

1910593

by Evan Thomas

A WELL PLANNED AND WELL MANAGED PROJECT.
REPORT READS WELL AND WAS PRESENTED CLEARLY
WITH DIAGRAMS APPROPRIATELY AIDING READABILITY.

EXTENSIVE FEEDBACK GIVEN.

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Summary

This project will be carried out at a Welsh Water pumping station where upgrades need to be carried out so that a service reservoir (SRV) can be drained and cleaned. This will be done by bypassing the SRV and changing the control from level to delivery pressure. This project will research into the best way of controlling the delivery pressure on this site. Research will be carried out into different solutions which will look at the positives and negatives of each, after this research one solution will be chosen to carry out the task. The project will be created and monitored where improvements will be made. After the completion of the project, it will be tested to prove that it functions properly and to make sure it fulfils the brief. A logbook will be kept throughout this assignment where evidence will be taken and information on what research has been carried out.

A good summary

Acknowledgements

Thank you to the ATC department of Welsh Water and especially to Richard Clement who guided and helped with the creation of this project. Thank you to Coleg Sir Gar for using the facilities and especially to Robert Jenkins who gave advice on the best steps to take to complete this project.

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*A good
breakdown
of elements
in the table
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*Good use of
tables*

1.Introduction

Dwr Cymru Welsh Water (DCWW)

This project will take place at Penybanc WPS (Water Pumping Station) which is a Welsh Water owned pumping station. Welsh Water is a not-for-profit company which supplies wastewater services and drinking water services to most of Wales and western parts of England. Welsh Water are responsible for 26,500km of water mains and 30,000km of sewers and they produce around 828 million litres of water a day. Welsh water is the 4th largest company in Wales with around 3000 employees. (Cymru, 2020)



Figure 1 Welsh Water logo (Cymru, 2020)

Most large companies which supply goods are regulated by a certain group. Welsh Water are regulated by OfWat who regulate water companies in Wales and England where they issue these companies with targets, limits, and rules which they must follow. If companies have any non-compliances, then they could be issued with fines and ordered to make improvements. (Ofwat, 2020)

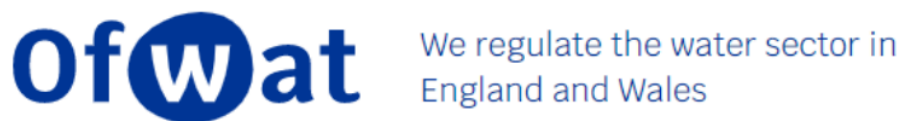


Figure 2 OfWat logo (Ofwat, 2020)

Good informative introduction

The Problem

The problem that needs to be solved is that Troedyrhiw service reservoir needs cleaning which means it needs to be emptied and put out of service which will result in many customers losing their water supplies and resulting in Welsh Water receiving fines. Also, if the service reservoir is not cleaned and maintained then water quality failures could occur which again could result in fines being issued. As you can see from figure 3 Troedyrhiw is supplied by Penybanc WPS and the plan is to bypass the reservoir and have the pumps maintain the pressure in the pipes to keep the customers with water.

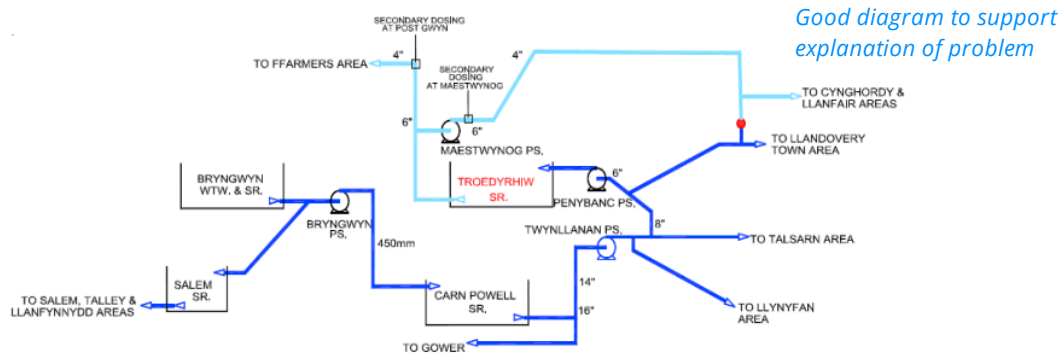


Figure 3 Water Network Diagram

Currently Penybanc WPS is controlled via the level of Troedyrhiw SR so when the level drops to 70% the pumps start and when it reaches 85% the pump stops. The WPS already has variable speed drives installed and this was done so at start up the pumps would slowly increase the pressure so that there is not a sudden spike in pressure which could result in pipe bursts. Using variable speed drives to control the pressure in the pipes can significantly reduce the power consumption of the pumps as the pumps will only run when needed and reduce the amount of hydraulic energy produced. (Csanyi, 2015)

Good explanation and ref source



Figure 4 Penybanc WPS

2. Specification

The main target for this project is to maintain the water supply to Welsh Water customers during urgent maintenance is done on the service reservoir which is currently supplying them. The water pressure also needs to be maintained as many domestic appliances do not work unless they have 1 bar of pressure, also the new solution should not affect the quality of the water supplied.

As this is a temporary solution Welsh Water do not want to spend too much money on the project but as the reservoir needs to be bypassed every year for a couple of days it would be beneficial to have a permanent modification which is easy to change. The Gantt chart in table 1 shows the time scale for this project where it will display several steps within the design and making of this project.

When designing and building anything for the water production side of Welsh Water it is important that the improvements do not affect the water quality. Regulation 31 of the water supply (Water quality) regulation 2016 states that all chemicals and construction products used by water companies, from the source of the water to the point of delivery (customers supply) should not prejudice water quality and consumer safety. (DWI, 2021)

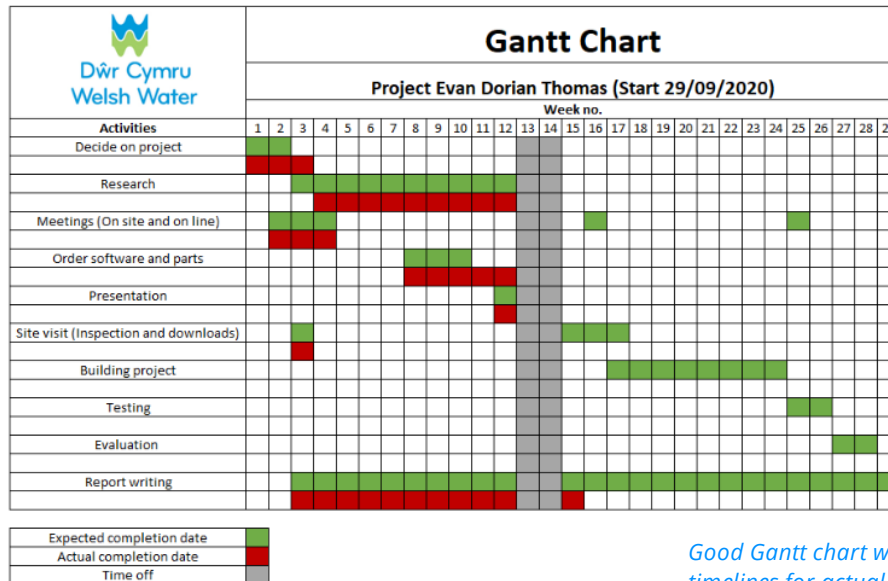
For this project they have asked for the controlling of the new system to be as user friendly as possible which will reduce the amount of training for the people who operate this site and there will be less disruption when there is a change in staff. The aim is to be able to make the change with a push of a button.

*Specification gives a good
overview of what is required.
There should be a detailed
account of what system is*

*going to be used and its
requirements.*

3. Planning

To ensure that this project will be completed a gantt chart was produced. The gantt chart shows all the activities that need to be completed and what time has been allocated to that specific activity.



Good Gantt chart with comparison of timelines for actual and predicted times

Table 1 Gantt chart

To keep track of what activities that have been completed the 'actual completion date' will be continually updated and highlighted red to indicate that it has been done. Once a solution for this project has been decided a test procedure will be written to ensure that all aspects of the new system will work. To test the new system the following sequence will be followed –

Test	Expected result
Download new programme	System should run as normal with no issue
Switch system from level control to pressure control	Pump should ramp up or down to match the selected pressure setpoint
Leave system running for 10mins	Outlet pressure should be stable at selected setpoint
Open a flushing valve located after pumping station which will result in the pressure dropping	If the pressure drops then the speed of the pump should increase so that the setpoint is reached again
Shut flushing valve	As the pressure will rise the pump speed should reduce

Table 2 Testing procedure for new system.

4. Solutions considered

For any project it is important to investigate more than one solution so that the best solution can be selected, and possible changes made if new ideas from other solutions will appear. For this project three solutions will be researched to find the best suited solution for this problem.

Solution 1

The first idea is to use a pressure transducer which is connect to a variable speed drive. The pressure transducer will send a 4-20mA signal to the variable speed drive which will increase and decrease dependant on the outlet pressure of the water pumping station. With the advances with variable speed drives the control options they now have means that they can be used in many applications. Here are the positives and negatives for this solution-

Positives

- No software needed so less training is needed.
- Can visually see where the system has stopped working (relay not switching when power is applied).

Negatives

- Hard to fault find due to the large number of relays and timers.
- Harder to design a duty standby system using relays.
- Will need a large amount of space in the MCC for all the components.
- Relays tend to fail due to the constant switching.
- No visual aid for the Network inspectors (No HMI).



Figure 5 ABB VSD (ABB, 2021)

The cost for installing this system would be £4936.54. For industry, this cost is not too high when considering that these pumping stations cost thousands or possibly millions of pounds to build. The fact that this solution does not need software is true, but ABB drives do have programmes which allow you to monitor and set up VSD drives which is a useful tool.

Solution 2

Solution 2 will again use a VSD but this time a PLC will be used to control the system. Here are the positives and negatives for using a PLC-

Positives

- Easy to fault find if you are trained to use the software.
- Less space required in the MCC.
- Longer life span.
- Easy to modify the programme.
- HMI will be able to display a large amount of information

to the user.



Figure 6 Mitsi PLC (trade, 2021)

Negatives

- Only employees who are trained to use PLC's can programme and fault find.
- PLC and software can be expensive.

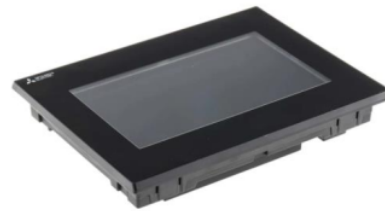


Figure 7 Mitsi GOT HMI (Electric, 2021)

The cost for installing this solution would be around £5864.88 which is more than the first solution but because the relays used in PLC are solid state relays, they have a longer life span compared to mechanical switching relays (Realpars, 2021). Because of this in the long run the cost will be less, and the amount of breakdowns should be less meaning that the system will be more reliable. By using a PLC the programme the functions available will be more complex compared to using relays and timers. For example, on most of Welsh Water pumping stations they are setup so that if the pump runs at a high speed for a long period of time this will trigger a burst protection fault as it would be out of its normal running conditions which will then alert the Network inspector to come out and investigate.

*Good
explan
ation
with
suppor
ting ref
source*

Solution 3

The 3rd solution is to use an Arduino system which is an open-source electronics platform based on easy-to-use software and hardware. Arduino systems can read inputs and using the programme will generate the desired output. Due to its simple and accessible programme this system is widely used in a wide range of applications (Arduino, 2020). The positives and negatives of this system are-

Positives

- Inexpensive.
- Clear and simple programming.
- Large following.

Negatives

- Small system which is hard to work on.
- Not used on any of Welsh Water sites.
- Not an approved way of control within Welsh Water.
- Could struggle to work on a system which has many inputs/outputs.

