

Project Report – Spaleck 6th Dosing Pump & Upgrades

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07/07/2022

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L5 - Work Based Project

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Module Code – ACDA5016

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3. Spaleck 6th Dosing Pump Installation & Upgrades

3.1 Abstract

The overarching plan for the Spaleck finishing machine was to install an additional (sixth) pump, which will be used to feed cleaning chemicals into the rotating bowl. The engineering management team conducted a risk assessment on the plant to attempt to determine areas of concern which may require investment to improve lead times or reduce downtime. The current Spaleck machine was identified as an area of concern as when a single pump out of the 5 breaks down, the entire line must stop until a replacement is sourced and installed. This can take up to a day if not more which is not acceptable. Various solutions were thought up to allow the plant to prevent this downtime. The chosen solution was to add an additional pump to the 5 that are currently in place. This will allow more solution to be pumped into the bowl, as well as remove a single point of failure, as this pump can be switched to in the event of a pump failing, and then ran whilst the failed unit is being replaced.



[17] Figure 1 - Spaleck Logo

Aging plant has also been highlighted as high risk in the risk assessment that was conducted by production management. The parts that required changing included the HMI, the pumps, and much of the wiring on the pumps.

Spaleck provided The Royal Mint with a quote for their staff to replace the equipment. The engineering team asked if the project could be completed far cheaper than what they offered to drastically reduce the company's spending. Spaleck's work would cost a total of 46800.00 euros, which is £39630.90. The project must cost less than this to be successful.

At the time of the production of this report, the project was still in the planning stage so there is not implementation section present. However, all of the planning and required parts are listed to show the progress of the project up to the date of this report being written. The total cost of all of the required parts totalled to a far lower price than what Spaleck quoted, being £12965.34 rather than £39630.90. This does not include the man hours required to install the project however, but it would still be cheaper. The task will be planned in according to the Gantt chart, and signed off following the MOC sign off procedure in The Royal Mint.

3.2 Introduction

This report explains the overall project involving upgrades to existing production equipment at The Royal Mint, Llantrisant. The 'Spaleck' is one of two finishing machines that features a rotating bowl, in which coin blanks are mixed with varying types of polishing media. Demineralised water is then added to the bowl, mixed with different chemicals to aid with the finishing of the blanks. There are 5 pumps used to pump the fluids into the bowl. The main aim of this project is to add an additional pump to the machine so that there will be 6 pumps in total. This project report will contain all stages of the project, with information on how the project was planned, managed, and designed. However at the time of this report the project is still in the planning stage as the project was not yet started due to delays.

3.3 Background

3.3.1 The Plant

The project is based in The Royal Mint in Llantrisant, UK. This plant specialised in manufacturing both circulation and collectors/commemorative coins, as well as jewellery. The factory is involved in all stages of the manufacturing of the blanks, from the rolling of the metal strips, to punching out the shape of the coin (blanks), rimming the edge, plating the blanks, finishing them, and then finally striking them to be sent out to the customer(s).



[19] Figure 2 - Entrance of The Royal Mint, Llantrisant, UK

3.3.2 The Process Being Improved

The area of focus in this project and report is the finishing section of the process involved in producing collectors/commemorative coins. The finishing section of the coin manufacturing process involves carrying out some minor abrasion of the surface of the blanks to polish them and allow the plate to have a more smooth appearance before striking. This occurs by the operator placing blanks into a rotating bowl, mixed with a varying type of polishing media as well as a cleaning solution. The polished finish on finished blanks results in a more accurate and more attractive finish on the struck coin, due to the surface being more consistent and flat/smooth, as shown in figure 3. When the blank is struck between two dies, the metal will flow into every peak and trough in the die more consistently as any high or low points in the blank have been reduced in severity due to the abrasion process.



Figure 3 - Cut Blank (Left), Finished Blank (Right)

3.3.3 Operation of the Finishing Machine

The Spaleck finishing machine operates by requiring the operator to first insert a type of media, which varies in shape and material. This media may consist of ceramic or metal cone shaped pieces, or round balls made of either a ceramic material or metal. These abrade against the coin blanks to polish the face to an almost mirror finish. The operator must also set the composition of the liquid entering the bowl by selecting different chemicals and soaps to be placed on the bund underneath the pumps. This mixes with demin water to lubricate and clean the blanks as they are finished in the bowl. The blanks are then placed into the bowl which can be seen at the centre of figure 4 and 5, then the machine is started by the operator vis the HMI. The nozzles then move into the bowl automatically and the bowl begins to rotate at high speed to polish the blanks. Once the cycle is complete, the bowl then tilts forwards to pour the blanks and media onto the vibrating conveyor, which separates the blanks and shakes the remaining fluid off of the blanks.



Figure 4 - Rear View of the Spaleck Finishing Machine

The HMI is mounted on the panel shown on the left here, finishing bowl and vibrating conveyor is at the centre, and the pumps and electrical control panel is shown on the right.



Figure 5 - Spaleck Bowl and Conveyor

3.4 Planning

3.4.2 Issues Highlighted by the Risk Assessment

Different products such as blanks that are polished and cleaned in this process require different finishing chemicals to be added for the blanks to have a clean and smooth surface finish once the process is completed. These chemical containers are positioned beneath the pumps as shown in figure 6. For the chemicals to be changed for different products, the chemical containers that the pumps take fluid from must be manually switched between by carrying them around the machine. An additional pump will allow the changeover process to be reduced to the switching of a button as the other chemical can be stored at the additional pump. This reduces the frequency of chemical container changes to reduce the handling of hazardous chemicals, and drastically reduces the time taken to change chemical mixture due to not needing to carry the tanks around any more. This improvement also prevents a single point of failure as there is an additional pump to revert to by the operator simply switching to it via the HMI controls in the event of a pump failing.



Figure 6 - 5 Chemical Tanks Beneath the Pumps

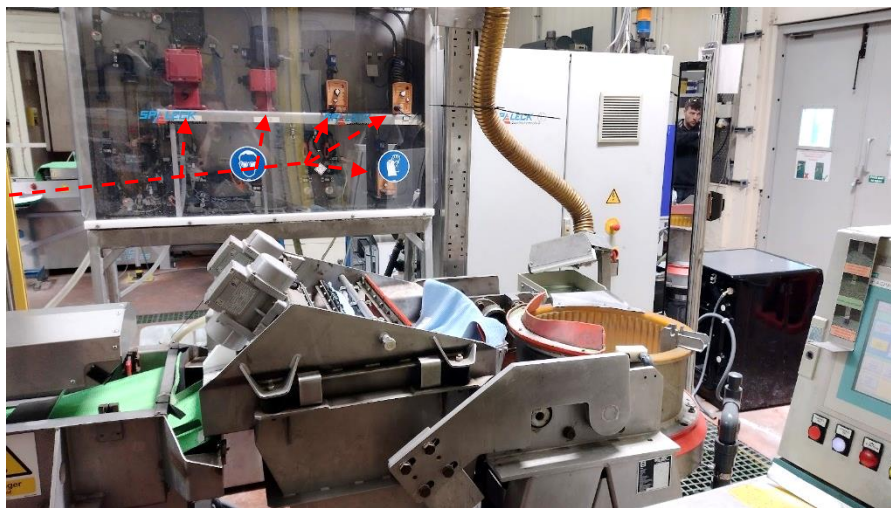


Figure 7 - Side View of the Spaleck Finishing Machine, With 5 x Pumps Shown

The 5 x dosing pumps can be seen here in the panel at the left side of the Spaleck machine. These pump from plastic containers placed on top of a bund underneath the panel.

