

1909757

by Scott Jones

MOST REQUIREMENTS OF THE BRIEF HAVE BEEN MET BY THE PROTEST, BUT THE REPORT LACKED DETAIL. PROTEST MANAGEMENT TECHNIQUES WERE EVIDENT, BUT THE DEGRADATION OF THE PROTEST IMPLEMENTATION WAS A WALL OF RED.

EXTENSIVE CONSTRUCTIVE FEEDBACK GIVEN.

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Introduction

The Technology Centre at Marelli UK were approached by Jaguar Land Rover and asked to provide them with a machine that is capable of carrying out inner erosion tests on their heat exchange products. The Technology Centre at Marelli UK is responsible for overseeing the design and testing of the heat exchange products supplied to Jaguar Land Rover UK, this meant that the new machine would be based in the Technology Centre so that the engineers responsible for testing could ensure it was carried out correctly before putting the heat exchange products into production.

The new machine could have been purchased from a local company however this would have been expensive and due to the limited budget available at the time the decision was made to bring me *Avoid using first person terms* into the Technology Centre one day a week to design and produce the machine internally, while still allowing me to gain maintenance experience in the main factory during the rest of the week.

The machine is required to perform high flow erosion testing, this means that a solution made up of water and antifreeze will be pumped through a car radiator (heat exchanger) at 300l/min and 107°C for a continuous 1440 Hours (60 days). The purpose of this is to simulate the lifespan of the radiator and measure how long it will last when it is out in the field, the product must last a minimum of roughly 40 days.

*Good
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mative
introduction*

Specification

What the Project Must Achieve

For this project to be considered successful the machine will need two pumps that are capable of pumping a water/antifreeze mixture, with a respective ratio of 60:40, through a car radiator continuously for up to 60 days. The mixture must be pumped through the system at 300 l/min and 107°C, there is a tolerance of ± 2 l/min and $\pm 3^\circ\text{C}$ which has been allowed by Jaguar Land Rover for this particular heat exchange product. The specification sheet provided is shown in [Figure 6](#).

A data-logger screen will be required to keep track of the variables mentioned previously which are being monitored 24 hours a day for a maximum of 60 days, the results recorder by this data logger will then be assessed by one of the test engineers to determine whether or not the heat exchange product meets the requirements of the customer.

Time and Budget Constraints

A generous timescale was given for this project, a completion date of the end of April 2021 was expected by the customer. It was important that the set timescale was met due to the customer needing the heat exchange products entering production by the end of summer 2021. This meant that the completion of the test machine by the end of April 2021 would give the engineers all summer to get the product within the expected specification ready to be in production as soon as possible.

The budget for this project was initially set at £5000, however due to some large breakdowns in the Technology Centre this budget was needed elsewhere. This left the project with no funding so any plans had to be scrapped and an alternative solution had to be used in order to produce the test machine.

Health and Safety Requirements

While work was being carried out on the project it was important that everyone involved followed all of the relevant Health and Safety rules and regulations, these include the following:

- The Health and Safety at Work Act (1974)
- Control of Substances Hazardous to Health (2002)
- The Provision and Use of Work Equipment Regulations (1998)
- Manual Handling Operations Regulations (1992)
- The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (1995)
- The Electricity at Work Act (1989)

It was also crucial that while in the work area everyone wore the correct Personal Protective Equipment (PPE) at all times. Due to COVID-19 Pandemic additional PPE was required alongside the usual PPE that is worn, which include:

- Steel Toe Capped Boots
- Work Clothes
- Safety Glasses if using the hand drill
- Gloves when working with hot water
- Face Mask (COVID-19)
- Face Shield – When Impeding 2 Metre Rule (COVID-19)

Due to the COVID-19 Pandemic a new 2 Metre Rule was put in place to protect employees, this rule was to be followed at all times and if employees needed to enter within 2 Metres of someone to assist them, they both had to wear a Face Shield for protection.

A Risk Assessment was produced to highlight any hazards that could cause injury to those working on the project. A risk rating has been calculated by multiplying the Probability of an incident occurring with the Severity of the incident if it was to occur, the higher the number the greater the risk involved. This is shown in [Figure 1](#).

Maintenance and Reliability Requirements

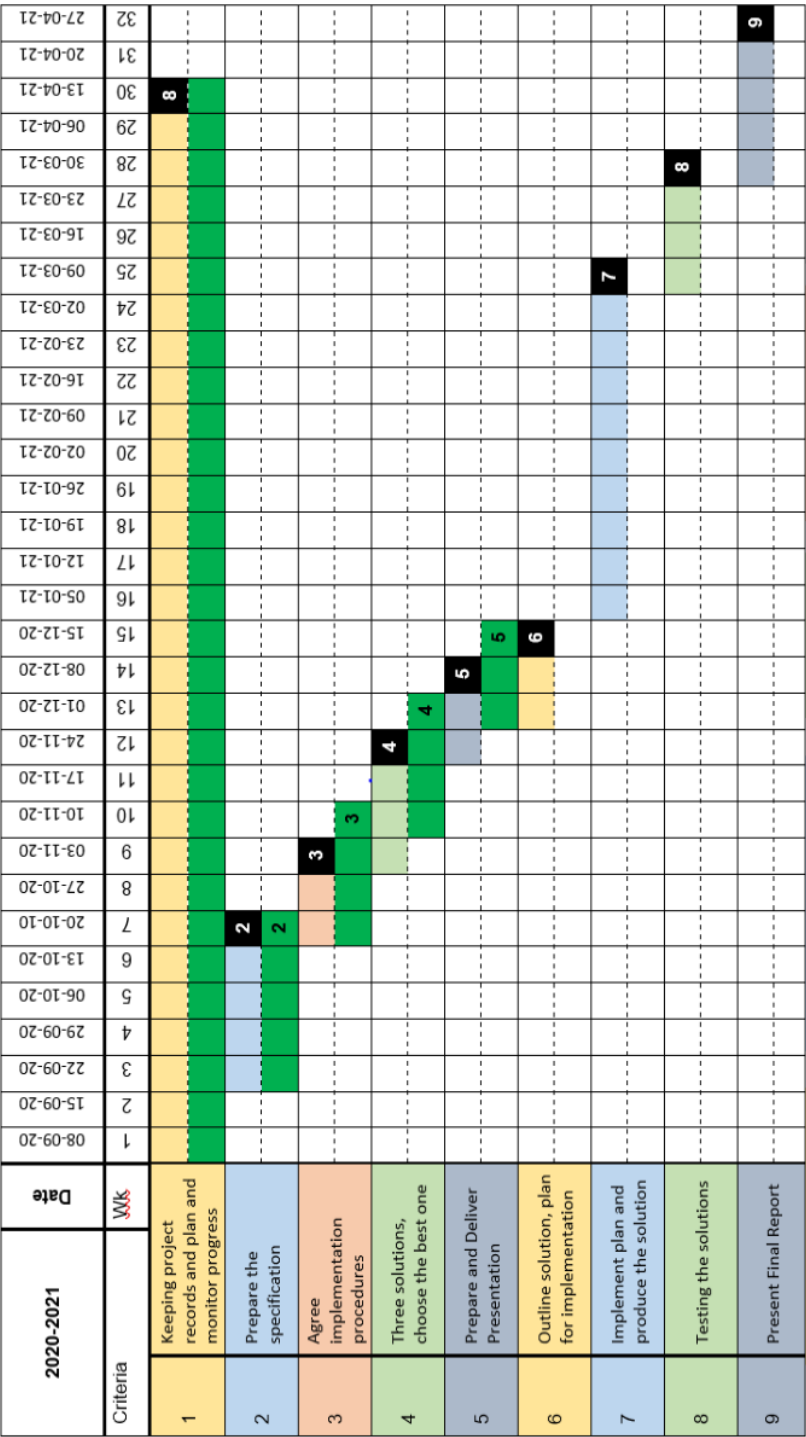
This Test Machine should be capable of running constantly for up to 60 days without fail in order to get the best test results for customer. When the machine is not running the maintenance department should carry out planned maintenance activities to reduce the risk of component failure during operation and to find issues before they occur. A planned maintenance sheet has been created which highlights all of the requirements for the planned maintenance task to be carried out, this is shown in [Figures 2, 3 and 4](#). A document was also produced which shows the installation instructions for the test machine being produced, this is a small bit of information describing the electrical and pneumatic requirements of the machine in order for it to run, this is shown in [Figure 5](#).

Environmental Protection

Due to the water/antifreeze solution being used in the testing of the heat exchangers extra care should be taken to ensure that any leaks are cleaned up in the correct way and when changing the solution for a fresh batch the old mixture should be disposed of in a way that complies with COSHH regulations to ensure environmental safety.

Planning

The Gantt Chart below shows the expected life span of the project. The coloured bars show the expected deadlines and the green bars show the actual time taken for each task to be completed.



Solutions Considered

Solution 1 – PLC Control

The first solution considered was to build the machine and implement PLC control via a Siemens PLC which would carry out all of the control operations required for the machine to function. The PLC would also be capable of performing PID Control on the system, this would allow the temperature and flow values to be as accurate as possible and react to any sudden changes in a way that would allow them to return to the correct levels as quickly as possible without overshooting the allowed tolerances.

Due to the maintenance department in the Technology Centre being made up of only two multiskilled electrical engineers it was important for the solution to be easy to fault find and understand. The two engineers who will be fixing and maintaining the machine are both competent and trained to use the Siemens PLC software, due to this the PLC could be used as a fault-finding tool to help them find faults more quickly than they may be able to on traditional hard-wired systems where there would be no visual indication provided in the form of a ladder diagram and electrical drawing would need to be utilised more often. Using this solution could mean a decrease in overall machine downtime not only for this machine but also other machines which may need attention at the same time, the quicker the engineers can find the faults the quicker they can be rectified and work can be started on the next machine.

Using a Siemens PLC also provides the opportunity to simulate the software and screens without needing to build the machine first. This will allow for testing to be carried out before the beginning work on the system, any necessary alterations can be made on the go and then re-tested. By simulating the software first, it would be possible to iron out any issues with the screens or software and then it would be ready to download and try out as soon as the hardware has been fitted and the machine has been built.

Some research was carried out to find some more information on the Siemens PLCs and Siemens Drives that would be required for this solution, these are shown in the Log Book.

(ManualsLib, 2012) (ManualsLib, 2012) (Siemens, 2018)

The PLC hardware required for this solution was researched on the Parmley Graham website and an overall cost was found for the components required. This cost breakdown is shown in [Figure 7](#).

A description is given on the possible function the PLC could have to benefit the project solution. This should be supported by an application

Shown below is a list of Advantages/ Disadvantages for this solution:

Advantages

- Easy to maintain and fault find
- Less wiring required
- All machine operations can be controlled from one screen
- Results can be simulated for testing

Disadvantages

- Expensive initial cost
- Maintenance must be PLC trained

Solution 2

The second solution was to build the machine using contactors, relays and a data logger screen instead of a PLC and HMI. This method would be much cheaper to carry out than solution 1 as all of the parts required could be salvaged from the spares in the Technology Centre and also from the main factory. There would be no need to spend large amounts of money on the PLC hardware and software required to carry out this build. The panel could be built in house and electrical drawings could be made up on Microsoft Visio, these drawings would be crucial for fault finding activities carried out by the maintenance engineers.

The maintenance engineers in the Technology Centre are capable of reading electrical drawings and fault finding without the assistance of the PLC software so this solution would also be manageable for them to maintain effectively.

The advantages and disadvantages of a hard-wired system are shown below, this list was then compared against the list produced for solution 1 and the most appropriate solution was chosen based on how its strengths improved the quality of the machine from both production and maintenance perspectives.

Advantages

- No programming required
- Cheap to build

Disadvantages

- Harder to fault find
- A lot of wiring required
- Requires a lot of buttons to operate
- Results cannot be simulated, the machine needs to physically run in order to test

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Final Solution and Implementation

The original solution that was chosen for this project was Solution 1, this was to use a Siemens PLC and HMI alongside drives that could all communicate to the PLC via ProfiNet connections. This solution would have allowed for the use of a Siemens HMI screen which would act as a control interface between the operator and machine allowing them to start/ stop the machine. The screen would have also displayed the values for the flow, temperature and pressure which could be monitored live or recorder so that the engineers developing the heat exchange product could assess the data from the test and pin point the exact time where the product failed. PID control would have been set up using the PLC and there would have been potential to add a product selection screen which would have allowed the operator to select a different type of heat exchange product, this would then select a different program in the PLC and the PID control would change to adjust the flow, pressure and temperature to the correct setpoint for the new product. This would allow the one machine to be used for the testing of multiple heat exchange products.

Although the PLC control from Solution 1 would have been the best solution, at the last moment before purchasing the software and hardware packages there was a major breakdown on one of the other machines in the Technology Centre which wiped out the whole budget for the project. This meant that there was no other option but to implement Solution 2 and build the machine using more dated technology and methods. This meant that electrical drawings needed to be designed for the system so that the wiring of the panel could be started, these drawings are shown in [Figures 8-19](#). Alongside the electrical drawings a flow diagram was produced to show the direction of flow of the water/ antifreeze solution around the machine and through the heat exchange product, this is shown in [Figure 20](#).

A list of the electrical parts required was then made once the drawings were complete, the parts list produced is shown in [Figure 21](#). As shown on the parts list there are part numbers for the critical parts, these numbers are the manufacturers part numbers and there is also a column for the RS part number, the Technology Centre purchases a lot of its parts and equipment from RS so the part numbers have been provided to make it easier for the maintenance engineers to source spares or replacements if they are necessary. Part numbers were not provided for items such as contactors or overloads as any type can be used as long as the engineer ensures that they are rated the same as what is already on the machine. The Declaration of Conformity for each of these parts is provided in the Logbook, these were found on the RS Components site and is a declaration that the parts are compliant with the claimed manufacturers specifications and British Standards.

Once the parts list was complete and all of the electrical components required had been found measurements were taken and a drawing was produced to plan the positioning of the buttons, lights and data logging screen on the front panel. The drawing was produced with accurate measurements and each measurement is shown on the drawing. The measurements or names can't be seen in the image shown in [Figure 22](#) as the window had to be zoomed out in order to show the whole panel, this is because it was drawn to scale using the computer software.

A plan was also produced for the layout of the inside of the electrical panel, the measurements of components were taken and the drawing shown in [Figure 23](#) was produced. A document was produced to go alongside the panel drawing which lists all of the abbreviations used and their meanings, this was done to make it easier for maintenance in the future when they are trying to fault find as they will be able to see where things such as the 24v and 0v terminals are just by looking at the panel layout drawing. This document is shown in [Figure 24](#).

Once the planning had been completed and all of the electrical drawings and panel layouts were finished the implementation of the project could begin. The front panel was measured out and all of the holes for the buttons, lights and the controllers were cut/ drilled out, the hole for the data logger was also cut out. All of the necessary components were fitted to the front panel and then the trunking and DIN rail was measured and fitted inside the electrical panel. The electrical components were all fitted to the DIN rail in the pre-planned location, the wiring was then started with the power circuit being wired in first. This was the cables from the isolator into the MCBs and overloads at the top of the panel, this is shown in [Figure 25](#). The wiring then comes down into the two inverter drives, there is one drive for each of the two motors, these drives are shown in [Figure 26](#). From the output of the inverter drives the power cable goes down the panel and into the contactors, from here the cabling goes out to the motors. The contactors are switched off timers, this creates a delay so that the first pump can build up enough pressure in the system before the other pump kicks in, these contactors are shown in [Figure 27](#) with the timers attached to the front.