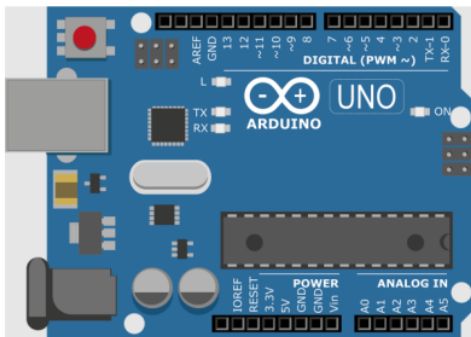


Figure 9 Arduino controller (Differencebetween, 2020)

```
1  #include <LiquidCrystal.h>
2  LiquidCrystal lcd(13, 12, 11, 10, 9, 8);
3
4  //pin 1 in  LCD 1 >>>>>>>>>> ground
5  //pin 2 in  LCD 2 >>>>>>>>>> vcc
6  //pin 3 in  LCD 3 >>>>>>>>>> ground
7  //pin 4 in  LCD 4 >>>>>>>>>> 13
8  //pin 5 in  LCD 5>>>>>>>>>> ground
9  //pin 6 in  LCD 6 >>>>>>>>>> 12
10 //pin 7 in  LCD 7 >>>>>>>>>> NO
11 //pin 8 in  LCD 8 >>>>>>>>>> NO
12 //pin 9 in  LCD 9 >>>>>>>>>> NO
13 //pin 10 in LCD 10 >>>>>>>>>> NO
14 //pin 11 in LCD 11 >>>>>>>>>> 11
15 //pin 12 in LCD 12 >>>>>>>>>> 10
16 //pin 13 in LCD 13 >>>>>>>>>> 9
17 //pin 14 in LCD 14 >>>>>>>>>> 8
18 //pin 15 in LCD 15 >>>>>>>>>> vcc
```

Figure 8 Example of Arduino coding (Arduino, 2020)

Figure 8 is an example of the code used to control the speed of a DC motor and the direction of rotation. This could be used to maintain the pressure and having the ability to change the direction of flow is useful because if the water network needed rezoning, then these pumps could possibly supply a different area.

*Good
argument
with
supporting
source and
example*

5. Final Solution and Implementation

Solution 2 was selected as the final solution as this method of control is widely used in Welsh Water on their pumping stations, water treatment works, and wastewater treatment sites. There are several different makes and models of PLC available but the one that is used on this system is a Mitsubishi Melsec FX 3U-32M, by using a PLC for this type of application there will be always the ability to expand the system by using additional analogue or digital modules so that more inputs and outputs are available. When programming a PLC you will have to consider what programming language that is going to be used, there are 5 different type of PLC language which are –

- (SFC) Sequential Function Charts
- (LD) Ladder Diagram
- (FBD) Function Block Diagram
- (IL) Instruction List
- (ST) Structured Text

Explanation is informative about PLC and options for programming

In 1993 a new standard was created regarding PLC programming languages and these five different programming languages were added to the IEC 61131-3 (International Electrotechnical Commission) standard. (Visaya, 2019)

(SFC) Sequential Function Charts

Sequential function chart works in sequence as the name suggests. SFC is a graphical programming language, Figure 10 shows a basic SFC programme where it starts at step 1 and will only move to step 2 when the step enabling conditions are met. This will continue to happen and work through each step where it will come to the end and loop back to the start. Because of the structure of SFC it makes the programme easy to follow. (Budimir, 2017)

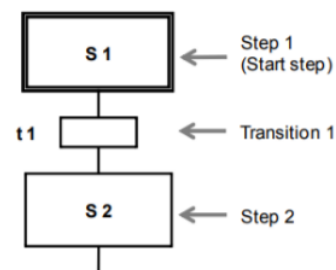


Figure 10 Basic sequential function chart (Siemens, 2010)

(LD) Ladder Diagram

Ladder Diagram is again easy to read and follow because of how its structured. Figure 11 is an example of a LD systems where you have horizontal rungs with two vertical rails which are the positive and negative. A negative with LD programming it is unable to process any variable readings like flow or pressure. (Muthukrishnan, 2021)

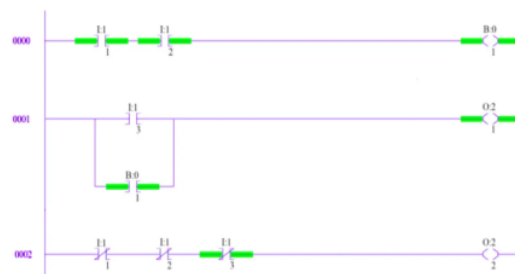


Figure 11 Ladder Diagram(LD) (St.Micheal, 2019)

(FBD) Function Block Diagram

Figure 12 is an example of FBD and like SFC and LD this is a graphical programming language. With FBD you have different function blocks which can carry out different tasks such as counters, timers, and PID loops. If the FBD is designed well then, the programme can be easy to follow and therefore easy to fault find. (Dixon, 2018)

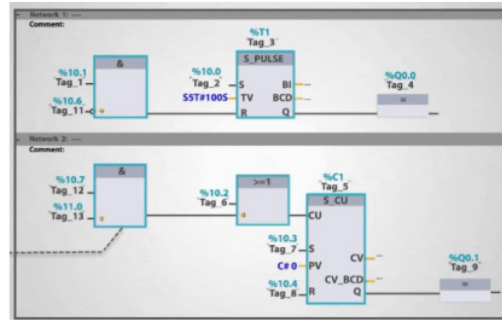


Figure 13 Function Block Diagram(FBD) (Dixon, 2018)

(IL) Instruction List

Figure 12 is an example of IL and it is basically a set of instructions within text. IL is a good programming language if memory is an issue as it does not use up as much compared to the more graphical programming languages. IL is not widely used within industry so the amount of people who can use this kind of language is limited.

```
LD %I1.1
OR %M1
ST %Q2.3

LD %M2
ORN %I1.2
ST %Q2.2

LD %I1.3
ORR %I1.4
ST %Q2.4

LD %M3
ORF %I1.5
ST %Q2.5
```

Figure 12 Instruction list (IL)

(ST) Structured Text

Structured text is a text-based language which uses Pascal and Basic language. ST uses terms such as ELSE, THEN, and IF when programming. Figure 14 is an example of ST and again with this programming language it is easy to follow if you have a basic programme because the terms used while programming basically tell you what it is doing. But ST gets complicated when you want the PLC to perform a more complex task. (Dixon, 2018)

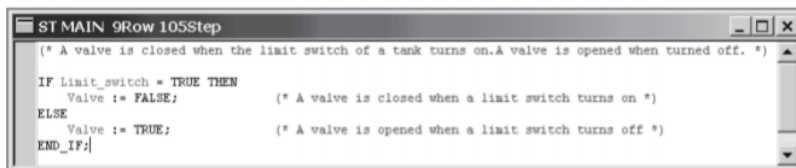


Figure 14 Structed Text (ST)

Table 3 shows the positives and negatives associated with all 5 of the PLC languages. For this project FBD will be used as it is able to perform complex tasks and can be easy to read and fault find if it is designed well. Also, FBD is used on most of Welsh Waters sites so it is also important to standardise all the sites to make it easier when breakdowns happen.

PLC Language	Text/Graphical PLC language	Advantage	Disadvantage
SFC	Graphical	• Easy to write programme. • Easy to fault find.	• Unable to carry out complex tasks.
LD	Graphical	• Easy to read. • Widely used.	• Unable to carry out complex tasks. • Uses a large amount of memory.
FBD	Graphical	• Works well with complex tasks. • Can carry out most PLC tasks	• Can be hard to fault find if the programme is not structured well.
IL	Text	• Does not need a large amount of memory. • Fast process time.	• Fault finding is hard. • Least used PLC language in industry
ST	Text	• Works well with complex tasks.	• Can be hard to fault find.

Table 3 PLC languages

PLC Programme download

The first step was to download the original programme from the PLC this was done by plugging a laptop which had the software and then downloading both the PLC and HMI programmes. The original was saved so that if any issues occur then there will be an option to revert to it.



Figure 15 PLC download

Delivery pressure scaling

The pressure sensor connected to this system is a Trafag 0-16 bar pressure sensor so when programming the PLC it is important to scale it appropriately. The pressure sensor sends out a 4-20mA signal to the PLC through a screened cable which prevents any noise effecting the quality of the signal. The screened cable is then terminated into one of the analogue cards which is connected to the PLC.

Image supports explanation



Figure 16Trafag 0-16 pressure transducer

In the programme the delivery pressure was scaled with the minimum and the maximum set to 0 and 16.

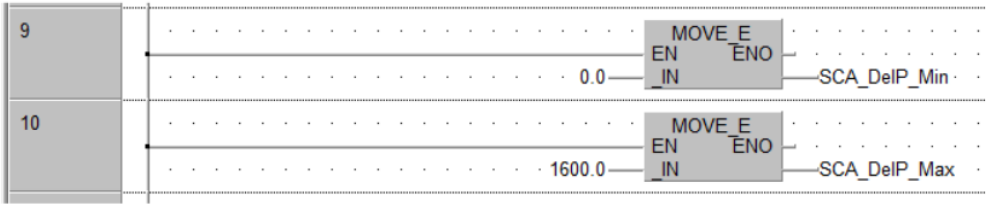


Figure 17 Pressure transducer scaling

Diagram shows the scaling parameters clearly

SRV out of service HMI button

One addition added to the PLC programme was a pushbutton that will be on the HMI, this pushbutton will change the control mode from level control to delivery control.

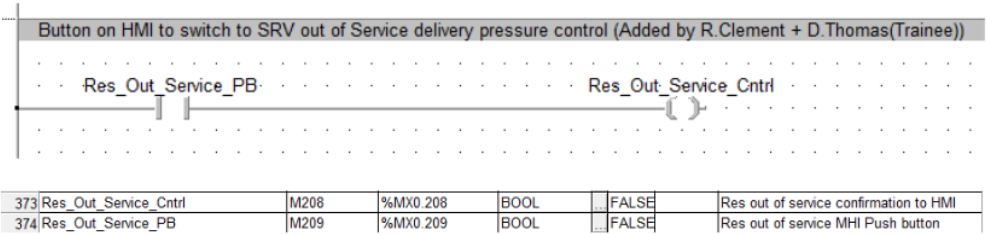


Figure 18 SRV out of service HMI switch bit.

As mentioned before the original system for this pumping station was controlled by the level of the SRV but then the suction pressure would also control the pumps.

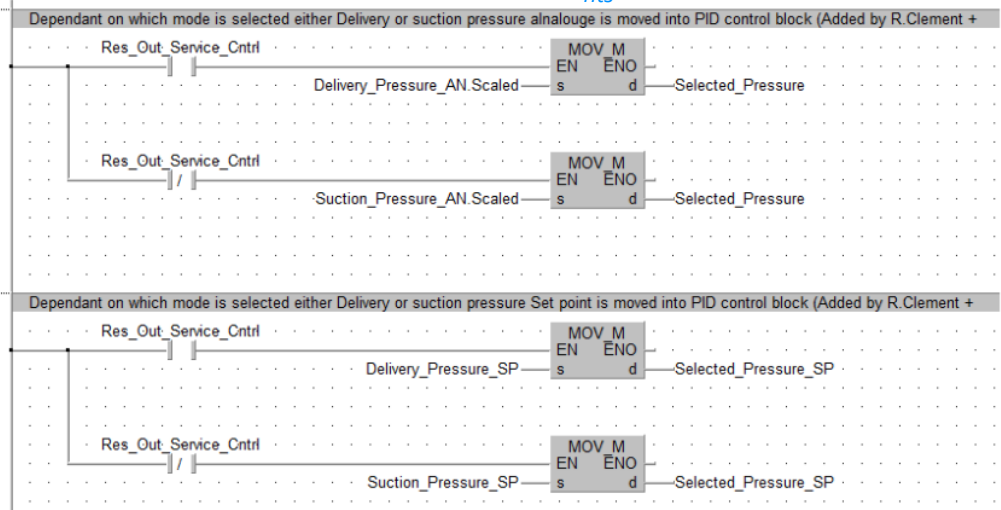


Figure 19 Delivery to Suction control.