Aging plant has also been highlighted as high risk in the risk assessment that was conducted by production management. This is because much of the plastic pipework, sensors, buttons, wiring, and the pumps themselves have suffered severe corrosion over the last 10 years due to the humid atmosphere present in the room, and with contact with the corrosive cleaning solutions. Numerous breakdowns have recently occurred due to cable sheathing going brittle and cracking, causing the unprotected conductor to be exposed and short out to various equipment nearby. Damaged cables can be seen in figure 9. This is also a serious health hazard to nearby staff as serious injury or death could occur in the event of someone coming into contact with exposed and unprotected live conductors. The wiring is in dire need for replacement as part of this project. There are different size pumps being used. This is to achieve different flow rates as required by the machine's original manufacturer.



Figure 8 - 5 x Existing Pumps

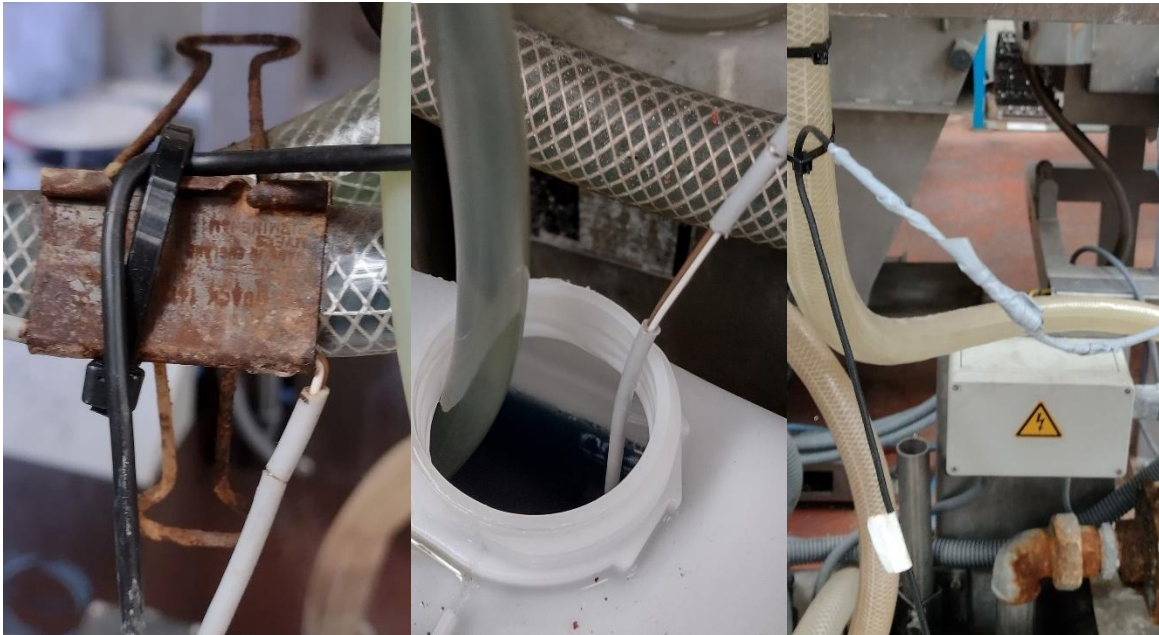


Figure 9 - Damaged Container Level Sensor Cables

The HMI (human machine interface) which is a display and control screen mounted at the side of the machine, was found to be obsolete. This is because the program can no longer be modified to accommodate the additional pump, as well as being generally too slow and unresponsive due to its age.

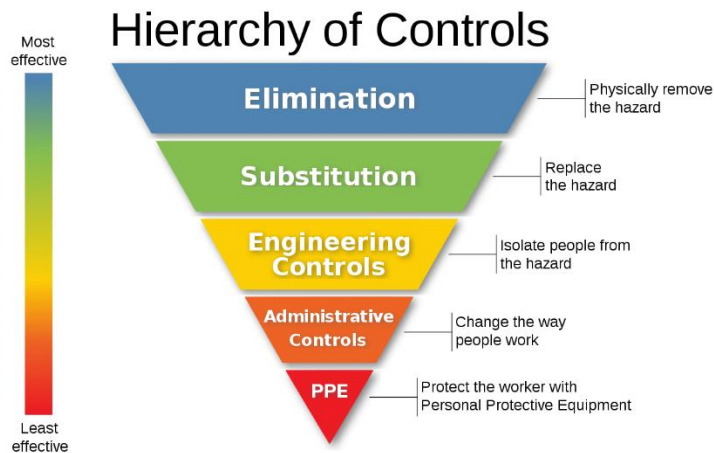


Figure 10 - HMI, Positioned at the Right Side of the Machine

3.4.3 What Are the Benefits to the Machine / Company?

The additional 6th dosing pump will result in increased production capacity due to the machine being able to continuously run uninterrupted as the operator no longer needs to manually switch the chemical containers around whilst the machine is down for changeovers. These containers need to be carried around the shop floor using pallet trucks, and the old chemical container must be taken to the recycling bin at the other side of the plant. This process can take anywhere between 30 minutes to 1 hour. This additional pump means the chemicals can be switched between by simply switching from one pump to the new pump via the controls on the HMI. The chemical tank can be switched over while the machine is running, minimizing the changeover period. This also drastically reduces the frequency that the operators must handle the chemical containers. This reduces the risk of them coming into contact with hazardous substances and potentially being harmed.

The HSE (Health and Safety Executive) states the hierarchy of control for risk assessments [1]. In the hierarchy, PPE is the last resort, and engineering controls is number 3. This reduced frequency of handling the substances due to the machine switching between containers and pumps is an engineering control and is a more effective risk control measure than simply giving operators PPE



[18] Figure 11 - Hierarchy of Controls

With many of the machine's equipment and components being found to be obsolete and failing, the project will aim to replace all of this with brand new equipment. This will prevent downtime due to breakdowns which have been identified as increasing in frequency and severity. The PUWER (Provision and Use of Work Equipment Regulations 1998) requirements state that the employer must maintain all production equipment in an efficient state and order, as well as being safe to operate for employees [2]. As the equipment on this process has become hazardous to employees with the live conductors being exposed on the corroded cables, the machine does not comply with PUWER. This project will involve replacing all damaged and corroded cables and components on the machine, with all required equipment being added to the parts list.

