

PSDE 4033 Project Report

by Thomas Wood

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HNC ELECTRICAL AND ELECTRONIC ENGINEERING

PSDE 4033 PROJECT – Installation of new ethanol blending pump and motor starter modification to ensure compliance with new gasoline regulations.



MAY 14, 2019
THOMAS WOOD
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Summary

This report has been produced in order to document the research, design, construction and testing of the commissioning of a new drive due to new ethanol additive regulations.

Extensive research has been carried out on this project, this research has been carried out into many of the aspects of the project, including the motor control options and the importance of selecting the most suitable motor.

The following section of the report is the project proposal, this is produced in order to underline the issue and how it must be solved. A basic project plan can also be seen within this section.

The specification for the project can be seen within the next section, the specification is used to determine whether the project has been a success. For the project to be successful all the specification points must be met.

The timing plan has been suitably updated throughout the project; this has been done to allow the actual completion dates of certain tasks. It can be seen that some of the project fell behind plan, this was due to certain issues that occurred.

There were then three solutions for the project considered, each of these solutions were thoroughly researched in order to determine their suitability for the project. Once each solution had been researched they were then all compared. The most suitable solution was then chosen; the use of a gemstart for the control of motor.

The chosen solution was then designed and implemented, this was first of all done by designing the layout of the starter and the settings for the gemstart. This was then tested and it was found to work correctly on a light run.

The final step was too conduct the final test of the system; this was done in two stages. A light run (motor shaft not connected to pump), and then the final run up of the motor. In order to ensure both of these tests are successful a certain amount of time must be allowed, also fault conditions must be simulated.

*Good
summary.*

Acknowledgements

I wish to offer my greatest thanks to the project department and also maintenance department at Valero Pembroke for the support and guidance throughout this project.

Mr Alex Wilkes, for allowing me responsibility of this project.

Finally, a thank you to my college tutors for their continual encouragements throughout the project.

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*Good list of
contents. The
sub-divided
headings
looks
professional.*

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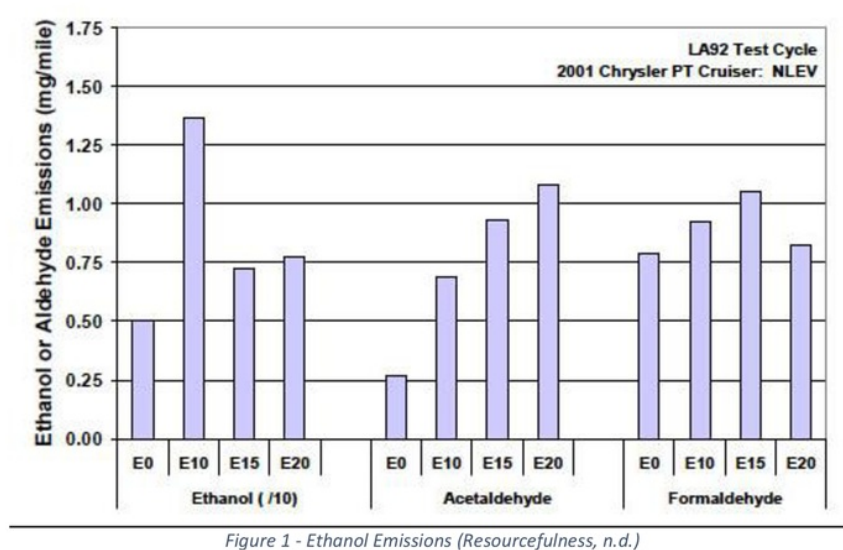
*Figures have
appropriate names and
are easily identified.*

1. Introduction and background research

1.1 Back ground information

In this project a new pump must be incorporated into an already functioning petrochemical industrial plant. The pump needs to be installed due to new regulations that state the amount of ethanol within gasoline must be increased. Therefore, the pump will be utilised in order to inject ethanol into the gasoline just before it is delivered to the consumer.

