figure 86 - 8mA input signal 25% travel



Figure 87 – 12ma input signal 50% travel



Figure 88 - 16mA input signal 75% travel

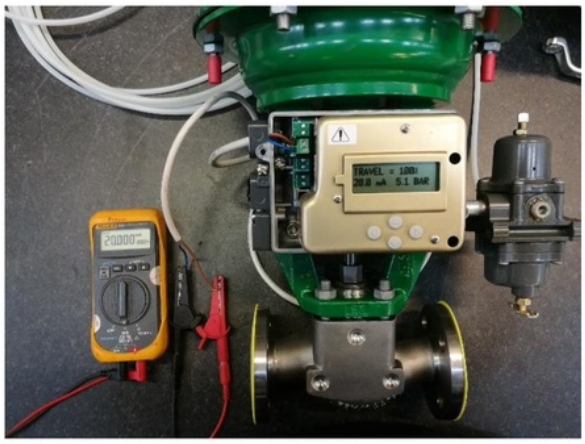


Figure 89 - 20mA input signal 100% travel

The results shown in Figure 84 to Figure 89 displayed that the valve travel was at the correct position for each of the input signals proving that the valve travel orientation and accuracy has been set up correctly and is ready for installation.

7.1.3. Foxboro IDP10S

Testing the IDP10S differential pressure transmitter consisted of a 3 point test inputting a test pressure using a pump and digital pressure reader of 0"Wg, 25"Wg and 50" Wg for – to 100%.

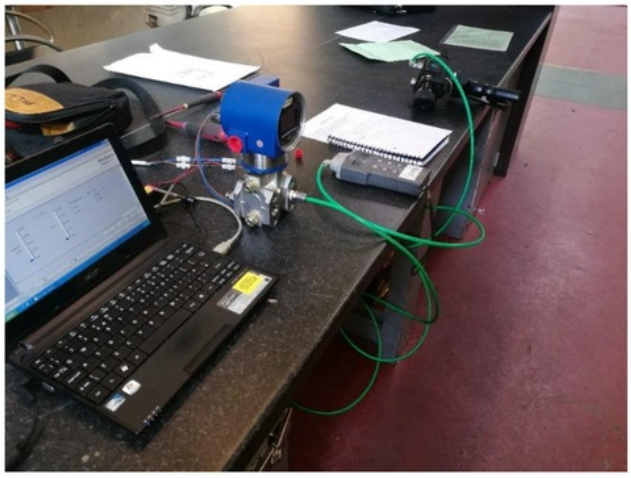


Figure 90 - Transmitter test set up

Figure 90 shows the test set up of the instrument. 1/4" swagelock compression fitting was used on the high side of the transmitter, 6mm nylon pipe was used to connect the pressure indicator and pump, to apply the correct pressure to the instrument to ensure calibration was accurate.

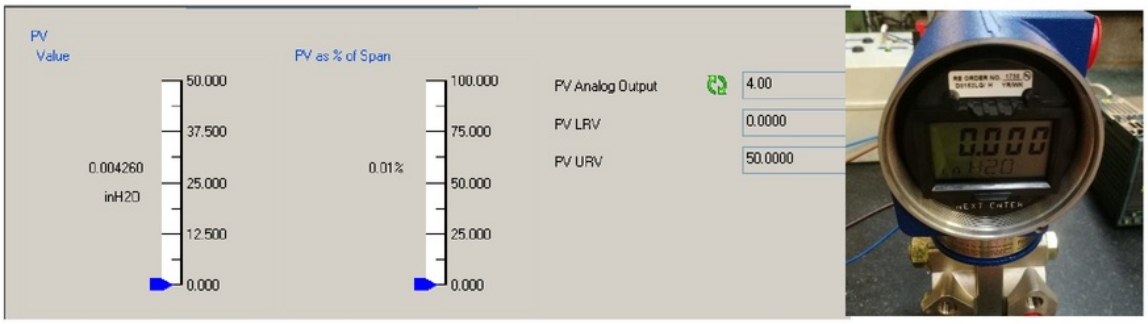


Figure 92 - Pactware and Transmitter 0% input

Figure 92 shows the readings of 0% input into the transmitter on Pactware and on the transmitter display.

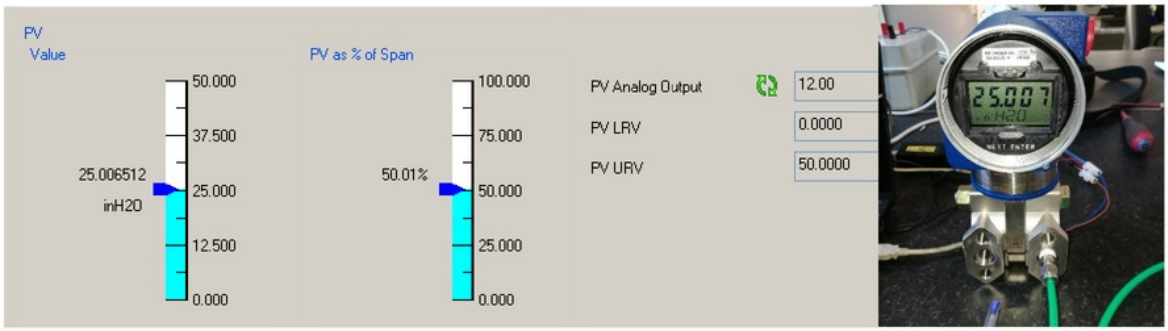


Figure 91 - Pactware and Transmitter 50% Input

Figure 91 shows the readings of a 50% input into the transmitter on Pactware and on the Transmitter.

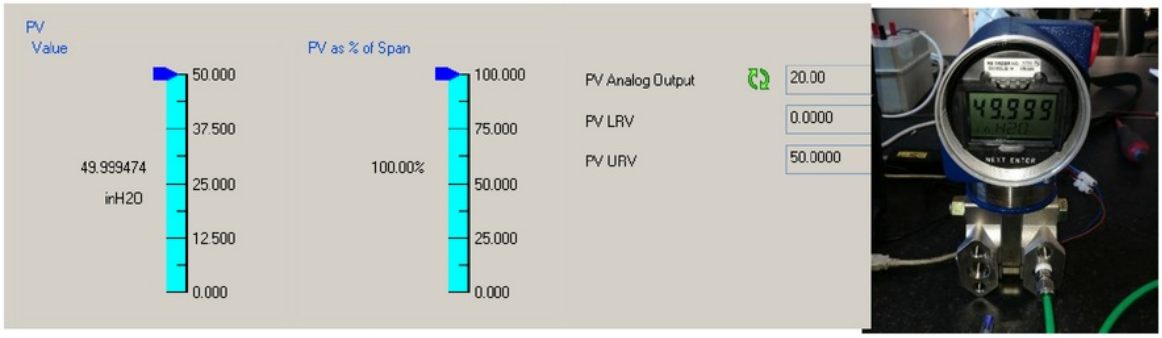


Figure 93 - Pactware and Transmitter 100% Input

Figure 93 shows the readings of a 100% into the transmitter on Pactware and the transmitter display. The results shown from Figure 92 to Figure 93 prove that the calibration of the instrument is accurate as when a input pressure of 0, 25 and 50 inH20 were applied, the transmitter and Pactware repeated the correct input signal. Calibration certificates were produced for the VegaFlex, Control valve and pressure transmitter and are in the appendix.

7.2. Functionality Testing of system in Workshop

Due to unplanned maintenance in the Lute pot Area restricting access for implementation. The system was modelled within the workshop to test its operation met expected results.A Eurotherm 2408 Controller was used.



Figure 94 - Workshop testing using Eurotherm controller

Figure 94 shows the test set up using the eurotherm controller. The controller received a 4-20mA signal from the VegaFlex where a 2.49Ω current sensing resistor was connected across the termianls. The controllers 4-20mA output signal was connected to the control valve for control. The bypass chamber was used to replicate the Lute pot where it was filled with water and drained into the bucket.

The controller was set up using a manual where the process variable was set 0 to 24 to replicate the distance between 0 and 100% full of the bypass vessel, input signal set up as 4-20mA with the output channel set as 24vs, 4-20mA output for the valve.



Figure 95 - 0 - 100% Level input to Eurotherm Controller

Figure 95 shows the results when the bypass vessel was filled from 0 – 24inches for 0 to 100% range to ensure the reference was accurate. The top line is the measured reading and the bottom line represents the set-point. The controller was set up as a Proportional-Integral controller with a proportional band of 100 and integral time of 15 seconds. A set point of 12.50 was set in the controller.

Testing the behavior of the control loop included filling the bypass vessel 0 to 24inches for 0 – 100% range in 1 inch increments recording the mA output of the level transmitter and the reference mA of the control valve. The results were plotted on a graph and shown in Figure 96.



Figure 96 - Functionality Testing Trend Graph

The graph shows the mA reference of the VegaFlex 81 and the control mA of the Fisher valve. The graph trend shows the behavior of the loop as the bypass chamber is filled, when the bypass

vessel is empty at 0inches, 4mA is outputttted from the level probe where the control valve is at 20mA for fully open position as the process variable is not at the set point.

As the level within the vessel gradually increases, the output mA of the VegaFlex rises in linear characteristics. As the controller is configured for PI control, there was no change in controller output until the set point was passed as there was no derivative action measuring the rate of change of the process variable so that the control action would only change once the set-point had been passed where the integral action will eliminate the error.

It can be seen as once the level reaches 12 inches the mA of the control valve begin to decrease, starting to close the valve. As the level is still climbing, the controller reduces the mA output to valve to close it further, trying to eliminate the error and keep the level at 12.50 inches. As the level further increases, the controller outputs 4mA for fully closed travel to stop the vessel from filling. This test therefore proves the correct operation of the system as the controller is trying to control the level within the vessel by closing the valve to prevent the level from increasing.

7.3. On Plant Testing

After mechanical and electrical installation was complete and the Foxboro DCS instrumentation loops configured, the instrumentation was tested back to the DCS following the on plant testing table.

7.3.1. VegaFlex 81 Level Transmitter

Figure 97 shows the Foxboro DCS 'block detail' screen of 'LT286' loop under test with 0% input.

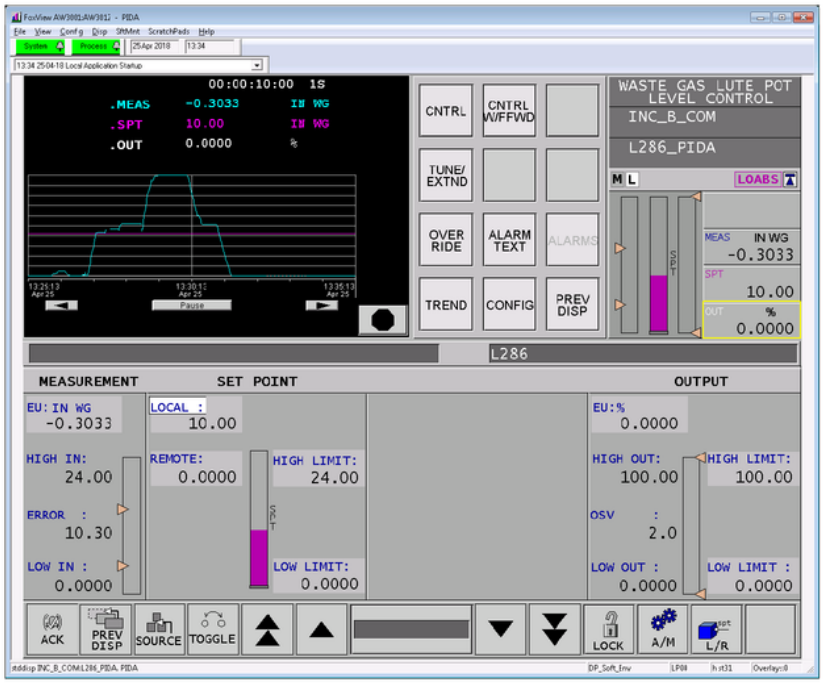


Figure 97 - LT286 with 0% Input

The block detail screen shows the historian trend of the instruments measurement as well as the process set-point value for automatic control and the control output of the loop to the valve. The trend shows the three point calibration test results where a cursor was placed at 0% input. A 0% input gave a result of -0.3inH20 that's shown in cyan coloured text above the trend.