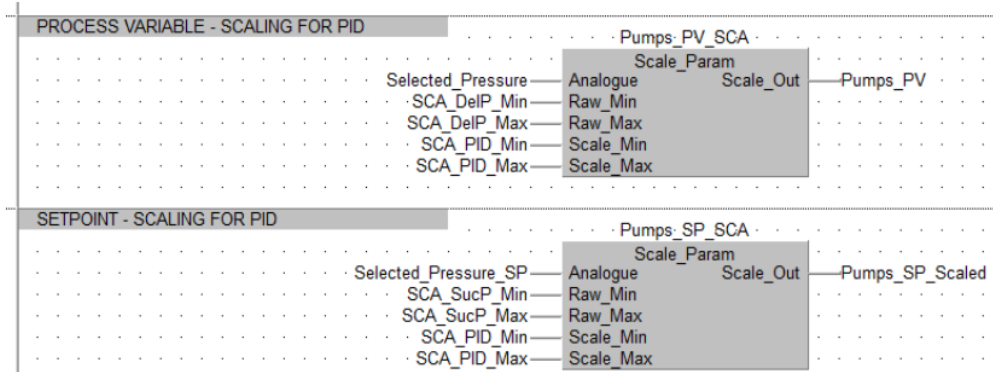
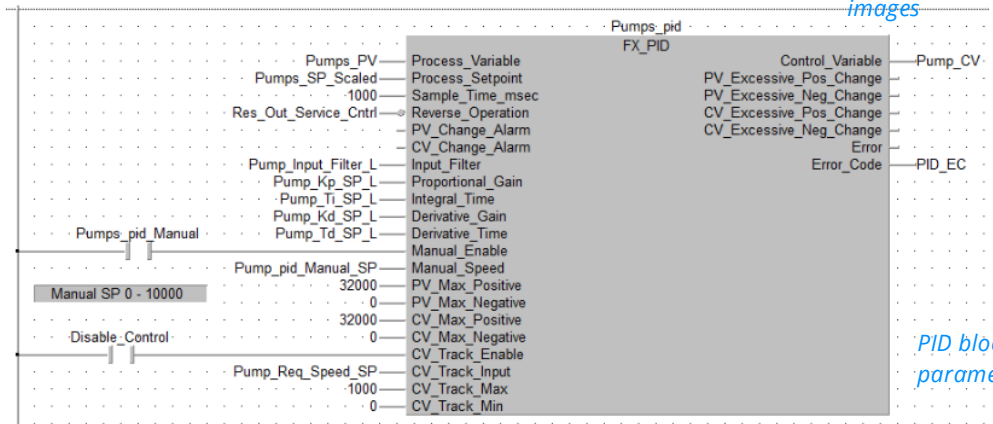


Figure 20 Scaling for delivery pressure

Figure 20 is the scaling for the delivery and suction pressure of this system. This works by scaling the 4-20mA in relation to 0-16bar of pressure. So, if there was a 4mA signal at the PLC then the HMI will display 0 bar of pressure and when there is 20mA signal the HMI will display 16bar.

Good explanation and supported with informative images



PID block shows all parameters

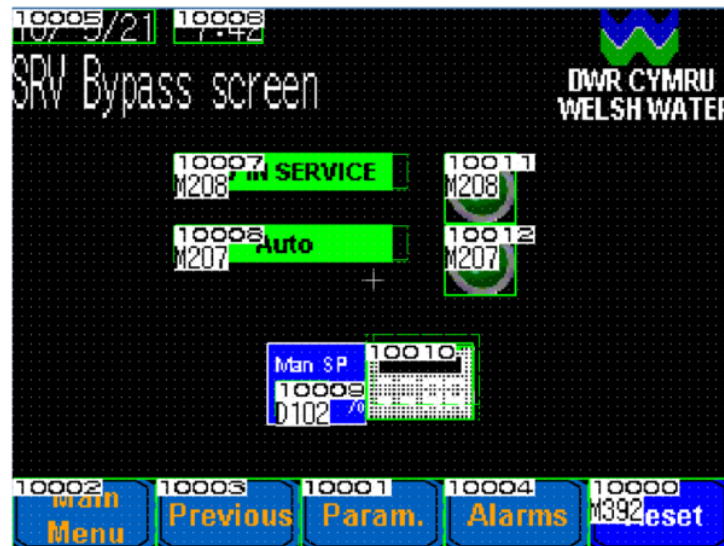
Figure 21 PID control

Figure 21 is the PID controller which is used to give a 4-20mA signal out to the VSD via the control variable. The 4-20mA is then scaled within the VSD drive so 4mA will be 0Hz and 20mA will be 50Hz.

AN image of the VFD would be useful here to support implementation

HMI Design

For the project new HMI screens were created and during the design process the input from the Network inspectors was given consideration. Figure 22 is the screen created for the Network inspectors where there are two buttons and a section to input the selected delivery pressure.



Good design that meets requirements set out in spec

Figure 22 SRV Bypass HMI

Figure 23 is the delivery pressure control HMI, this screen has more information on the screen to allow the Network Inspectors to further interrogate the system if they have to. This information was put on a separate screen to keep the SRV Bypass screen as simple as possible.

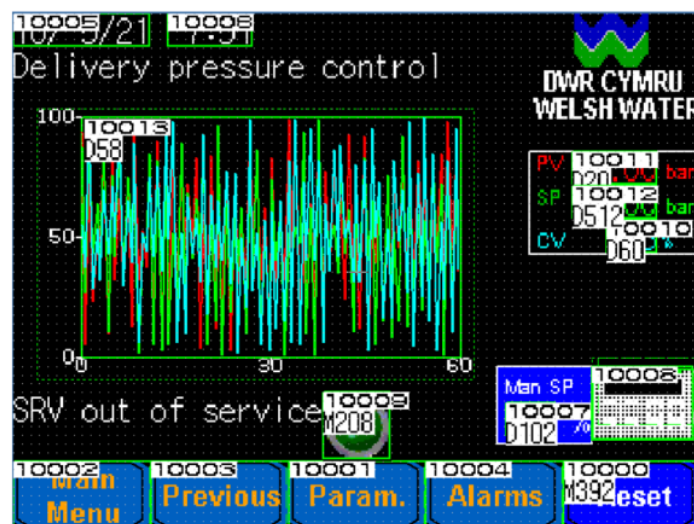
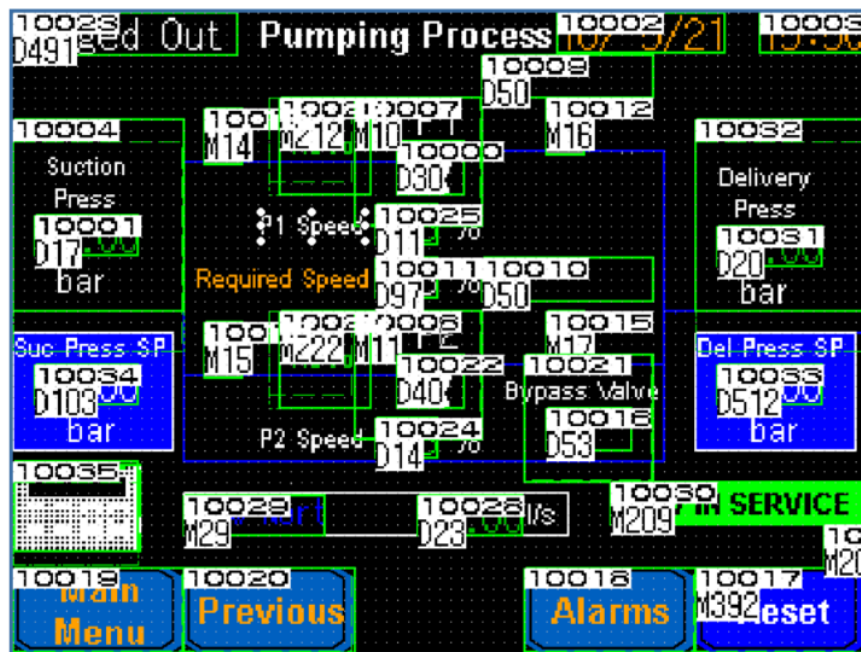


Figure 23 Delivery pressure control HMI



Good images of
HMI screen
designs

Figure 24 Pumping process HMI

Figure 24 is the final HMI screen created. This screen has further controls and displays. This screen would be more useful for ME and I staff as they could monitor different parts of the pumping station from one screen.

6. Testing and Results

After the upgrades were made the next step is to test the new system. Table 4 is the test procedure that was followed-

Test	Expected result	Actual results
Download new programme	System should run as normal with no issue	System ran as normal
Switch system from level control to pressure control	Pump should ramp up or down to match the selected pressure setpoint	Since the pressure was below the setpoint of 13.5 the pump ramped up to reach this setpoint.
Leave system running for 10mins	Outlet pressure should be stable at selected setpoint	Pressure was maintained.
Open a flushing valve located after pumping station which will result in the pressure dropping	If the pressure drops then the speed of the pump should increase so that the setpoint is reached again	As the outlet pressure dropped the speed of the pumps did increase.
Shut flushing valve	As the pressure will rise the pump speed should reduce	When the flushing valve was shut there was a bit of overshoot, but the pump did ramp down and level off at 13.5bar
Power down system (Mimic power cut) as there is no UPS connected to the PLC	The PLC should keep the new PLC programme and should return to normal state when power is renewed.	After cycling the power, the system did restart.

Good table of results

Table 4 Testing procedure

To monitor the running system a programme called Scopex was used where site information can be obtained remotely.

From figure 25 you can see that the pressure was maintained firstly at 13.5 bar and then dropped down to 13bar. This graph proves that the upgrades done to this system has worked.

Outlet pressure – RED

SRV level - BLUE

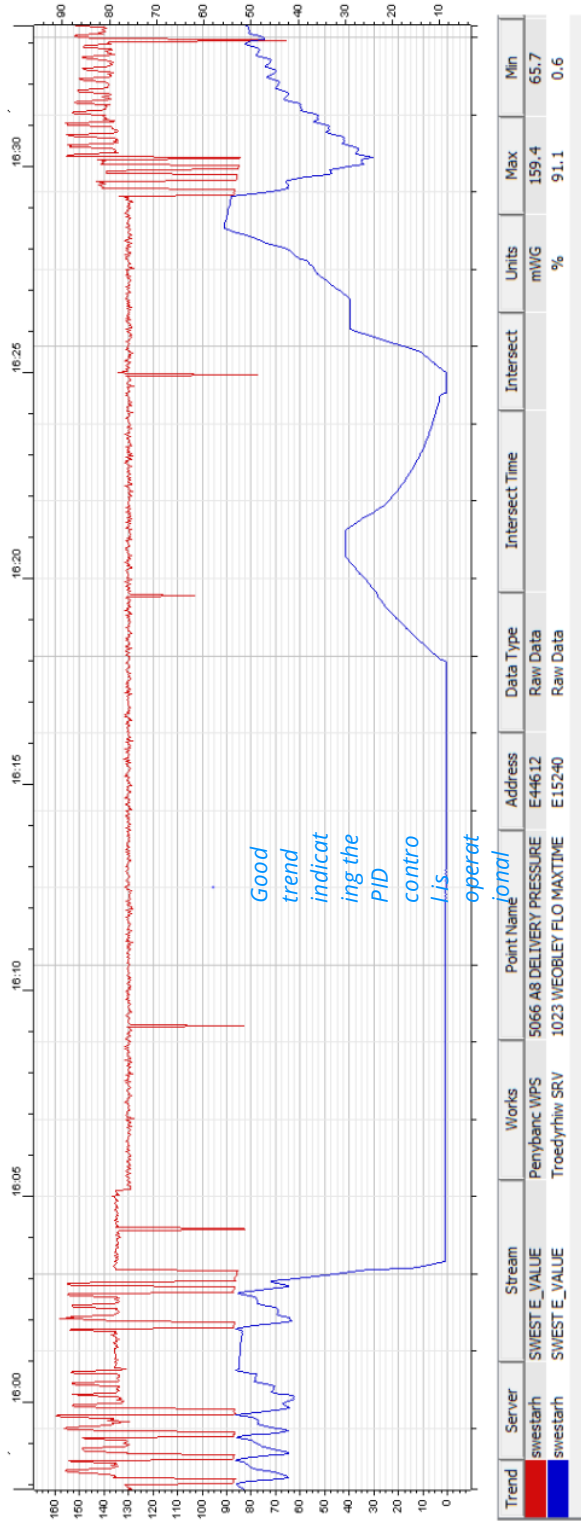


Figure 25 Scopex graph of outlet pressure(red) compared to SRV level(Blue)

HMI Testing

When testing the system, the HMI was tested the same time by operating the SRV out of service pushbutton. Also, the screens were monitored to make sure that the pressure values were accurate, this was done by comparing the HMI value to the mechanical pressure gauge that was on the system. When the SRV in service button was pressed it changed to red and the writing changed to SRV out of service. This was done to make it clear what mode the system was in.



Good explanation with supporting images

Figure 26 SRV in service HMI



Out of service is activated on HMI

Figure 27 SRV out of service HMI

7. Discussion, Conclusion and Recommendations

Overall, the project was a success with the system working as it should. By upgrading the system, the pressure was maintained, no customers were without water, the upgrade did not affect the water quality, and the upgrade is a permanent one so it can be used again. The project was completed within the budget and within the time frame allocated before the SRV clean.

From the Gantt chart you can see that most targets were met but ordering the software took longer than expected as the SmartHub department did not have the GT Designer Version 1.170C so an alternative needed to be found which was GT Works3 1.245F. Due to Covid-19 ordering the software took longer since all Welsh Waters staff were working from home which was an additional challenge to overcome. Also, the meeting which was scheduled for week 16 was cancelled due to Covid-19 and other work commitments by the managers, this did not affect the project too much as this meeting was just to check that everything was on track.