3.4.4 Electrical Design

3.4.4.1 PLC and HMI

The Siemens SIMATIC S7-300 PLC has been working flawlessly without any breakdowns recorded, so this is being kept to minimize expenditure. There are spare inputs and outputs in one of the I/O modules attached to the rack PLC (32K1) which is shown in figure 12.

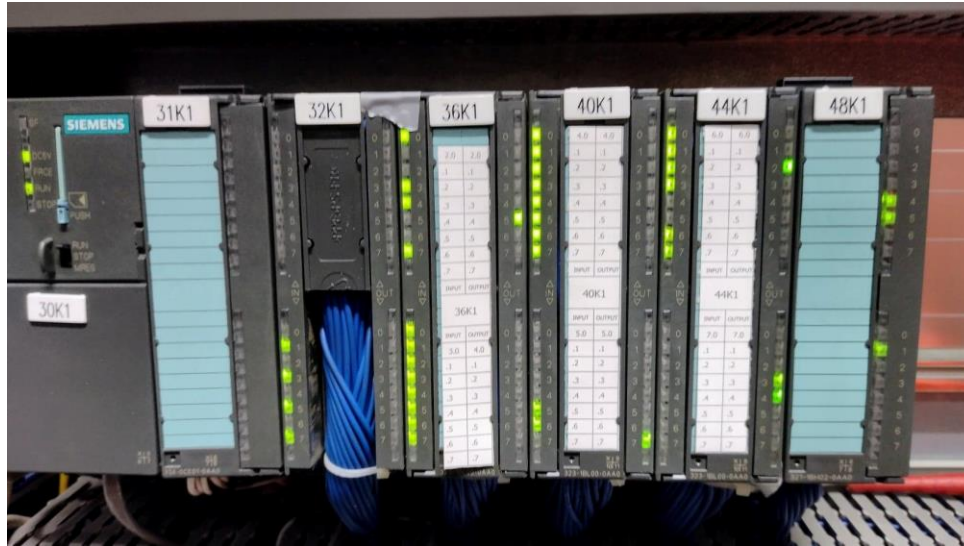


Figure 12 - Spaleck PLC (Siemens SIMATIC S7-300)

The HMI communicates to the Siemens PLC via an RS422, and has some supply cables connected to power it. Installing the new HMI will simply require cutting a 12 inch hole in the panel rather than the current 10 inch, re-connecting the supply cables, and plugging in the RS422. This is pretty much a straight replacement. Programming and designing the user interface will require assistance from the engineering team.

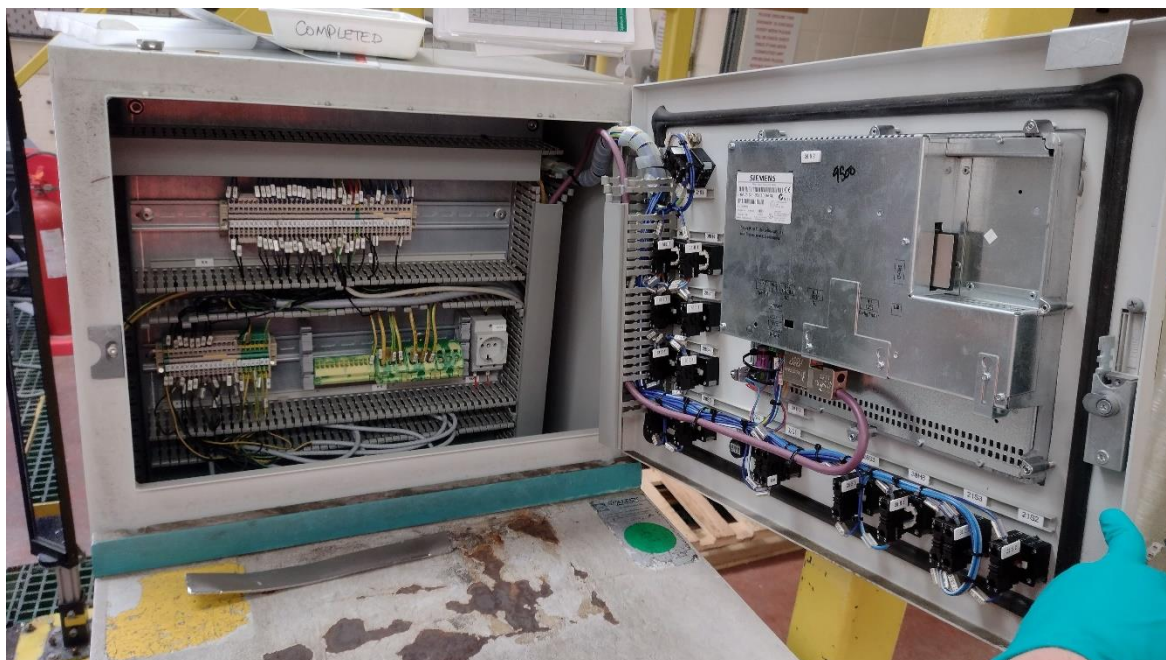


Figure 13 - Rear of HMI

3.4.4.2 Modifying the Electrical Diagrams

For every piece of machinery in the plant, the electrical and mechanical drawings are stored safely in the Engineering Maintenance Workshop. When any changes are made to the electrical control circuit, the changes must be shown in the circuit diagrams. This ensures that electricians and maintenance staff can have a good understanding of the circuits on the equipment in future, when further changes are required or during fault finding activities when breakdowns occur.

The electrical equipment that is being installed or replaced includes the following:

- Five existing pumps (three 240V two phase pumps and two three phase 415V pumps).
- Additional two phase 240V pump.
- Human machine interface.
- Flow control switches

The drawings have been edited in pen to be made changed in software later. There are spare cores in the multi core cable that runs between the control panel and to the pump cupboard to supply the new additional 6th pump. The pumps are controlled by the PLC. PLC sends an output to the contactor for each pump, this then switches the pump on or off. The input/output module 32K1 has a spare output at Ao.0 which can be used for the 6th dosing pump contactor signal. This can be seen in figure 14, where the PLC and it's outputs for this page are shown at the top, then the signals run downwards to the contactor for each PLC output. The new dosing pump will be connected to a new contactor called 35Q8, shown in figure 13. This contactor has a rating of 4kW, which is more than enough for the 9.6W rating of the pump being installed. [3] The panel itself is in an acceptable condition so this does not require replacement as part of this project.