Figure 98 – LT286 With 50% Input

Figure 98 shows the result of the instrument with 50% input. The trend of the instrument shows that the instrument reads 12.26inH20 at 50% input.

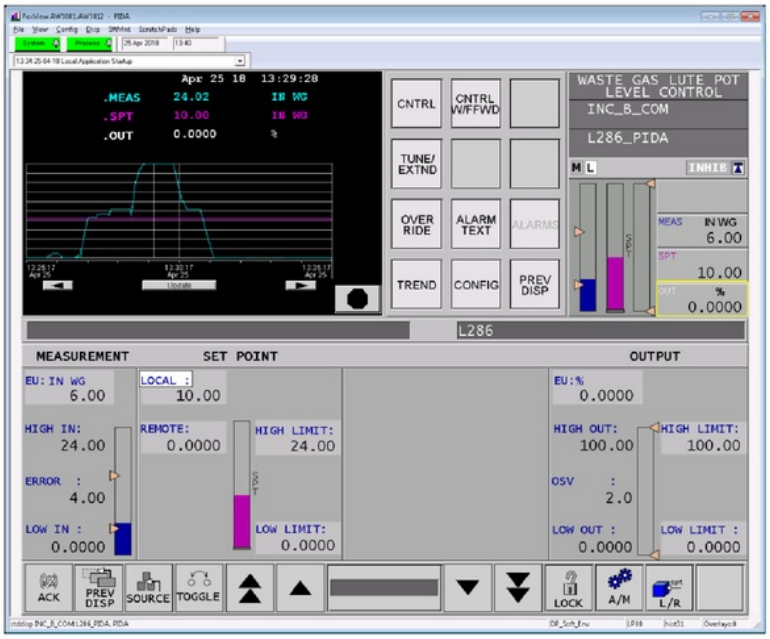


Figure 99 - LT286 With 100% Input

Figure 99 shows the test result of 100% input to the instrument. The trend of the instrument shows the instrument is reading top scale at 24.02inH20

7.3.2. Foxboro IDP10S Pressure Transmitter

Figure 100 shows the pressure transmitter trend throughout the three point calibration check back to the DCS.



Figure 100 - PT287 With 0% Input

The feedback from the instrument under 0% input was measured at -0.05inH20.

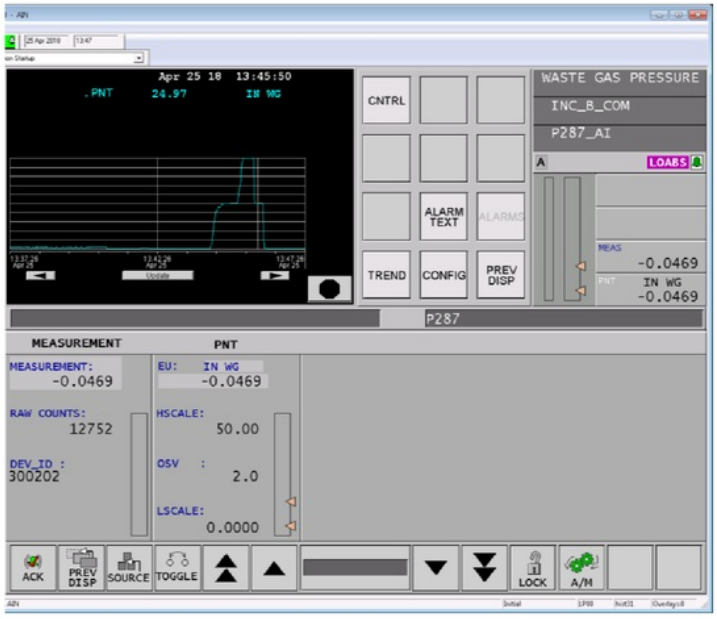


Figure 101 - PT287 With 50% Input

Figure 101 shows the instrument reading 24.97inH20 with an input of 50%.

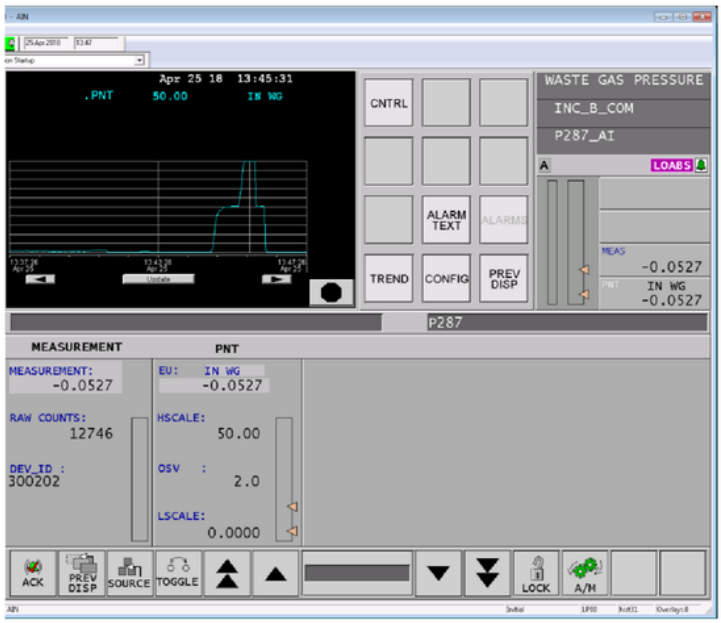


Figure 102 - PT287 With a 100% Input

Figure 102 shows the instrument reading 50.00inH20 with an input of 100% applied. The three point calibration check of the instrument was repeated returning to 0% with identical inputs as shown by the trend, the results replicated that of the initial test proving no hysteresis error. This proves that instrument is accurate and fit for use.

7.3.3. Fisher GX Control Valve

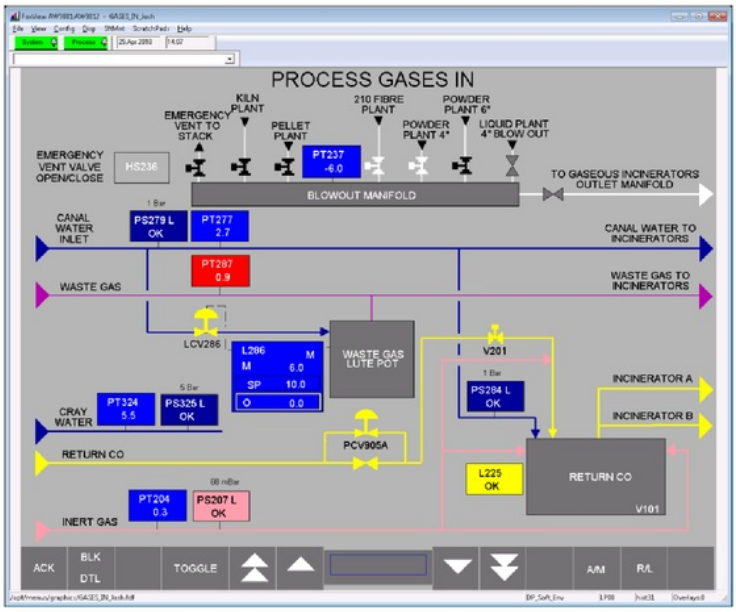


Figure 103 - LCV287 Valve Travel at 0% output on DCS

Figure 103 shows the graphic for the Lute pot control system. To test the operation of the control valve, the output of LT286 was to increment 0, 25, 50, 75, 100% to give 4 to 20mA step output to the valve.



Figure 104 - LCV287 position with 0% Output

Figure 104 shows the Fieldvue display of the valve with 0% output. The display shows the valve travel is at 0% with a 4mA control input from the DCS with no air supply to move the valve

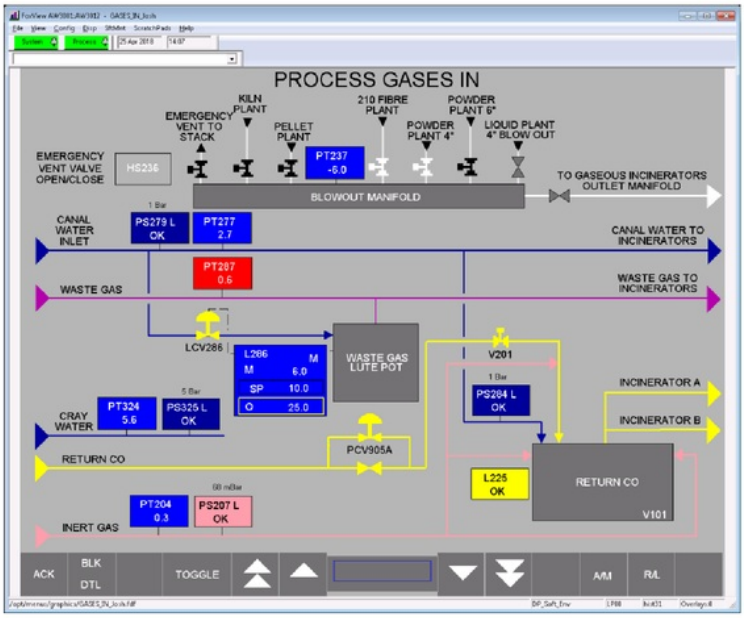


Figure 105 – LCV286 Valve Travel at 25% Output on DCS

Figure 105 shows the output of the control block to the control valve at 25%.



Figure 106 – LCV286 Position with 25% Output

Figure 106 shows the Fieldvue display of the control valve with 25% output from the DCS. The display shows that the actuator has a 8mA input from the DCS, position of the valve travel is at 25% and an air supply of 2Bar.

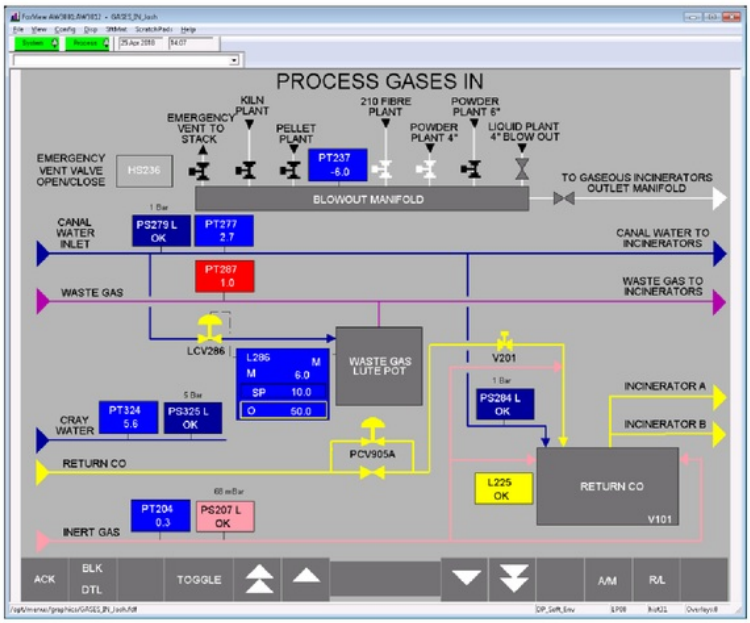


Figure 107 - LCV286 Valve Output at 50% on DCS

Figure 107 shows the output of the control block to the control valve at 50%



Figure 108 – LCV286 Position with 50% Output

Figure 108 shows the Fieldvue display of the control valve with 50% output from the DCS. The display shows that the actuator has a 12mA input from the DCS, position of the valve travel is at 50.5% and an air supply of 2.5Bar.