Once all of the power connections had been made, Shown in [Figure 28](#), the control circuit was produced. The control circuit is the 24v circuit used for powering the controllers, timers, data logger and the safety circuit. The control circuit includes all of the buttons and lights used on the machine; this circuit is what will start the machine when the start button is pressed. All of the lights and buttons were wired up for the control of the machine as per the electrical drawings provided. The PILZ safety relay shown in [Figure 29](#) is what controls the safety side of the machine. The door guards and E-Stops shown in [Figures 30 and 31](#) will be fed by two channels, if the door is opened or the emergency stop is pressed then these channels will be broken and the PILZ safety relay will drop out,

taking with it any auxiliary connections. All of the 24v control circuit is run through the PILZ relay and when it drops out it will create a break in all of these circuits stopping anything that is currently running and not allowing anything else to start up until safe conditions have been met. The CAL Controller for the temperature can be set to send out an alarm signal at a desired temperature. This was set to 50°C and the alarm signal was used to lock the GuardMaster door guards so that the doors could not be opened until the temperature inside the chamber had returned to below 50°C. This was done to protect the operators from scalding which was a point highlighted in the risk assessment in [Figure 1](#).

The connections for the CAL controllers for the temperature and flow were then wired in, this is shown in [Figures 32 and 33](#). There is a thermocouple connected to the CAL Controller for the temperature so that accurate measurements can be made. Then the timer was also wired, there was a terminal block that the wires were connected to and this was then pushed onto the pins on the back of the timer, the terminal block is shown in [Figure 34](#).

The Data Logger Screen was then wired up, a second thermocouple is connected to the Data Logger to allow the temperature to be logged during the test. Flow and Pressure transducers are also connected to the Data Logger in order for it to display accurate readings, these transducers were calibrated using the calibration equipment in the Technology Centre. The connections on the Data Logger screen are shown in [Figure 35](#) and the Data Logger screen is shown in [Figure 36](#) with the graphed data.

The Drive and CAL controller parameters were set up and a document was created so that the maintenance engineers could insert the parameter values to replacement parts in the future if required, these parameters are shown in [Figures 39-41](#).

A hole was also drilled into the bottom of the test chamber at its lowest point and pipework was added to drain the water back to the tank. If the heat exchange product did fail and leak or one of the pipes blew off then the water would run down into the pipework where a flow switch would be triggered, this opened a valve to drain the water back to the tank and also put the machine into a shutdown mode where the pumps were shut off and the heater was knocked off so that the machine would be left to idle until the next test was started.

The Completed Rig is shown without all guarding attached in [Figure 37](#).

Testing

Testing was carried out on the Rig to ensure that it functioned correctly. One of the heat exchange products that would be tested on the machine was put inside and the hoses were connected to the inlet and outlet pipes on the radiators tank. The machine was switched on but it would not start the test, after fault finding it was found that the PILZ safety relay was not healthy, this meant that there was an issue with an E-Stop or door guard. When wiring the safety circuit each E-Stop or door guard is wired in series so to find the issue each door guard or E-Stop would have to be opened individually and tested, however when this machine was wired the cable would go from the terminal block out to the door guard and then back into the next terminal block before going out to the next guard or button in the circuit, this meant that the entire safety circuit could be tested from inside the electrical panel without needing to remove and open the door guards or E-Stop buttons, this is shown in [Figure 38](#). This made testing and fault finding the circuit much easier as the faulty guard switch or E-Stop could be identified and then targeted individually, the issue was that there was a loose connection on one of the guard switches, this was re-terminated and the safety circuit was healthy.

Once the test began and the flow, temperature and pressure had ramped up and settled reading were taken, these are shown below and they are also shown on the Data Logger Screen in [Figure 36](#). The flow rate on a full component test would be 300l/min but for this test it was set to 200l/min so that the machine would be able to run for the full period as the radiator would not blow as quickly as it would at 300l/min. The result is highlighted in green if it meets the required specification.

	Expected	Actual
Temperature (°C)	107	107
Flow (l/min)	200	202
Minimum Run Time (Hours)	1440	1440

The table of results is a good method

There is too much unnecessary detail in the explanation here

The Following testing table was produced.

	Expected	Actual	Pass/Fail
Temperature (°C)	The Temperature should rise to 107°C and hold steady for the test	The Temperature rose to the expected level and remained constant for the test duration	PASS
Flow (l/min)	The flow rate should rise to 200l/min (300l/min when in production) and remain within a tolerance of $\pm 2\%$	The flow rate rose to the expected level and fluctuated around the 200l/min set point, it did not veer more than $\pm 2\%$ from the set point	PASS
Minimum Run Time (Hours)	The minimum run time expected of this rig is 1440 hours, after which it should shut down and remain idle	The rig was able to run unsupervised over the weekend and accumulated a total of 1440 hours before safely shutting itself down	PASS
Safety Circuit	The rig should respond to any changed in the safety state such as E-Stops being pressed or door guards being opened	The rig was capable of responding to all Emergency scenarios and shutdown all activity within the allowed time frame	PASS
Leak Detection	The rig should be capable of detecting a leak and shutting itself off in less than 10 seconds while draining any liquid back to the sump tank to avoid leaking into the environment.	The rig was able to detect the leak and immediately shut off in half the time. It was able to drain the liquid back to the sump tank so that it could be re-used and it was successful at preventing any liquid leaking into the nearby environment.	PASS

Conclusion

In conclusion the project has been successful, the time scale set in September was met and the machine is currently being used in the Technology Centre to test Jaguar Land Rover's heat exchange products. The initial budget of £5000 has been met as all of the parts used were salvaged from around the Llanelli plant, therefore it could be said that aside from the wages paid to carry out this project there was no cost to produce the test rig.

The rig itself has passed all of the testing carried out as shown in the testing table above. The health and safety manager has been to the Technology Centre and assessed the machine from a safety standpoint and they were present to oversee the testing of the safety circuit. They are happy that the cut off time when the machine is introduced to Emergency Conditions is so low and they have signed the machine off as safe to run. Numerous test cycles were carried out and all of the results were saved on an SD card by the Data Logger, these results have been looked over by the lead engineer and also by a Jaguar Land Rover representative and both are confident that the rig will be suitable for the testing of the heat exchange products. Although the rig is running well it could have been improved by implementing the PLC and HMI screen, this would have streamlined the rig as all controls would be accessible from the HMI screen removing the possibility of damaging buttons and indicator lights which could affect the performance of the machine. Password protected screens could have been added for the maintenance engineers to manually operate the pumps and heaters to test their operation during a planned maintenance activity, the screen could have also been used to adjust the product setting allowing the process values to be changed to a new set value rather than adjusting the flow with a potentiometer as is the case now.

A filtration system could also be added which would filter the water/antifreeze mixture before it returns to the sump tank, this would be used to remove any swarf picked up from the heat exchange product. By filtering the mixture, it would dramatically extend its life meaning that it could be used for much longer than it is currently.

The leak detection system that was implemented will not only save the company money by saving the water/antifreeze from being wasted but it will also prevent the solution from leaking into the environment. The machine is sustainable as it does not produce any harmful emissions and if the suggested filtration system was added then the sustainability would be further increased as less water and antifreeze would be used.

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Available at: [https://support.industry.siemens.com/cs/document/70155469/sinamics-g%3A-speed-control-of-a-g120-\(startdrive\)-with-s7-1200-via-profinet-profibus-dp-with-safety-integrated-\(via-terminal\)-and-hmi?dti=0&lc=en-WW](https://support.industry.siemens.com/cs/document/70155469/sinamics-g%3A-speed-control-of-a-g120-(startdrive)-with-s7-1200-via-profinet-profibus-dp-with-safety-integrated-(via-terminal)-and-hmi?dti=0&lc=en-WW)
[Accessed 18 October 2020].

There should be more relevant sources for the research

Appendix

Hazard	Who Might Be Harmed?	Risk Rating			Precautions in Place	Further Actions Needed
		Probability	Severity	Risk		
Removing Guarding	People in the Area	2	4	8	Interlocked Guards	Be Cautious When Guards Are Not in Place
Drilling	Person Using the Drill	3	3	9	PPE	Competency Training
Electrocution	Person in the Panel	2	5	10	Panel Should be Isolated	Lock Isolator in the OFF Position
Scalding	Person Working on System	3	4	12	PPE	Wait for the System to Cool Down

Figure 1 - Risk Assessment

MAINTENANCE Checksheet				Ref: D52	
Maintenance instruction for:				D52	
Facility Maintained By:			Maintenance Approved By:		
Name			Name		
Signature			Signature		Date
Date					
			Hand Back to Rig Owner:		
			Name:		
			Signature:		Date
Safety note					
Ensure electrical and pneumatic supply has been isolated and locked off, and the test fluid is below 30 degrees Celsius before commencing any work.					
All safety guards removed for maintenance MUST be refitted on completion of this maintenance activity.					
Environmental note					
All fluids, filters, removed must be disposed of in accordance with Calsonic environmental safety procedures.					
Refrigerants must be decanted into recovery bottles.					
PPE					
PPE to be worn:		Safety Glasses			
		Gloves			
		Safety Footwear			
Maintenance Note					
Carry out the planned maintenance on the machine and fill in the check sheet as required.					
On completion of the planned maintenance activity, hand this check sheet to the rig owner for approval and handback back of machine.					
Once signed, scan this document and save a copy with the 'Internal Maintenance' folder in the relevant test rig folder.					

Figure 2 - Maintenance Check Sheet (1)

MAINTENANCE Checksheet				Ref: D52	
Maintenance instruction for:				D52	
Electrical					
Measure and record current draw on the following					
		Expected reading	Actual reading	Notes	
Voltage		415V			
Total current draw(coolant module)					
Heater					
Hot Coolant Pump @ 100% Speed					
Measure and record Zs value for incoming electrical supply				Ω @	kA
				(Zs value must not exceed Ω)	
Check operation of float switch in:					
Test Cell					
Fluid Return Tank - Level Switch					
Check operation of Emergency Stops:					
Rig control panel E-Stop					
Operation of GuardMaster Switches					
Door remains locked above 50°C					
Sample check electrical connections					
On 12 month service interval, change compressor contactor.					
Mechanical					
Check for leaks in the system:					
Coolant					
Air					
Check the fluid level of primary tank (Outside)					
Check operation of the actuators					
Clean all strainers					
Wipe down rig with machine wipes					
Run the test rig to ensure it is in full working order.					

Figure 3 - Maintenance Check Sheet (2)

D52 Installation Instructions

Electrical Supply Requirements

415V 3 phase Neutral earth

16A

Compressed Air Supply

Between 5-8 Bar

Figure 5 - Installation Instructions

- **PURPOSE:**

To subject a heat exchanger to thermal fatigue when coolant velocities are above 3m/s in plain tubes and 1.5m/s in dimpled tubes.

- **OPERATING PARAMETERS**

Operating Temperature: 107°C

Max. Flow Rate: 300 l/min.

Flow Rate Tolerance: $\pm 2\%$

Coolant Mixture: 15% Production Intent Coolant
85% Water

Test Duration: 60 Days (1440 Hours)

Reference in spec

Name	Part Number	Price
CPU 1215C Siemens PLC	6ES72151AG400XB0	£545.00
7" Colour Touch Siemens HMI	6AV21232GB030AX0	£646.00
Siemens Thermocouple Module	6ES72315QD320XB0	£300.00
0.75kw Siemens Drive	6SL32101KE132AF2	£466.00
2.2kw Siemens Drive	6SL32101KE175AF1	£649.00
	Total Cost:	£2,606.00