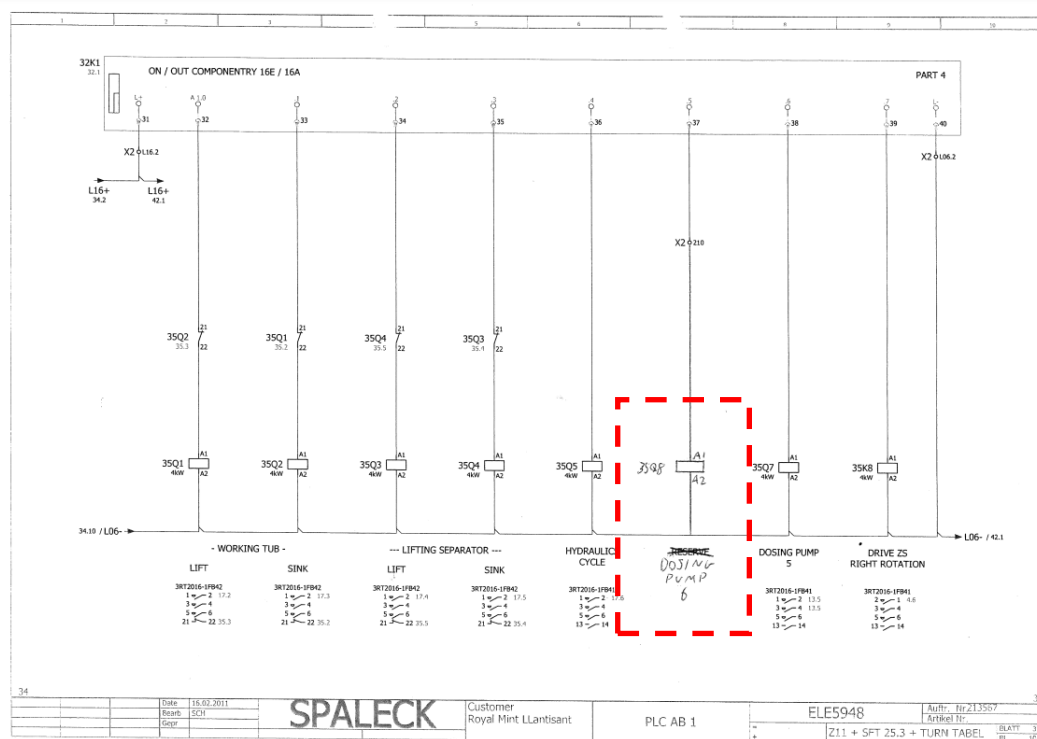


Figure 14 - PLC I/O Module 32K1 with Pumps 5 & 6 Contactors Drawing

The contactors for the other 4 pumps are shown in figure 15.

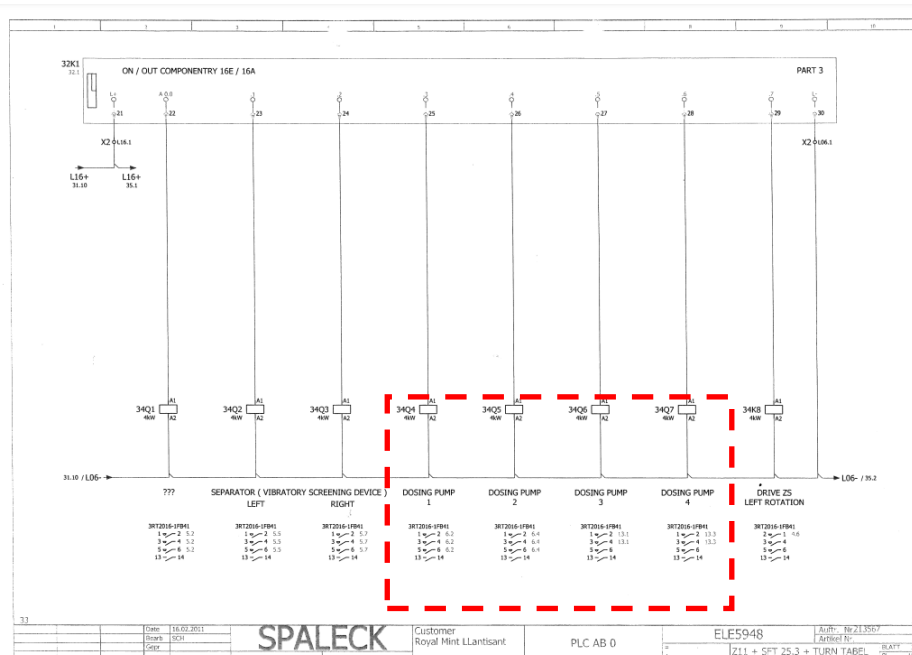


Figure 15 - Contactors for Dosing Pumps 1, 2, 3, & 4 Drawing

Next, the drawing for the contactor switching connections for the supply to the new pump must be modified. The same supply connections have been used for each pump as shown at the top, shown in figure 15, live and neutral (240V). The live and neutral supplies then run through plug 6X1 on cores 13 and 14 which are spare cores, shown in figure 16. This then connects to the pump's live and neutral connections via the X6 line of connector blocks 617, 618, and 619 in a panel external to the main control panel, then to the pump via a cable and socket. The new pump has been labelled as 13M4 for traceability to the circuit drawing. The cable between the panel and new pump were originally for a potential spare 3 phase pump left by the original manufacturer. These were used for this single phase pump with the 3 phase drawing being edited to show this change (shown in figure 17).