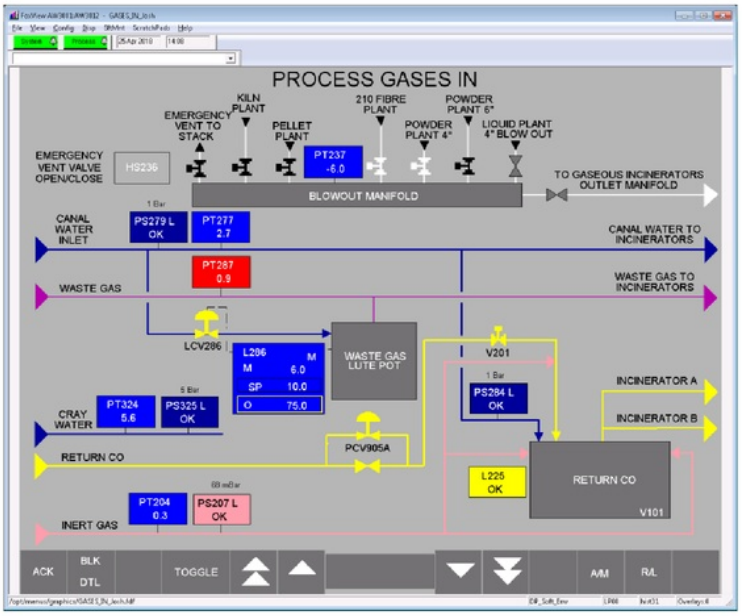


Figure 109 – LCV286 Valve Travel at 75% Output on DCS

Figure 109 shows the output of the control block to the control valve at 75%



Figure 110 – LCV286 Position with 75% Output

Figure 110 shows the Fieldvue display of the control valve with 75% output from the DCS. The display shows that the actuator has a 16mA input from the DCS, position of the valve travel is at 75.2% and an air supply of 2.9Bar.

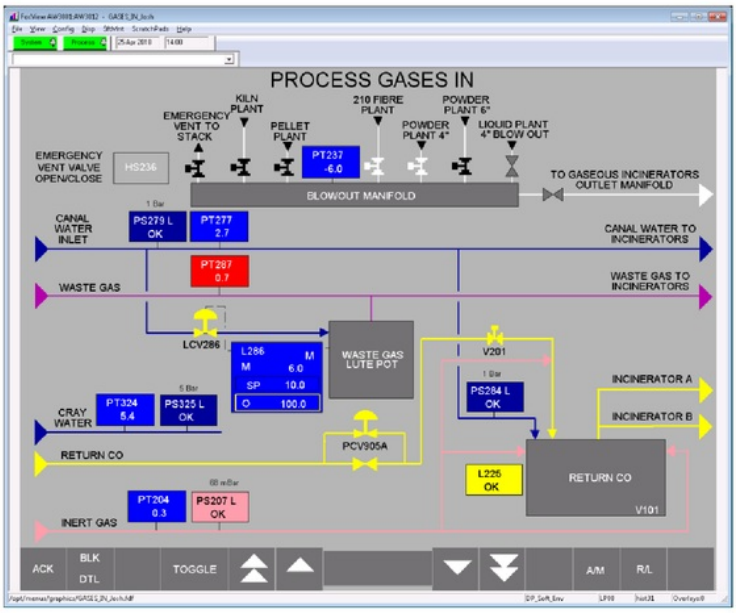


Figure 111 – LCV286 Valve Travel at 100% Output on DCS

Figure 111 shows the output of the control block to the control valve at 100%



Figure 112 – LCV286 Position with 100% Output

Figure 112 shows the Fieldvue display of the control valve with 100% output from the DCS. The display shows that the actuator has a 20mA input from the DCS, position of the valve travel is at 00%. The air supply of the actuator is shown as '???', this error has occurred as the actuator pressure doesn't recognize the input air pressure. This issue will be rectified in the future.

The esults shown from the operation test of the valve show that the valve travel is accurate to a 4-20mA control signal.

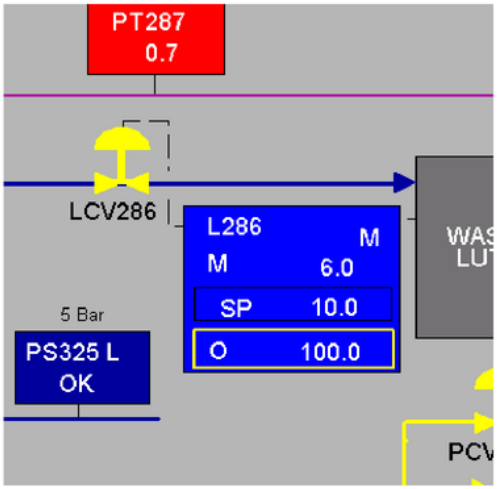


Figure 113 - Control block in Manual

Figure 113 shows the level control loop control in manual control. The type of control is shown by the 'M' in the top right of the control block.

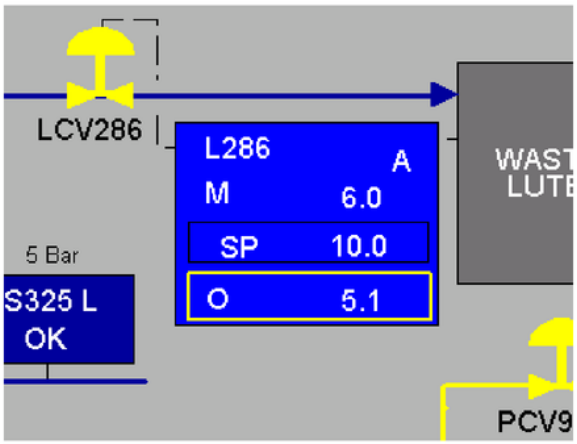


Figure 114 - Control Block in Automatic Control

Figure 114 shows the level control loop in automatic control as 'A' is shown in the top right of the control block. The output of the valve had dropped to 5.1% when the control was toggled to automatic to start controlling the canal water into the lute pot. This occurred as default Proportional-Integral parameters of 14 and 0.5 were applied to the control block however tuning was required prior to implementing automatic control where this test proved the toggle between control mode.

7.4. Evaluation

Table 12 shows the populated test table with results for the instrument tests and functionality test of the system within the workshop.

Table 12 - Workshop and System functionality Test Results

Test	Expected Outcome	Actual Outcome	Pass/Fail
Three point calibration check of VegaFlex 81	VegaFlex 81 to output 0, 50 and 100% range within ±5%	VegaFlex 81 displayed 0, 50 and 100% within ±5%	Pass
Three point calibration check of Pressure Transmitter	Pressure Transmitter to output 0, 50 and 100% range within ±5%	Pressure Transmitter displayed 0, 50 and 100% within ±5%	Pass
Operation check of Fisher GX valve with 4-20mA input	Valve travel to 0% at 4ma, 50% travel at 12mA, 100% travel at 20mA	Valve travel 0% at 4mA, 50% travel at 12mA, 100% travel at 20mA	Pass
Air Failure to Valve	Valve travel to move to closed position	Valve moved to closed position	Pass
Power loss to valve	Valve travel to closed position	Valve moved to closed position	Pass
System Functionality Testing			
Bypass vessel at 0% full with a setpoint of 12.50	Controller to output 20mA for valve to be fully open when vessel empty	Controller outputted 20mA to the control valve for fully open when Bypass vessel at 0% full	Pass
Bypass vessel at 50% full with a setpoint of 12.50	Controller to reduce mA output to valve to start closing to keep level at set point	Controller mA output started to reduce once the level measurement matched the set-point	Pass
Bypass vessel at 100% full with a setpoint of 12.50	Controller to output 4mA for valve to be fully closed when vessel full	Controller outputted 4mA to the control valve for fully closed when bypass vessel was at 100% full	Pass

The results show that the workshop testing stage was a success as all tests passed. The Vegaflex measurements at 0, 50 and 100% input were within the ±5% tolerance. The IDP10S pressure transmitter measurements were also within the ±5% tolerance. The Fisher GX control valve was operated using a loop injector to simulate a 4-20mA where at each stage the Fieldvue displayed the correct travel percentage and the mA input to the valve.

To test the air failure operation of the control valve, the air supply was isolated. After the air was vented the valve returned to fully closed position with a 20mA input signal. With the air re-instated, the loop injector was disconnected where the valve again returned to fully closed position as there was no longer a 20mA signal to drive the valve open thus, proving the safe shutdown operation of the Air to open, spring return close configuration of the valve.

The functionality test of the level control system using a Eurotherm 2408 controller proved the operation of the systems design meeting the expected outcome of each test. The test proved the design as with a given set-point of 12.50inH20, when the level measurement input was below the set point, the controller outputted a 20mA signal to the control valve to open and fill the vessel.

As the level reference was incremented to 100% full, the controller began to decrease the output signal to the valve to begin closing it once the set point threshold had been overshot. With the controller decreasing the output control signal to the valve and the level reference still incrementing the controller dropped the control signal further to 4mA to close the valve to prevent the vessel from filling to keep the level at the desired set-point.

Table 13 shows the populated test table with results for the testing of instrumentation after implementation on plant back to the DCS.

Table 13 – On Plant Testing Results

Test	Expected Outcome	Actual Outcome	Pass/Fail
Three point calibration check of VegaFlex 81 to DCS	VegaFlex 81 to display 0, 50 and 100% range on DCS to a tolerance of ± 5%	VegaFlex feedback measurement back to DCS displayed 0, 50 and 100% under test input within ± 5%	Pass
Level High Alarm	DCS to alarm when level is above alarm threshold of 15inH20	DCS alarmed when the high threshold of 15inH20 was passed.	Pass
Level Low Alarm	DCS to alarm when Process variable is below alarm threshold of 5inH20	DCS alarmed when the low threshold of 5inH20 was passed.	Pass
Break in feedback loop from VegaFlex	feedback measurement from Vegaflex to show 100%	Instrument loop measurement outputted top scale but retained last measured value.	Pass

Three point calibration check of Pressure Transmitter to DCS	Pressure Transmitter to display 0, 50 and 100% range on DCS to a tolerance of ± 5%	VegaFlex feedback measurement back to DCS displayed 0, 50 and 100% under test input within ± 5%	Pass
Pressure High Alarm	DCS to alarm when pressure is above alarm threshold	DCS alarmed when the high threshold of 15inH20 was passed.	Pass
Pressure Low Alarm	DCS to alarm when pressure is below alarm threshold	DCS alarmed when the high threshold of 15inH20 was passed.	Pass
Break in feedback loop from Pressure Transmitter	feedback measurement from transmitter to show 100%	Instrument loop measurement outputted top scale but retained last measured value.	Pass
Operation check of Fisher GX valve travel from DCS control block of outputs of 0 ,25, 50, 75, and 100%	Valve travel to replicate the output percentage from DCS	Fieldvue display of valve showed correct travel of valve at individual output.	Pass
Automatic/ Manual control toggle	Control to toggle between automatic and manual when toggled on DCS	Mode of control toggled between automatic and manual when operated	Pass
Automatic controls' response time within 3 minutes	Measured variable to stabalise on set-point within 3 minutes.	Testing still required	
Introducing a set point change	Level of Lute pot to settle at new set point within 3 minutes.	Testing still required	

The testing of the instrumentation on plant was a success despite two tests not being able to have been carried out due to the plant not being available for tuning within the time constraints. The Vegaflex was tested back to the DCS where the results at each input of the three point calibration check were all accurate and within a tolerance of ± 1.2inH20 (5%) and the DCS alarmed when the measured reference of the instrument rose above and below the high alarm of 15inH20 and low alar of 5inH20. The instrument output upon loop failure also passed as the output went to top scale but displayed its last known value.

The Foxboro IDP10S was successfully tested back to the DCS where the measured value was accurate and within ± 2.5inH20 (5%) tolerance at each point of the calibration check. The DCS alarmed when the high and low alarm thresholds of 14 and 4inH20 were passed.

The instrument output upon loop failure also met the specification as the measured variable went to bottom scale but displayed its last known value.

The operation of the valve was proven successful meeting the specification as the position of the valve replicated that of the DCS output in incremental linear steps proving that the control output signal was accurate on the 5 point check of the valve. The specification was met as with no control signal, the valve was in 0% fully closed position and when a loss of air supply occurred the valve returned to fully closed position to prevent the vessel from filling.