Figure 7 - Solution 1 Cost

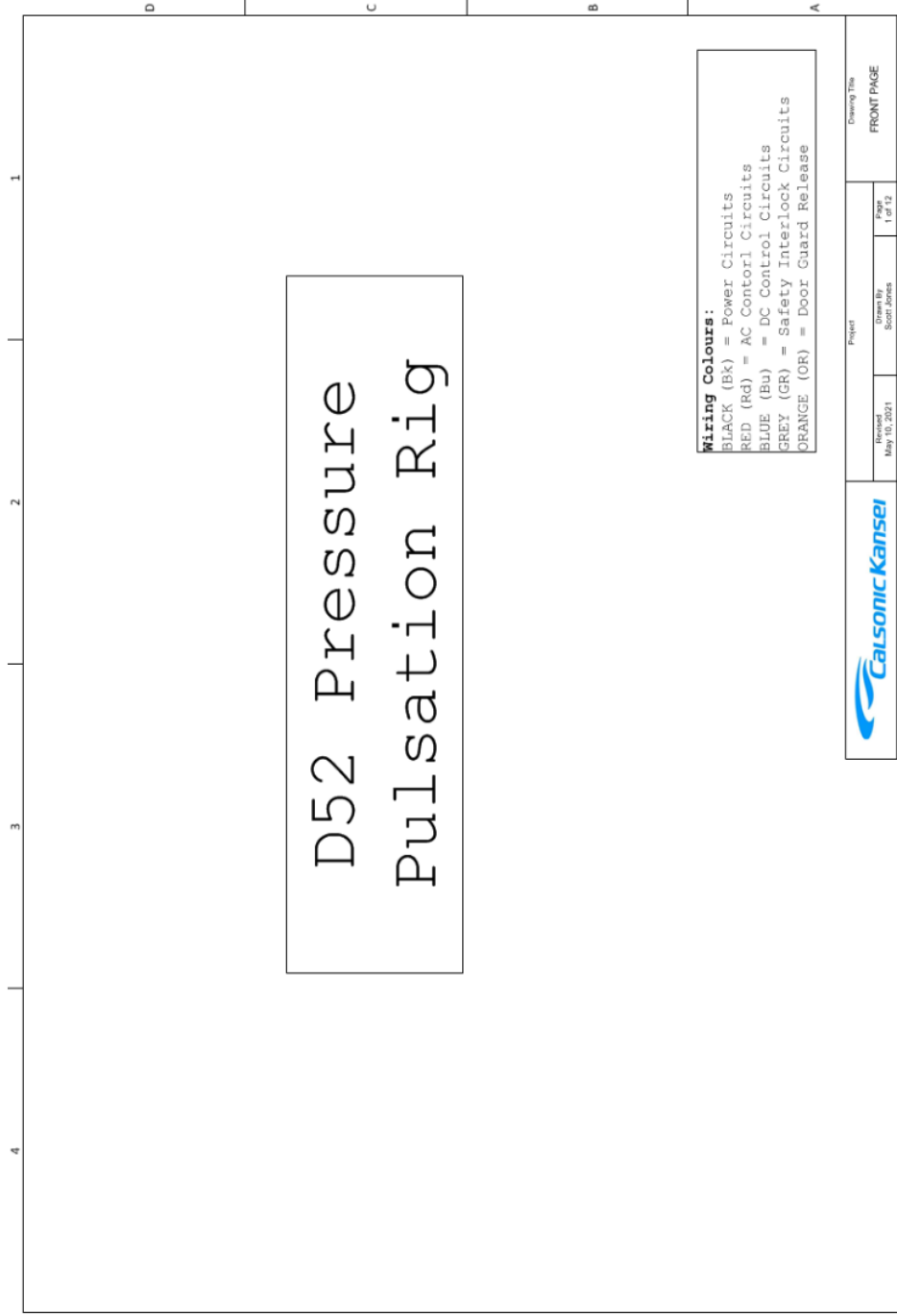


Figure 8 - Electrical Drawings

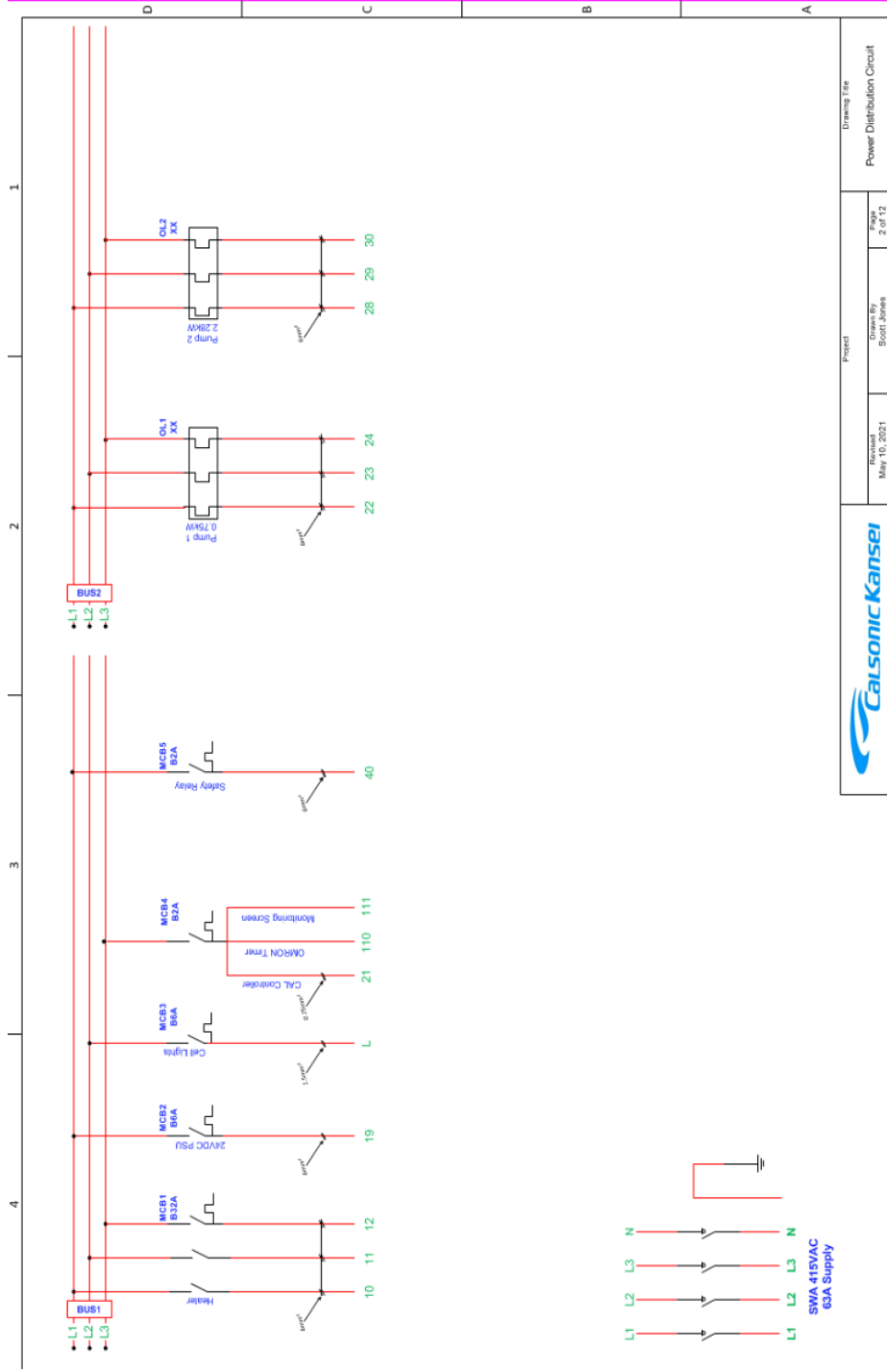


Figure 9 - Electrical Drawings

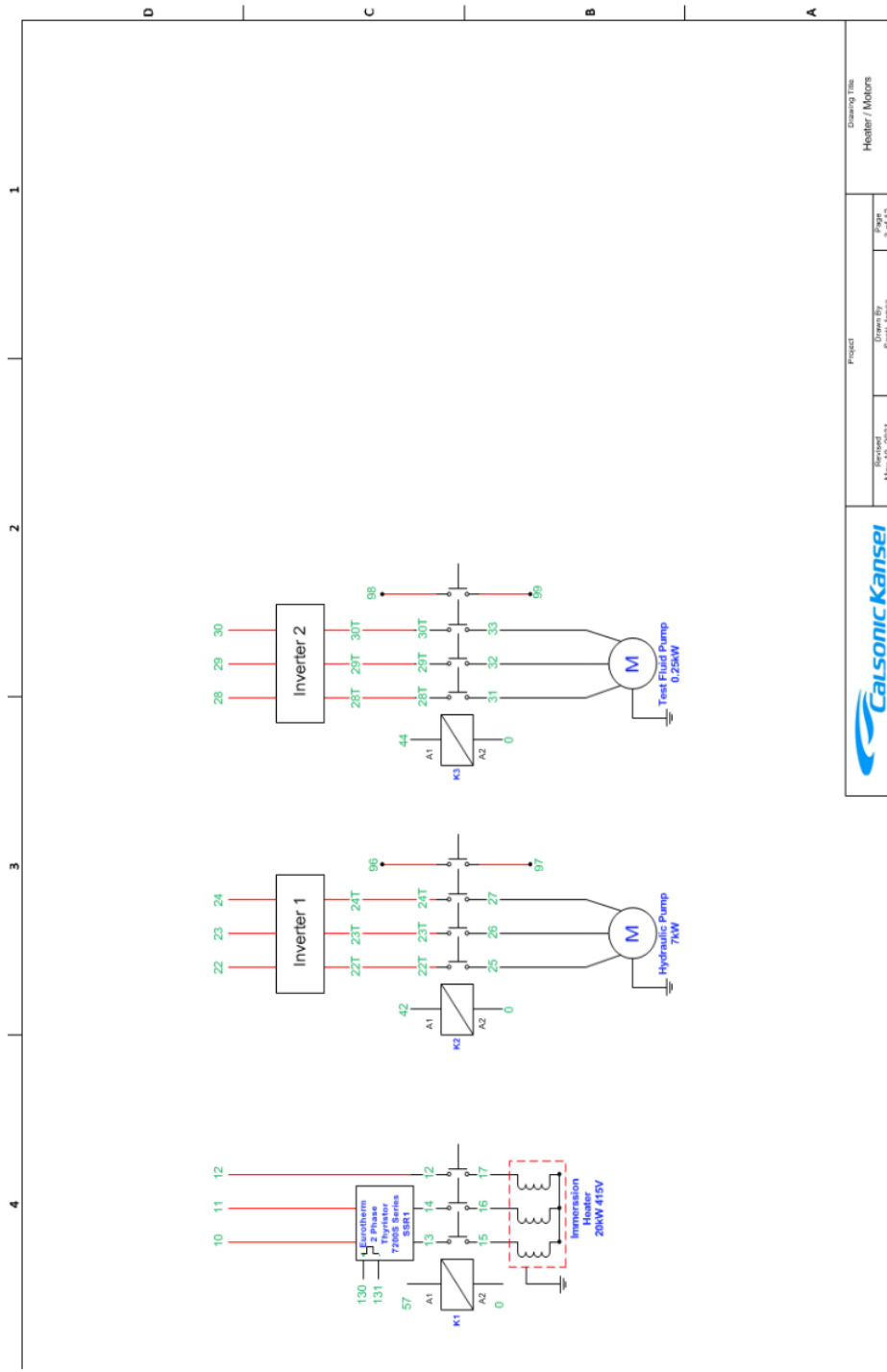


Figure 10 - Electrical Drawings

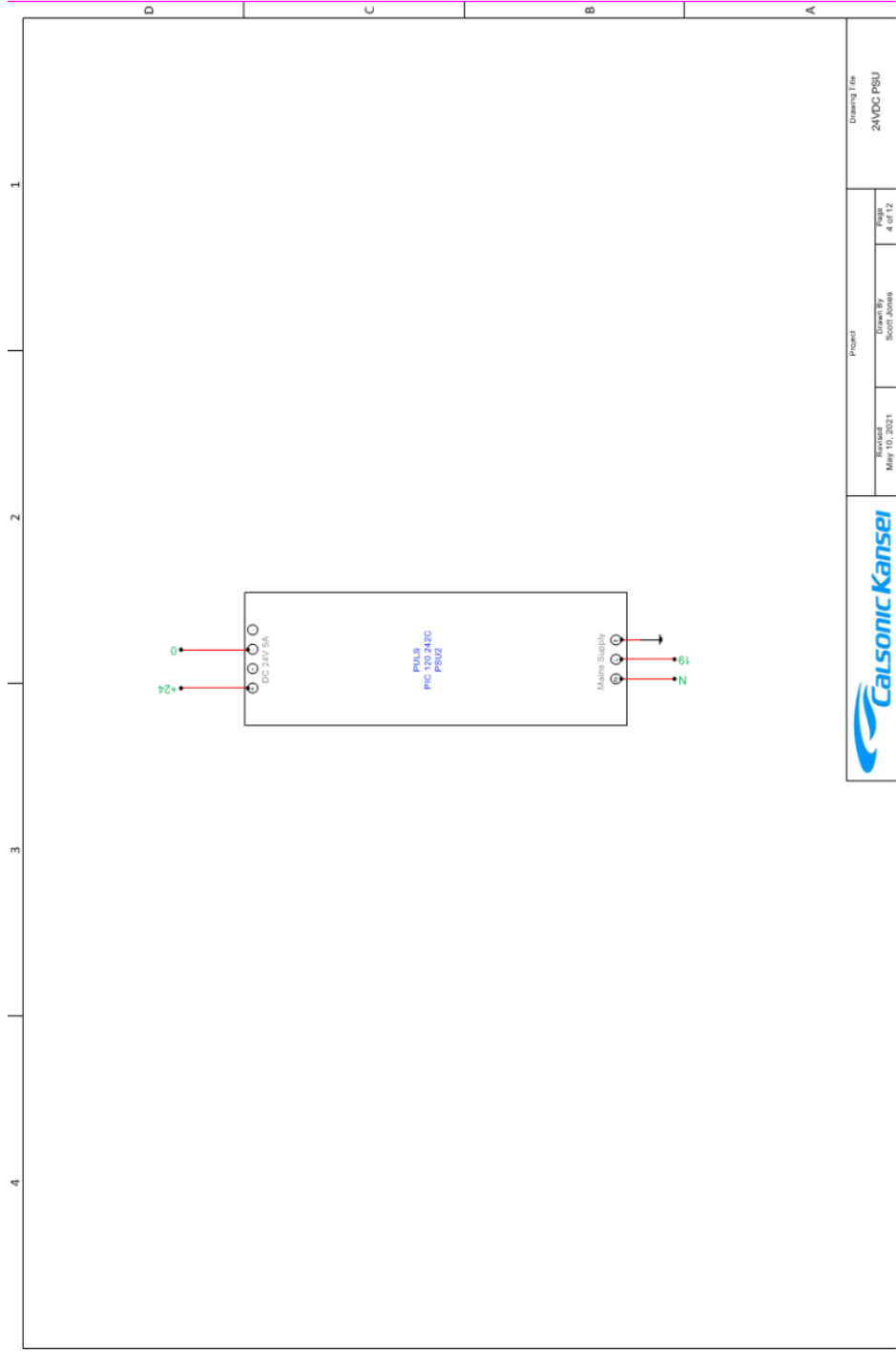


Figure 11 - Electrical Drawings

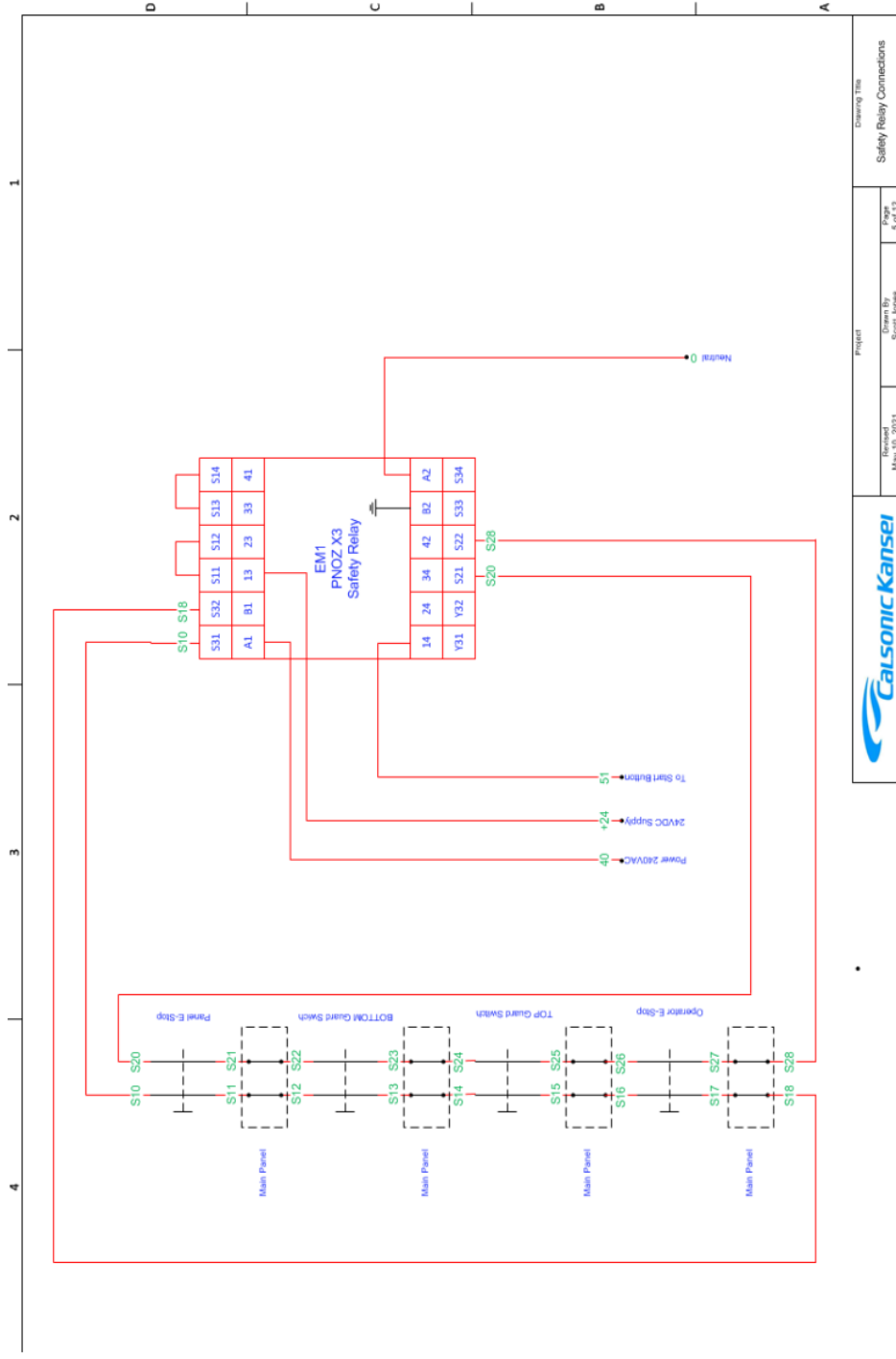