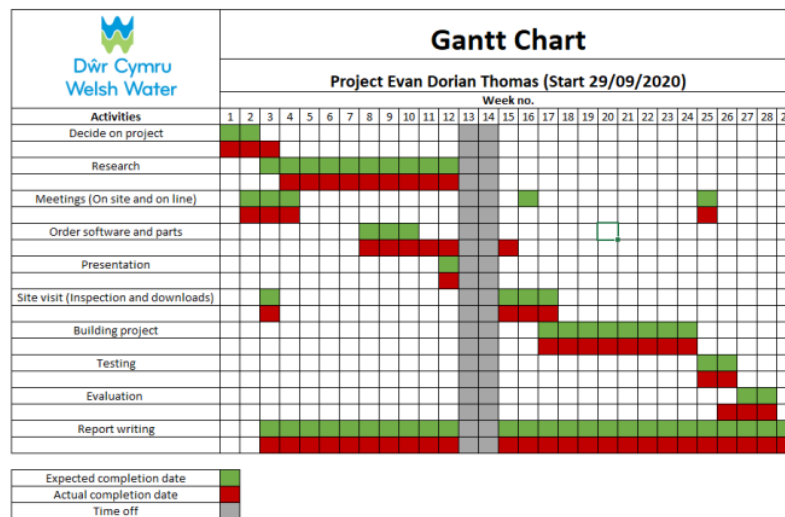


Table 5 Completed Gantt chart.

During site visits Covid-19 was an additional challenge as the number of people on site was limited and working in large groups was impossible. During site meetings Covid-19 rules were always followed with employees wearing masks and always keeping 2 meters from other staff members.

One additional upgrade that could have been done during this project was to add a FX3U-422-BD to the PLC which is a communication module (RS232) which fits to the base of the Mitsubishi PLC. The communication module can



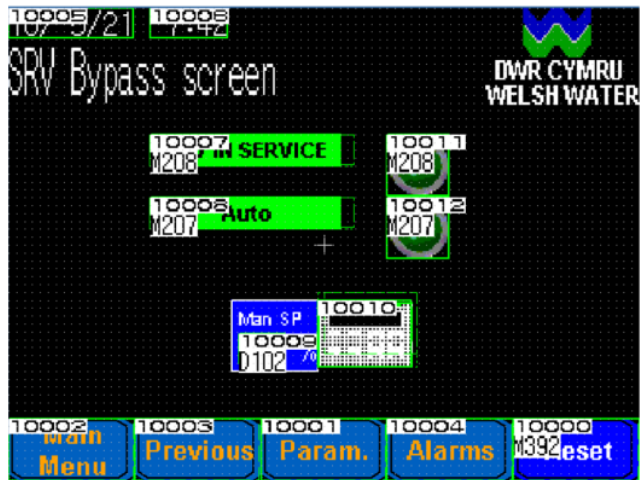
Figure 28 Communication module (Components, 2021)

be used to connect the PLC to a PC or an HMI. By having a second communication module on the PLC it will allow the user to communicate with the PLC using a PC without the need to unplug the HMI. This will allow the user to operate the HMI and watch the programme live which will be beneficial when fault finding.

Good recommendation

By reusing most of the original components on the system it has significantly reduced the environmental impact of this project as there was no waste. But if new components were used it would be important to investigate how environmentally friendly the new parts are, if they can be recycled, and if they do breakdown can they be repaired rather than replaced. By using the delivery pressure as the control, it will reduce the energy consumption of this site as the pumps will only be running when there will be a demand. Further savings could be made by surveying the condition of the water main to ensure there are no leaks and no waste.

The HMI screens created for this project did meet the brief as the new screen for the Network inspectors was clear with two buttons and a section to input the delivery pressure setpoint. Further screens were created to display actual delivery pressure in relation to selected delivery pressure.



This is a good mod to meet the customer needs

Figure 29 SRV Bypass screen

8. References

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<https://search.abb.com/library/Download.aspx?DocumentID=3AXD50000048678&LanguageCode=d&LanguageCode=en&LanguageCode=es&LanguageCode=fi&LanguageCode=fr&LanguageCode=ru&LanguageCode=sv&DocumentPartId=1&Action=Launch>

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[Accessed 7 05 2021].

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Available at: <https://www.automation.siemens.com/sce-static/learning-training-documents/pcs7/v7-0/p01-07-sequential-function-chart-rc1012-en.pdf>
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St.Micheal, S., 2019. *Control*. [Online]

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[Accessed 4 2 2021].

*A good
number
of
relevant
sources
used*

9. Appendix

Penybanc WPS (Water pumping station) PLC + HMI upgrade

Where?

This project will be situated at Penybanc WPS. Where the programme which controls the flowrate through the pumping station needs changing.

Why?

The WPS needs this upgrade because the reservoir it supplies needs maintenance done to it which involves emptying the reservoir which will leave customers without water if this upgrade is not made. To continue to supply the customers with water the reservoir will be bypassed, and the pumps will change from being controlled by level to being controlled via delivery pressure.

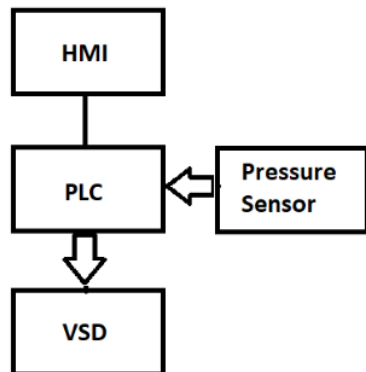
What?

The aim of this project will be to change the way the pumps are controlled from level control to pressure control and also updating the existing HMI so that there is a new screen which allows you to change from level control to pressure control by a press of a button for future maintenance.

How?

As this is an existing site there will be no need for any materials. The upgrade will be done within the Mitsubishi PLC in the main MCC. There is an existing pressure switch on the delivery side of the pump which is currently used to shut the pumps down if the delivery pressure goes high, so I will use this signal to control the pump speed.

Block diagram



How much?

The cost of this project will be £5864.88

When?

The project will be completed by the 28th of April. A Gantt chart will be created with specific milestones to monitor progress.

10. Log books

Log Sheet

Log No	1
No hrs	1.5
Running total hrs	1.5

29/09/2020

After a discussion with Robert Jenkins in our weekly lesson I had to decide on a work-based project. He gave us a list of possible project ideas we could try and do in work –

Project ideas

PLC based projects:

Industry based project requirement (your own choice)
Analogue sensors with conditional limits
Stepper motor / servo motor direction and speed control (conveyor / CNC machine)
IOT Industry 4.0 based project (Read analogue / digital sensor data) Possibly college based

LabVIEW (contactless sensing)

Colour image sensor
Pattern matching test for PCB's
DSP - Frequency sensing (motor bearing wear)

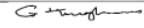
Arduino based project – C++ Programming

Any suitable project for level 4 (pressure, temperature control)
Arduino PID with LabVIEW interface
IOT Industry 4.0 using Arduino

Micro board with Proteus CAD design - C programming

DC motor speed control
State machine conditioning

I will contact our Asset Engineer (David Moore) to see if there are any projects that are planned to be done soon.

Student signature	
Supervisor Signature	
Lecturer Signature	

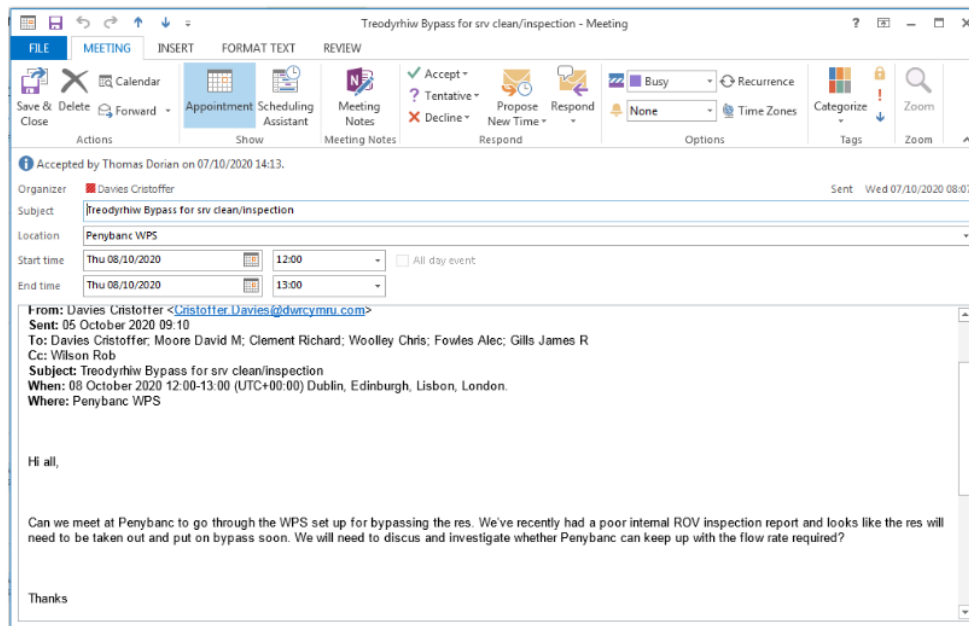
Log Sheet

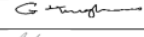
Log No	2
No hrs	3.5
Running total hrs	5

06/10/2020

After a discussion with our Asset Engineer, I was given a job to upgrade a system at Penybanc WPS (Supplies Treodryhiw SRV) which involved changing the way the pumping station was controlled. I discussed with Robert Jenkins that my project will be PLC based with an HMI screen for controlling.

A site meeting was organized to work out what the next step will be and to see what equipment we have on site.



Student signature	
Supervisor Signature	
Lecturer Signature	

Log Sheet

Log No	3
No hrs	7.5
Running total hrs	12.5

08/10/2020

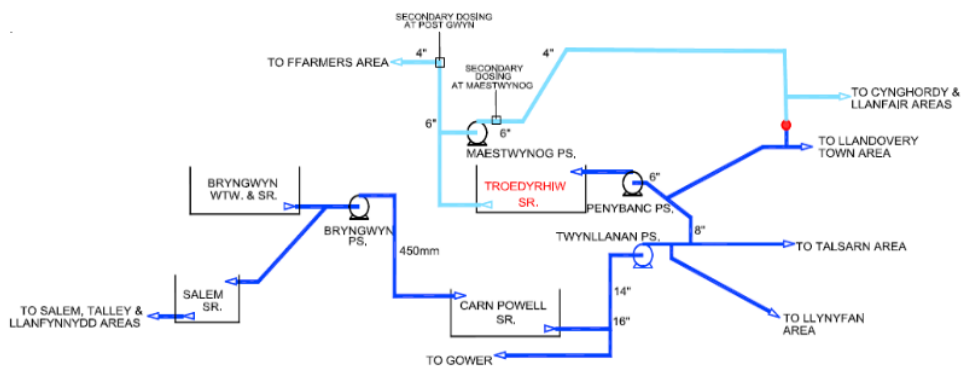
During our site visit I took details of all the equipment that we have on site. I also had a discussion with our Network inspectors and their manager to see what alterations that they would like to see and what they would like to see on the HMI.

Network inspectors' comments

-Simple HMI

-Simple HMI button to change from level control to pressure control for future use

-WPS outlet pressure control setpoint which can be easily changed



Student signature	
Supervisor Signature	
Lecturer Signature	

Log Sheet

Log No	4
No hrs	4
Running total hrs	16.5

13/10/2020

Handed in my proposal to Robert Jenkins so he could advise me if my project idea is good enough.

Penybanc WPS (Water pumping station) PLC + HMI upgrade

Where?

This project will be situated at Penybanc WPS. Where the programme which controls the flowrate through the pumping station needs changing.

Why?

The WPS needs this upgrade because the reservoir it supplies needs maintenance done to it which involves emptying the reservoir which will leave customers without water if this upgrade is not made. To continue to supply the customers with water the reservoir will be bypassed, and the pumps will change from being controlled by level to being controlled via delivery pressure.

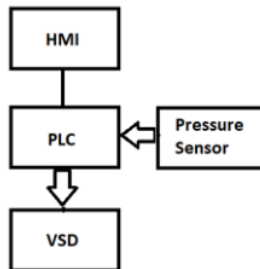
What?

The aim of this project will be to change the way the pumps are controlled from level control to pressure control and also updating the existing HMI so that there is a new screen which allows you to change from level control to pressure control by a press of a button for future maintenance.

How?