The control mode toggle feature was proven successful as the mode of control toggled between automatic and manual.

The overall testing of the new system was a success as all tests that were able to be carried out met the expected test outcome and therefore the specification. However, two tests remain to be carried out and that is to test the automatic controls' response time to be within 3 minutes and introducing a step change to test that the process can stabalise on a new set point/ correct a disturbance within 3 minutes. This test will be carried out after the loop has been tuned.

8. Conclusions, Recommendations & Reflection

8.1. Conclusion

In conclusion, the aims of the project were met as an automatic control system was designed and implemented to control the level of canal water within the Refinery Waste Gas (RWG) Lute pot pressure relief system. However, final implementation of tuning the control loop for automatic control over run the time constraints of the project as the plant was not available until a planned shutdown.

Continuous level measurement was achieved and displayed on the Foxboro DCS, an output signal can be given to the lute pot control valve to control the flow of canal water into the lute pot to maintain a desired level. Instrumentation accuracy was within the tolerance of ±5%. Instrumentation was to a DSEAR protection standard of "II 2G Ex d IIC T6" for protection against hydrogen and correct failure output modes were configured within the instrumentation for safe control of the process under instrument failure. The plant monitoring graphics for the operations team was updated displaying the new system and instrument readings.

Refinery standardized instrumentation of Vega, Foxboro and Fisher were used for the level control system. Process alarms were implemented on instrument feedback on the DCS to aid the operations department. The level control mode had the ability to toggle between automatic and manual control.

The project met budgetary constraints with a total spend of £12,599.41 of a £15,000.00 budget leaving a remainder of £2,400.59.

8.2. Recommendations

Tuning for Automatic control of the implemented level control system is required to complete the project where two further tests are to be carried out to ensure that that the control of the process variable meets the specification of stabilizing within a response time of 3 minutes after a set-point change or disturbance.

The Lute pot level control system can be improved by adding drain option. This would include implementing an actuator valve in place of the current manual gate valve to empty the system. A drain toggle can be added to the DCS graphic that will energize a solenoid valve to operate an

actuator for open or closed position. This can easily be installed as there are spare pairs and terminals within the local marshalling box at the Lute pot.

With further budget, the level control system can be progressed so that instead of only controlling the level control to give the desired RWG at the incinerators, the level control loop can be cascaded within a pressure control loop so that the desired set point of pressure can be inputted into the control block.

A pressure instrument can feedback the measured pressure to the controller that will output a corrective control signal to the level controller to increase or decrease the level within the lute pot to keep the RWG pressure to the incinerator to the given set point..

8.3. Reflection

A great deal of experience was gained from running the project. A number of obstacles occurred throughout the duration of the project from being naive of real-world scenarios. Ignorance towards lead times of components delayed progression of the implementation stage as it was thought components were 'off the shelf' and ready to be dispatched immediately rather than manufactured to order.

With the delay of components arriving on site the window for implementation was shortened. An unplanned maintenance activity from storm damage further delayed the implementation as the work area at the Lute pot was unsafe and access was restricted due to damaged drainpipe preventing electrical and mechanical implementation.

If a stronger contingency plan was set it could have been possible to implement the project closer to the project plan preventing long delays.

You could have considered Tony Ennis' paper (2006) available on line about using lute pots to control pressure

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10. Appendix including Project Planning

10.1 Project Planning

Task Name	Durati	Start	Finish	F	Resource Names	Cost
Project Planning	**115 days**	**Fri 18/08/17**	**Thu 25/01/18**			**£0.00**
Project Start	1 day	Fri 18/08/17	Fri 18/08/17			£0.00
Project Selection	1 wk	Mon 21/08/17	Fri 25/08/17	3		£0.00
Project Proposal	6.8 wks	Mon 28/08/17	Thu 12/10/17	4		£0.00
Project Research	14 wks	Fri 15/09/17	Thu 21/12/17			£0.00
Interim Report	13 wks	Fri 20/10/17	Thu 18/01/18	5		£0.00
Interim Presentation	1 wk	Fri 19/01/18	Thu 25/01/18	7		£0.00
Execution	**39 days**	**Fri 26/01/18**	**Wed 21/03/18**			**£9,272.63**
Procurement of Components	6 wks	Fri 26/01/18	Thu 08/03/18			£0.00
Cold Test	**12 days**	**Fri 02/03/18**	**Mon 19/03/18**	**10**		**£6,268.61**
Level Transmitter	1 day	Fri 02/03/18	Fri 02/03/18		VEGA Controls	£1,809.00
Pressure Transmitter	1 day	Mon 05/03/18	Mon 05/03/18	12	Schneider Electric	£1,104.61
Control Valve	1 day	Mon 19/03/18	Mon 19/03/18		Emerson Fisher	£3,355.00
Implement	**2.4 wks**	**Mon 05/03/18**	**Tue 20/03/18**	**11**		**£3,004.02**
Mechanical Installation	2 days	Mon 05/03/18	Tue 06/03/18		Skelton & Thomas	£0.00
Electrical Installation	5 days	Mon 05/03/18	Fri 09/03/18		Hornbill Engineering	£3,004.02
Software	5 days	Mon 05/03/18	Fri 09/03/18		Vale	£0.00
Control Valve	1 day	Tue 20/03/18	Tue 20/03/18		Skelton & Thomas	£0.00
Commission	**1.6 wks**	**Mon 12/03/18**	**Wed 21/03/18**	**15**		**£0.00**
Instruments in situe	1 day	Mon 12/03/18	Mon 12/03/18			£0.00
Alarms	1 day	Mon 12/03/18	Mon 12/03/18			£0.00
Failure state	1 day	Mon 12/03/18	Mon 12/03/18			£0.00
Control Valve	1 day	Wed 21/03/18	Wed 21/03/18			£0.00
Acceptance	**22 days**	**Mon 26/03/18**	**Tue 24/04/18**	**20**		**£0.00**
Handover	1.4 wks	Mon 26/03/18	Tue 03/04/18			£0.00
Training	1 wk	Wed 04/04/18	Tue 10/04/18	26		£0.00
Performance Monitoring	4.4 wks	Mon 26/03/18	Tue 24/04/18			£0.00
Report	**62 days**	**Wed 28/02/18**	**Thu 24/05/18**			**£0.00**
Final Report	42 days	Wed 28/02/18	Thu 26/04/18			£0.00
Final Presentation	25 days	Fri 20/04/18	Thu 24/05/18			£0.00

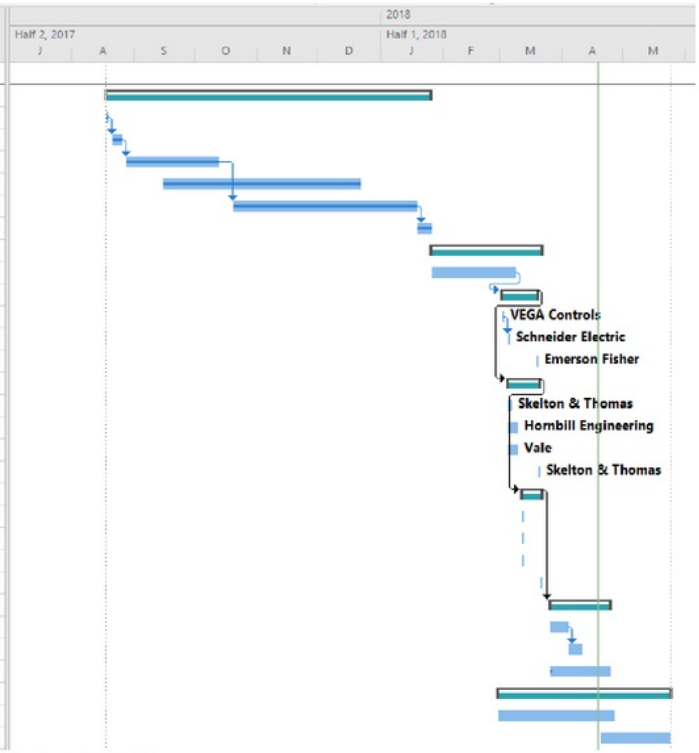


Figure 115 - Planned Project Gantt Chart

Figure 115 shows the planned project Gantt chart. The project was planned to be completed and handed back to the operations team in the last week of march where training of the new system could be provided, to monitor the performance of the level control system and also to add any recommendations that the operations team wanted to improve the system further.

Task Name	Duratio	Start	Finish	Pre	Resource Names	Cost
Project Planning	**115 days**	**Fri 18/08/17**	**Thu 25/01/18**			**£0.00**
Project Start	1 day	Fri 18/08/17	Fri 18/08/17			£0.00
Project Selection	1 wk	Mon 21/08/17	Fri 25/08/17	3		£0.00
Project Proposal	6.8 wks	Mon 28/08/17	Thu 12/10/17	4		£0.00
Project Research	14 wks	Fri 15/09/17	Thu 21/12/17			£0.00
Interim Report	13 wks	Fri 20/10/17	Thu 18/01/18	5		£0.00
Interim Presentation	1 wk	Fri 19/01/18	Thu 25/01/18	7		£0.00
Execution	**64 days**	**Fri 26/01/18**	**Wed 25/04/18**			**£9,272.63**
Procurement of Components	7.6 wks	Fri 26/01/18	Tue 20/03/18			£0.00
Installation of Cable from IA Cabinet to local Marshalling Box	2 days?	Fri 26/01/18	Mon 29/01/18			£0.00
Configuration and Functional Test (Workshop)	**12 days**	**Fri 02/03/18**	**Mon 19/03/18**	**10**		**£6,268.61**
Level Transmitter	1 day	Fri 02/03/18	Fri 02/03/18		VEGA Controls	£1,809.00
Pressure Transmitter	1 day	Wed 14/03/18	Wed 14/03/18		Schneider Electric	£1,104.61
Control Valve	1 day	Mon 19/03/18	Mon 19/03/18		Emerson Fisher	£3,355.00
Delay for Unplanned Maintenance	32 days	Fri 02/03/18	Mon 16/04/18			£0.00
Implement	**0.6 wks**	**Fri 20/04/18**	**Tue 24/04/18**	**12,16**		**£3,004.02**
Mechanical Installation, Vessel, Valve, Airline	1 day	Fri 20/04/18	Fri 20/04/18		Skelton & Thomas	£0.00
Electrical Installation, Marshalling Box to Instruments	1 day	Mon 23/04/18	Mon 23/04/18	18	Hornbill Engineering	£3,004.02
Software	1 day	Tue 24/04/18	Tue 24/04/18	19	Vale	£0.00
Commission	**0.4 wks**	**Tue 24/04/18**	**Wed 25/04/18**	**17**		**£0.00**
Instruments calibration check	1 day	Tue 24/04/18	Tue 24/04/18			£0.00
Alarms	1 day	Tue 24/04/18	Tue 24/04/18			£0.00
Failure state	1 day	Tue 24/04/18	Tue 24/04/18			£0.00
Control Valve	1 day	Tue 24/04/18	Tue 24/04/18			£0.00
Tuning	1 day?	Wed 25/04/18	Wed 25/04/18			£0.00
Acceptance	**22 days**	**Mon 30/04/18**	**Tue 29/05/18**	**21**		**£0.00**
Handover	1.4 wks	Mon 30/04/18	Tue 08/05/18			£0.00
Training	1 wk	Wed 09/05/18	Tue 15/05/18	28		£0.00
Performance Monitoring	4.4 wks	Mon 30/04/18	Tue 29/05/18			£0.00
Report	**57 days**	**Wed 28/02/18**	**Thu 17/05/18**			**£0.00**
Final Report	43 days	Tue 27/02/18	Thu 26/04/18			£0.00
Final Presentation	15 days	Fri 27/04/18	Thu 17/05/18	32		£0.00