Figure 12 - Electrical Drawings



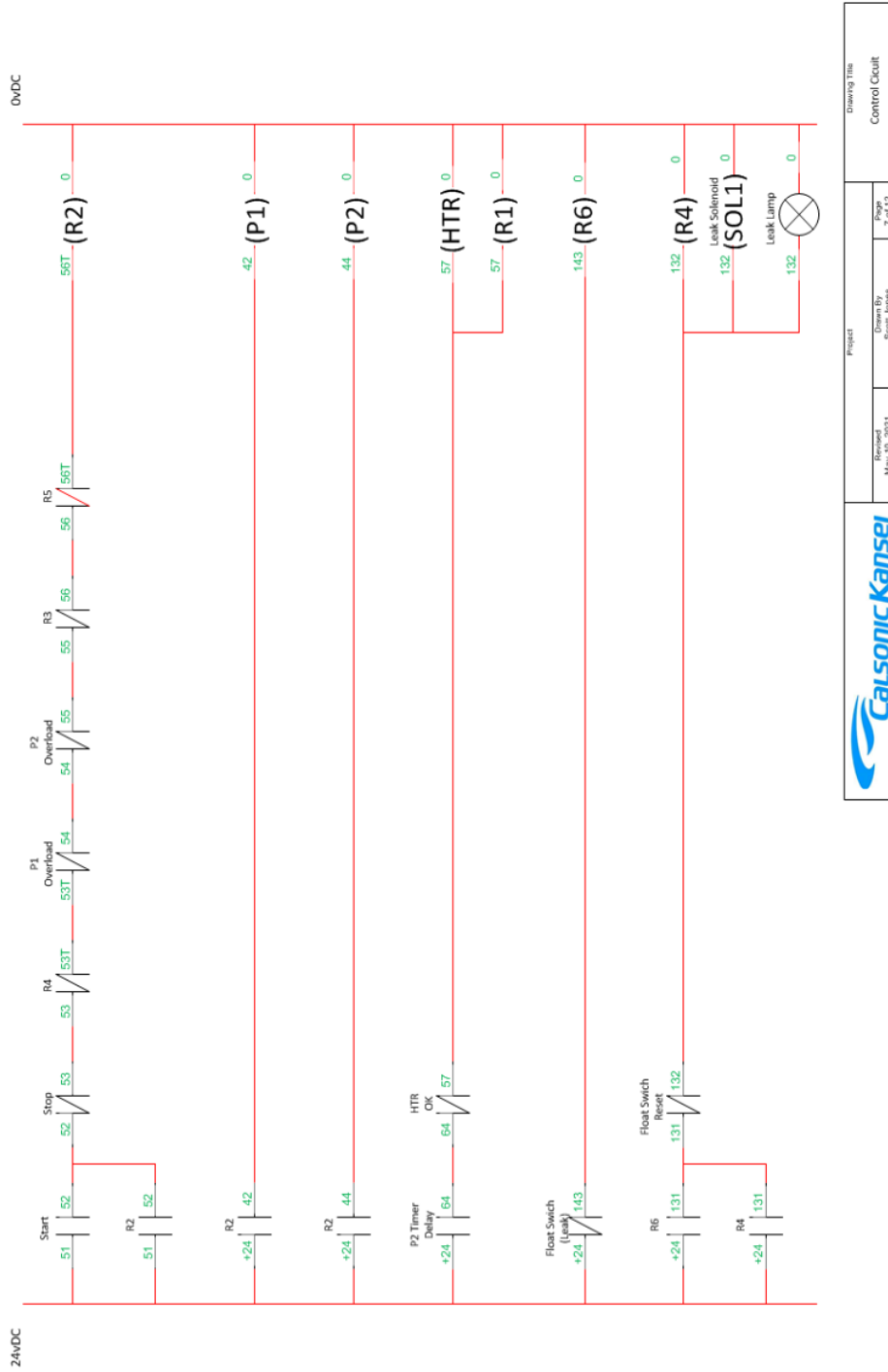


Figure 14 - Electrical Drawings

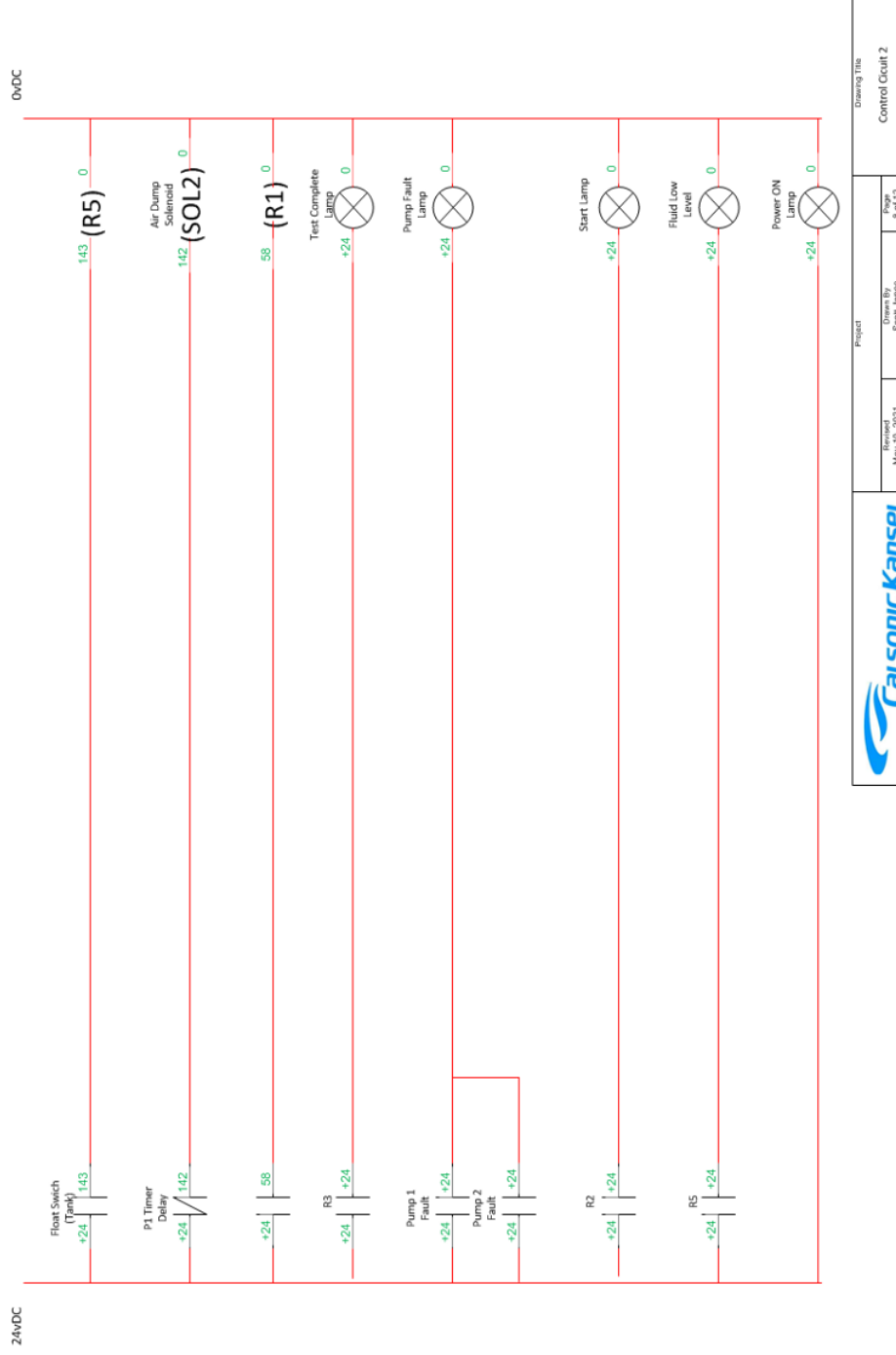


Figure 15 - Electrical Drawings



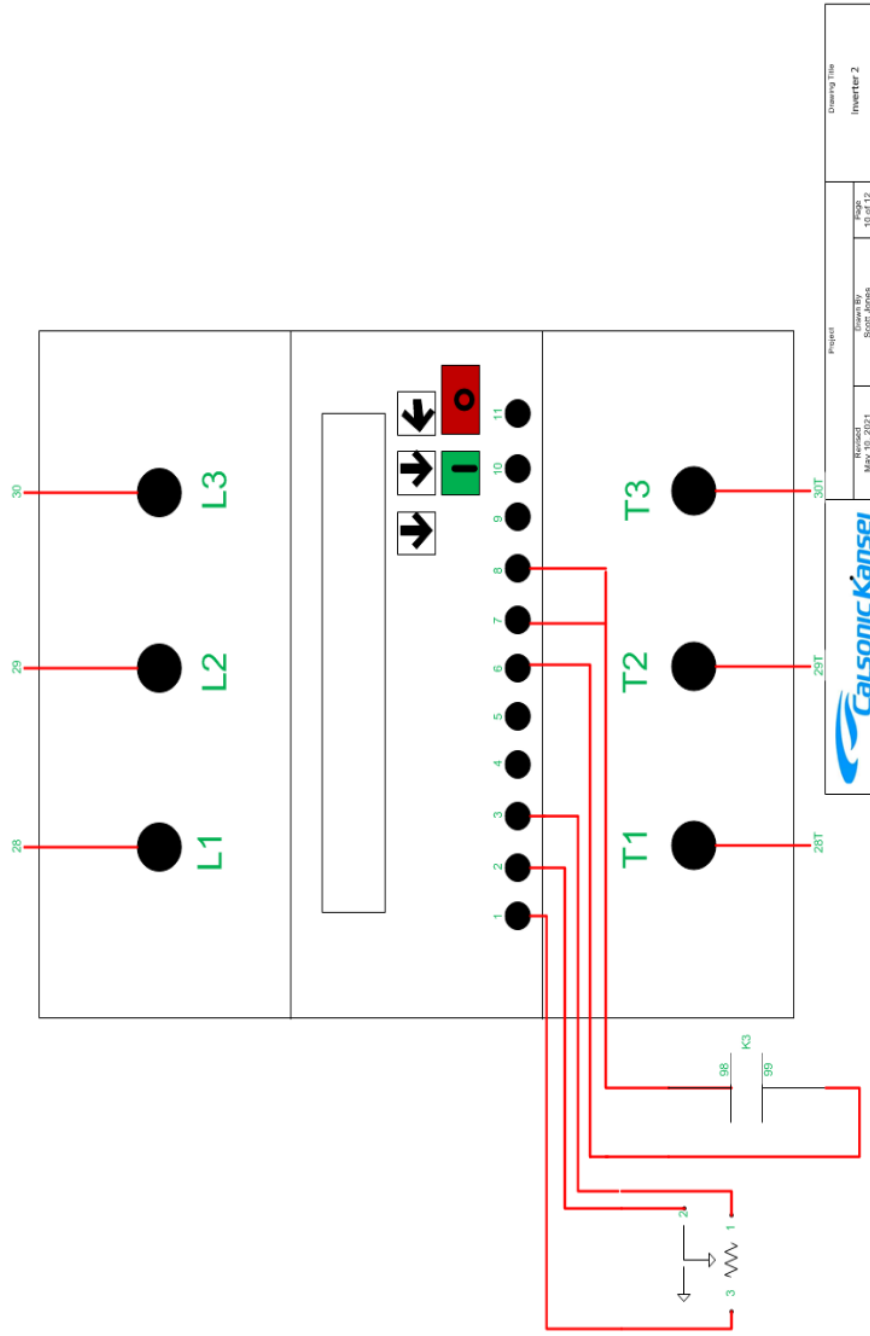
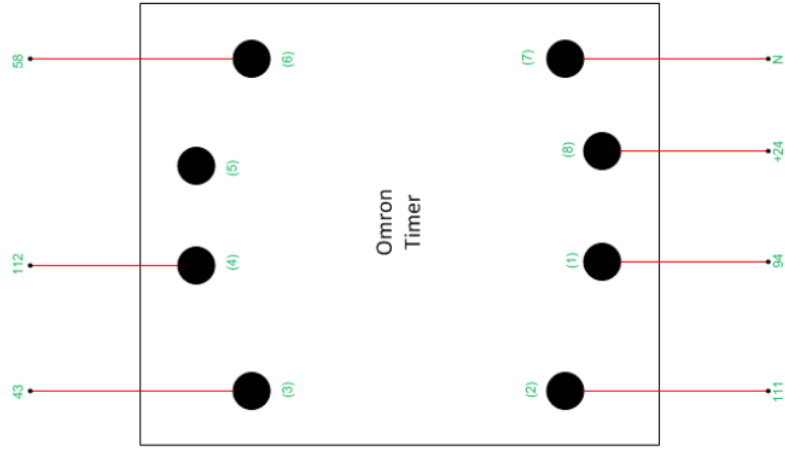


Figure 17 - Electrical Drawings



		Project		Drawing Title	
		Revised May 10, 2021	Drawn By Scott Jones	Page 11 of 12	OMRON Timer