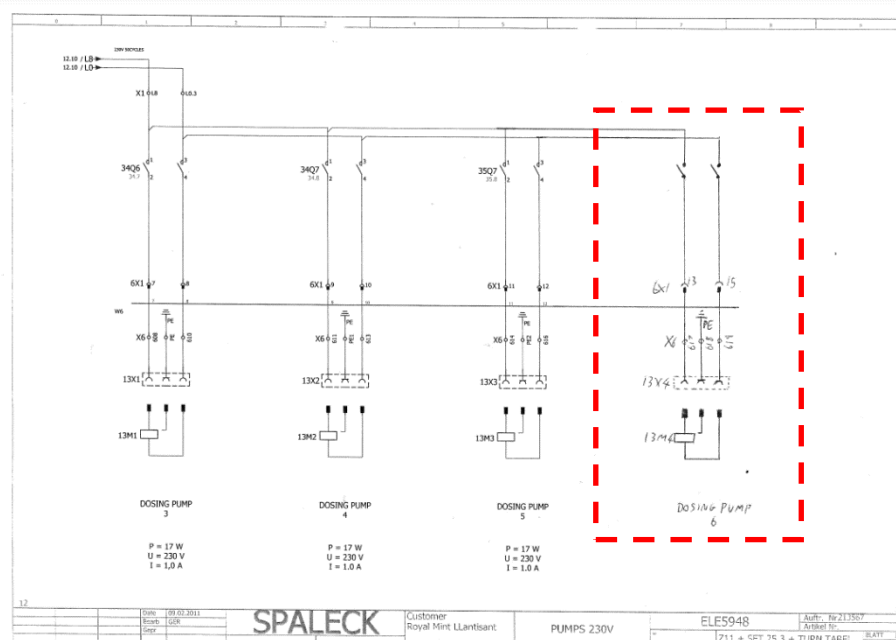


Figure 16 - Dosing Pump 6 Supply Connections Drawing

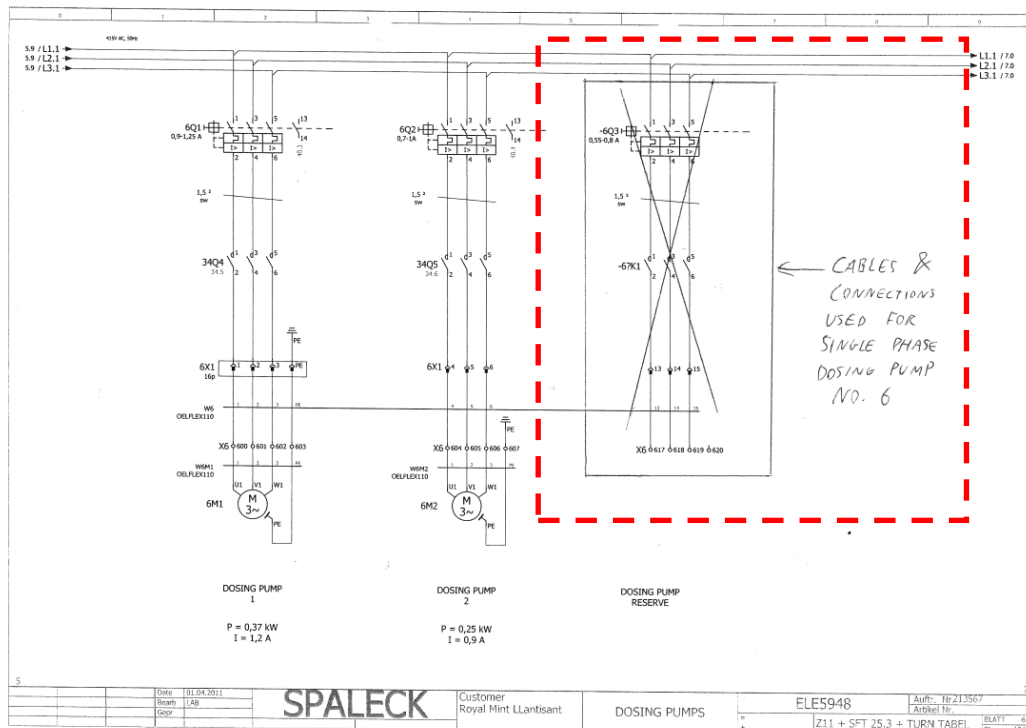


Figure 17 - Edited 3 Phase Spare Dosing Pump Supply Drawing, Showing Cable Numbers Used for New Pump

The next drawing that must be modified is the flow control drawing, with the flow control switches. These are used to notify the PLC that a fault has occurred with one of the pumps and stop the machine. These monitor the flow, and send a signal to the machine when there is fluid flow present, and switches the signal off when there is no flow. If the PLC is signaling for a pump to operate, the flow switch should see fluid flow. However, if it doesn't it notifies the PLC and operates a fault state to stop the machine. There could be no flow due to either the pump failing, a blocked or leaking pipe, or the flow controller cable may have disconnected or broken. This can be seen in figure 18. A spare PLC input on card 44K1 (E7.0) was used for pump 6 flow switch.