As this is an existing site there will be no need for any materials. The upgrade will be done within the Mitsubishi PLC in the main MCC. There is an existing pressure switch on the delivery side of the pump which is currently used to shut the pumps down if the delivery pressure goes high, so I will use this signal to control the pump speed.

Block diagram

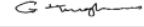


How much?

As this is an existing WPS there will be no material costs involved.

When?

The project will be completed by the 28th of April. A Gantt chart will be created with specific milestones to monitor progress.

Student signature	
Supervisor Signature	
Lecturer Signature	

Log Sheet

Log No	5
No hrs	3.5
Running total hrs	20

20/10/2020

Research

PLC on site – (Mitsubishi Melsec FX 3U-32M)

https://www.allied-automation.com/wp-content/uploads/2015/02/MITSUBISHI_FX3U-Users-Manual-%E2%80%93-Hardware-Edition.pdf



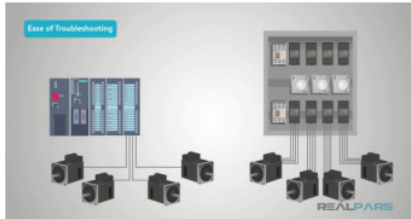
Log Sheet

Log No	6
No hrs	8
Running total hrs	28

10/11/2020

Research and presentation prep

<https://realpars.com/advantages-plcs-over-relay-systems/>



https://www.phoenixcontact.com/online/portal/us?1dmy&urile=wcm%3Apath%3A%2Fusen%2Fweb%2Foffcontext%2Finsite_landing_pages%2F25e09d46-8d09-4a19-81e5-15d1551a2362%2F25e09d46-8d09-4a19-81e5-15d1551a2362

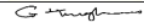
<https://dl.mitsubishielectric.com/dl/fa/document/manual/plc/sh080040/sh080040s.pdf>



MELSEC-Qi/QnA Programming Manual
(PID Control Instructions)



[Solid State Relay \(SSR\) - Types of SSR Relays - Construction & Operation \(electricaltechnology.org\)](https://electricaltechnology.org/solid-state-relay-ssr-types-of-ssr-relays-construction-operation/)

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Lecturer Signature	

Log Sheet

Log No	7
No hrs	3.5
Running total hrs	31.5

17/11/20

Research

<https://docs.rs-online.com/403c/0900766b8158598d.pdf>

[illegible]

Timer

<https://docs.rs-online.com/a063/0900766b81546362.pdf>

<https://docs.rs-online.com/08e4/0900766b81544df5.pdf>

Technical drawings of the 2000 Series Pressure Washer. The left drawing is a front view showing dimensions: 100mm total width, 50mm mounting bracket width, 100mm handle length, 100mm trigger gun length, 100mm spray lance length, and 100mm nozzle length. The right drawing is a side view showing dimensions: 100mm total width, 50mm mounting bracket width, 100mm handle length, 100mm trigger gun length, 100mm spray lance length, and 100mm nozzle length. The drawings are labeled with dimensions in mm and inches.

Pressure transducer

<https://docs.rs-online.com/2cb9/0900766b816cd5f3.pdf> (Relay)

<https://www.ofwat.gov.uk/households/supply-and-standards/supply-interruptions/>

Student signature	
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Lecturer Signature	

Log Sheet

Log No	8
No hrs	4
Running total hrs	35.5

24/11/2020

Evidence

Presentation preparation

<https://search.abb.com/library/Download.aspx?DocumentID=3AXD50000048678&LanguageCode=de&LanguageCode=en&LanguageCode=es&LanguageCode=fi&LanguageCode=fr&LanguageCode=ru&LanguageCode=sv&DocumentPartId=1&Action=Launch>



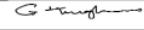
English	3
English - USA	9
Deutsch	17
Español	23
Suomi	29
Français	35
Русский	41
Svenska	47

FBD SCL

<https://electrical-engineering-portal.com/most-popular-plc-programming-languages>

<https://support.industry.siemens.com/tf//WW/en/posts/which-programming-language-to-use-stl-lad-fbd-scl-or-graph/243484?page=0&pageSize=10>

<https://www.plcademy.com/function-block-diagram-programming/>

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Supervisor Signature	
Lecturer Signature	

Log Sheet

Log No	9
No hrs	3
Running total hrs	38.5

01/12/2020

Evidence

Presentation preparation

<https://www.ofwat.gov.uk/households/supply-and-standards/supply-interruptions/>

Research carried out into the guidelines that have been set in regards to customers supply of water.

← → ↻ 🔒 <https://www.ofwat.gov.uk/households/supply-and-standards/supply-interruptions/> 📄 ☆ ⚙

 We regulate the water sector in England and Wales

About us ▾ Regulated companies ▾ Residential customers ▾ Business customers ▾ Investors ▾ Publications Consultations | 🔍 Search

Home > Residential customers > Supply and standards > **Supply interruptions**

< Residential customers

Industry customer service

Your water bill

Customer assistance

Supply and standards

Getting a connection

Responsibility for pipes and pumping stations

Pipes on private land

Information from your company

Leakage

Supply interruptions

Supply interruptions

Planned interruptions

For planned interruptions of longer than four hours, [your water company](#) should normally give you 48 hours' notice.

Emergency interruptions

If the supply fails or is interrupted for emergency works, your company should tell you:

- that the supply has been interrupted or cut off
- where to get an alternative supply
- the time by when the supply will be restored

<https://dl.mitsubishielectric.com/dl/fa/document/manual/plc/sh080041/sh080041x.pdf>

delivered by

THE NATIONAL ARCHIVES

Cymraeg

Home Understanding Legislation EU Legislation and UK Law Browse Legislation Changes To Legislation Search Legislation

Title: Year: Number: Type: All UK Legislation (excluding originating from the EU) Search

Advanced Search

The Water Supply (Water Quality) Regulations 2018

Wales Statutory Instruments ► 2018 No. 647 (W. 121) ► Table of contents

Table of Contents Content More Resources

Plain View Print Options

What Version

Latest available (Revised)

Original (As made)

Opening Options

More Resources

Status: This is the original version (as it was originally made).

Collapse all -

Introductory Text

Collapse -

PART 1 General

1. Title, commencement and application

2. Interpretation

Collapse -

PART 2 Water Supply Zones

3. Water supply zones

Collapse -

PART 3 Wholesomeness

4. Wholesomeness

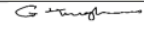
Collapse -

PART 4 Monitoring of Water Supplies

5. Interpretation and application of Part 4

6. Monitoring: general provisions

<https://www.legislation.gov.uk/wsi/2018/647/contents/made>

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Supervisor Signature	
Lecturer Signature	

37

Log Sheet

Log No	10
No hrs	1.5
Running total hrs	40

08/12/2020

Software request email. Software requested –

- GT Designer 3 Version 1.170C
- Mitsubishi GXIEC V7.03
- Mitsubishi GXIEC V7.00

Operational Technology Software Request Form	
PTF020	
Name	Dorian Thomas
DCWW Network ID	C005737
FULL DCWW ASSET ID	17462
Is the software licensed (for telemetry only)	No
Cost Code (needed regardless of licence)	AA028
Is this request related to an incident?	NO
Reason for requesting Software:- Work requirement	
Details of software required, version & where to purchase license from	GT Designer 3 Version 1.170C Mitsubishi GXIEC V7.03 Mitsubishi GXIEC V7.00
Local ATC Manager or Smart Hub Systems Manager	Paul Bell
Job Title	ICA
Signature	
Receipt & Action Box	Date Time Signature
Software Request Form Received	☐ ☐ ☐
Passed to ATC to purchase license	☐ ☐ ☐
Confirmation to User that Software has been installed	☐ ☐ ☐

Note: Please print clearly!

If this software is licensed then we will need to check if we have any available licenses, it could be that we need to order one specifically for you with costs booked against the cost code provided
It is strongly advised that your machine is connected to the DCWW Network for the application to install to your machine
Once form is completed please email into: SmartHub@dwrcymru.com

Dorian Thomas Software request form

 Dorian Thomas
To: SmartHub

 Dorian Thomas software request form.docx
53 KB

Hello

I have attached a copy of my software request form for approval.

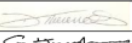
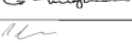
Thanks

Dorian Thomas

Technegydd ICA/ICA Technician
Trydanwr/Electrician
Gogledd Dyfed/North Dyfed

Strata Florida WTW: 01974 831260
Bontgoch WTW: 01970 832271
Ffôn symudol/Mobile:- 07773011011
E-bost/E-mail: dorian.thomas@dwrcymru.com



Student signature	
Supervisor Signature	
Lecturer Signature	

Log Sheet

Log No	11
No hrs	3
Running total hrs	43

15/12/2020

<https://www.machinedesign.com/automation-iiot/sensors/article/21831887/introduction-to-pid-control#:~:text=PID%20is%20an%20acronym%20for,greater%20or%20less%20than%20one.>

Presentation

Project Design presentation

Dŵr Cymru Welsh Water

Company background

- Not for profit company
- Responsible for supplying 828 million litres of water a day
- 3 million customers
- 4th largest company in Wales
- Around 3000 employees
- 26,500km of water mains and 30,000km of sewers

The Problem

- Maintenance needs to be done at Troedryhiw SR
- Pen y banc WPS currently being controlled by the level of the SR
- Only way of maintaining the water supply is to manually control the pumps via the variable speed drives whilst the SRV is bypassed

The Project

- Design a system so that the user is able to switch from level control to delivery pressure control.
- Make the system as user friendly as possible for the network inspectors.
- Upgraded system should not disrupt the customers water supply.

Solution 1

Solution 2

Chosen solution

- Site standardisation
- Long term costs will be cheaper
- Can programme modifications
- Less components needed to build solution 2

Testing

- Simulation
- Download and test that original programme (Level control)
- Switch over to new programme using the HMI
- Monitor system to see if the pressure is maintained
- With assistance from a Network Inspector have them open a flush out valve positioned after the pumps to see if the pump speed will ramp up

Gantt Chart

Any Questions?