Figure 18 - Electrical Drawings

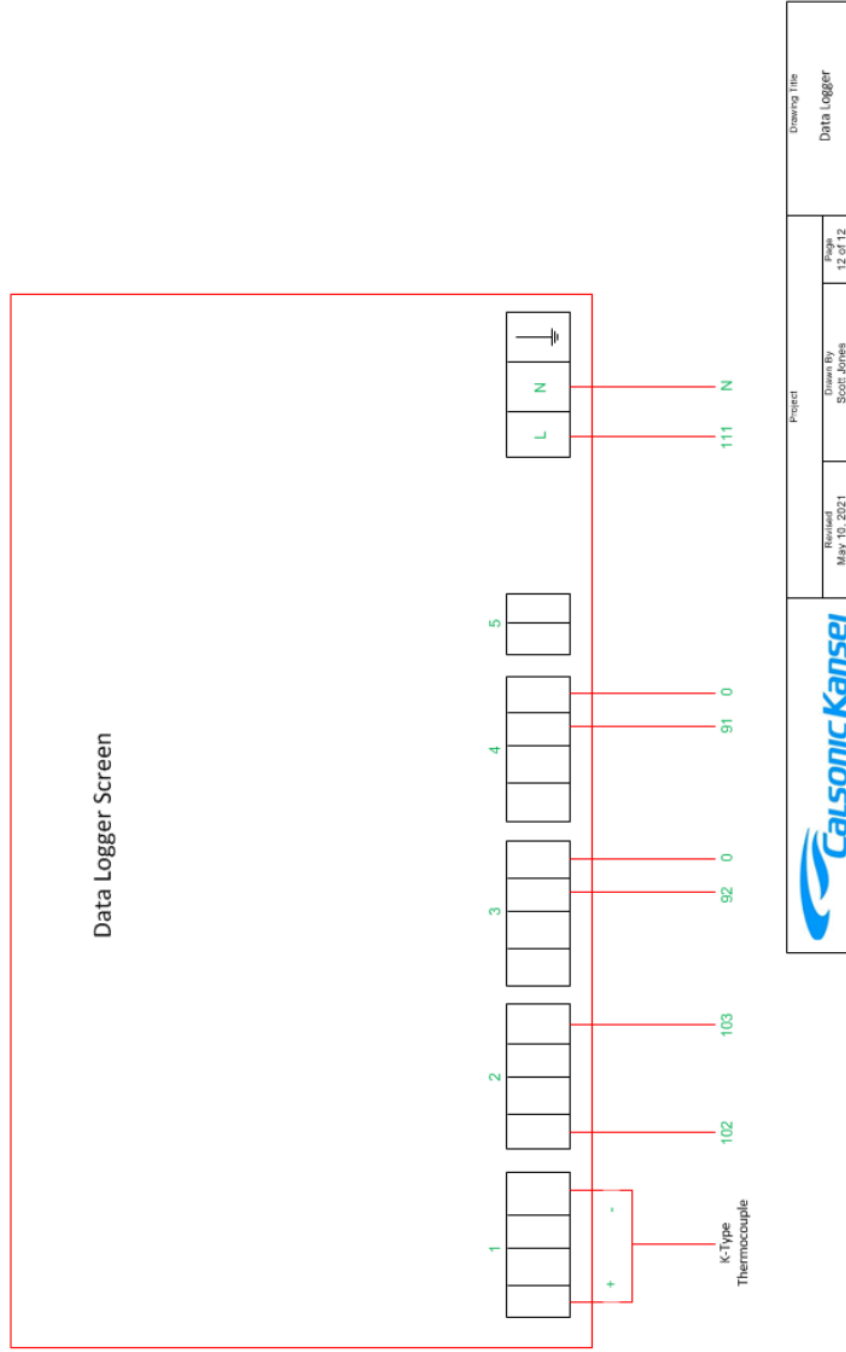


Figure 19 - Electrical Drawings

D52 FLOW DIAGRAM

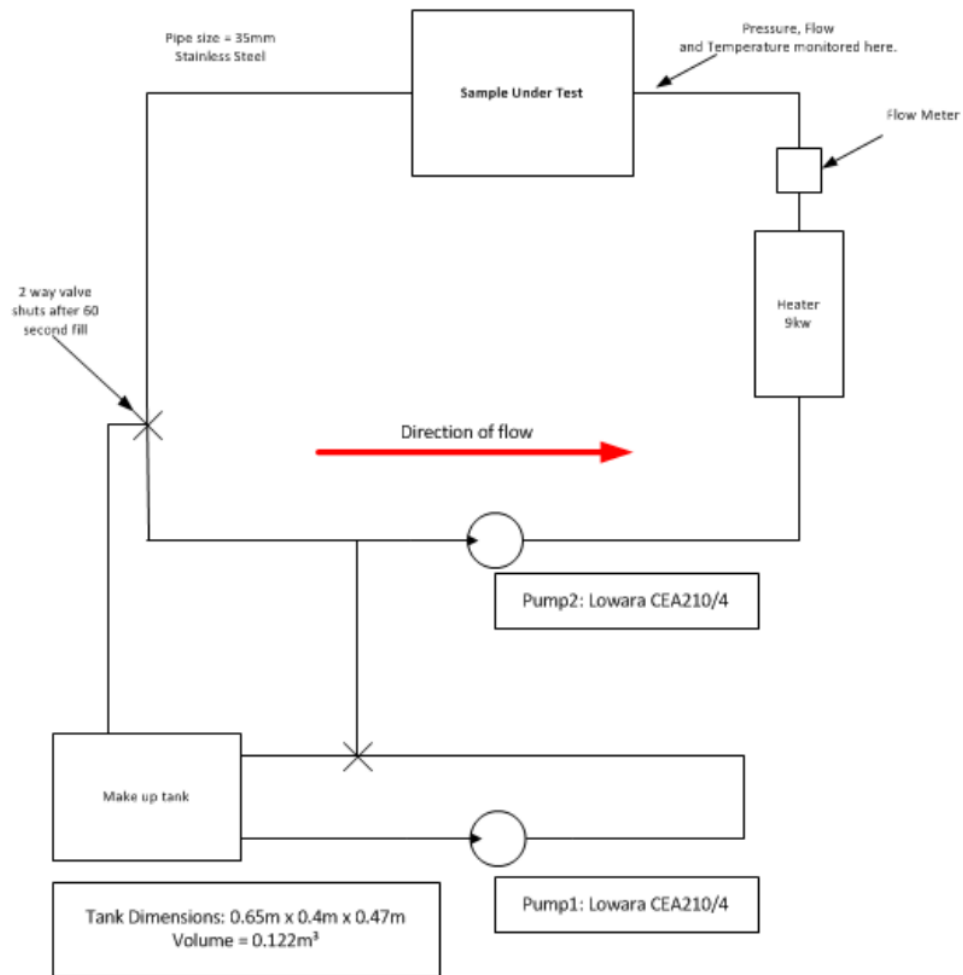


Figure 20 - Flow Diagram

Electrical Components Part List					
Name	Description	Part No:	RS Stock No:	Manufacturer	Quantity
MCB1	Heater MCB (10A)	N/A	N/A	N/A	1
MCB2	PSU MCB (6A)	N/A	N/A	N/A	1
MCB3	Cell Light MCB (4A)	N/A	N/A	N/A	1
MCB4	CAL Controller, OMRON Timer and Monitoring Screen MCB (2A)	N/A	N/A	N/A	1
MCB5	Safety Relay MCB (4A)	N/A	N/A	N/A	1
OL1	Pump 1 Overload	N/A	N/A	N/A	1
OL2	Pump 2 Overload	N/A	N/A	N/A	1
K1	Heater Contactor	N/A	N/A	N/A	1
K2	Pump 1 Contactor	N/A	N/A	N/A	1
K3	Pump 2 Contactor	N/A	N/A	N/A	1
Timer	Delay Timer for Pump 1/2	LADT4	394-9829	Schneider	2
PILZ	Safety Relay	PNOZ X3	245-1848	PILZ	1
Freq Conv	Frequency Converter	PXF-20	338-4187	BRODERSEN	1
PSU1	Power Supply Unit	DRP60-1	N/A	LAMBDA	1
SSR1/2	Solid State Relay	CMRD2455	291-2999	CRYDOM	2
Inverter 1	Pump 1 Inverter	160-BA03NSF1	330-3267	Allen Bradley	1
Inverter 2	Pump 2 Inverter	160-BA06NSF1	330-3289	Allen Bradley	1
CAL Controller	Temperature controller	CAL 9300	312-1835	CAL	2
Timer	Test Timer	H5CX-L8-N	687-6109	OMRON	1
Data Logger	ABB Data Logger Screen	SM500F	742-6825	ABB	1
R1/2/3/4/5	24VDC Relay	N/A	N/A	N/A	5
X1/2/3/4/5	Terminal Block	N/A	N/A	N/A	

Figure 21 - Electrical Parts List

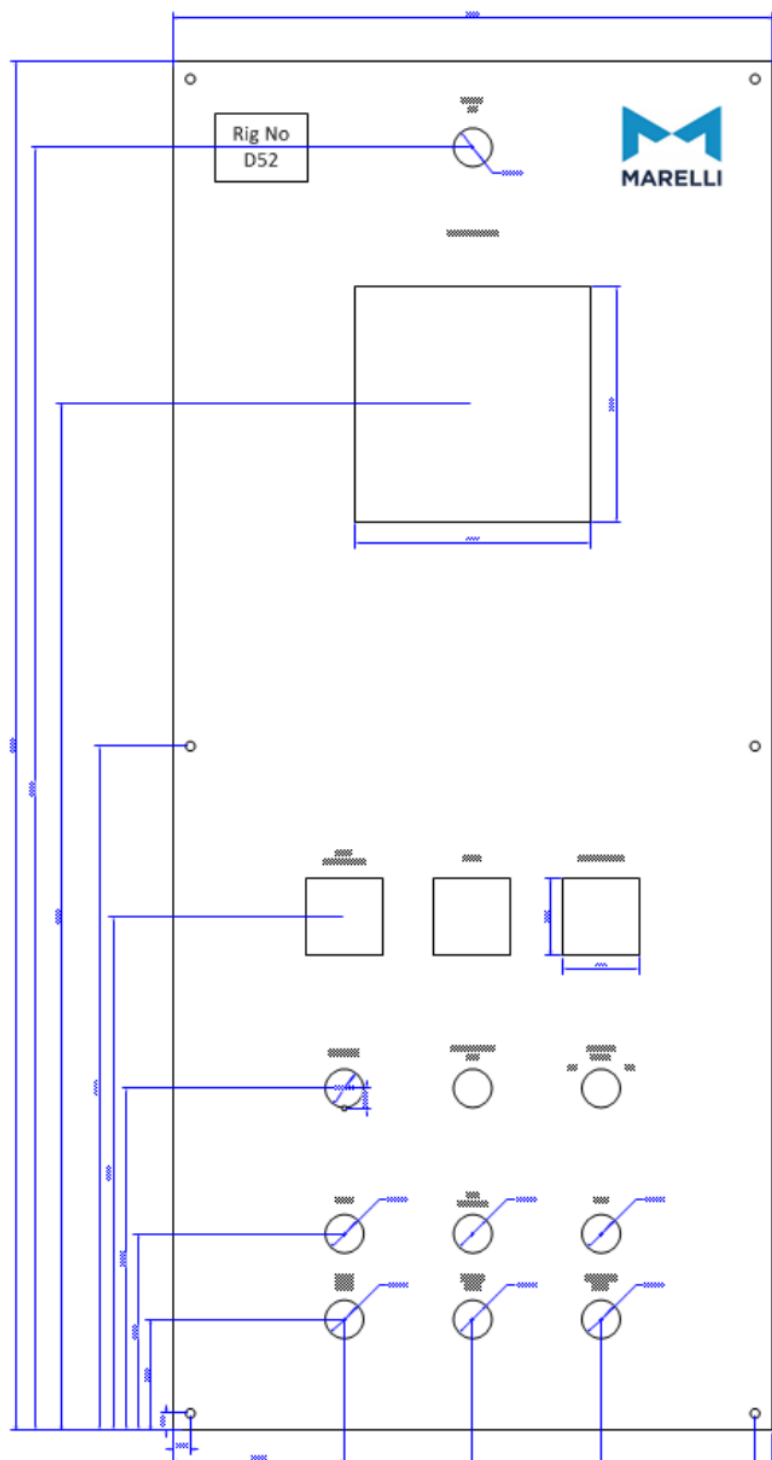


Figure 22 - Front Panel Layout

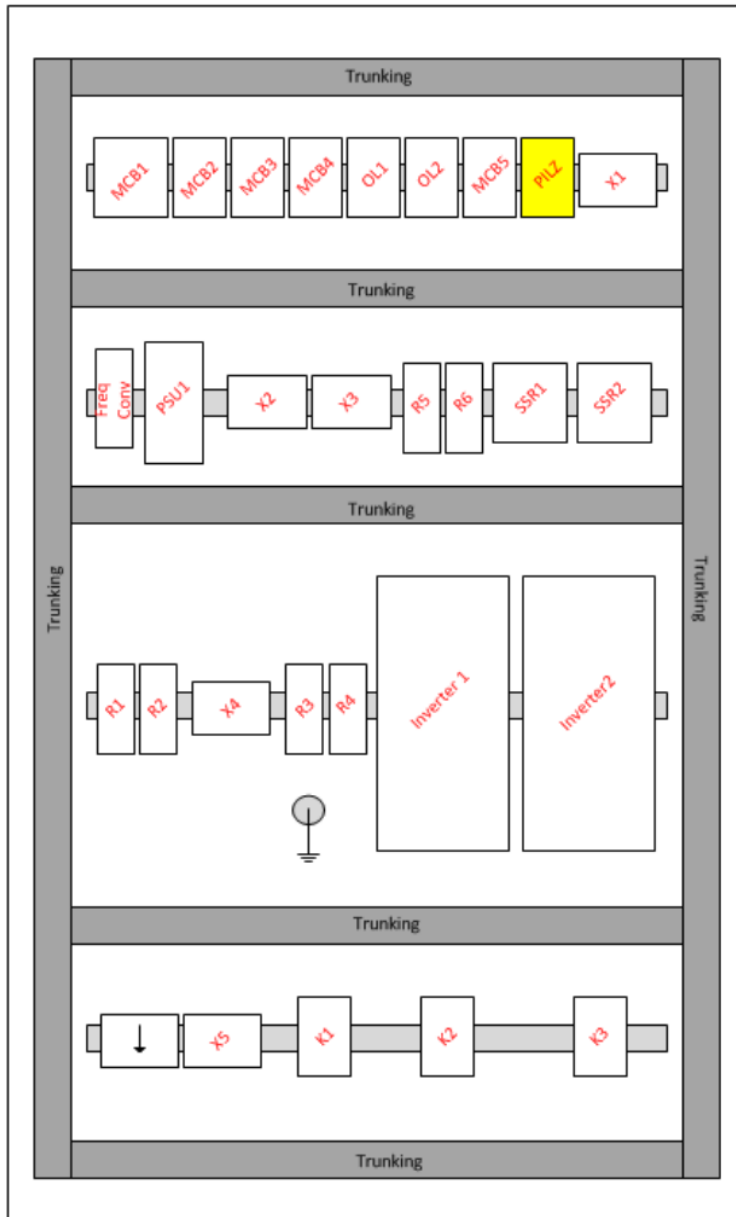


Figure 23 - Inside Electrical Panel Layout

Electrical Panel Breakdown	
Name	Purpose
MCB1	Heater MCB (10A)
MCB2	PSU MCB (6A)
MCB3	Cell Light MCB (4A)
MCB4	CAL Controller, OMRON Timer and Monitoring Screen MCB (2A)
OL1	Pump 1 Overload
OL2	Pump 2 Overload
MCB5	Safety Relay MCB (4A)
PILZ	PILZ Safety Relay
X1	Safety Circuit Connections
Freq Conv	Frequency to Analogue Converter
PSU1	24v Power Supply Unit
X2	0V Terminal Blocks
X3	24V Terminal Blocks
R5	Tank Low Level Relay
R6	Leak Detect Relay
SSR1	Solid State Relay for Heater Phase 1
SSR2	Solid State Relay for Heater Phase 2
R1	Timer Signal Relay
R2	Main Power Relay
X4	Connections for Pressure Transducer
R3	Test Complete Relay
R4	Leak Detect Retainer
Inverter 1	Inverter Drive for Pump 1
Inverter 2	Inverter Drive for Pump 2
Ground	Earth Terminal Blocks
X5	Incoming Connections From Float Switches and Valves
K1	Heater Contactor
K2	Pump 1 Contactor
K3	Pump 2 Contactor

Figure 24 - Electrical Panel Descriptions



Good image that supports the reference in the report

Figure 25 - Wiring the MCBs and Overloads



Image supports reference in report

Figure 26 - Inverter Drives



Image has been referenced in report

Figure 27 - Contactors with timers



Good image for supporting reference in main report

Figure 28 - Complete Power Circuit



Figure 29 - PILZ Safety Relay

Image is referenced in report



Figure 30 - GuardMaster Door Switch

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Figure 31 - GuardMaster Door Switch



Figure 32 - CAL Controller Connections

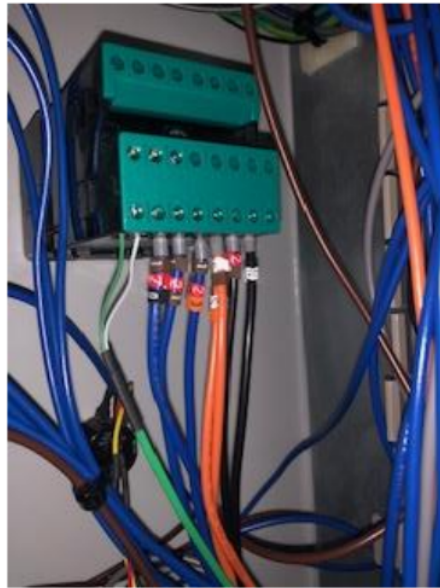


Figure 33 - CAL Controller Connections



Good evidence of implementation

Figure 34 - Timer Connections



Image is referenced in main report

Figure 35 - Data Logger Connections



Data logging is clear

Figure 36 - Data Logger Screen



Image supports explanation in report

Figure 37 - The Finished Rig Before Guarding was Fitted



Figure 38 - Safety Circuit Connections

Inverter 1 Parameters	
P#	Parameter Setting
30	10
31	15
32	0
33	35
34	0
35	50
36	460
37	460
38	2
39	240
40	0
41	0
42	2.64
43	150
44	0
45	0
46	9
47	0
48	0
49	4
50	0
51	10
52	0
53	0
54	0
55	SFFE
56	0
57	0
58	25
59	1
60	0
61	3
62	20
65	45
66	50
69	20
70	20
71	50
72	0
73	0
74	0
75	0
76	100
78	0
79	0
80	0
81	0.5
82	0.1
83	21

Figure 39 - Inverter 1 Parameters

Inverter 2 Parameters	
P#	Parameter Setting
30	10
31	10
32	0
33	60
34	0
35	60
36	460
37	460
38	2
39	240
40	0
41	0
42	6.9
43	150
44	0
45	0
46	0
47	0
48	0
49	4
50	0
51	10
52	0
53	0
54	0
55	SFFE
56	0
57	0
58	60
59	0
60	0
69	20
70	20
71	50
72	2
73	0
74	0
75	0
76	100

Good evidence of implementation

Figure 40 - Inverter 2 Parameters

CAL Controller Parameters					
Level 1		Level 2		Level 3	
Parameter	Value	Parameter	Value	Parameter	Value
Tune	OFF	SP1.P	100	SP1.D	SSD
Band	10	Hand	OFF	SP2.D	RLY
Int	2	PL.1	100	Burn	UP.SC
Deriv	24	PL.2	100	REV.D	lr.2r
Dac	1.5	SP2.A	FS.Lo	REV.L	ln.2n
Cycle.T1	20	SP2.B	NONE	Span	2.3
Offset	0	Disp	0.1°	Zero	-1.6
SPlk	OFF	Hi.Sc	120	Check	OFF
SPrr	0	Lo.Sc	0	Read	VAR°
SPrn	OFF	Inpt	tc k	Teach	CT A
Soay	--	Unit	°C	Ver	393
Set.2	50			rSet	NONE
Band.2	2				
Cycle.T2	ON.OF				

*Image supports
reference in report*

Figure 41 - CAL Controller Parameters

LOG BOOK

Log No	1
No hrs	5
Running total hrs	5

This week I started thinking of ideas for my project. I am going to be doing a work-based project so I will need to find a problem in the workplace that I can find a solution for. I will need to speak to my manager to see if there is anything that he can recommend that I base my base my project on.