The new regulations state that in order for fuel to be considered “biofuel” the ethanol content must be increased from 10% too 15%. This new type of fuel is called E15. The current fuel that is created is E10 which contains 10% ethanol and 90% petrol, therefore in order to prevent the need for large construction changes in the plant, it was decided that the additional 5% of ethanol that is now needed will be injected just before being loaded onto tankers for the consumers.



Good graph to support the explanation and from a good source.

Figure 1 shows the emissions from different types of fuels, it can be seen that E0 has the most efficient emissions. However, due to this mix having no ethanol in it, it is not considered to be biofuel. It can also be seen that from moving to E15 fuel the ethanol emissions drop drastically compared to E10 fuel.

The project itself requires the designing and implementation of the injection motor to allow these regulations to be followed. The overall project is a very large one therefore, this particular project is going to focus on the electrical side of the project, this being installing the motor and its suitable control/protection systems.

This is good background information.

1.2 Basic research

This project requires research into 3 possible solutions for the project, due to the motor being selected by industrial standards this cannot have three different solutions. Therefore, the control and protection of the motor will be decided utilising three solutions. The control of the motor is important in order to ensure minor faults do not become major faults. The motor will be tagged 23-PM-412 and will be fed from 30-MCC-6-1 in substation 6.



Figure 2 - 30-MCC-6-1

1.2.1 Requirements for good motor protection

In order to develop 3 solutions to the problem an understanding of what protection a motor needs must be developed. Protection is needed to ensure that if a fault occurs it can safely trip the motor or provide an alarm/warning to the user to inform them. There is a large variety of protection for motors, however the most important protection that has been found are; Overload protection and Starting current. "Overload is the operation of equipment in excess of its current rating" (Holt, 2013). Therefore, overload protection can be achieved by analysing the running current and ensuring it is not 110% of the motors FLC (full load current).

1.2.2 Arduino

Arduino is a form of microcontroller that is easily programmed to undergo certain projects (Figure 3). The processing board is powered through the use of a USB at a voltage of between 7 – 12 VDC, the programming of the board requires a free to download software called "Arduino Development" (Wyoming, 2013). The Arduino board contains a 28 pin, 8-bit microcontroller, this allows the "processor to complete 20 million instructions per second" (Wyoming, 2013). Through the use of the software many things can be undergone, therefore through the use of Arduino the current can be analysed and alarms that eventually trip the motor can be incorporated into the program for when the FLC is exceeded.

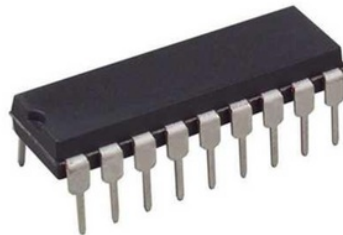
Good argument for the Arduino which is more than capable of monitoring multiple analogue signals and controlling outputs. The argument for the Arduino is supported by further test and implementation further in the report.



Figure 3 - Arduino Board

1.2.3 Microprocessor

A microprocessor is a mass storage device, which is a form of advanced computer (Figure 4). They are useful in different applications due to the low cost, small weight, low power and high computing capabilities. "Now a days, a microprocessor based systems are used in many different applications such as; automatic testing product, speed control of motors and traffic light control" (Scanftree, n.d.). Due to these capabilities a microprocessor would be suitable to be used for the protection of the motor due to its ability to compare inputs with desired values and then provide an output depending upon the state of the input.



Good argument which is backed up further in the report with some testing.

Figure 4 - Pic Chip

1.2.4 Gemstart

A gemstart (Figure 5) is a type of controller that has been specifically designed for the greatest possible motor protection. The gemstart is designed to work in co-operation with any motor starter and other electrical applications, this is done through utilising suitable control wiring. The gemstart is able to be programmed to suitably protect a specific motor.

The gemstart can also increase the efficiency of the motor through analytics that it carries out. In order to program the gemstart a computer is required.



Good argument for this PLC with more information to support this further in the report.

GemStart5

Figure 5 - Gemstart

2. Specification

For the project to be deemed as successful it must satisfy all of the following criteria in the specification.