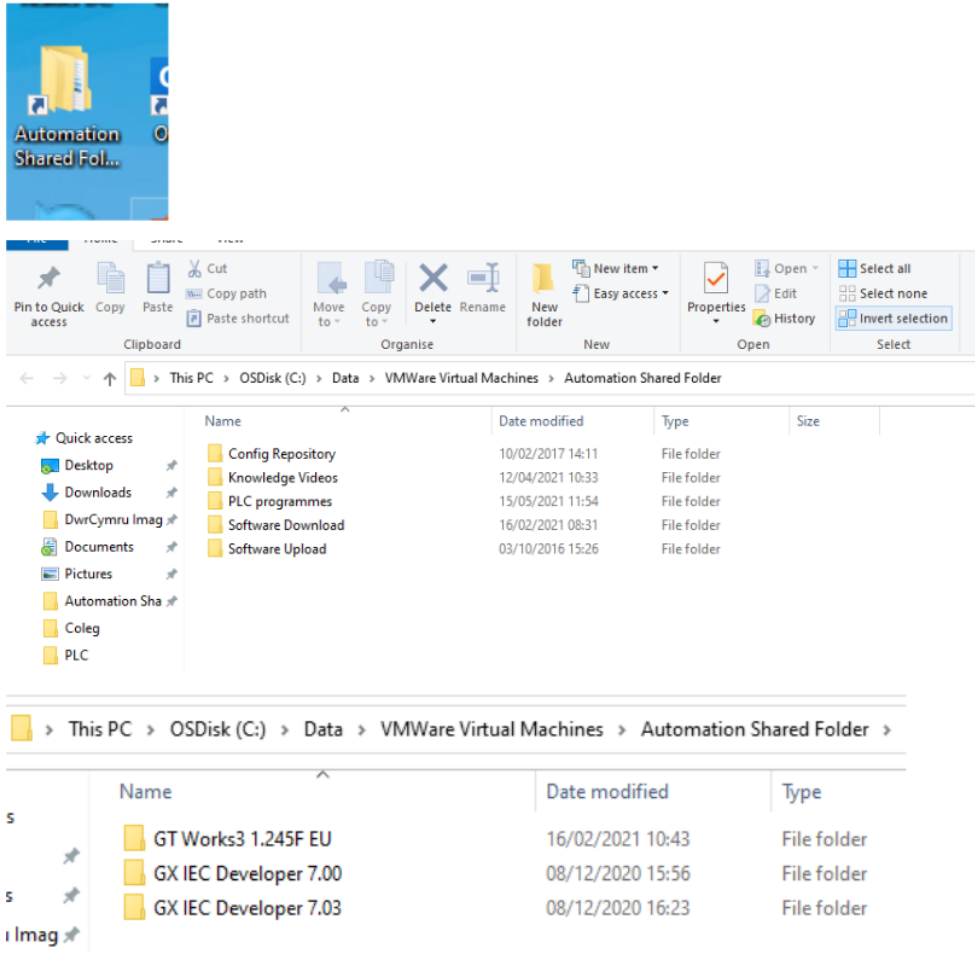
Dŵr Cymru Welsh Water

Student signature	
Supervisor Signature	
Lecturer Signature	

Log Sheet

Log No	12
No hrs	8
Running total hrs	51

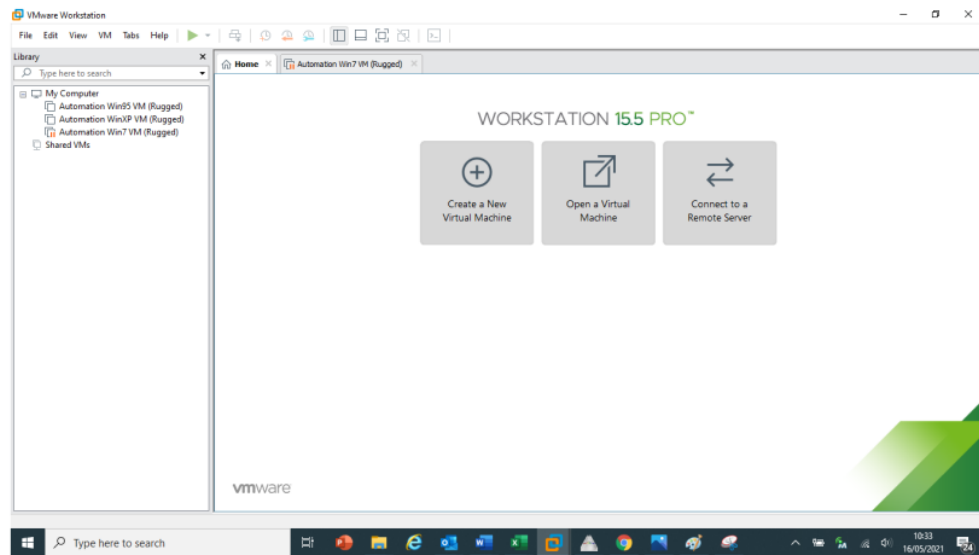
Before attending site, the software needed had to be downloaded. Unfortunately, DCWW SmartHub department did not have the GT Designer Version 1.170C but I was informed that GT Works3 1.245F EU would work and was available for download. The new downloaded software could not run using windows 10 so VM(Virtual Machine) was used where you can run an older version of Windows on your newer laptop.

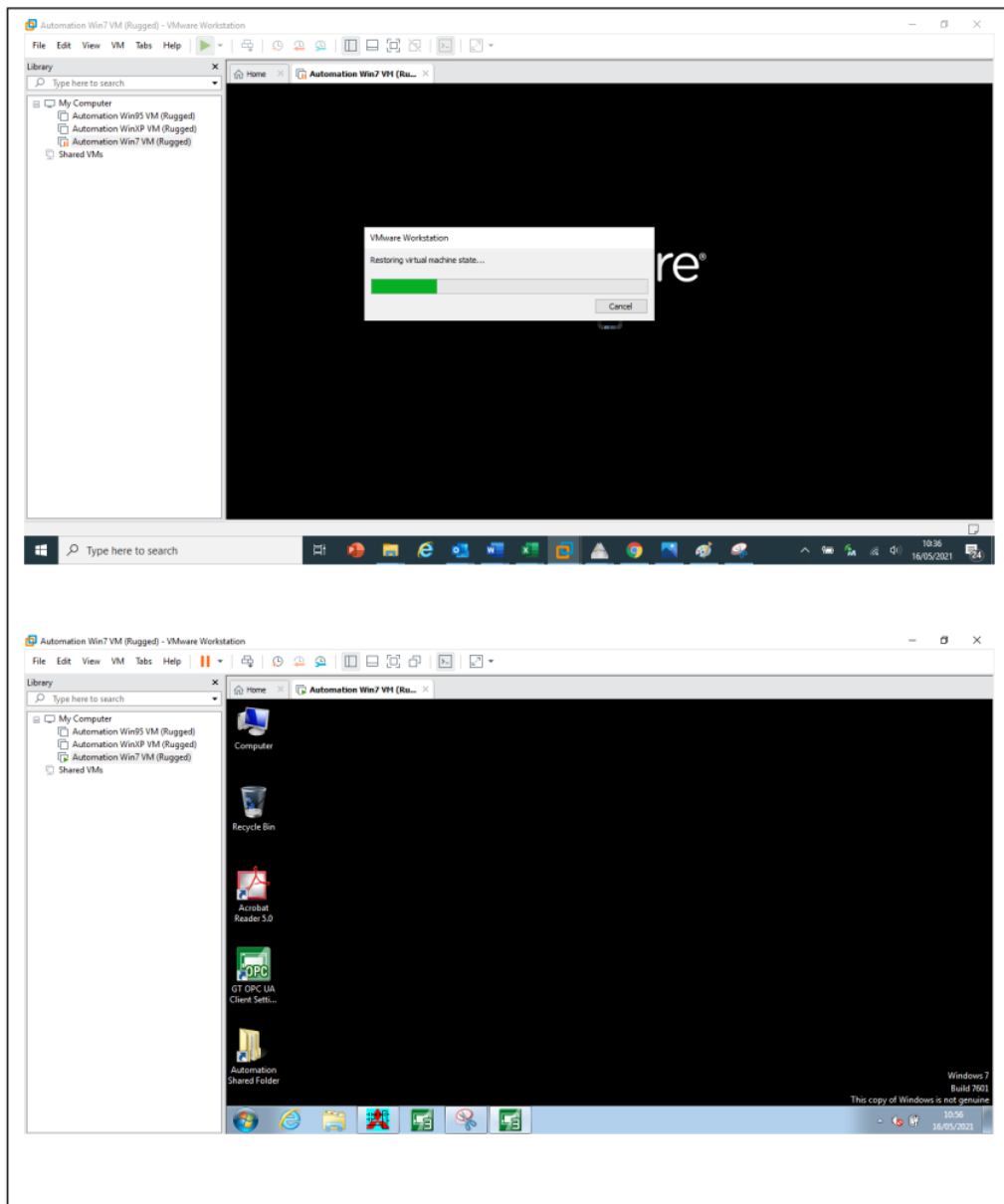


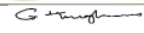
All three were downloaded

This PC > OSDisk (C:) > Data > VMWare Virtual Machines > Automation Shared Folder > Software Download > GT Works3 1.245F EU					
	Name	Date modified	Type	Size	
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ds	Catalogues	16/02/2021 08:35	File folder		
u Imag	GTOPCUA	16/02/2021 08:36	File folder		
ts	GTW3	12/04/2021 10:49	File folder		
ts	Manuals	16/02/2021 10:53	File folder		
on Sha	autorun	21/05/2019 12:34	Application	6,278 KB	
ts 8-2-21 t	autorun	13/03/2019 09:07	Setup Information	1 KB	
	lua5.1.dll	10/02/2015 20:10	Application exten...	323 KB	
	lua51.dll	28/08/2008 20:04	Application exten...	11 KB	
	settings	22/10/2015 10:12	Configuration sett...	1 KB	

VMware





Student signature	
Supervisor Signature	
Lecturer Signature	

Log Sheet

Log No	13
No hrs	15
Running total hrs	66

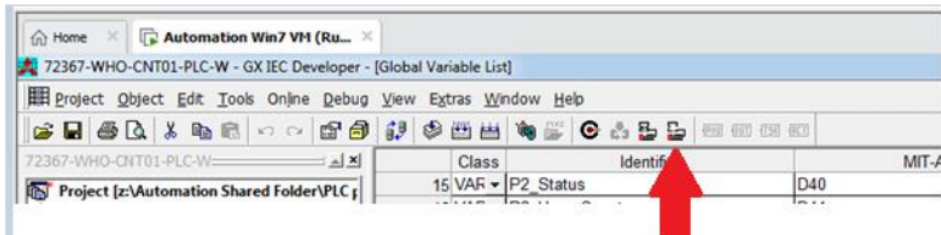
5/1/2021

Dŵr Cymru Welsh Water		Access to Assets Procedure HSP 811 Form AF01	
Form AF01			
This form is mandatory for access to undertake any work on DCWW operational assets			
If any of the agreed arrangements change prior to or during access, you must STOP WORK and contact the Site Controller to agree new arrangements This is not a Permit to Work			
In case of HAZARDOUS MATERIAL spills into sewers, those in control of sewer entries must be registered on Welsh Water's HAZMAT Alert System. To register / de-register contact Welsh Water on Tel: 0303 3130109			
Part A details of access requirements (to be completed by the party requiring access)			
1	Site Name (NB if access to multiple sites is required list in Part D overleaf):	Troedyrhiw WPS	Asset number:
Are other parties affected (mark Y or N):		N	If Yes, who? N/A
2	Name of your organisation:	DCWWATC	
Which organisation instructed you to do this work:		DCWW	
Dates access required "No access is to be made outside these dates without agreement":			
Contact details		Name	Telephone
Office contact:		Richard Clement (DCWWATC)	07557 617128
Person in Control of the Work:		Robert Wilson (DCWW)	07824354364
Out of hours contact:			
3	Brief description of proposed work: Upgrade the control system so that there will be pressure and level control.		
4	Nature of intended activities (mark Y, N or N/A): Deliveries: N Survey / Inspection: Y Physical Works: Y		
Will the work interfere with the process (mark Y, N or N/A): Y If Yes, attach sufficient details to assess effect.			
5	Arrangements agreed with Site Controller (mark Y, N or N/A):		
Induction arrangements – contractors must receive site induction(s) and watch the corporate induction video click here to view Y			
a	Access dates and times	Y	h Shutdowns or isolations Y
b	Delivery and storage area	N	i Certificates / Permits Y
c	"No-Go" areas	N	j Site Meeting Y
d	Offloading facilities / arrangements	N	k Site Hazards and rules provided Y
e	Escort arrangements	N	l Transfer of access been arranged Y
f	Asset operator to contact control room at start/finish	Y	m Opnotes N
g	Other	N/A	
Part B Access approval (to be completed by Site Controller)			
Is site normally manned? (mark Y, or N):		N	Is yes, what are site hours? N/A
6	Contact details	Name	Telephone
Unit Manager:		Robert Wilson	
Supervisor:		Cris Davies	07772 448412
Operator:		Cris Davies	07772 448412
Out of hours contact:			
7	Site Controller's Checklist (Mark Y, N or N/A):		
a	Arrangements approved and access granted:	N/A	c Work start notification received:
b	Other:		
Name:	Cris Davies	*Signature:	C Davies Date: 5/1/21
Part C Cancellation (to be completed by Site Controller)			
8	Comments (Mark a to d Y, N or N/A)		
a	Work completion notification received		c Keys returned
b	Details of work done & residual H&S risks notified		d Other:
Name:		*Signature:	Date:
Part D Access to multiple sites			
9	Please list site names		

To gain access to the site to start any work which will affect the running of the WPS a AF01 form had to be completed.



A download was made from the PLC by using an RS232 cable which was plugged from the laptop to the PLC. The Mitsubishi GXIEC V7.00 software was then used to download the original programme so this could be upgraded. This process was also done to download the HMI programme.



PLC programme upload to laptop icon. After pressing this a new screen appears where you choose how the computer is connected to the PLC.

Automation Win7 VM (Ru...

Transfer Setup

PC side I/F

Serial USB

CC IE Cont NET/10(H) board

NET(II) board

CC-Link board

Ethernet board

PLC board

AF board

SSC net

PLC side I/F

PLC module

CC IE Cont NET/10(H) module

MNET(II) module

CC-Link module

Ethernet module

C24

G4 module

Bus

Other station

No specification

Other station(Single network)

Other station(Co-existence network)

Network route

C24

CC IE Cont NET/10(H)

NET(II)

CC-Link

Ethernet

Co-existence network route

C24

CC IE Cont NET/10(H)

NET(II)

CC-Link

Ethernet

COM COM 1 Transmission speed 115.2Kbps

PLC mode FXCPU

Time out (Sec.) 5

Retry times 0

Target system

Multiple CPU setting

1 2 3 4

Connection channel list...

PLC direct coupled setting

Connection test

PLC type

Detail

System image...

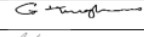
TEL (FXCPU)...