I have also been looking into some backup projects that I can carry out in college just in case there is nothing suitable for me to do in work.

Student signature	S.Jones
Lecturer Signature	

LOG BOOK

Log No	2
No hrs	10
Running total hrs	15

This week I have spoken to my manager in work and we had a meeting with the maintenance manager to discuss any potential ideas. He asked me if I have come across any problems during my time working in the maintenance department that may be suitable for the project. He told me that he would like me to try and find a problem myself that could be solved with this project.

While I was thinking of problems that I had come across the Electrical Engineer from the Technology Centre came to the maintenance department looking for some spare parts and I told him that I was looking for a project for my HNC. He told me that there was an opportunity for me to build a machine up in the Technology Centre that would be used to test heat exchange components such as radiators that were still in the development stage for Jaguar Land Rover.

I spoke to my manager and told him that I could build the machine on my own from scratch as my project and he gave me permission to go to the technology centre on a Monday every other week to work on the project for 8 hours.

I went up to the technology centre and sat down with the electrical engineer and the process engineer who was in charge of the testing of the new radiators. They explained to me what would be required of the machine and what the specifications would be. We agreed on a time scale that was influenced by Jaguar Land Rover and we also agreed a budget of £5000 which I would need to complete the machine build.

Student signature	S Jones
Lecturer Signature	

LOG BOOK

Log No	3
No hrs	8
Running total hrs	23

This was my first week up in the Technology Centre and I started by researching different solutions that I feel will be capable of carrying out the task.

I have to two different solutions:

- Solution 1 – PLC Control
- Solution 2 – Hard Wired

I have carried out research into the PLC solution as there is a lot more to it than there would be just wiring the machine the old way using contactors and relays.

I have decided that if I am going to use a PLC, I will use a Siemens PLC because it is the same as what we use in college and the engineer is familiar with PLC programming so it should not be an issue for him to use in the future. The HMI and drives from Siemens can all be connected using ProfiNet which will reduce the amount of wiring required even further and streamline the system keeping it up to date with modern technologies and Industry 4.0.

Below is a links to websites that I found useful:

Wiring diagram for Siemens Drive:

<https://www.manualslib.com/manual/1181981/Siemens-Sinamics-G120.html?page=47#manual>

Siemens S7-1200 PLC complete guide

<https://www.manualslib.com/manual/1453610/Siemens-S7-1200.html?page=9#manual>

Siemens S7-1200 PLC to G120 Drive Documents

[https://support.industry.siemens.com/cs/document/70155469/sinamics-g%3A-speed-control-of-a-g120-\(startdrive\)-with-s7-1200-via-profinet-profibus-dp-with-safety-integrated-\(via-terminal\)-and-hmi?dti=0&lc=en-WW](https://support.industry.siemens.com/cs/document/70155469/sinamics-g%3A-speed-control-of-a-g120-(startdrive)-with-s7-1200-via-profinet-profibus-dp-with-safety-integrated-(via-terminal)-and-hmi?dti=0&lc=en-WW)

Student signature	S.Jones
Lecturer Signature	

LOG BOOK

Log No	4
No hrs	8
Running total hrs	31

I arranged a meeting and discussed the solutions that I had found with the engineers in the technology centre, I explained that I would like to use a PLC in the system as I feel this would make the machine easier to operate and maintain, I also feel that it would make it easier for the engineer to fault find on the machine in the future as he could go online with the PLC to monitor the sequence.

They told me to go ahead with the PLC control as they also felt that this was the best solution.

I then visited the Parmley Graham website as they have a contract with the Technology Centre so it would be easier for me to obtain the parts required and I may also get a slight discount due to the contract.

I found that I would be able to obtain the following:

- PLC
- HMI
- Thermocouple input card
- Two drives

The price that Parmley Graham came back with was £2606.00 which came in under budget by £2394.00, this gave me plenty of money to spend on other components for the project.

Student signature	S.Jones
Lecturer Signature	

LOG BOOK

Log No	5
No hrs	8
Running total hrs	39

When I arrived at the technology centre this week, I was told that there had been a major breakdown the previous week and that they had spent over £6000 in an attempt to repair a high priority machine. This meant that was unfortunately no budget available at all for me to produce this machine.

I arranged a meeting with the engineers and told them that I had stripped a number of machines for parts before they had been sent out for disposal over the last couple of years and that I may still be able to produce the machine for them however it would mean that I would need to use solution 2 and not include a PLC. They agreed so I started planning to carry out solution 2

I began by writing out electrical drawings on paper.

Student signature	S.Jones
Lecturer Signature	

LOG BOOK

Log No	6
No hrs	8
Running total hrs	47

This week I continued producing the electrical drawings and then consulted the electrical engineer to double check my drawings, once he was happy, I had to draw them up on Microsoft Visio and printed them off so that I could work from them.

I then produced a list of parts that I would need to try and find in both the technology centre and the main factory.

I produced a flow diagram which I checked with the engineer to ensure it was accurate. The diagram was designed to show the direction of flow required from the sump tank to the radiator and back around, this would make it easier to fit the pipework as I had something to follow.

Student signature	S.Jones
Lecturer Signature	

LOG BOOK

Log No	7
No hrs	8
Running total hrs	55

I spent my day in the technology centre finding all of the parts that I needed to build the machine. Unfortunately, I didn't have time to continue with the design or planning of the project as I spent the whole day trying to find the parts that I needed, luckily, I did manage to find everything that was on my list.

I looked up all of the part numbers and found datasheets for the components I was going to be using, I also found their part numbers on RS components which is where the technology centre buys their parts. I made a list of all the part numbers to make it easier for the engineer to source spares in the future. I was also asked to find the Declaration of Conformity for each of the products I was using and store them in the rig file on the computer system.

The data sheets and Declaration of Conformities can be seen below.

Student signature	S.Jones
Lecturer Signature	

Allen-Bradley

Technical Data

Bulletin 160 "Series C" Smart Speed Controllers



Frequency Converter

Signal Converters & Isolators
Frequency To Analogue Converter PXF-20



DESCRIPTION

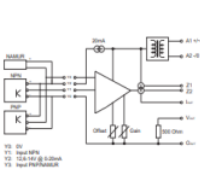
Frequency converter for converting frequency to an analogue process signal. The frequency converter has 8MHz/Hz/0.001Hz input in 5 ranges from 0-5kHz.

- Features**
- 8MHz/Hz/0.001Hz input in 5 ranges.
 - Output 0-10VDC/0-10VDC/0.001V/0.001mA - selected via terminals.
 - Output offset and gain adjustable ±10%.
 - Yellow LED indication of input less than 5%.
 - Galvanically isolated output signal.
 - Internal sensor supply 12.6V to 14V @ 0.20mA.
 - Operating voltage 24-48V AC/DC, 110-230V AC.

VERSIONS/ORDERING CODES

Type: Frequency converter PXF-20
Supply Voltage: 12-24V AC/DC 230V
110-230V AC

BLOCK DIAGRAM



10 001
11 002
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14 005
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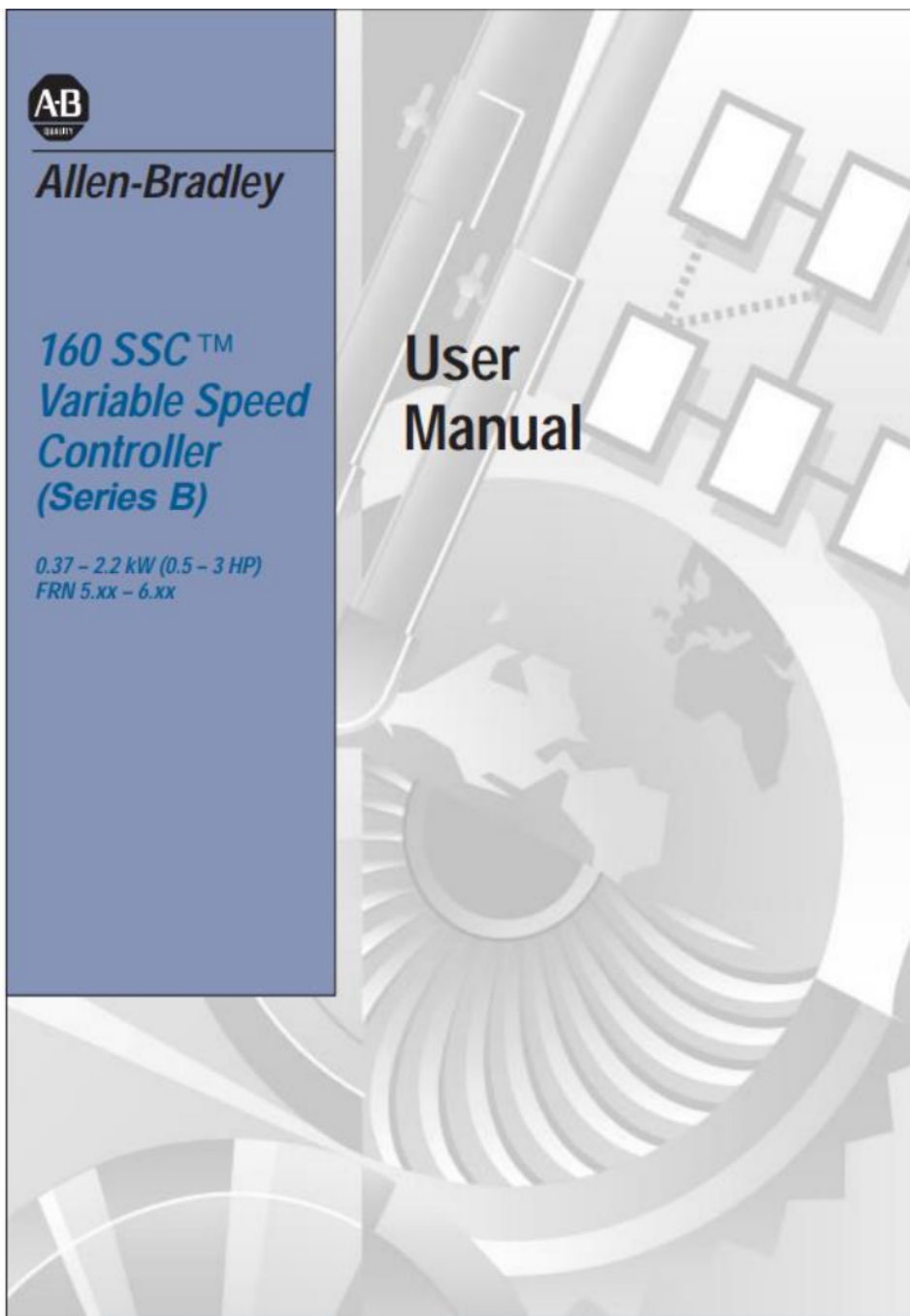


Allen-Bradley

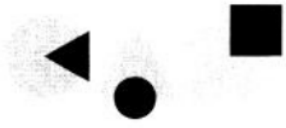
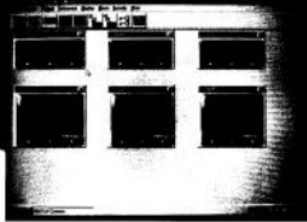
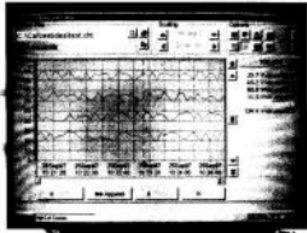
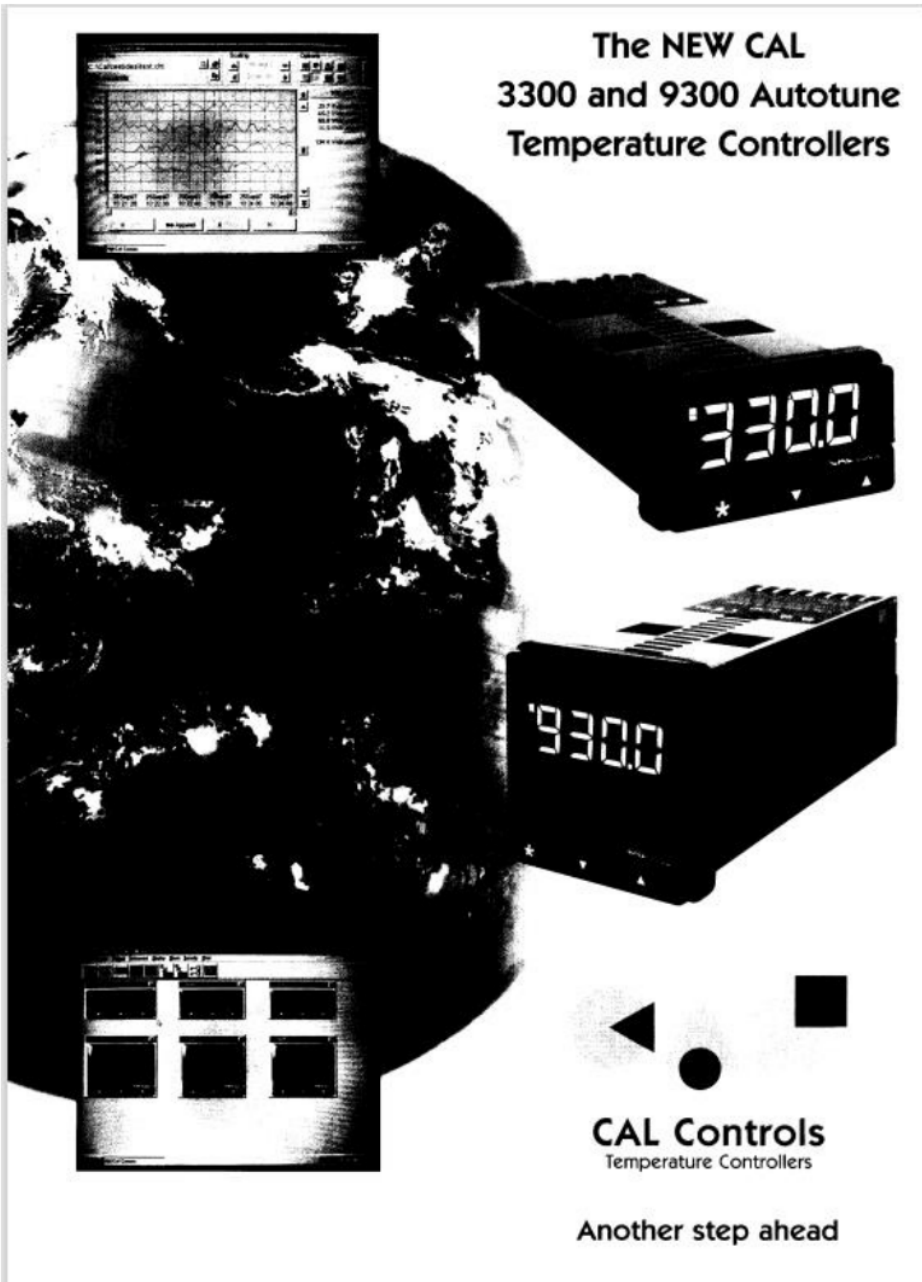
**160 SSC™
Variable Speed
Controller
(Series B)**