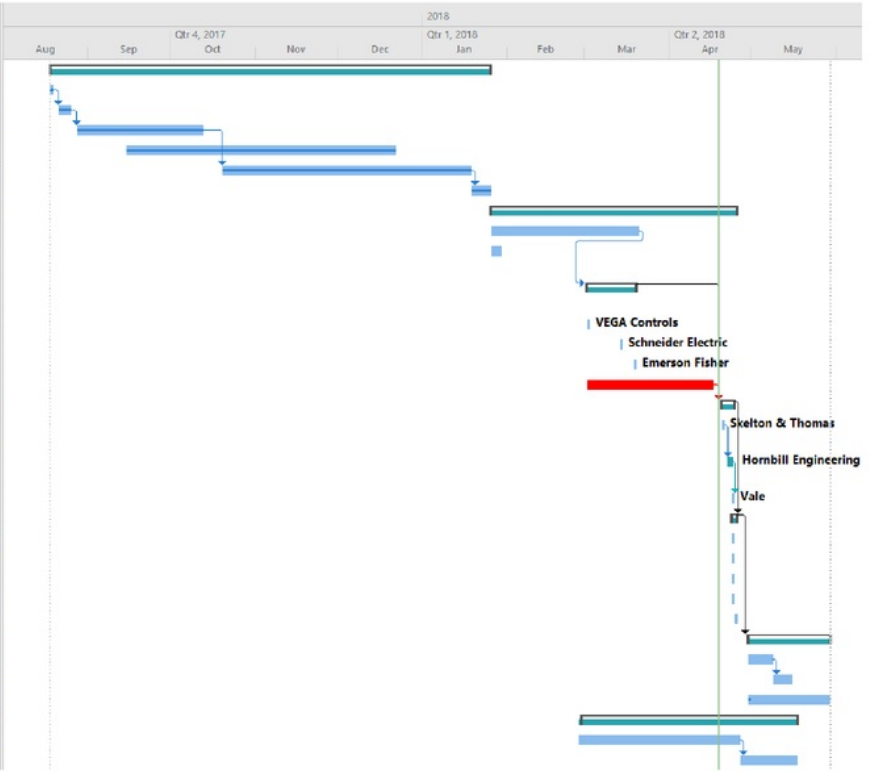


Figure 116 - Actual Project Gantt Chart

Figure 116 shows the actual project timeline. The time delays of lead times of instrumentation delayed progression of the project where storm damage further delayed the progression of the implementation stage. Whilst the area was restricted, a functionality test of the system was carried out to prove the system operated to design. The project was able to be implemented and tested within the time constraints with automatic control being implemented when plant becomes available. The project overrun the time constraints in regards to the handover, training and performance monitoring.

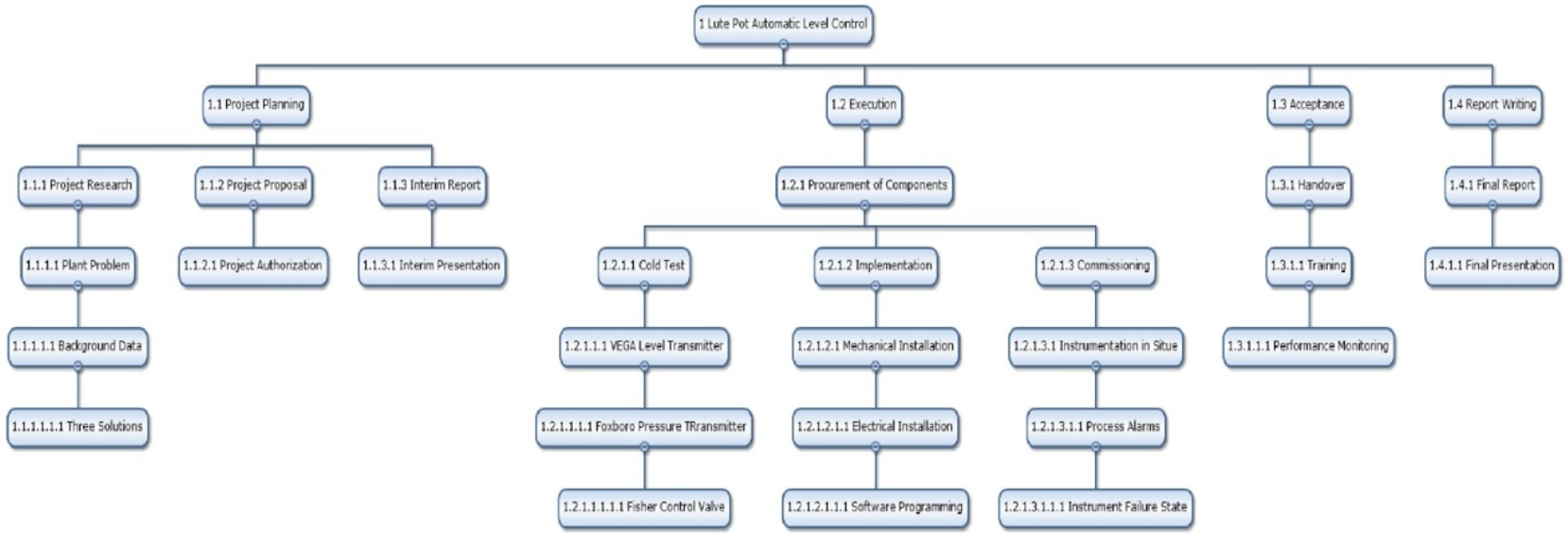


Figure 117 - Work Breakdown Structure of Project

Figure 117 shows the work breakdown structure of the project.

10.2. Management of Facilities Change (MoFc)

Management of Facilities Change Request Document

(Complete all Sections)

No.:

OWNER	AREA	PLANT
D. Amour	Production	Gaseuous Incinerator

Details of Work Required

To install an automatic water level control loop on the waste gas Lute pot that will control the waste gas pressure efficiently whilst also displaying a local reading as well as on the I/A in the PPP control room. The Lute pot water level directly affects the waste gas pressure. Refinery waste gas pressure will also be monitored through a transmitter.
The upgrade to an automatic level control system will improve the control of the waste gas pressure and thus improve the efficiency and operation of the incinerator. A pipeline has already been prepared previously during a shut down for the installation. Project also to provide new schematic and P&ID drawings.

Attach all relevant documentation, e.g. Hazop

PRIORITY						
High	1	2	3	4	5	Low
		v				

Purpose and Necessity (tick as required)

Environmental	Safety/Statutory	Process Improvement:	Replacement:	Cost Saving:
v	v	v		v

-Summary *(Add attachments as required).*

The level of the water within the waste gas lute pot directly affects the waste gas pressure to the incinerator. By introducing a level measuring instrument and cascading the output of the instrument to a control valve, this automatic control will greatly improve the incinerator waste gas burner control and thus remove the need for process operators' manual intervention after the lute pot level has gone awry.

When the lute pot level isn't stable, it results in noise complaints from neighbours due to the constant opening and closing of the waste gas valves. At present, there are no alarm or indication for the system apart from a local gauge, the production team are reacting to the effect of the pressure change rather than controlling the system efficiently.

This upgrade is also an opportunity for cost saving as the amount of natural gas the incinerator uses will be reduced as the incinerator will be heated by the waste gas more effectively thus reducing the usage of natural gas.

Available Expenditure **£15,000**

Expected Savings/Benefits **Safety/process control improvement /cost/environment noise complaints**

Requested by:	Approved by: SG Wilson
D Amour	
Date: 15.11.17	Date: 15.11.17

FOR ENGINEERING USE ONLY

PROJECT ENGINEER:	PROJECT SUPPORT ENGINEER:

10.2 Electrical Risk Assessment

VALE

Clydach Refinery Occupational Risk Assessment Record Form

SAFE PRODUCTION ZERO HARM

RAP06/WI01/SF04 (v4) Nov 2015

Department / Location:	**Engineering - Incinerator Plant**													
Description of Subject / job / task to be assessed:	Electrical Installation - Incinertor Lute pot Cable installation													
Reference No:	CIE_ORA_313													
Version No:	1	**Task No:**	10											
Date of this assessment:	06/01/2018	**ORA Team Leader:**	N P Hopkins	**ORA Team Members:**										
Next scheduled review:	06/01/2021	**Approved By:**	N P Hopkins	JD, NH										

Likelihood / Impact / Severity	Rare 2	Unlikely 3	Occasional 5	Likely 8	Frequent 13	Risk Levels
Catastrophic (E) 32	64	96	160	256	416	>=140
Critical (D) 16	32	48	80	128	208	
Severe (C) 8	16	24	40	72	104	70 - 140
Moderate (B) 4	8	12	20	32	52	25 - 70
Minor (A) 2	4	6	10	16	26	<25

No:	Activity / Step / Area / component: *Subject broken down into manageable components, sections or steps*	Hazard: *What has the potential to cause harm?*	Hazardous Event and Impact: *How could it go wrong? What would be the likely impacts?*	Potential Risk (assuming no controls in place): Impact	Like'd	Risk	Existing Control Measures: *Describe the existing control measures relevant to each hazard*	Residual Risk (Taking into account existing controls and their effectiveness): Impact	Like'd	Risk	Further Actions: *Number and transfer to Action tab*
Consider if there is a risk of exposure to asbestos **(mandatory field)**											
	LINK TO ASBESTOS REGISTERS										
A1	Fuseboards, Cable, Brackets and Lighting Maintenance / Installation	Working directly with asbestos containing materials in Fuseboards	Breathing fibres containing asbestos materials could cause long term health affecting respiratory system	2	2	4	It is not anticipated that any exposure to Asbestos is likely on this job. Avoid contact with asbestos wall sheets.	2	2	4	
Consider the risk of the environmental Impact of the job **(mandatory field)**											
E1	Fuseboard, Cable, Brackets and Lighting Maintenance / Installation	Emission to Land	Uncontrolled disposal of waste materials	4	3	12	Hornbill Technicians to follow site protocol for waste disposal	4	2	8	
Consider the manual handling risks associated with the task **(Mandatory Field)**											
Consider the manual handling risks associated with the task **(Mandatory Field)**											
M1	Fuseboard, Cable, Brackets and Lighting Maintenance / Installation	Load	Muscular Problem, Back Problem	4	5	20	Ensure personnel present have undergone manual handling training and adhere to good manual handling practises/procedures.	4	2	8	
M2	Fuseboard, Cable, Brackets and Lighting Maintenance / Installation	Stretching	Muscular Problem, Back Problem	4	5	20	No over stretching, ensure enough personnel present when installing supply cable.	4	2	8	
M3	Fuseboard, Cable, Brackets and Lighting Maintenance / Installation	Sharp Edges	Cuts to Hands	4	5	20	Ensure all brackets are filed smoothly and gloves worn when installing cable.	4	2	8	
Consider the work at height risks associated with the task **(Mandatory Field)** NB: EMERGENCY ARRANGEMENTS MUST BE IN PLACE BEFOR WORK AT HEIGHT COMENCES											
H1	Fuseboard, Cable, Brackets and Lighting Maintenance / Installation	Falling from height whilst working off a step ladder.	Falling could cause injuries raging from bruising through to broken bones.	16	5	80	Ladder to be checked for defects prior to use and to be footed at all times.	16	2	32	
H2	Fuseboard, Cable, Brackets and Lighting Maintenance / Installation	Falling from height whilst working off a fixed scaffolding.	Falling could cause injuries raging from bruising through to broken bones and or	16	5	80	Check that scaffolding has been scafftagged and that the last inspection is within the due date.	16	2	32	
H3	Fuseboard, Cable, Brackets and Lighting Maintenance / Installation	Falling from height whilst working off a mobile scaffolding.	Falling could cause injuries raging from bruising through to broken bones and or	16	5	80	Ensure scaffolding is bult by PASMA trained operator and has been inspected.	16	2	32	
H4	Fuseboard, Cable, Brackets and Lighting Maintenance / Installation	Falling from height whilst working off a cherry picker	Falling could cause injuries raging from bruising through to broken bones and or death.	16	5	80	Operator to have an up to date MEWP License and to wear a safety Harness at all times whilst in the cherry picker. Safety man to be present at all times.	16	2	32	