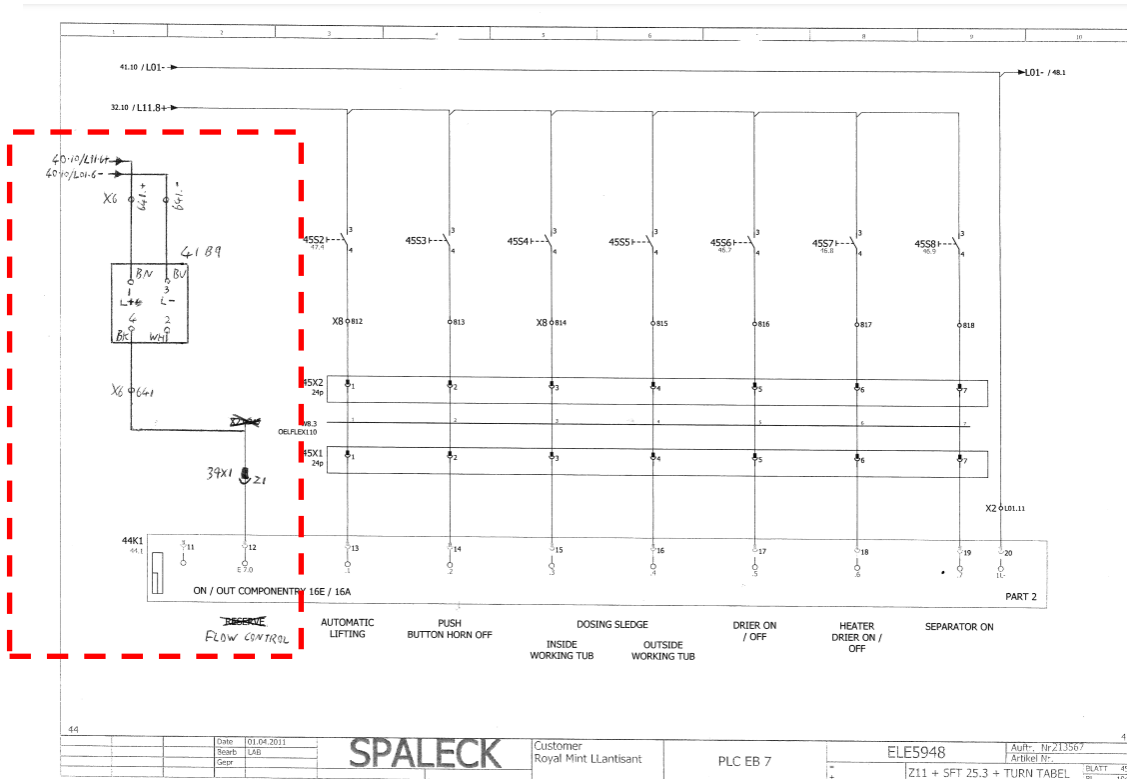


Figure 18 - Pump 6 Flow Switch Drawing

3.4.4.3 Electrical Drawings

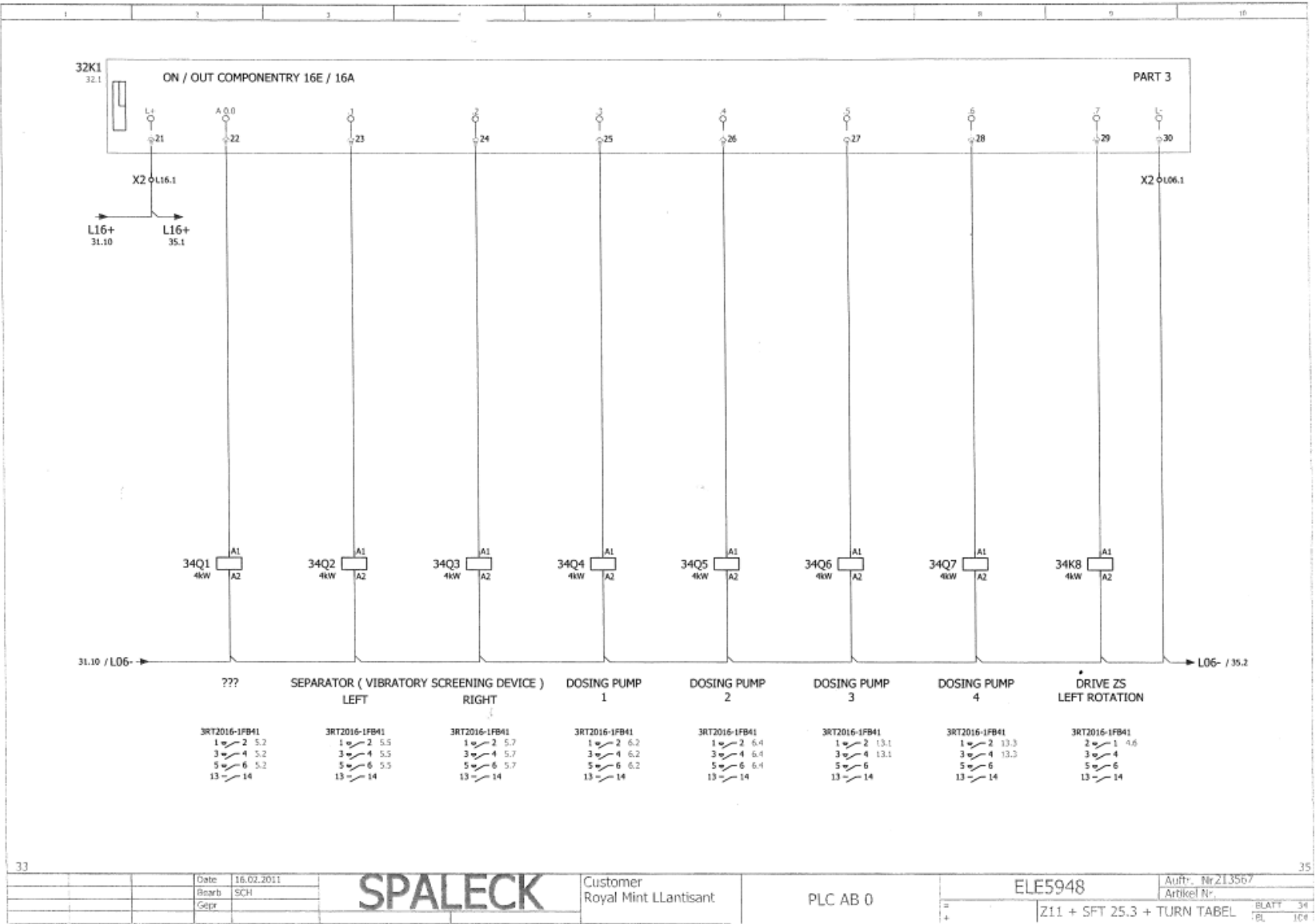


Figure 19 - Circuit Drawing | Dosing Pumps 1, 2, 3, & 4 Contactors & PLC Outputs

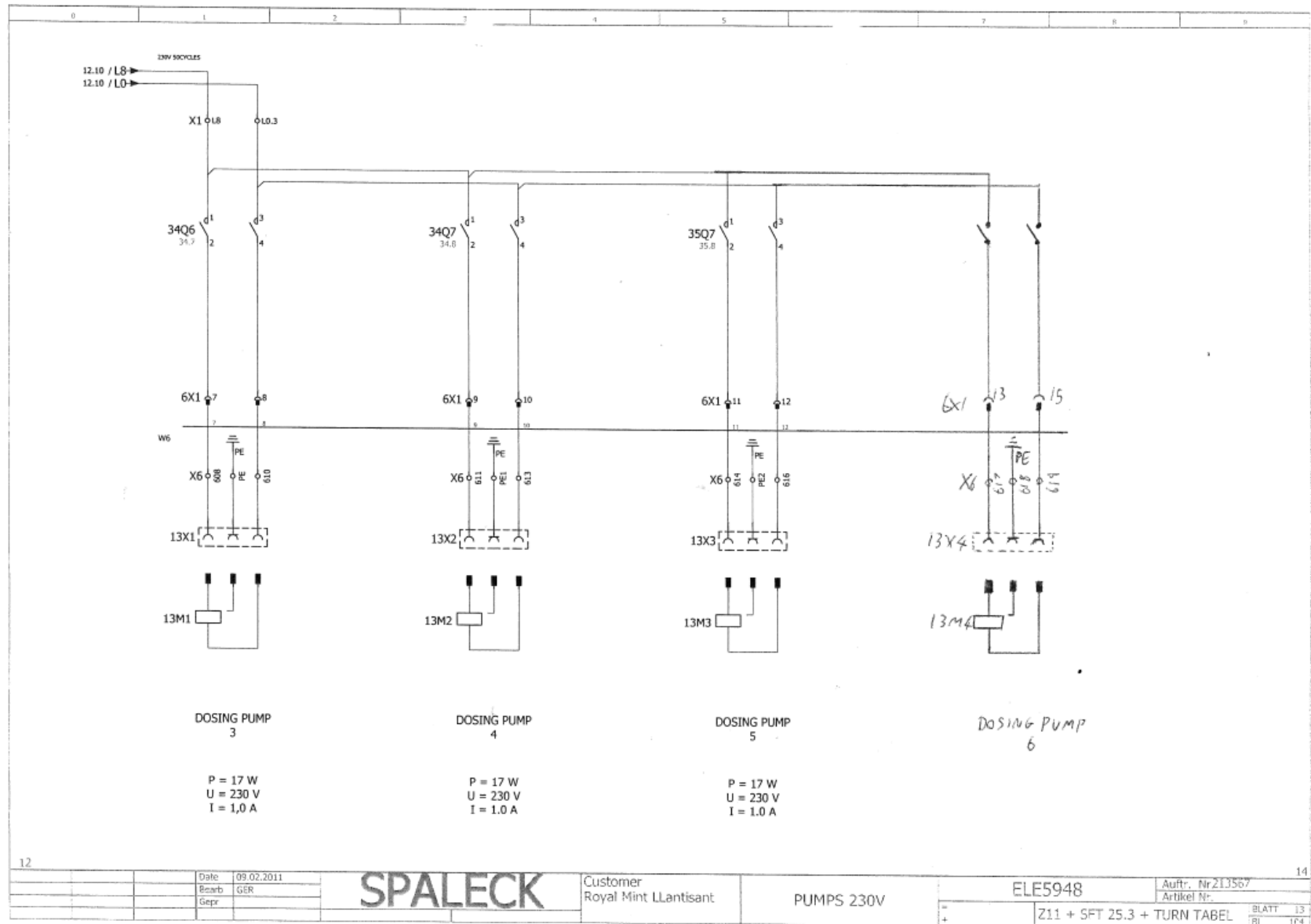


Figure 21 - Circuit Drawing | Electrical Supplies for Dosing Pumps 3, 4, 5, & 6 with Contactor Switching