*0.37 – 2.2 kW (0.5 – 3 HP)
FRN 5.xx – 6.xx*

**User
Manual**



The NEW CAL
3300 and 9300 Autotune
Temperature Controllers



CAL Controls
Temperature Controllers

Another step ahead



ABB MEASUREMENT & ANALYTICS | DATA SHEET

SM500F

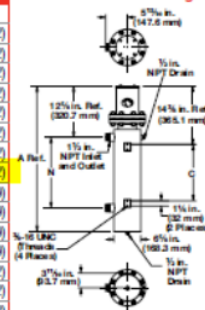
Field mountable paperless recorder



Circulation Heater

4 inch - 150 lb ANSI Flange (WATROD)														
23 W/in ² Steel Tank 6-Steel Elements (3.6 W/cm ²)	240	6.0	1	1	CFOS718A10S	C/F	C/F	C/F	125 (57)	39	(989)	20 1/2 (521)	17	(432)
	240	6.0	3	1	CFOS718A3S	C2-50	C2-92	C/F	125 (57)	39	(989)	20 1/2 (521)	17	(432)
	480	6.0	1	1	CFOS718A11S	C/F	C/F	C/F	125 (57)	39	(989)	20 1/2 (521)	17	(432)
	480	6.0	3	1	CFOS718A5S	C2-43	C2-35	C/F	125 (57)	39	(989)	20 1/2 (521)	17	(432)
	240	9.0	1	1	CFOS725J10S	C/F	C/F	C/F	160 (73)	39	(989)	20 1/2 (521)	17	(432)
	240	9.0	3	1	CFOS725J3S	C2-50	C2-92	C/F	160 (73)	39	(989)	20 1/2 (521)	17	(432)
	480	9.0	1	1	CFOS725J11S	C/F	C/F	C/F	160 (73)	39	(989)	20 1/2 (521)	17	(432)
	480	9.0	3	1	CFOS725J5S	C2-43	C2-35	C/F	160 (73)	39	(989)	20 1/2 (521)	17	(432)
	240	12.0	1	2	CFOS733A10S	C/F	C/F	C/F	163 (74)	49 1/2 (1256)	31	(787)	27 1/2 (699)	
	240	12.0	3	1	CFOS733A3S	C2-236	C2-214	C/F	163 (74)	49 1/2 (1256)	31	(787)	27 1/2 (699)	
	480	12.0	1	1	CFOS733A11S	C/F	C/F	C/F	163 (74)	49 1/2 (1256)	31	(787)	27 1/2 (699)	
	480	12.0	3	1	CFOS733A5S	C2-43	C2-35	C/F	163 (74)	49 1/2 (1256)	31	(787)	27 1/2 (699)	
	240	15.0	1	2	CFOS740J10S	C/F	C/F	C/F	229(104)	70 1/2 (1789)	52	(1321)	48 1/2 (1232)	
	240	15.0	3	1	CFOS740J3S	C2-236	C2-214	C/F	229(104)	70 1/2 (1789)	52	(1321)	48 1/2 (1232)	
	480	15.0	1	1	CFOS740J11S	C/F	C/F	C/F	229(104)	70 1/2 (1789)	52	(1321)	48 1/2 (1232)	
	480	15.0	3	1	CFOS740J5S	C2-43	C2-35	C/F	229(104)	70 1/2 (1789)	52	(1321)	48 1/2 (1232)	
240	18.0	1	2	CFOS748A10S	C/F	C/F	C/F	234(107)	70 1/2 (1789)	52	(1321)	48 1/2 (1232)		
240	18.0	3	1	CFOS748A3S	C2-236	C2-214	C/F	234(107)	70 1/2 (1789)	52	(1321)	48 1/2 (1232)		
480	18.0	1	1	CFOS748A11S	C/F	C/F	C/F	234(107)	70 1/2 (1789)	52	(1321)	48 1/2 (1232)		
480	18.0	3	1	CFOS748A5S	C2-43	C2-35	C/F	234(107)	70 1/2 (1789)	52	(1321)	48 1/2 (1232)		
240	25.0	3	2	CFOS764J3S	C2-218	C2-224	C/F	298(136)	91 1/2 (2326)	73	(1854)	66 (1676)		
480	25.0	1	2	CFOS764J11S	C/F	C/F	C/F	298(136)	91 1/2 (2326)	73	(1854)	66 (1676)		
480	25.0	3	1	CFOS764J5S	C2-225	C2-226	C/F	298(136)	91 1/2 (2326)	73	(1854)	66 (1676)		
240	30.0	3	2	CFOS777A3S	C2-218	C2-224	C/F	306(139)	91 1/2 (2326)	73	(1854)	66 (1676)		
480	30.0	1	2	CFOS777A11S	C/F	C/F	C/F	306(139)	91 1/2 (2326)	73	(1854)	66 (1676)		
480	30.0	3	1	CFOS777A5S	C2-225	C2-226	C/F	306(139)	91 1/2 (2326)	73	(1854)	66 (1676)		

4 inch - 150 lb ANSI Flange





SPOOL VALVES

pilot operated or air operated, spool type
single/dual solenoid or air
aluminium body, "NAMUR" style, 1/4 to 1/2



3/2-5/2
5/3
Series
551-552
553

FEATURES

- The solenoid operated spool valves have threaded port connections and NAMUR interface
- The same spool valve can be adapted for 3/2 NC or 5/2 functions for controlling double-acting and single-acting actuators
- All the exhaust ports of the spool valve are connectable, providing better environmental protection. Particularly recommended for sensitive areas, such as clean rooms, and applications in the pharmaceutical and food processing sectors
- The valves offer environmental protection against the ingress of liquids, dusts or other foreign matter (environmentally-protected construction)
- The monostable spool valves have TÜV-EXIDA certified IEC 61508 Functional Safety data and can be used up to SIL 4 (551/TÜV)-SIL 3 (552-553/EXIDA)
- The solenoid valves satisfy all relevant EC directives

GENERAL

Differential pressure

2 - 10 bar [1 bar = 100 kPa]

Flow (Qv at 6 bar)

l/min (ANR)

1/4	3/8	1/2
700	3000	3000

fluids (+)	temperature range (TS)	seal materials (+)
air, inert gas, filtered	-25°C to +60°C	NBR (nitrile) + PUR (polyurethane)

MATERIALS IN CONTACT WITH FLUID

(+) Ensure that the compatibility of the fluids in contact with the materials is verified

Body, end cover

Aluminium, black anodized

End cover (spring return)

Glass fibre filled PA

Spool valve internal parts

Zamak, stainless steel, POM, aluminium

Seals

NBR + PUR

Core and core tube

Stainless steel

Shading coil

Copper

ELECTRICAL CHARACTERISTICS

Coil insulation class

F

Connector

Spade plug (cable Ø 6-8 mm or Ø 6-10 mm)
DIN 43650, 11 mm, industry standard B (type 01)
or ISO 4400 / EN 175301-803, form A (type 02)
IEC 335

Connector specification

Moulded IP65 (EN 60529)

Electrical safety

DC (-): 24V - 48V

Standard voltages

AC (-): 24V - 48V - 115V - 230V / 50 Hz

(Other voltages and 60 Hz on request)

prefix option	power ratings				operator ambient temperature range (TS)	replacement coil		type ⁽¹⁾
	inrush ~ (VA)	holding ~ (VA)	hold (W)	hold (W)		230 V/50 Hz	24 V DC	
SC	6	3,5	2,5	2,5/3	-25 to +60	43004886	43004889	01
SC	15	7	5	2,5/6,9	-25 to +60	43004849	43004647	02

⁽¹⁾ Refer to the dimensional drawings on the following page

SPECIFICATIONS

pipe size	orifice size	flow coefficient Kv	operating pressure differential (bar)				power coil (W)	catalogue number	options	
			min.	max. (PS)		remitted max. spandor				
				air (°)						
G	(mm)	(m³/h)	(l/min)							
3/2 NC - 5/2 - Solenoid air pilot operated - spring return (monostable)										
1/4	6	0,6	10	2	10	10	2,5	3	SCG551A001	MS - -
3/8	12	2,49	41,5	2	10	10	5	6,9	SCG552A001	MS - -
1/2	13	2,49	41,5	2	10	10	5	6,9	SCG553A001	MS - -
3/2 NC - 5/2 - Solenoid air pilot operated and return (bistable)										
1/4	6	0,6	10	2	10	10	2,5	3	SCG551A002	MS - -
3/8	12	2,49	41,5	2	10	10	5	6,9	SCG552A002	MS - -
1/2	13	2,49	41,5	2	10	10	5	6,9	SCG553A002	MS - -
5/3 - W1 - pressure held, solenoid air pilot and return										
1/4	6	0,6	10	2	10	10	2,5	3	SCG551A065	MS - -
3/8	12	2,49	41,5	2	10	10	5	6,9	SCG552A065	MS - -
1/2	13	2,49	41,5	2	10	10	5	6,9	SCG553A065	MS - -
5/3 - W3 - pressure released, solenoid air pilot and return										
1/4	6	0,6	10	2	10	10	2,5	3	SCG551A066	MS - -
3/8	12	2,49	41,5	2	10	10	5	6,9	SCG552A066	MS - -
1/2	13	2,49	41,5	2	10	10	5	6,9	SCG553A066	MS - -
3/2 NC - 5/2 - Solenoid air pilot operated spring return (monostable), certified IEC 61508 Functional Safety data										
1/4	6	0,6	10	2	10	10	2,5	3	SCG551A001SL	- - -
3/8	12	2,49	41,5	2	10	10	5	6,9	SCG552A001SL	- - -
1/2	13	2,49	41,5	2	10	10	5	6,9	SCG553A001SL	- - -

All leaflets are available on: www.asconumatics.eu

VRR-1



Lowara

CEA-CA
CEA(N)-CA(N) Series
made of AISI 316

Single and twin-impeller
Centrifugal Electric Pumps equipped
with high efficiency PLM motors

50 Hz



Engineered for life

E-STOP relays, safety gate monitors



Up to PL e of EN ISO 13849-1
PNOZ X3.2

Preparing for operation

Supply voltage

Supply voltage	AC	DC

Input circuit

Input circuit	Single-channel	Dual-channel
E-STOP without detection of shorts across con- tacts		
E-STOP with detection of shorts across contacts		
Safety gate without detection of shorts across con- tacts		
Safety gate with detection of shorts across contacts		

Reset circuit

Reset circuit	E-STOP wiring Safety gate without position monitoring	Safety gate with position monitoring
Automatic reset		
Monitored reset		

LADT4

TeSys D - time delay auxiliary contact block -
1NO + 1NC - screw clamp terminals

Product availability: Stock - Normally stocked in distribution facility



Main

Commercial Status	Commercialised
Range of product	TeSys D TeSys F
Product or component type	Time delay auxiliary contact block
Pole contact composition	1 NO + 1 NC
Connections - terminals	Screw clamp terminals 2 cable 0.0...0 in ² (1...2.5 mm ²) - cable stiffness: solid - without cable end Screw clamp terminals 2 cable 0.0...0 in ² (1...2.5 mm ²) - cable stiffness: solid - with cable end Screw clamp terminals 2 cable 0.0...0 in ² (1...2.5 mm ²) - cable stiffness: flexible - without cable end Screw clamp terminals 2 cable 0.0...0 in ² (1...2.5 mm ²) - cable stiffness: flexible - with cable end Screw clamp terminals 1 cable 0.0...0 in ² (1...2.5 mm ²) - cable stiffness: solid - without cable end Screw clamp terminals 1 cable 0.0...0 in ² (1...2.5 mm ²) - cable stiffness: solid - with cable end Screw clamp terminals 1 cable 0.0...0 in ² (1...2.5 mm ²) - cable stiffness: flexible - without cable end Screw clamp terminals 1 cable 0.0...0 in ² (1...2.5 mm ²) - cable stiffness: flexible - with cable end

Complementary

Mounting location	Front
[Ui] rated insulation voltage	600 V - certifications CSA 690 V - conforming to IEC 60947-5-1 600 V - certifications UL
[Ue] rated operational voltage	690 V AC 25...400 Hz
[Ith] conventional free air thermal current	10 A at <= 140 °F (60 °C)
Irms rated making capacity	250 A at <= 690 V DC conforming to IEC 60947-5-1 140 A at <= 690 V AC conforming to IEC 60947-5-1
Permissible short-time rating	140 A at 23...140 °F (-5...60 °C) 100 ms 120 A at 23...140 °F (-5...60 °C) 500 ms 100 A at 23...140 °F (-5...60 °C) 1 s
Protection type	GG fuse <= 10 A rating according to operational current for Ue <= 690 V
Associated fuse rating	IEC 60947-5-1
Mechanical durability	5 Mcycles
Minimum switching current	5 mA
Minimum switching voltage	17 V
Non-overlap time	1.5 ms on energisation (no overlap between NC and NO contact) 1.5 ms on de-energisation (no overlap between NC and NO contact)
Timer type	On delay
Time delay range	10...180 s
Insulation resistance	> 10 MOhm
Product weight	0.13 lb(US) (0.06 kg)

The information provided in this documentation contains general descriptions and/or technical characteristics of the performance of the products contained herein. This documentation is not intended as and is not to be used for determining suitability or reliability of these products for specific user applications. It is the duty of any such user or integrator to perform the appropriate and complete risk analysis, evaluation and testing of the products with respect to the relevant application. Neither Schneider Electric Industries SAS nor any of its affiliates or subsidiaries shall be responsible or liable for misuse of the information contained herein.

New Product

OMRON

Digital Timer H5CX-□-N

Ultra-compact Timer Provides Advanced Functions and Security Settings.



Basic Features

- Short body with depth of only 59 mm (for 24-VAC / 12 to 24-VDC Models with Screw Terminals).^{*1}
- Character height of 12 mm for better readability (on models with 4 digits).
- The present value display characters can be switched between red, green, and orange.^{*2}

Safety and Reliability

- Power supply circuit and input circuits are isolated for safety and reliability.^{*3}
- New set value limit and output counter functions have been added.

Other Features

- Front Panel can be changed to white or light gray.^{*4}
- Models with instantaneous contact output added to the series.

- ^{*1} For 100 to 240 VAC Models with Screw Terminals 78 mm, Models with Sockets: 63.7 mm (case dimension).
^{*2} The H5CX-A11, H5CX-L8 and H5CX-B Timers have only red characters.
^{*3} Specifications: 100 to 240 VAC.
^{*4} Replacement Front Panels sold separately.



NEW

Refer to "Safety Precautions" on page 41.