Consider the risk of exposure to hazardous substances (mandatory field) - Please inform Safety & Hygiene Coordinator of all tasks with significant hazardous substance risks											
	Electrical Installation Work Cable, Marshalling Boxes, Brackets, Testing.	Exposure to gases	Breathing of gases on site could cause a range of symptoms from mild irritation through to asphyxiation	16	2	32	Atmospheric monitoring is in place in areas of increased risk. All Hornbill staff to wear personal CO monitors on site (TBA at site kick off meeting) and report to Plant team leaders before work commences. Any work which could result in the release of harmfull gases must be controlled by PTW.	16	2	32	
S1	Electrical Installation Work Cable, Marshalling Boxes, Brackets, Testing.	Exposure to chemicals	Can cause issues with skin tissue, from irritations and rashes through to severe burns	16	5	80	All chemicals on site must have the correct COSHH assessment. Substances must be stored in correct labelled containers and kept in the designated location.The correct PPE, as directed by COSHH assessment, must be used when working with any	16	2	32	
	Electrical Installation Work Cable, Marshalling Boxes, Brackets, Testing.	Portable Tools	Misuse of tools could cause broken bones, lacerations, possible electric shock.	4	3	12	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.	4	2	8	
	Electrical Installation Work Cable, Marshalling Boxes, Brackets, Testing.	Electrocution	Termination / Testing of all cables - Electric Shock	16	5	80	All Electrical Contractors have completed relevant apprenticeships. Vale Isolation procedures to be followed when working on circuits with energy potential to cause harm. Isolations to be carried out by Authorised persons deemed competent by Vale Electrical Manager. NO LIVE WORKING IS PERMITTED, without written authorisation from the	16	2	32	
	Electrical Installation Work Cable, Marshalling Boxes, Brackets, Testing.	Hand Tools	Cuts and bruising to hands. Possible broken fingers.	4	5	20	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.	4	2	8	
	Electrical Installation Work Cable, Marshalling Boxes, Brackets, Testing.	Road Traffic	Contact with: Refinery Pedestrians, Other Road Traffic or Bildings/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 Work area to be coned off	8	2	16	
	Electrical Installation Work Cable, Marshalling Boxes, Brackets, Testing.	Obstacles and trip hazards	Falls and impact injuries	4	5	20	SLAM, maintain situational awareness and good housekeeping to be kept at all times	4	2	8	
	Electrical Installation Work Cable, Marshalling Boxes, Brackets, Testing.	Hazardous area working.	Providing energy source which could interact with dangerous substances or explosive atmospheres, causing explosions.	16	5	80	Where applicable all personnel have been COMPEX trained. Area to be gas tested before opening boxes. Tools and equipment to be ATEX rated. All installations are to ATEX standard, have documented Risk Assessments and are	16	2	32	
	Electrical Installation Work Cable, Marshalling Boxes, Brackets, Testing.	Exposure to Dust	Exposure to general dust and/or nickel powder can cause symptoms with respiratory system	8	5	40	In areas of exposure, half face masks to be worn. Installation technicians must be fitted for half face mask by the Occupational Health Department.	8	2	16	
	Electrical Installation Work Cable, Marshalling Boxes, Brackets, Testing.	Noise	Temporary or permenant damage to hearing	8	5	40	Noise surveys regularly conducted. Hearing protection is mandatory in some areas. These areas are clearly marked.	8	2	16	
	Electrical Installation Work Cable, Marshalling Boxes, Brackets, Testing.	Pedestrians passing work area	Items falling on heads	8	5	40	Work area to be coned off	8	2	16	

	Electrical Installation Work Cable, Marshalling Boxes, Brackets, Testing.	Falling objects	Falling object contact with personnel	8	5	40	PPE - Hard Hat Work area to be coned off	8	2	16	
	Electrical Installation Work Cable, Marshalling Boxes, Brackets, Testing.	Extreme temperatures	High temperatures causing severe burns. Extreme low temperatures cause binding of skin to metal or frost burns.	8	5	40	ALL work is to be carried out under a work order with completed safety instruction. Temperatures shall be checked before commencing work. If working with extreme temperatures is unavoidable, a specific risk assessment is required.	8	2	16	
	Electrical Installation Work Cable, Marshalling Boxes, Brackets, Testing.	Exposure to Fire Extinguishing Gases in Switchroom / IA Room	Asphixiation of gas	8	5	40	Isolation of Fire alarm system prior to work starting	8	2	16	
	Working in the production facility	Plant Emergencies	Unaware of Plant Emergency situations and proeedures	8	3	24	Plant Maintenance, Alarm systems, PTW, Induction process and supervision	8	2	16	
	Isolation of Plant equipment	Unintentional Production plant equipment isolation	Loss of production	4	2	8	Co-ordination with production staff	4	2	8	

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.

10.3. Electrical Notification of Work

INCO EUROPE CLYDACH REFINERY	NOTIFICATION OF WORK TO BE UNDERTAKEN BY CONTRACTORS	Ellipse Work Order Number: 201801104025

THIS IS NOT A PERMIT TO WORK

THIS FORM AND ITS ATTACHMENTS MUST BE SUBMITTED TO THE PERSON REQUIRED TO ISSUE THE PERMIT TO WORK OR HIS SUPERVISOR, IN SUFFICIENT TIME TO ALLOW SUITABLE PLANT PREPARATIONS TO BE CARRIED OUT FOR A PERMIT TO WORK TO BE ISSUED.

From: Neil Hopkins	To: PPP Control Room

THIS IS TO CERTIFY THAT THE CONTRACTOR MENTIONED IN SECTION 4 IS AUTHORISED TO ENTER THE REFINERY AND CARRY OUT THE WORK DESCRIBED BELOW UNDER THE TERMS OF THE CONTRACT AND IN COMPLIANCE WITH INCO RULES AND CONDITIONS FOR CONTRACTORS ON HEALTH, SAFETY AND ENVIRONMENT.

1

Name of Contractor: Skelton & Thomas

INCO Person in Charge of Contractors on Site: Neil P Hopkins

Exact Location of Work: Gaseous Treatment Plant

Type and Nature of Work to be Carried Out: Final tie in, Installation and termination of 3 single pair cables from Local Marshalling box to Level transmitter, Pressure Transmitter and Control Valve. Termination of 5 Pair cable from marshalling box to Incinerator IA Cabinet to FBM termination assembly. Details of termination on Loop drawing. Ferrules also to be placed.

Date Work is to Commence: 23/04/18	Estimated Date Work is to Finish:

2

SPECIAL SITE/PLANT CONDITIONS

TOOLS/EQUIPMENT TO BE USED

Hand tools, Step Ladder

MATERIALS TO BE USED

Single pair SWA cable, Containment, Cable glands

ANY OTHER SPECIAL SITE CONDITIONS WILL BE NOTED ON THE PERMIT TO WORK

RAP04A-SF09 - Revision 2

	PRE-JOB SAFETY CHECK LIST FOR CONTRACTORS	Mandatory	Comments
3	A Inco Risk Assessment Attached	Yes	
	B Contractors Work Method Statement attached	Yes	
	C Contractors Risk Assessment attached	Yes	
	D All Contractors have been inducted	Yes	
	E The Contracting Company is approved and on the active compliant Contractor list	Yes	
	F Contractor has read and understood all Risk Assessments and signed off below	Yes	
	G Has a COSHH assessment been carried out and all MSDS sheets attached	Yes	
	H If any MSDS are required, have they been approved by Occupational Health?	Yes	
	I The person accepting for the contractor to ensure that all contracting employees have been briefed on the work to be performed and the requirement of the Risk Assessments	Yes	
	Other		

	CONTRACTOR EMPLOYEES COVERED BY THIS NOTIFICATION			
	NAME	INDUCTION NO.	NAME	INDUCTION NO.
4				
5	NOTES: UNDER NO CIRCUMSTANCES MUST WORK COMMENCE UNTIL THE RELEVANT WORK PERMIT HAS BEEN OBTAINED AND SIGNED FROM THE ISSUING AUTHORITY IN WHOSE AREA THE WORK IS TO BE CARRIED OUT.			
	COMPLETION: ON COMPLETION THE CONTRACTOR IS TO HAND THIS NOTE TO THE JOB ENGINEER/SUPERVISOR, WHO WILL THEN SATISFY HIMSELF THAT THE WORK HAS BEEN COMPLETED IN A SATISFACTORY AND SAFE MANNER, AND THE SITE LEFT SAFE AND CLEAR OF DEBRIS OR OTHER MATERIALS.			
6	DECLARATION: SECTIONS 1 TO 5 SUMMARISES WORK TO BE DONE, NOTES AND SPECIAL CONDITIONS AND CONFIRMS SAFETY CHECK LIST AGREED WITH CONTRACTOR.			
	FOR INCO		FOR CONTRACTOR	
	PRINT NAME: NP HOPKINS SIGNED FOR INCO: Date: Time: 08:00hrs		PRINT NAME: SIGNED FOR CONTRACTOR: Date: Time:	

10.4 Electrical Scope of Work

Incinerator Lute Pot Level automation

Work would involve the automation of the Incinerator lute pot level system presently in operation at the base of the refinery stack.

Electrical and Instrument Installation

Containment

Unistrut containment to be installed at high level from the existing ladder racking located adjacent to the Pellet Plant Roller Shutter door to existing high level structural steel work situated above the lute pot. Cable to come down girder via Girder clips 1-2metres, uni strut to be fixed horizontally between steel girders using window brackets in level with the existing tray work above Lute Pot.

Heavy duty 100mm galvanised steel tray work to be installed from the high level structural steel work down to a local marshalling box situated adjacent to the Lute pot. Marshalling Box to be s/steel 300mm x 200mm with internal trunking and SAK terminals

Uni strut brackets to be made for single pair cables to reach level transmitter, Level control valve and Pressure Transmitter from Marshalling Box

Cable Installation

Following cables to be installed in order to complete the installation on new and existing containment. Each cable to be clipped along its entire length at both ends and tested.

- Five pair 0.75mm BS5308 XLPESWA/PVC Cable from DCS system cabinet 0191-PO1A Located in the Incinerator control room to a local marshalling box adjacent to the Lute pot.
- Single pair 0.75mm BS5308XLPESWA/PVC Cable from Marshalling box to Vega Probe through unistrut bracket.
- Single Pair 0.75mm BS5308XLPESWA/PVC Cable from Marshalling box to Control valve through unistrut brackets
- Single Pair 0.75mm BS5308XLPESWA/PVC Cable from Marshalling Box to Pressure Transmitter Located on landing of stairwell on girder, through unistrut brackets.
- HAWKE 501/453 Universal Glands to be used

Instrumentation

Vega Level transmitter – Free Issue (From Vale)

Control Valve – Free issue (From Vale)

Foxboro Pressure Transmitter - Free Issue (From Vale)

10.5. Mechanical Risk Assessment

Clydach Refinery Occupational Risk Assessment Record Form

VALE — SAFE PRODUCTION ZERO HARM — RAP06/ WI01/SF04 (v4) Nov 2015

Department / Location:	ENGINEERING/PGP		
Description of Subject / job / task to be assessed:	Waste Gas Lute Pot Mechanical Modification		
Reference No:	RA201801104025	**Work Order No:**	201801104025
Version No:	1	**Task No:**	
Date of this assessment:	17/04/2018	**ORA Team Leader:**	NH
Next scheduled review:	16/04/2021	**Approved By:**	NH

ORA Team Members: NH, JD

Likelihood / Impact Severity		Rare 2	Unlikely 3	Occasional 5	Likely 9	Frequent 13	Risk Levels
Catastrophic (E)	32	64	96	[illegible]	[illegible]	[illegible]	>=140
Critical (D)	16	32	48	80	[illegible]	[illegible]	
Severe (C)	8	16	24	40	72	104	70 - 140
Moderate (B)	4	8	12	20	36	52	25 – 70
Minor (A)	2	4	6	10	18	26	<25