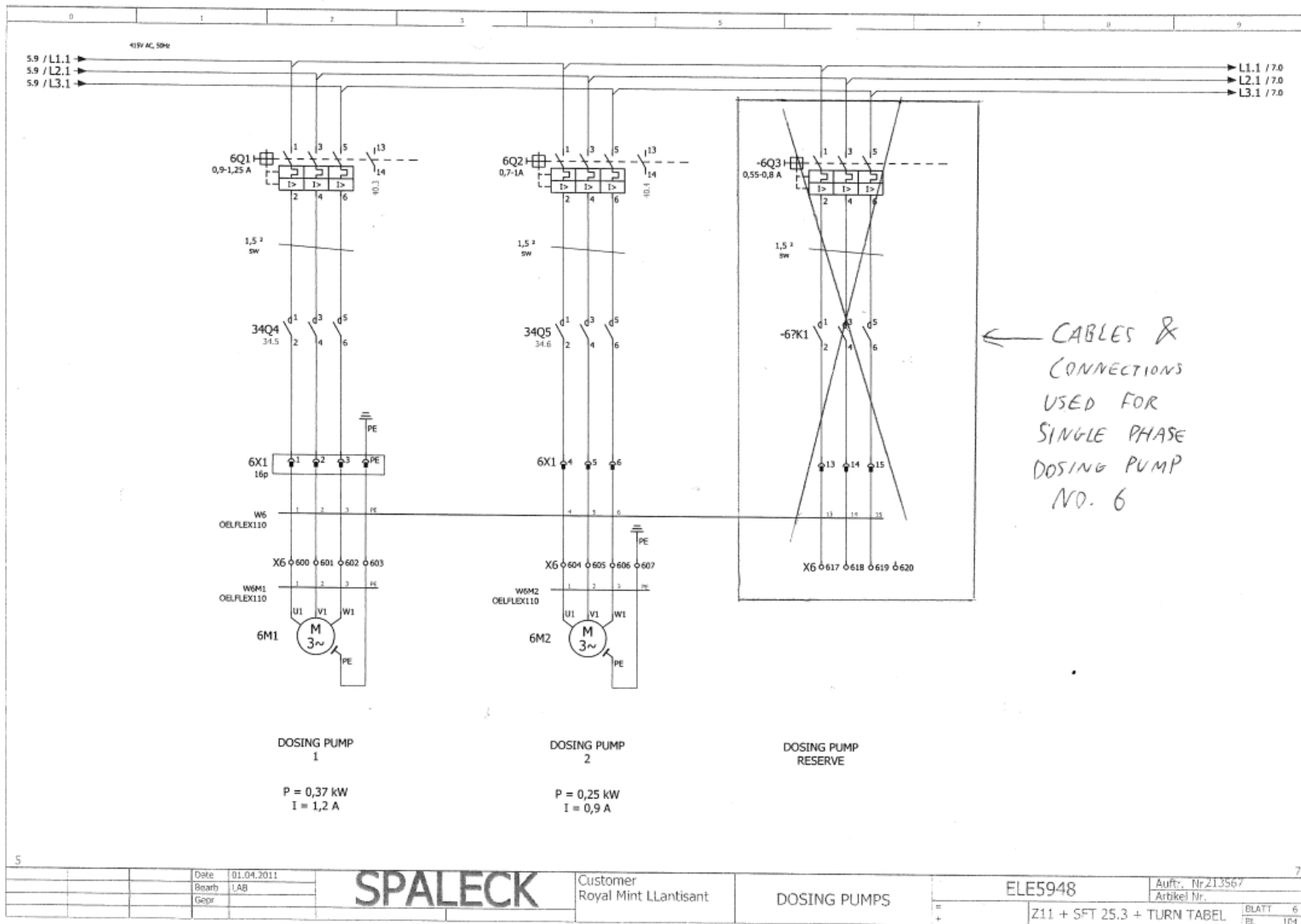


Figure 22 - Circuit Drawing | Reserve 3 Phase Dosing Pump Supply Cables Repurposed for Single Phase Dosing Pump 6