Ready

Project Edit Search/Replace View Screen Common Figure Object Tools Communication Window Help

16 Custom 4 ON OFF 10

HMI upload icon

Student signature	
Supervisor Signature	
Lecturer Signature	

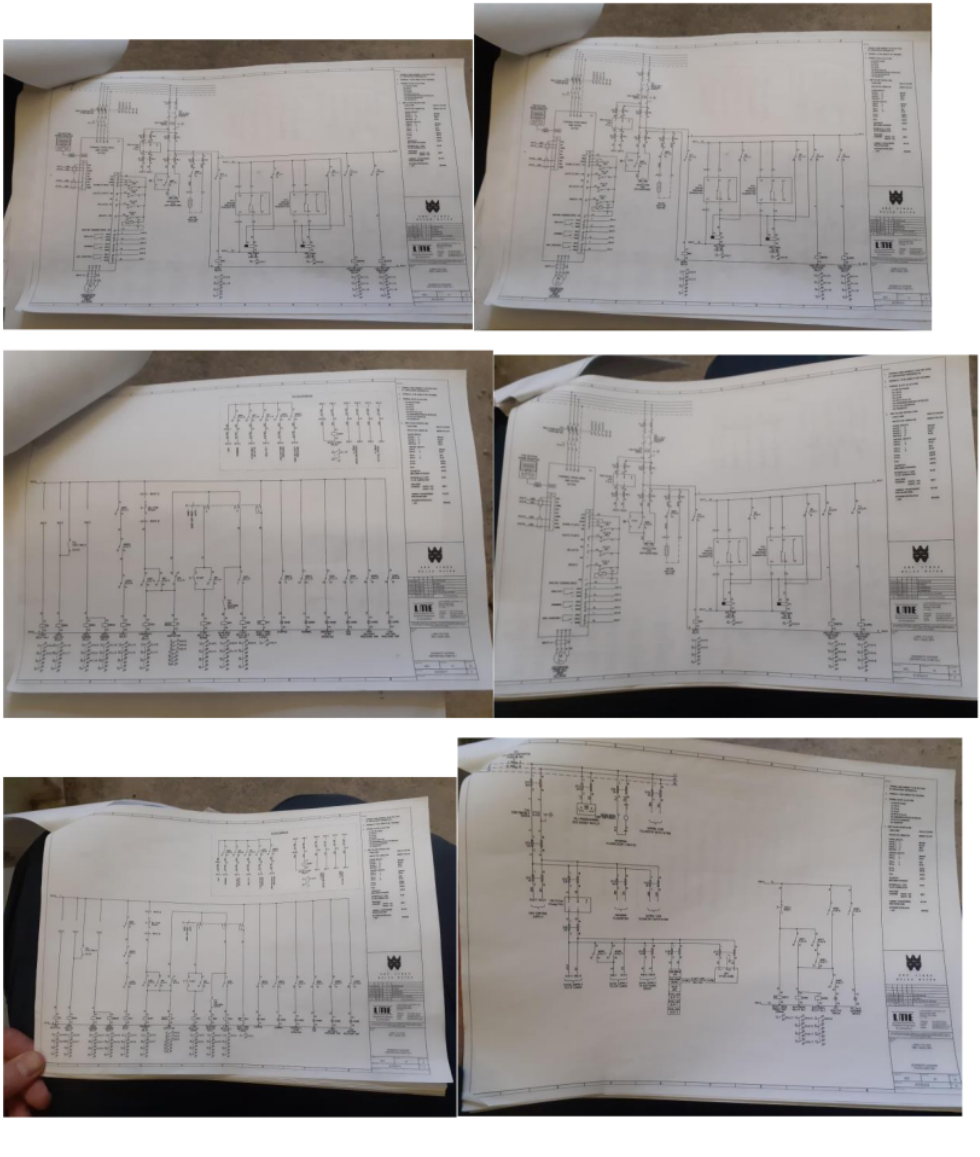
Log Sheet

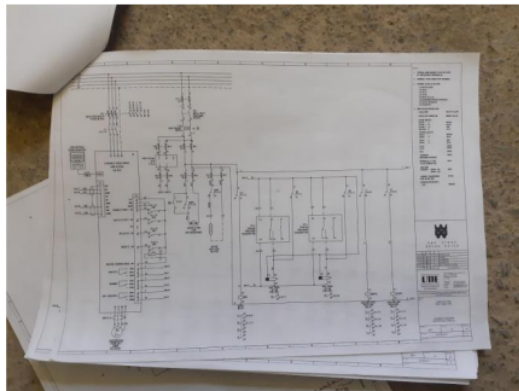
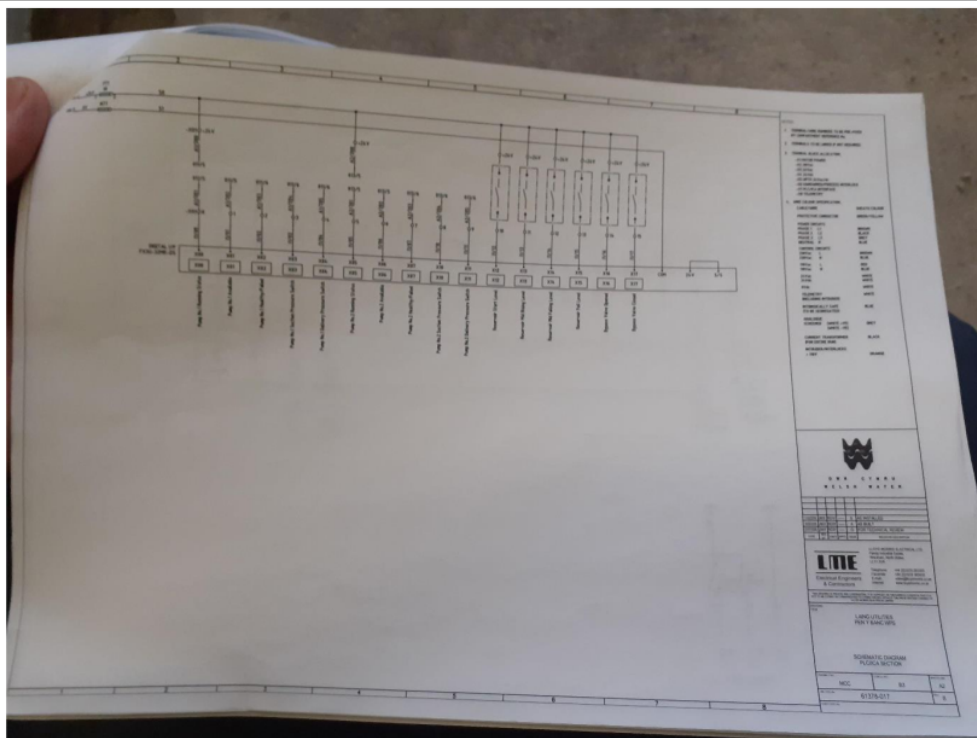
Log No	14
No hrs	15
Running total hrs	81

12/1/2021

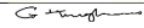
Further site investigation

- Drawings
- Telemetry outstation inputs/outputs
- WPS equipment







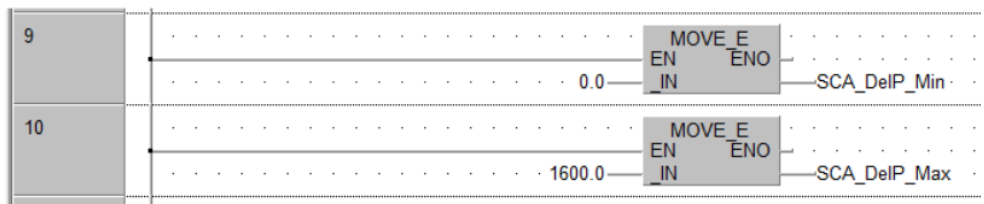
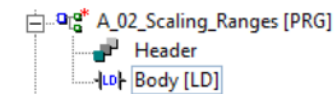
Student signature	
Supervisor Signature	
Lecturer Signature	

Log Sheet

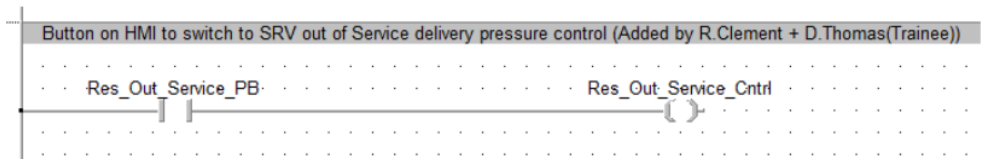
Log No	15
No hrs	16
Running total hrs	97