No:	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
	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 if there is a risk of exposure to asbestos (mandatory field)											
LINK TO ASBESTOS REGISTERS											
A1	N/A	choose from list				0				0	
A2	N/A	choose from list				0				0	
Consider the risk of the environmental Impact of the job (mandatory field)											
E1	Contaminated Process Liquid Spill	Emission to Land	Uncontrolled spillage of process liquid	4	13	52	Spill kits present on site. Isolations valves to be closed preventing process medium spills. All drainage lead to Effluent plant for filtration before output to River Tawe	8	2	16	
	Modification of Instrument air pipework & Removal of redundant pipework	Emission to Land	Uncontrolled disposal of waste materials	4	3	12	Contractors to adhere Vales' waste disposal protocol and use segregation bins provided	4	2	6	
E2	Exposure to RWG gas	Emission to Air	Opening Lute vessel when removing level indication	4	13	52	Isolation valves of level indication to be closed preventing process medium leaking to atmosphere. Gas Testing to be carried out before and during	4	2	8	
Consider the manual handling risks associated with the task (Mandatory Field)											
M1	Lifting and fitting Bypass vessel & Valve in Situ	Body position	Muscular strain	8	3	24	Adopt correct manual handling procedures, Utilize lifting equipment for heavy loads	8	2	16	
M2	N/A	Choose from list				0				0	
Consider the work at height risks associated with the task (Mandatory Field) NB: EMERGENCY ARRANGEMENTS MUST BE IN PLACE BEFORE WORK AT HEIGHT COMENCES											
H1	Modification of Instrument air pipework & Removal of redundant pipework	Fall from Height	Not working within the confines of Mewp. Mewp out of compliance. Non licensed contractor operating Mewp	8	9	72	Always work within the confines of the Mewp. Ensure Mewp is operated by competent personel. Ensure that Mewp is in compliance	8	2	16	
H2	Modification of Instrument air pipework & Removal of redundant pipework	Hit by falling object	People working below or above another person in the same area. Incorrect use of hand tools. Due care and attention.	4	3	12	Ensure nobody is working directly below or above when working at heights.	4	2	8	

Consider the risk of exposure to hazardous substances (mandatory field) - Please inform Safety & Hygiene Coordinator of all tasks with significant hazardous substance risks.											
S1	Lifting and fitting Bypass vessel & Valve in Situ	Inhalation of process Gases	The contractor could be exposed to process gasses if there is a leak in the area	4	5	20	Area to be gas tested by VALE personnel and certified clear before work ommences. Correct P.P.E and personal monitors to be worn. Awareness that the Lute Pot remains in operation otherside of isolated valves	4	2	8	
	Lifting and fitting Bypass vessel & Valve in Situ	Cutting and/or severing	Incorrect working practices	4	3	12	Correct P.P.E to be worn. Due care and attention.	4	2	8	
	Lifting and fitting Bypass vessel & Valve in Situ	Slips, Trips,striking against & falls	Falling from a height, injury from striking and trip	4	5	20	Site specific induction. Trained and experienced personnel. Caution & Awareness. SLAM procedure to be carried out by contractor.	4	2	8	
	Lifting and fitting Bypass vessel & Valve in Situ	Power tools	Incorrect use. Electric shock or cuts.	8	3	24	Use 110v PAT tested power tools only.	4	2	8	
	Lifting and fitting Bypass vessel & Valve in Situ	Vehicles	Due care and attention. Vehicle contact with personell	4	2	8	Always be aware of vehicles in plant and on refinery roads. (Mewp / Forklift trucks / Traffic)	4		0	
	Lifting and fitting Bypass vessel & Valve in Situ	Noise and vibration	Incorrect use PPE. Hearing Damage	4	2	8	Ear Defenders must be worn on plant.	4	2	8	
	Lifting and fitting Bypass vessel & Valve in Situ	Welding	Incorrect working practices, Injury, burns, fumes	8	3	24	Evaluate welding equipment are is for use prior to commencing work. Ensure adequate ventilation of work area. Wear correct PPE	8	2	16	
	Lifting and fitting Bypass vessel & Valve in Situ	Welding	Welding near RWG Line (Contains Hydrogen)	16	5	80	Hot work permit and gas test prior and during work	16	2	32	
	Instrument Air Supply	Pressurised Air	80PSI mains instrument air leaking into work space, contact with skin	4	13	52	Main Isolation valve to be closed prior to disconnecting pipework	4	2	8	
						0				0	
						0				0	

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.

10.7. Mechanical Notification of Work

INCO EUROPE CLYDACH REFINERY	NOTIFICATION OF WORK TO BE UNDERTAKEN BY CONTRACTORS	Ellipse Work Order Number: 201801104025

THIS IS NOT A PERMIT TO WORK

THIS FORM AND ITS ATTACHMENTS MUST BE SUBMITTED TO THE PERSON REQUIRED TO ISSUE THE PERMIT TO WORK OR HIS SUPERVISOR, IN SUFFICIENT TIME TO ALLOW SUITABLE PLANT PREPARATIONS TO BE CARRIED OUT FOR A PERMIT TO WORK TO BE ISSUED.

From: Neil Hopkins	To: PPP Control Room

THIS IS TO CERTIFY THAT THE CONTRACTOR MENTIONED IN SECTION 4 IS AUTHORISED TO ENTER THE REFINERY AND CARRY OUT THE WORK DESCRIBED BELOW UNDER THE TERMS OF THE CONTRACT AND IN COMPLIANCE WITH INCO RULES AND CONDITIONS FOR CONTRACTORS ON HEALTH, SAFETY AND ENVIRONMENT.

1	Name of Contractor: Skelton & Thomas INCO Person in Charge of Contractors on Site: Neil P Hopkins	
	Exact Location of Work: Gaseous Treatment Plant	
	Type and Nature of Work to be Carried Out: Installation of Bypass chamber to Lute Pot & Control valve to existing Canal water inlet pipework of Lute pot. Modification and removal of Instrument air supply pipework with aid of Mewp.Welding of Instrument mount to girder on landing of stairwell by Lute pot.	
	Date Work is to Commence:	Estimated Date Work is to Finish:
2	SPECIAL SITE/PLANT CONDITIONS	
	TOOLS/EQUIPMENT TO BE USED	
	Mewp, Hand tools, Welding Equipment	
	MATERIALS TO BE USED	
	ANY OTHER SPECIAL SITE CONDITIONS WILL BE NOTED ON THE PERMIT TO WORK	

	PRE-JOB SAFETY CHECK LIST FOR CONTRACTORS	Mandatory	Comments
3	A Inco Risk Assessment Attached	Yes	
	B Contractors Work Method Statement attached	Yes	
	C Contractors Risk Assessment attached	Yes	
	D All Contractors have been inducted	Yes	
	E The Contracting Company is approved and on the active compliant Contractor list	Yes	
	F Contractor has read and understood all Risk Assessments and signed off below	Yes	
	G Has a COSHH assessment been carried out and all MSDS sheets attached	Yes	
	H If any MSDS are required, have they been approved by Occupational Health?	Yes	
	I The person accepting for the contractor to ensure that all contracting employees have been briefed on the work to be performed and the requirement of the Risk Assessments	Yes	
	Other		

	CONTRACTOR EMPLOYEES COVERED BY THIS NOTIFICATION			
4	NAME	INDUCTION NO.	NAME	INDUCTION NO.

5	NOTES: UNDER NO CIRCUMSTANCES MUST WORK COMMENCE UNTIL THE RELEVANT WORK PERMIT HAS BEEN OBTAINED AND SIGNED FROM THE ISSUING AUTHORITY IN WHOSE AREA THE WORK IS TO BE CARRIED OUT.	
	COMPLETION: ON COMPLETION THE CONTRACTOR IS TO HAND THIS NOTE TO THE JOB ENGINEER/SUPERVISOR, WHO WILL THEN SATISFY HIMSELF THAT THE WORK HAS BEEN COMPLETED IN A SATISFACTORY AND SAFE MANNER, AND THE SITE LEFT SAFE AND CLEAR OF DEBRIS OR OTHER MATERIALS.	
6	DECLARATION: SECTIONS 1 TO 5 SUMMARISES WORK TO BE DONE, NOTES AND SPECIAL CONDITIONS AND CONFIRMS SAFETY CHECK LIST AGREED WITH CONTRACTOR.	
	FOR INCO	FOR CONTRACTOR
	PRINT NAME: NP HOPKINS	PRINT NAME:
	SIGNED FOR INCO:	SIGNED FOR CONTRACTOR:
	Date: Time: 08:00hrs	Date: Time:

10.8. Calibration Certificates of Instruments

VALE INCO

CLYDACH NICKEL REFINERY

SF07A/02	Page 1 of 2	Issue Status :- 2
Title :-Calibration Certificate		Date :- January 2009

Job Card No. 201801104025	Location No. Pellet Plant	Reference No. 200-18-158

Loop / Instrument No: V6 LT286

Type: Level Measurement — Service: Lute Pot Level

Manufacturer: Vega — Serial No: 39288432

Model No: Vega Flex 81

Initial Calibration Check	Measurement	Instrument Input	Instrument Output	% Error	Panel/Screen Reading	% Error
		0%	4.05 mA		0.33%	
		50%	12.02 mA		50.06%	
		100%	20.0 mA		100.03%	
	Control	Controller Output	Transducer Output	% Error	Control Valve Position	% Error
Final Calibration Check	Measurement	Instrument Input	Instrument Output	% Error	Panel/Screen Reading	% Error
	Control	Controller Output	Transducer Output	% Error	Control Valve Position	% Error

List of Calibration Equipment:

Netbook 1

Remarks:

Vega calibration accurate to configuration

Calibration Checked by: J.M.Davies — Date: 18-04-2018

Form Approval: *M.J. Desmond.* January 2009 — Form updated:

VALE INCO

CLYDACH NICKEL REFINERY

SF07A/02	Page 1 of 1	Issue Status :- 2
Title :-Calibration Certificate		Date :- January 2009

Job Card No. 201801104025	Location No. H2 Plant	Reference No. 200-18-157

Loop / Inst No: V6 LCV286						
Type: Level Control Valve					Service: Lute Pot Level	
Manufacturer: Fisher					Serial No: F001771171	
Model No: Fisher GX						
Initial Calibration	Measurem	Instrument Input	Instrument Output	% Error	Panel/Screen Reading	% Error
	Control	Controller Output	Transducer Output	% Error	Control Valve Position	% Error
		0%	4 mA		Closed	
		50%	12 mA		50%	
		100%	20 mA		Open	
Final Calibration Check	Measurem	Instrument Input	Instrument Output	% Error	Panel/Screen Reading	% Error
	Control	Controller Output	Transducer Output	% Error	Control Valve Position	% Error

Calibration Equipment:

Fluke Loop Injector – E2C0080

Remarks:

Valve stroke checked ok. mA input accurate with travel indication.

Calibration Checked by: J.M.Davies	Date:18-04-2018

Form Approval: *M.J. Desmond.* Form updated:

Styles

VALE INCO

CLYDACH NICKEL REFINERY

SF07A/02	Page 1 of 2	Issue Status :- 2
Title :-Calibration Certificate		Date :- January 2009

Job Card No. 201801104025	Location No. PELLET PLANT	Reference No. 200-18-159

Loop / Instrument No: V6 PT287						
Type: Differential Pressure					Service: Waste Gas Pressure	
Manufacturer: Foxboro					Serial No:18051053	
Model No: IDP10S-122B25AP-M1L1						
Initial Calibration Check	Measurement	Instrument Input	Instrument Output	% Error	Panel/Screen Reading	% Error
		0"Wg			0"Wg	
		25" Wg			25.0"Wg	
		50" Wg			49.99" Wg	
	Control	Controller Output	Transducer Output	% Error	Control Valve Position	% Error
Final Calibration Check	Measurement	Instrument Input	Instrument Output	% Error	Panel/Screen Reading	% Error
	Control	Controller Output	Transducer Output	% Error	Control Valve Position	% Error

List of Calibration Equipment:

Comark Digital Pressure Gauge – E2C0057

Remarks:

Pressure transmitter calibration accuarate.