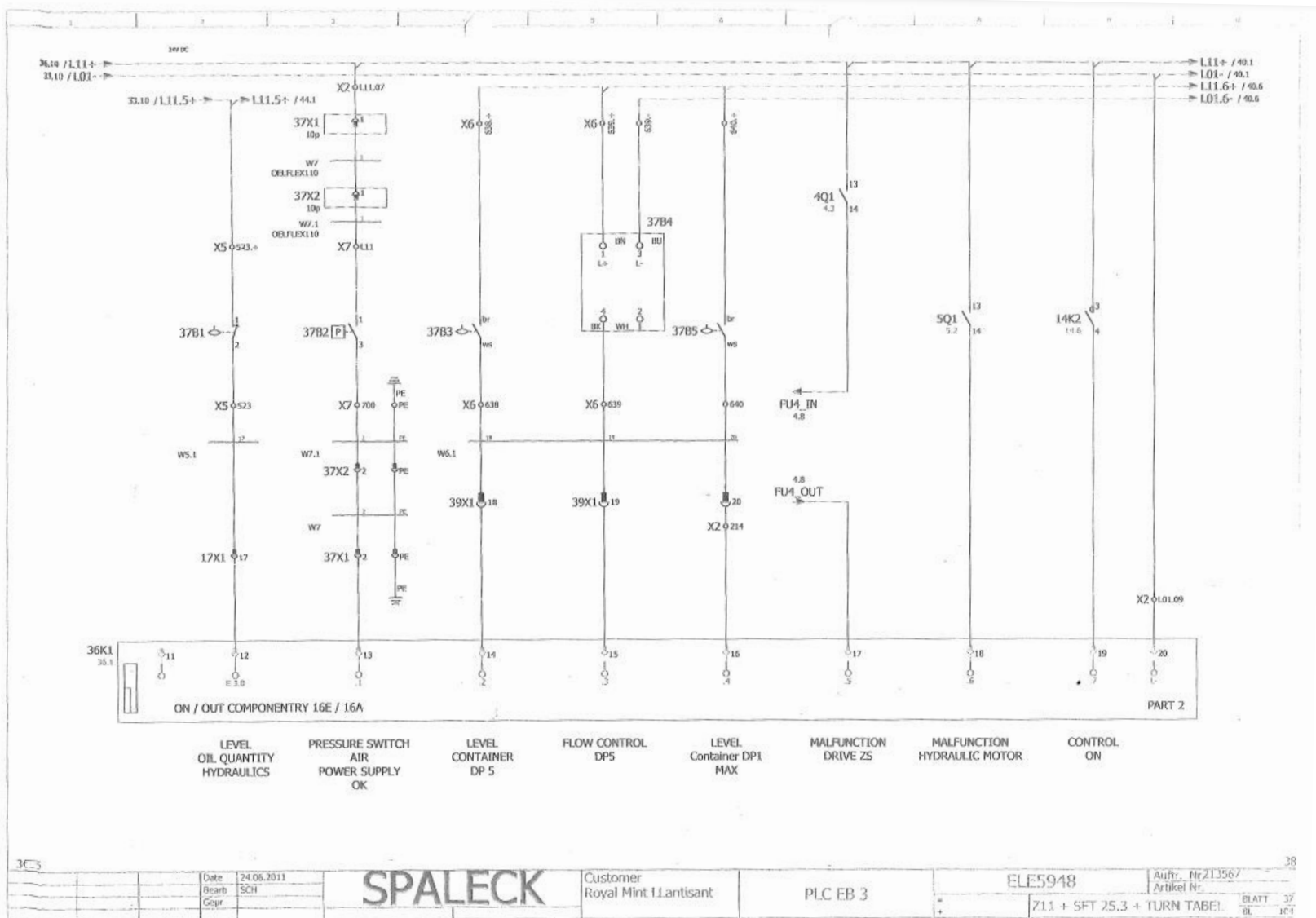


Figure 24 - Circuit Diagram | Flow Control Switch for Dosing Pump 5



3.4.5 Parts Selection

The required parts are listed in table 1 shown below. The 6th Pump and other pump replacements were chosen to be with the ProMinent BT4B 1601. This is because it is the closest match to the old obsolete pumps and suits the low required flow rate of 1.1L/hr. [4]

For the HMI, the Siemens TP1200 Comfort - 12" Colour Touch was chosen. This is because it will communicate with the Siemens PLC easily via an existing RS422/485 cable for the old HMI [5], and is IP65 externally, making it suitable for the damp environment. It is 2 inches larger than the current Siemens TP270 Touch-10 model, but there is space to accommodate it.

The other two larger pumps require a flow rate of 480L/hr and 100L/hr as required by the machine's manufacturer. For the 480L/hr pump, a 504L/hr pump was chosen. For the 100L/hr, a 114L/hr pump was chosen, as shown in parts list, table 1. These are designed to be suitable for aggressive media such as chemicals. [6]

The pumps that were chosen were selected as Brammer who orders all required equipment for the company, can order these pumps with this best price compared to other manufacturers, due to The Royal Mint regularly buying from these suppliers.

3.4.6 Parts List

Parts List				
Part Description	Image	Quantity	Price ea	Price Total
ProMinent BT4B 1601 Dosing Pump	 [7]	4	£736.00	£2944
Siemens SIRIUS Innovation 3RT2 Contactor, 110 V ac Coil, 3 Pole, 9 A, 4 kW, 3NO	 [8]	9	£31.66	£284.94

RS PRO Black 2.5 mm ² Single Core Control Cable, 13 AWG, 50/0.25 mm, 25m		1 Drum	£24.85	£24.85
	[9]			
RS PRO Green/Yellow 1.5 mm ² Single Core Control Cable, 15 AWG, 30/0.25 mm, 25m		1 Drum	£16.02	£16.02
	[10]			
RS PRO Blue 1.5 mm ² Single Core Control Cable, 15 AWG, 7/0.53 mm, 100m		1 Drum	£66.92	£66.92
	[11]			
RS PRO Vertical PP Float Switch, Float Type, 300mm Cable, Direct Load, 140V AC Max, 200V DC Max		7	£5.08	£35.56
	[12]			
Siemens TP1200 Comfort - 12" Colour Touch		1	£2833.00	£2833.00
	[13]			
Siemens 2.8 → 4 A Sirius Innovation Motor Protection Circuit Breaker		1	£67.45	£67.45
	[14]			

Lutz-Jesco Memdos LB510 Motor Pump 504L/H	 [6]	1	£2759.00	£2759.00
Jesco LB 110 PP FPM 400V Dosing Pump	 [15]	1	£1533.60	£1533.60
Thermal flow switch SDN 506 series	 [16]	6	Price on request, Approximately £400 ea	£2400
				Total Price : £12965.34

Table 1 - Parts List

3.4.7 Gantt Chart

			25/07-29/07	01/08-05/08	08/08-12/08	15/08-19/08	22/08-26/08	29/08-02/09	05/09-09/09	12/09-16/09	19/09-23/09	26/09-30/09	03/10-08/10	10/10-14/10	17/10-21/10	24/10-28/10	31/10-04/11	07/11-11/11	14/11-18/11
ID	Task Name	Duration	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17
1	Management of change raised	1																	
2	Physical change MOC to be raised	1																	
3	Process change MOC to be raised	1																	
4	MOC closure signing	1																	
5	Project approval	1																	
6	Identify required equipment for replacement	1																	
7	Investigate wiring requirements	1																	
8	Speak with engineering department to confirm wiring and equipment for replacement	1																	
9	Make temporary wiring drawings to follow	1																	
10	Order all required equipment with Brammer	1																	
11	Delivery of parts	2																	
12	Dynamic risk assessment	1																	
13	Electrical disconnection of equipment (Myself)	2																	
14	Mechanical removal of pumps (Mechanical team)	1																	
15	Mechanical Installation (Mechanical team)	1																	
16	Electrical installation of HMI and wiring to pumps and flow switches.	3																	
17	PLC Programming	1																	
18	HMI set up and program design (engineering team will assist)	2																	
19	Commission and test machine with operator and engineering team	1																	
20	Modify wiring drawings in wiring software	1																	
20	Sign off	1																	
21	Design review to be completed	1																	
22	Stat inspection	1																	

Table 2 - Gantt Chart

When tasks are completed early, they will be marked green, or red if late. This will be utilized to plan and complete the project as soon as possible.

3.5 Conclusion

To conclude, the project is so far successful, even though it is still in the planning stage. This is because the maximum cost of parts to order, being £12965.34 is far less than the original manufacturer's quoted £39630.90 for the same project. The roughly drawn circuit diagrams have aided with designing the circuit thus far, and these will be replaced with software edited diagrams, using Solidworks Electrical. This project will help to ensure the plant follows continuous improvement, by constantly keeping production equipment up to date with the most reliable and robust equipment available. The project will be carried out according to the Gantt chart.

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