26/1/2021

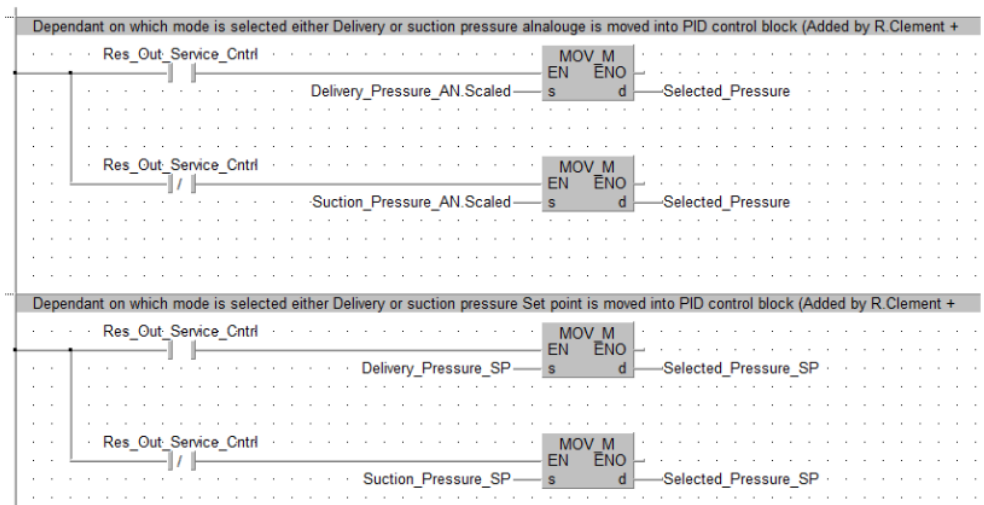
Programming

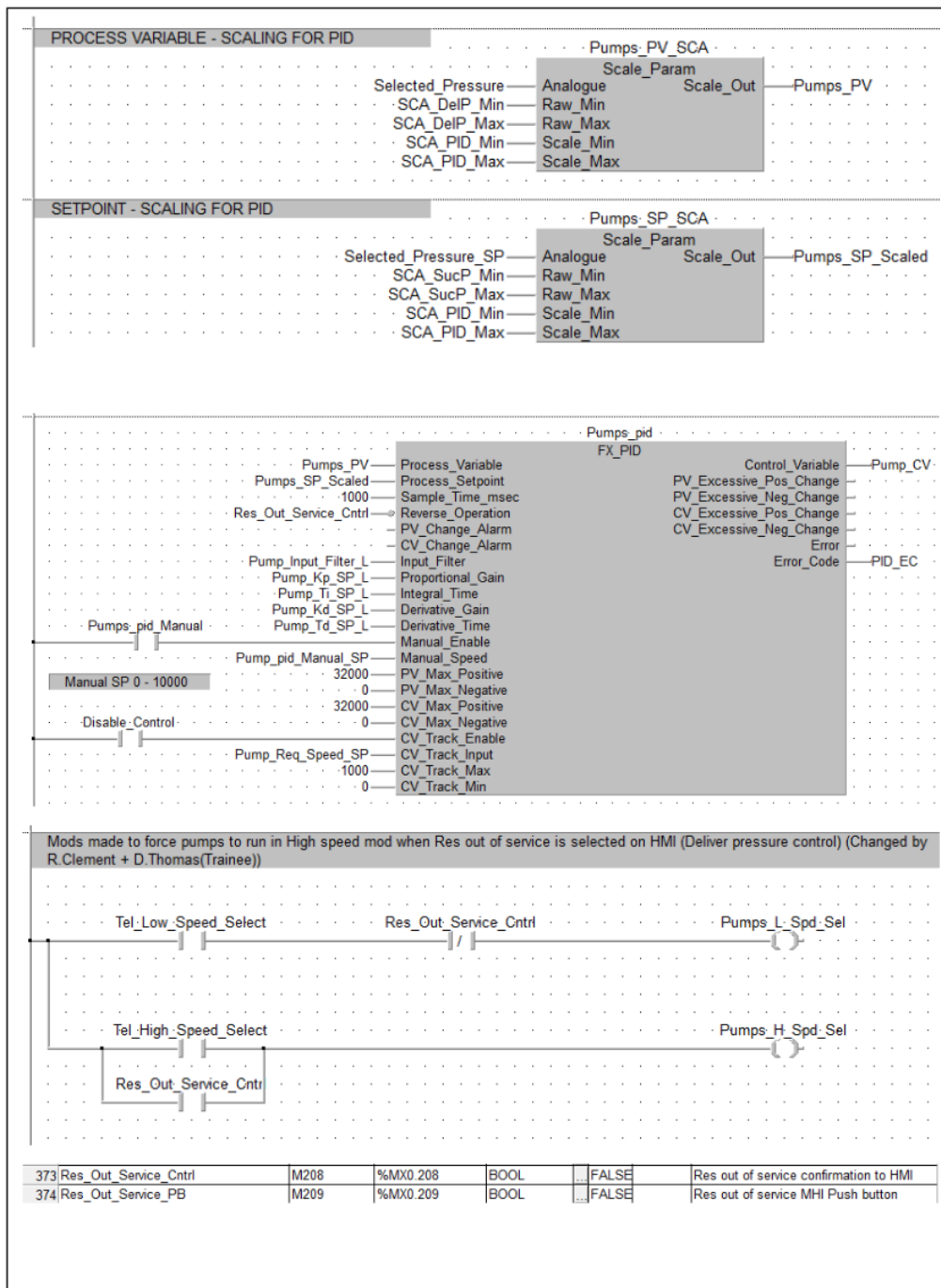


0-16 bar scaling



Srv out of service



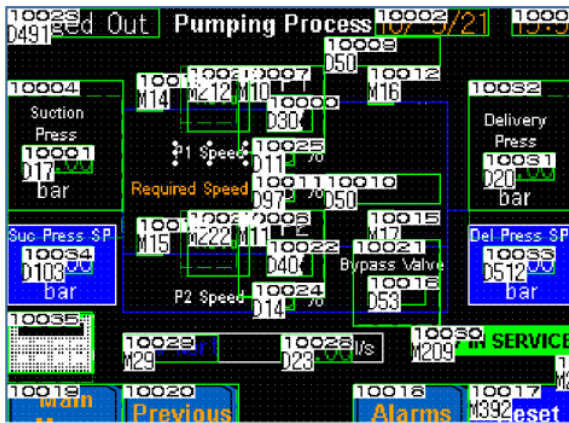
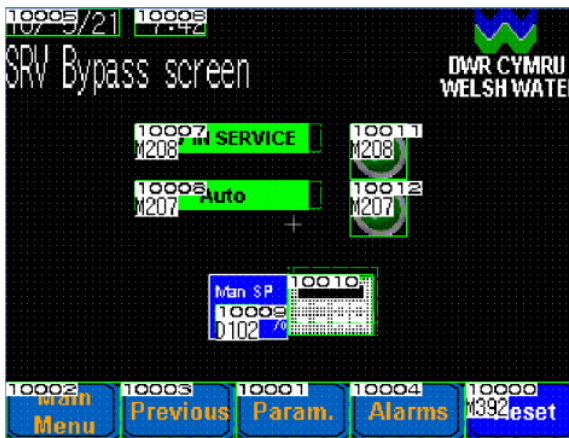
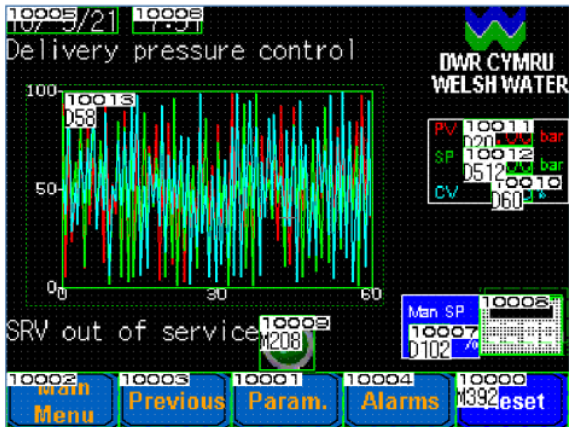


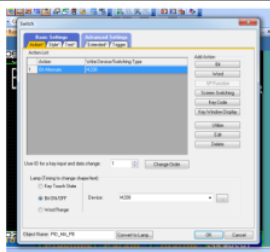
Student signature	
Supervisor Signature	
Lecturer Signature	

Log Sheet

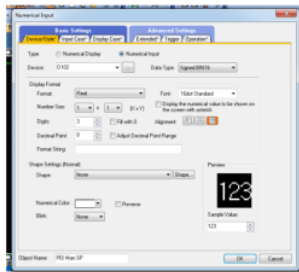
Log No	16
No hrs	15
Running total hrs	112

HMI design 9/2/2021 to 9/3/2021

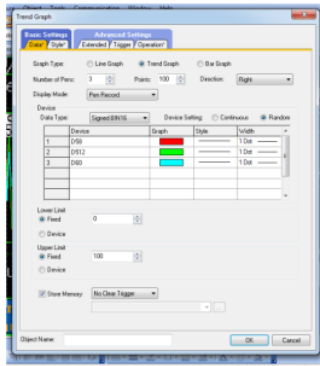




373	VAR ▾	Res_Out_Service_Cntrl	M208	%MX0.208	BOOL	FALSE	Res out of service confirmation to HMI
374	VAR ▾	Res_Out_Service_PB	M209	%MX0.209	BOOL	FALSE	Res out of service MHI Push button

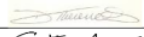
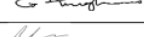


52	VAR ▾	Pump_pid_Manual_SP	D102	%MW0.102	INT	0	SETPOINT
----	-------	--------------------	------	----------	-----	---	----------



29	VAR ▾	Pumps_PV	D58	%MW0.58	INT	0	TREND
149	VAR ▾	Delivery_Pressure_SP	D512	%MW0.512	INT	0	SETPOINT
31	VAR ▾	Pump_CV	D60	%MW0.60	INT	0	TREND

Tagging new buttons on the HMI screens using addresses from the PLC programme.

Student signature	
Supervisor Signature	
Lecturer Signature	

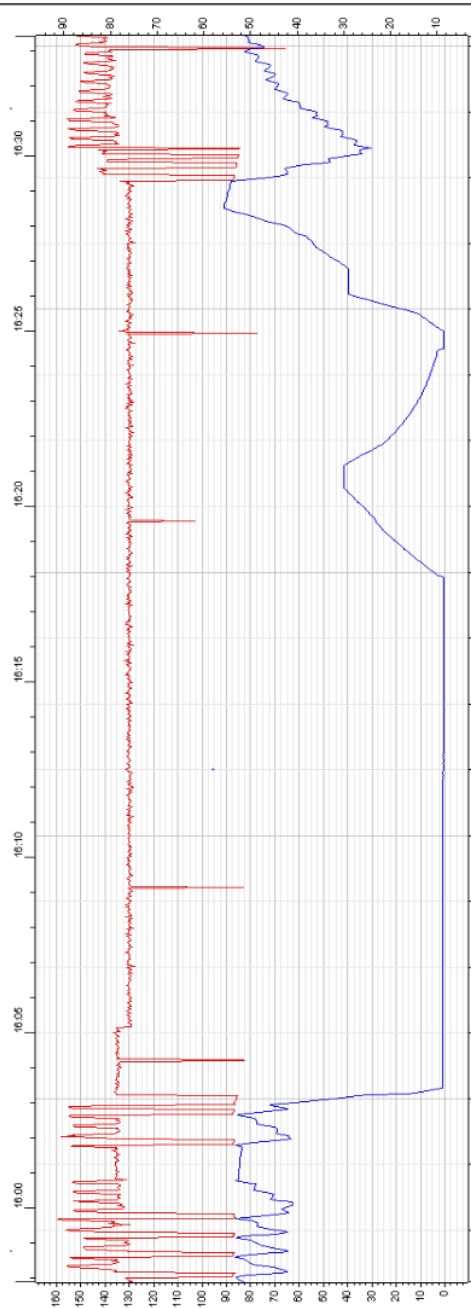
Log Sheet

Log No	17
No hrs	15
Running total hrs	127

16/3/2021 to 23/3/2021

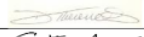
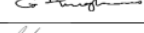
The new programme was uploaded on to the PLC and tested.

Test	Expected result	Actual results
Download new programme	System should run as normal with no issue	System ran as normal
Switch system from level control to pressure control	Pump should ramp up or down to match the selected pressure setpoint	Since the pressure was below the setpoint of 13.5 the pump ramped up to reach this setpoint.
Leave system running for 10mins	Outlet pressure should be stable at selected setpoint	Pressure was maintained.
Open a flushing valve located after pumping station which will result in the pressure dropping	If the pressure drops then the speed of the pump should increase so that the setpoint is reached again	As the outlet pressure dropped the speed of the pumps did increase.
Shut flushing valve	As the pressure will rise the pump speed should reduce	When the flushing valve was shut there was a bit of overshoot, but the pump did ramp down and level off at 13.5bar
Power down system (Mimic power cut) as there is no UPS connected to the PLC	The PLC should keep the new PLC programme and should return to normal state when power is renewed.	After cycling the power, the system did restart.



The HMI was tested.



Student signature	
Supervisor Signature	
Lecturer Signature	

A very good detailed log book

1910593

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

76/100

PAGE 1

PAGE 2

Text Comment. A good summary

PAGE 3

Text Comment. A good breakdown of elements in the table of contents

PAGE 4

Text Comment. Good table of figures

Text Comment. Good use of tables

PAGE 5

Text Comment. Good informative introduction

PAGE 6

Text Comment. Good diagram to support explanation of problem

Text Comment. Good explanation and ref source

PAGE 7

Text Comment. Specification gives a good overview of what is required. There should be a detailed account of what system is going to be used and its requirements.

PAGE 8

Text Comment. Good Gantt chart with comparison of timelines for actual and predicted times

Text Comment. Good use of table for test plan

PAGE 9

PAGE 10

Text Comment. Good explanation with supporting ref source

PAGE 11

Text Comment. Good argument with supporting source and example

PAGE 12

Text Comment. Explanation is informative about PLC and options for programming

PAGE 13

PAGE 14

Text Comment. A good evaluation of the programming possibilities with the PLC

Text Comment. Good supporting image

PAGE 15

Text Comment. Image supports explanation

Text Comment. Diagram shows the scaling parameters clearly

PAGE 16

Text Comment. Image supports explanation and requirements

Text Comment. Original system is explained and supported with good image

PAGE 17

Text Comment. Good explanation and supported with informative images

Text Comment. PID block shows all parameters

Text Comment. AN image of the VFD would be useful here to support implementation

PAGE 18

Text Comment. Good design that meets requirements set out in spec

PAGE 19

Text Comment. Good images of HMI screen designs

PAGE 20

Text Comment. Good table of results

PAGE 21

Text Comment. Good trend indicating the PID control is operational

PAGE 22

Text Comment. Good explanation with supporting images

Text Comment. Out of service is activated on HMI

PAGE 23

PAGE 24

Text Comment. Good recommendation

Text Comment. This is a good mod to meet the customer needs

PAGE 25

PAGE 26

Text Comment. A good number of relevant sources used

PAGE 27

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PAGE 55

Text Comment. A very good detailed log book

EVAN THOMAS

0

RESEARCH-INFORMED LITERATURE



Research is good and plenty of evidence in the solutions. 7/10 Good number of relevant sources. 8/10

15/20

KNOWLEDGE AND UNDERSTANDING



The specifications outlines the requirements but should include details of the system requirements. 5.5/10 Solutions considered are covered in good detail and very good arguments are put forward. 8.5/10

14/20

ANALYSIS



Test results are fully explained and supported with good images. Testing using tables and HMI tests for customer requirements have been carried out. HMI test showed full sequence . Monitoring graph software used for trend analysis. 8/10 Conclusion is good with relevant recommendations. 7/10

15/20

PRACTICAL APPLICATION AND DEP.



Good Planning methods used such as Gantt chart with timeline comparison for actual and predicted times . Chart contains required details. Test plan using table of parameters is a good method for evaluation. 4/5 Solutions considered are explained in detail and very good arguments are drawn. Good diagrams and images support the arguments. 8/10 Implementation is explained in detail. PLC config and program are covered very well in this section. Good images and diagrams support the process. 8/10

20/25

SKILLS FOR PROFESSIONAL PRAC.



A very good report with a good logical sequence and well written.

12/15