Calibration Checked by: J.M.Davies	Date: 18-04-2018

Form Approval: M.J. Desmond. Form updated:
January 2009

10.3. HAZOP Study 2015-002

INCO CLYDACH REFINERY

PPP Plant Hazop

HAZOP NO. 2015-002

15th April 2015, RCM Room Engineering

Present:

Damien Bousher
Matthew Francis
Dai Amour
Steve Notzing

Overview
A proposal has been suggested to automatically control the water level in the RWG main lute pot and thereby the RWG pressure which will improve pressure stability and incinerator performance.
The Hazop node: from (and including) the inlet pressure transmitter and to include the lute pot and all associated pipework and valves (see diagram of the system).

INCO EUROPE LTD. CLYDACH NICKEL REFINERY Standard form

RAP06/WI02/SF02	Page 3 of 10	Issue Status :- 1	Hazop No. 2015-002
Title :-HAZARD AND OPERATIONAL STUDY (HAZOP)		Date :- 15/4/15	

Equipment/Procedure: Associated Docs. (Rev.) :			Drawing Number :		
Guide Word	**Deviation**	**Causes**	**Consequences**	**Protection**	**Actions**
FLOW	No	Inlet water manual valve shut	Lute pot water level will drop.	Operator checks. RWG pressure indication on I/A.	DB: install low pressure or low level alarm on lute pot.
		Inlet water control valve fails shut.	Lute pot water level will drop.	Operator checks. RWG pressure indication on I/A. Bypass pipework around control valve.	DB: install low pressure or low level alarm on lute pot.
		Water inlet pipe blockage	Lute pot water level will drop.	Operator checks. RWG pressure indication on I/A.	DB: install low pressure or low level alarm on lute pot.
		Outlet manual valve shut	Lute pot water level will increase.	Operator checks. High pressure alarm P280 visible on I/A in kiln and PPP. Overflow fitted to lute pot	
		Outlet water control valve fails shut.	Lute pot water level will increase.	Operator checks. High pressure alarm P280 visible on I/A in kiln and PPP. Bypass pipework around control valve. Overflow fitted to lute pot	

Equipment/Procedure: Associated Docs. (Rev.) :			Drawing Number :		
Guide Word	**Deviation**	**Causes**	**Consequences**	**Protection**	**Actions**
		Water outlet pipe blockage	Lute pot water level will increase.	Operator checks. High pressure alarm P280 visible on I/A in kiln and PPP. Overflow fitted to lute pot	
	More	Inlet control valve fails open	Lute pot water level will increase.	Operator checks. High pressure alarm P280 visible on I/A in kiln and PPP. Bypass pipework around control valve. Overflow fitted to lute pot	
		Outlet control valve fails open.	Lute pot water level will drop.	Operator checks. RWG pressure indication on I/A. Bypass pipework around control valve.	
		Inlet bypass valve left open	Lute pot water level will increase.	Operator checks. High pressure alarm P280 visible on I/A in kiln and PPP. Bypass pipework around control valve. Overflow fitted to lute pot	
		Outlet bypass valve left open	Lute pot water level will drop.	Operator checks. RWG pressure indication on I/A. Bypass pipework around control valve.	

Equipment/Procedure: Associated Docs. (Rev.) :			Drawing Number :		
Guide Word	**Deviation**	**Causes**	**Consequences**	**Protection**	**Actions**
	Less	Same principle as no flow, see above.			
	Reverse flow	Not considered possible.			
	Other				
TEMP	Higher	High ambient temperature.	None forseen		
	Lower	Below zero ambient in winter.	Frozen pipework	Steam tracing and lagging on inlet/outlet lines and lute pot.	
PRESSURE	Higher	Not considered an issue			
	Lower	Pipe leaking	Possible reduction in flow to lute pot and Lute pot water level will drop. (depending on leak size).	Operator checks. RWG pressure indication on I/A.	
LEVEL	Higher	See "more flow"	Lute pot water level will increase.	Operator checks. High pressure alarm P280 visible on I/A in kiln and PPP. Overflow fitted to lute pot	

Equipment/Procedure: Associated Docs. (Rev.) :			Drawing Number :		
Guide Word	**Deviation**	**Causes**	**Consequences**	**Protection**	**Actions**
	Lower	See "low / no flow"	Lute pot water level will drop.	Operator checks. RWG pressure indication on I/A.	
Composition	Change	Not expected and no different from current situation.			
Phase	Change	Water freezing in pipes, see "lower temp"			
Operation	Sooner	Sticky automatic valves	Other automatic valve would adjust to compensate.	By pass lines enable isolation / cleaning of automatic valves.	
	Later	Same as above.			
Loss of containment	Loss of pipe integrity.	Pipe / lute pot failure / rupture	Same as low / no flow	Same as low / no flow. Stainless steel lute pot making it less likely to fail due to corrosion.	
Static	N/A				

Equipment/Procedure: Associated Docs. (Rev.) :			Drawing Number :		
Guide Word	**Deviation**	**Causes**	**Consequences**	**Protection**	**Actions**
Loss of Utilities (purge gas, instrument air, blowout suction)	Canal water	Canal water failure	Same as "no flow"	Multiple alarms round the plant to indicate interruption to water flows.	
	Instrument air	Loss of instrument air	Automatic valves fail shut. Lute pot level would eventually drop.	Low pressure alarm on lute pot. Instrument air alarms at PGP.	
	Electricity	Loss of electricity	Automatic valves fail shut. Lute pot level would eventually drop.	Indication in I/A is backed up by UPS.	
Contamination	N/A				
Relief	N/A				
Human factors	N/A				
Operability	N/A				
Ignition	No different from normal operation.				

final draft major report

GRADEMARK REPORT

FINAL GRADE

70/100

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

Text Comment. repetition

PAGE 3

Text Comment. Good

PAGE 4

Text Comment. Well structured

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

Text Comment. Clear statements of objectives

PAGE 11

QM

Punctuation Error

Punctuation error

QM

Punctuation Error

Punctuation error

QM

Citation Needed

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

PAGE 12

Text Comment. you should always refer to and explain your figures in the text of the report

PAGE 13

PAGE 14

PAGE 15

Text Comment. This section does set the project in context. However, it should contain citations

PAGE 16

QM

Spelling

Spelling error

QM

Punctuation Error

Punctuation error

QM

Punctuation Error

Punctuation error

PAGE 17

QM

Punctuation Error

Punctuation error

PAGE 18

QM

Punctuation Error

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Punctuation error

PAGE 19

QM

Spelling

Spelling error

PAGE 20

PAGE 21

QM

Spelling

Spelling error

PAGE 22

QM

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QM

Punctuation Error

Punctuation error

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PAGE 25

PAGE 26

QM

Spelling

Spelling error

PAGE 27

PAGE 28

Text Comment. This is a detailed section that puts the project in context but it is very involved and by the end of reading it, it is easy to forget the purpose of it.

Text Comment. A clear statement of what you intend to deliver and therefore research for solutions could have been stated here.

PAGE 29

Text Comment. A P & I Diagram would have been helpful

Text Comment. You could have focused more on the valve and sensor types particularly knowing that the controller type was fixed by plant standard.

PAGE 30

PAGE 31

PAGE 32

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PAGE 34

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PAGE 37

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PAGE 39

Text Comment. Not very accurate

PAGE 40

PAGE 41

PAGE 42

QM

Spelling

Spelling error

PAGE 43

QM

Spelling

Spelling error

PAGE 44

PAGE 45

Text Comment. Integrity

Text Comment. You could have provided a P & I diagram

PAGE 46

PAGE 47

QM

Punctuation Error

Punctuation error

QM

Punctuation Error

Punctuation error

PAGE 48

PAGE 49

PAGE 50

PAGE 51

Text Comment. This is a helpful diagram

Text Comment. This could have been part of your literature review

Text Comment. You could have explained the other tow first before showing that linear is the best method

PAGE 52

PAGE 53

PAGE 54

PAGE 55

PAGE 56

QM

Spelling

Spelling error

PAGE 57

PAGE 58

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PAGE 60

QM

Punctuation Error

Punctuation error

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QM

Spelling

Spelling error

PAGE 100

PAGE 101

Text Comment. You could have considered Tony Ennis' paper (2006) available on line about using lute pots to control pressure

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PAGE 123

GRADING FORM: MAJOR PROJECT 2017_18

JOSHUA DAVIES **69.80**

RESEARCH (20%)

Research Informed Literature: 1. Abstract, acknowledgements, introduction and setting out of aims and objectives. (/20) 2. Background research, setting the context of the project, statement of user or customer needs. (/30) 3. Literature review, solutions considered and choice made. (/40) 4. Use of Harvard Referencing for citing and listing sources. (/10)

13.8

1. A good abstract and acknowledgement section. Introduction provides a clear set of objectives to meet the overall aim. However, there could be citations added to this section. (16) 2. Good evidence of reading setting the project in context and clearly stating customer needs. Good graphical evidence provided showing the current status. However, this section is very long and drawn out and could be said more succinctly. More than enough evidence has been provided to justify the project. (22) 3. Three solutions considered and compared and choice made based on a range of factors, including cost, with evidence of background reading to support some of the reasoning. However, the main thrust of the review is around the controller where it would have been beneficial to have reviewed, with more details, the valves and sensors available seeing that they form the main part of the project. (23) 4. A large range of sources

have been cited and listed correctly. (8)

KNOWLEDGE (20%)

Knowledge & Understanding of Subject: 1. Specification, design requirements and project outcomes, time and financial constraints. (/30) 2. Test planning and procedures. (/20) 3. Formal project planning and identification of milestones. (/25) 4. Consideration of maintenance and reliability. (/25)

1. A good general specification is stated with technical and performance specifications, and budget constraints. Detailed design noted. (19) 2. Two good testing tables have been included for functional and commissioning tests. (12) 3. Gantt shows planned and actual actions but no milestones identified. However, good work break-down structure shows the stages in the development of the project. (13) 4. Good consideration given to both in accordance with company standards. (15)

11.8

ANALYSIS (20%)

Analysis: 1. Evaluation of Implementation stage, monitoring of progress and milestone activities. (/20) 2. Testing & test results. (/30) 3. Comparison of project outcomes to specification. (/20) 4. Conclusions, recommendations and reflections. (/30)

1. Good evidence provided. However, more details could have been given of milestones and when they were achieved in relation to the plan together with progress monitoring. (11) 2. Very good evidence of functional and onsite testing. It is a shame that the loop could not be closed and tuned but this is

14

understandable. (25) 3. A good section showing that the specification has been reviewed and outcomes explained. However, it would have been helpful if you had used the specification items by number and explained how each had been met. (15) 4. Very good with useful recommendations and a reflection. (19)

PRACTICAL APPLICATION (20%)

Practical Application & Deployment: 1. Quality, innovation and creativity of design solution. (/20) 2. Implementation stage, working independently with limited supervision. (/30) 3. Meeting customer or user needs, fitness of solution to purpose, working within time and financial constraints. (/20) 4. Log book. (/30)



1. Very good choice of components and design work which involved electrical and mechanical aspects together with software configuration and screen designs. (17) 2. The project has been well executed with little assistance from the college supervisors and assistance from Vale and contractors have been acknowledged working within the company's standard practice. (22) 3. Customer needs have been almost fully met with tuning left to do. Solution is clearly fit for purpose but its long term performance can only be proved after the loop is closed. Project has met the financial requirements but time has overrun. (15) 4. Very good detail showing the development of the project(21)

15

PROFESSIONAL PRACTICE (20%)

Skills for Professional Pracice: 1. Professionalism and ethical conduct.

(/25) 2. Health and safety, assessment of risk. (/25) 3. Sustainability and environmental protection.. (/25) 4. Presentation and organisational quality of report. (/25)

1. Project has been executed to company standards and procedures as noted in Section 4. (20) 2. A detailed standard risk assessment is included with a subsection given to safety. (19) 3. Good consideration given in the report in Section 4. (18) 4. Report is well structured and presented. However, there are several spelling, punctuation and grammatical errors.(19)

15.2