Features

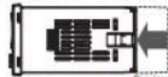
Basic Features

Ultra Short Body

The body depth has been greatly reduced. Helps in making thinner control panels. (Models with Screw Terminals)

24-VAC / 12 to 24-VDC Models with Screw Terminals: 59 mm
 100 to 240-VAC / VDC Models with Screw Terminals: 78 mm¹
 Models with Sockets: 63.7 mm (case dimension)

¹ The shortest body for a timer with isolated power supply and input circuits and a maximum ambient temperature of 55°C (according to OMRON investigation in June 2009).



New models
Previous models

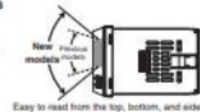
Easier to Read

For better readability, the character height for the present value display is 12 mm (on models with 4 digits), the largest class in the industry. The wide viewing angle and brightness provide excellent visibility. The number of display segments has also been increased to make settings easier to understand, and the present value display can be switched between red, green and orange so that output status can be seen from a distance.

Model with 4 Digits Model with 6 Digits



down (Display example)



Note: The H5CX-A11 and H5CX-L8 Timers have only red characters.

The Easiest Operation

Operation is simplified by the Up/Down Keys for each digit on 4-digit models and Up Keys for each digit on 6-digit models.

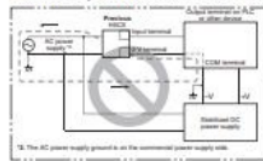


Safety and Reliability

Isolated Power Supply and Input Circuits^{*1}

Power supply circuit and input circuits are isolated for safety and reliability.

Previous non-isolated timers had wiring restrictions and could be damaged if wired incorrectly. The New H5CX removes these worries.



^{*1} New Models (H5CX-□-N) with 100 to 240-VAC specifications.

Forget These Worries with the New H5CX

Set Value Limit

You can set an upper limit for the set value to prevent unexpected operation of output devices caused by setting mistakes.



Output Counter

The output counter counts the number of times the output turns ON (alarm display, count monitoring, count in increments of 1,000). This counter is useful in managing the service life of the Timer or the load.



RS Components

Statement of conformity

The product detailed below complies with the specifications published by RS Components. Where applicable it provides assurance that electrostatic discharge sensitive devices have been handled and packed under conditions that meet the administrative and technical requirements of the ANSI/ESD S20.20:2014 and BS EN 61340-5-1:2007 Electrostatic Control Standards.

RS Stock No.	245-1848
Description	Pilz PNOZ X3 24 V ac/dc Safety Relay Dual Channel With 3 Safety Contacts - PNOZ X Range and 1 Auxiliary Contact
Manufacturer/Brand:	Pilz
Mfr. Part No.	774310

The foregoing information relates to product sold on, or after, the date shown below.

RS COMPONENTS

Date Sep 7, 2020

RS Components Ltd, Birchington Road, Corby, Northamptonshire, NN17 9RS, UK



RS Components

Statement of conformity

The product detailed below complies with the specifications published by RS Components. Where applicable it provides assurance that electrostatic discharge sensitive devices have been handled and packed under conditions that meet the administrative and technical requirements of the ANSI/ESD S20.20:2014 and BS EN 61340-5-1:2007 Electrostatic Control Standards.

RS Stock No.	312-1835
Description	CAL 9300 PID Temperature Controller, 48 x 48 (1/16 DIN)mm, 2 Output Relay, 100 V ac, 240 V ac Supply Voltage
Manufacturer/Brand:	CAL
Mfr. Part No.	931100000

The foregoing information relates to product sold on, or after, the date shown below.

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Date Sep 7, 2020

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RS Stock No.	338-4187
Description	Brodersen Controls Analogue Output, Signal Conditioner
Manufacturer/Brand:	Brodersen Controls
Mfr. Part No.	PXF-20.924/RS

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RS Stock No.	742-6825
Description	ABB SM50DFC/B000010E/STD, 6 Channel, Graphic Recorder Measures Current, Resistance, Temperature, Voltage
Manufacturer/Brand:ABB	
Mfr. Part No.	SM50DFC/B000010E/S

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RS Stock No.	687-6109
Description	Omron Multi Function Timer Relay - 0.001 s → 9999 h, 1 Contacts, Flicker OFF Start 1, Flicker OFF Start 2,
Manufacturer/Brand:	Omron
Mfr. Part No.	H5CX-L8-N

The foregoing information relates to product sold on, or after, the date shown below.

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RS Stock No.	330-2999
Description	Asco 3/2, 5/2 Pneumatic Control Valve Pilot/Spring G 1/4 551 Series
Manufacturer/Brand:	Asco
Mfr. Part No.	SCG551A001MS 230V CA

The foregoing information relates to product sold on, or after, the date shown below.

RS COMPONENTS

Date Sep 17, 2020

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RS Components

Statement of conformity

The product detailed below complies with the specifications published by RS Components. Where applicable it provides assurance that electrostatic discharge sensitive devices have been handled and packed under conditions that meet the administrative and technical requirements of the ANSI/ESD S20.20:2014 and BS EN 61340-5-1:2007 Electrostatic Control Standards.

RS Stock No.	394-9829
Description	TeSys D Series Analogue (ON Delay) Pneumatic Timer, Range 10 → 180s, NO/NC Contacts
Manufacturer/Brand:	Schneider Electric
Mfr. Part No.	LADT4

The foregoing information relates to product sold on, or after, the date shown below.

RS COMPONENTS

Date Sep 17, 2020

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RS Components

Statement of conformity

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RS Stock No.	330-3289
Description	160 C 3 phase inverter, 380-460V 2.2kW
Manufacturer/Brand:	Allen Bradley
Mfr. Part No.	160-BA06NSF1

The foregoing information relates to product sold on, or after, the date shown below.

RS COMPONENTS

Date Sep 17, 2020

RS Components Ltd, Birchington Road, Corby, Northamptonshire, NN17 9RS, UK



RS Components

Statement of conformity

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RS Stock No.	330-3267
Description	160 C 3 phase inverter,380-460V 0.75kW
Manufacturer/Brand:	Allen Bradley
Mfr. Part No.	160-BA03NSF1

The foregoing information relates to product sold on, or after, the date shown below.

RS COMPONENTS

Date Sep 17, 2020

RS Components Ltd, Birchington Road, Corby, Northamptonshire, NN17 9RS, UK

LOG BOOK

Log No	8
No hrs	8
Running total hrs	63

Since I collected all of the parts and found all of the data sheets last week, I could now take measurements of the components so that I could design the front panel where all of the buttons and the data logger screen would be fitted. I managed to draw up a scaled design for this on Microsoft Visio and included all of the measurements, I was then able to insert the measurements for the gaps between each of the buttons etc.

Due to this drawing showing me all of the measurements I will be able to prepare the front panel next week and add all of the buttons, controller and data loggers to it.

The same thing was carried out for the inside of the electrical panel, all of the components were measured and a drawing was produced showing their position in the electrical panel. The electrical panel had already been provided so I had to find a way to make all of the components fit, ideally, I would have finished the drawing and then ordered the electrical panel to the required size.

Student signature	S.Jones
Lecturer Signature	

LOG BOOK

Log No	9
No hrs	8
Running total hrs	71

This week I began the construction of the machine, I began by marking out the front panel as per the drawing that I produced last week. I drilled and cut out all of the necessary holes and then began fitting the components in their pre-planned positions.

Once the front of the panel had been completed, I began measuring and cutting the trunking and DIN rail and mounting it inside the electrical panel. All of the components that I collected were then fitted to the DIN rail and holes were marked out, drilled and tapped for the two inverter drives, these were then fitted.

The power circuit was then wired in, the power was taken from the isolator and fed into the MCBs and overloads, from there the cables were brought into the inverter drives, the power supply and the PILZ safety relay, each fed off their own circuit breaker.

Student signature	S.Jones
Lecturer Signature	

LOG BOOK

Log No	10
No hrs	8
Running total hrs	79

This week the power circuit was finished off and anything that needed a supply of 240v was wired up. Two cables were run out of the motor contactors to the motors, these were wired up and will need to be checked when the machine is finished to ensure that they are turning in the right direction so that they can act as pumps.

The control circuit wiring was started and the drawings produced a few weeks ago were followed closely to ensure the wiring was being done correctly. If any alterations to the wiring were being made then they were also made on the drawings, the drawings can then be updated once the project is complete.

Student signature	S.Jones
Lecturer Signature	

LOG BOOK

Log No	11
No hrs	8
Running total hrs	87

The wiring of the control circuit was completed this week and the safety circuit was also completed. The door guards were mounted to the machine, two have been added so that the door can be locked at the top and the bottom to prevent any leaks if the high-pressure hoses come off during the testing of the radiators.

The machine was powered on and the direction of the pumps was checked. One of the pumps was spinning the wrong way so the machine was isolated and two of the three phases were swapped over at the bottom of the contactor as it was easier to do this than it was to get under the machine to the pump to do it in the terminal box on the motor.

Student signature	S.Jones
Lecturer Signature	

LOG BOOK

Log No	12
No hrs	8
Running total hrs	95

The pipework underneath the machine had still not been done yet so this week I fitted that. Following the flow diagram that I produced a few weeks ago gave me a rough idea of where I would need to run the piped. Due to the high flow rate and the fact that there would be hot water in the system the pipes used needed to be stainless steel. The pipework was measured and cut to length and then joined together using steel pipe fittings and tightened with a stilson wrench. The flow switch for the leak detection was added in the pipe from the test chamber to the sump.

Thermocouples and flow sensors were added to the other pipework to measure the flow and temperature of the water/antifreeze mixture flowing through the system.

Student signature	S.Jones
Lecturer Signature	

LOG BOOK

Log No	13
No hrs	8
Running total hrs	103

This week was the final week of building the machine, all that was left to do was to insert the parameters into the drives and the CAL controller. This took the whole day to do as I had to look up the parameters on the datasheets and then figure out which settings I needed and which were irrelevant. I had to try a number of different values until I got where I wanted to be.

For the inverter drives you I needed to set up a PID control and adjust the gain, I had to guide to go off so it became a trial-and-error scenario where I would adjust the values and then run the machine to see how long the flow rate would take to rise and then I would have to adjust the values to limit the overshoot. It was all about finding the right balance between the ramp up, overshoot and response to change, once I had done this for the two inverter drives the machine was ready for testing, this would be done in a fortnight.

Student signature	S.Jones
Lecturer Signature	

LOG BOOK

Log No	14
No hrs	8
Running total hrs	111

This week was the first week of testing the machine. I asked the health and safety manager if he could come up for the day to carry out some tests and sign the machine off as safe to run. I fitted the guarding around the machine to conceal all of the internals and then the machine was ready to be tested. I was asked to demonstrate a few things such as pressing E-Stops so that we could see how the machine would react in an emergency situation. Everything went well and the machine passed all of the safety tests.

A setting was added to the temperature controller which would lock the door guards if the temperature was to surpass 50°C, this was so that nobody could scald themselves with the hot water. Once the temperature was below 50°C the doors would unlock and could be opened if required.

Student signature	S.Jones
Lecturer Signature	

LOG BOOK

Log No	15
No hrs	8
Running total hrs	119

The machine was tested this week, it was started up and monitored to see if the flow rate was going to stay withing the allowed tolerance.

The same test was carried out for the temperature.

Some changes were made to the PID control to allow the flow rate to stay more stable however the temperature was controlled very well and no changes were required.

I started a full test at the end of the day, this should still be running when I am back in the technology centre in 2 weeks' time.

Student signature	S.Jones
Lecturer Signature	

LOG BOOK

Log No	16
No hrs	8
Running total hrs	127

The test that I had put on 2 weeks ago was still running when I arrived in the morning so I monitored the machine running. The data logger screen was working well and was recording data for the flow rate, temperature and pressure, I was able to scroll back through almost two weeks' worth of data and found that the machine had been stable the entire time so this was a big positive.

Later in the afternoon I was lucky enough to see the radiator that was under test fail and therefore I got to see the leak detection system in action. It was able to stop the machine and drain all of the liquid back to the sump tank quickly. I was happy that the machine was capable of running as intended and it had passed all testing prior to this so I handed the machine over to the engineer.

I showed him all of the information that I had collected about the machine such as data sheets and also the drawings that I had made. I stored all of these files in a folder specifically for this machine which was called Rig D52 – High Flow Erosion Test Rig and handed the machine over.

Student signature	S.Jones
Lecturer Signature	

1909757

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

47/100

PAGE 1

PAGE 2

Text Comment. Good table of contents

PAGE 3

Text Comment. Good list o figures

PAGE 4

Text Comment. Avoid using first person terms

Text Comment. Good informative introduction

PAGE 5

Text Comment. Requirements are outlined

Text Comment. Time and budget are clear

PAGE 6

Text Comment. The specification should include some technical requirements for the system

PAGE 7

PAGE 8

Text Comment. A description is given on the possible function the PLC could have to benefit the project solution. This should be supported by an application example with

reference sources.

PAGE 9

PAGE 10

Text Comment. Second solution is valid but does require some form of support evidence such as an application example with relevant reference sources.

PAGE 11

PAGE 12

PAGE 13

Text Comment. There is far too much detail here which is not necessary. only the significant points and technical issued need to be explained. Simple images should be here with brief explanations

PAGE 14

Text Comment. The table of results is a good method

Text Comment. There is too much unnecessary detail in the explanation here

PAGE 15

Text Comment. Good method using table to evaluate test results

PAGE 16

Text Comment. There is far too much unwanted detail here. All that is required are the test results conclusion and any recommendations.

PAGE 17

Text Comment. There should be more relevant sources for the research

PAGE 18

PAGE 19

PAGE 20

PAGE 21

Text Comment. These industrial specific docs are not required

Text Comment. Reference in spec

Text Comment. Good image that supports the reference in the report

Text Comment. Image supports reference in report

Text Comment. Image has been referenced in report

Text Comment. Good image for supporting reference in main report

PAGE 44

Text Comment. Image is referenced in report

Text Comment. Image is referenced in report

PAGE 45

PAGE 46

Text Comment. Good evidence of implementation

PAGE 47

Text Comment. Image is referenced in main report

Text Comment. Data logging is clear

PAGE 48

Text Comment. Image supports explanation in report

PAGE 49

PAGE 50

Text Comment. Good evidence of implementation

PAGE 51

Text Comment. Image supports reference in report

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GRADING FORM: CSG-RUBIC

SCOTT JONES**0****RESEARCH-INFORMED LITERATURE**

Research is limited and there is very little evidence from the sources in the text. 3/10 Not enough sources to support research. 3/10

6/20**KNOWLEDGE AND UNDERSTANDING**

Specification covers the requirements but there is far too much unnecessary content . 5/10 Solutions considered cover brief descriptions of possible benefits and evaluation. There are no referenced sources or application examples which are needed here to support research section. This section should include images and / or block diagrams to support arguments. 4/10

9/20**ANALYSIS**

Testing and results tables used are a good method for evaluating the level of success. The supporting explanations have far too much unwanted content. There are supporting test images in the appendix.

11/20

5.5/10 Conclusion has far too much unwanted content. The recommendations are valid for the project. 5.5/10

PRACTICAL APPLICATION AND DEP.



Planning - Gantt chart has a detailed timeline and comparison for predicted and actual times. No explanation and no test plan is included. 3/5 Solutions considered should have at least some example application with images or block diagrams with relevant reference sources. This would have supported the research section. There is an evaluation to justify solution choice and a valid reason for change of solution. 4/10 There is good evidence for the implementation of the final solution with supporting images in the appendix. The explanation includes far too much unnecessary content 6/10

13/25

SKILLS FOR PROFESSIONAL PRAC.



The report contains far too much unnecessary content. The link with referenced images is not easy to locate in the report. First person terms should be avoided. The report does correspond to the table of contents. 8/15

8/15