2.1 Technical Specification

Performance

The drive must be as efficient as reasonably practicable to reduce the amount of wasted energy/power

[Sustainability here](#)

Service

The drives must be operable 24 hours a day

The motor must be able to operate without maintenance for 2 years

Life Span

The motor must be purchased from a company that will provide parts for at least 6 years after purchase

Costs

The cost for the installation of the drives must be no more than £8000

Maintenance

Planned maintenance must be carried out on the drive annually

When required reactive maintenance can be carried out on the motor

Installation

Motor must be suitable to be installed by mechanical department at Valero

Safety

The drive must user friendly and must have the suitable fixings to install a cowl onto the back of the motor to prevent entanglement in the fan, the motor must have suitable means of isolation in order to allow maintenance to be carried out.

Testing

The motor must be suitably tested to ensure operation before and after installation.

Documentation

The drives must be provided with suitable documentation that will allow the company to suitably prepare for the installation of the motor before it is delivered.

Ergonomics

The motor must have local and remote control, this will allow the motor to be suitably controlled in the field and also from the panel man.

Standards

The renewably powered motor must be suitably atex rated.

The wiring for the renewably powered motor must be in line with BS 7671.

Reliability

The motor must be reliable so that it does not require reactive maintenance within the first 2 years of operation

Sustainability

The motor must utilise the most sustainable components possible in order to promote sustainable development

Aesthetics

The motor must be well maintained to ensure a good appearance

2.2 Timing

For the timing of the project to be successful it must be fully completed by April 2019.

A breakdown of the vital times can be seen below:

- The research for the project must be completed by the 23/10/18
- The chosen solution must be made by the 11/12/18
- The specification must be written by 6/11/18
- A project plan must be developed by the 13/11/18
- Further research into the chosen solution must be undergone by the 25/12/18
- A component list must be produced by the 5/2/19
- The final test of the solution must be carried out by the 9/4/19

2.3 Budget

This project was given a rolling budget; however, it was deemed desirable to keep the components within the project to a maximum price of around £8000. The installation costs should be minimal due to no training being required as the maintenance team are already familiar with the parts going to be used. Also no training will be required when it comes to operating the motor as it will be operated in the same manner as every other motor currently on site.

Spec is good but seems it only includes the motor and drive. There should also be a controller as discussed in the research. This should not be specific to a drive.

3. Planning

3.1 Gantt chart

The entire project has been planned out using a Gantt chart, this Gantt chart can be seen within Appendix A. The Gantt charts illustrates the dates certain tasks must be completed by and then the actual completion dates.

It can be seen on the Gantt chart that a few tasks have fallen behind time, these have many reasons that have led to this, mainly complications with completing other tasks that have led to other tasks being started later than expected. This therefore has a knock on effect on the whole project and starts to put the project behind schedule. However, it can be seen that in places extra work was carried out in order to ensure the project was put back on schedule.

From the Gantt chart it can be seen that there were two deadlines that were not met, these tasks were to produce the project plan and to produce the component list. The project plan took longer than expected due to the substantial amount of time it took to decide upon the best solution. This therefore meant that the project plan was not started at the planned time.

The second complication was the component list; this task took longer than planned due to the vast array of different components that were available. It therefore meant that each component had to be analysed in order to ensure it is suitable for the project.

3.2 Testing plan

In order to test the final project 3 main tests must be carried out, these tests are;

- Testing of the starter (protection)
- Light run of the motor
- Full run of the motor

By conducting all 3 of these tests the system can be deemed operable, this is due to the protection being tested and then the motor being tested both with a load and without a load.

Good explanation and supported by good use of Gantt chart which has comparative timeline.

4. Solutions Considered

For this Project three solutions must be considered, each of these solutions will be analysed and then later compared in order to determine the most suitable solution.

4.1 Solution 1

The first solution is to provide the protection of the motor through the use of Arduino. The Arduino will be programmed with different alarms for set values; for example, if the running current exceeds the FLC (full load current) then an alarm can be triggered, this alarm can be programmed to then trip the motor if the running current does not drop after a set amount of time. The in rush current of the motor can also be analysed by the Arduino board, the in rush current is far greater than the eventual running current therefore the Arduino board can be programmed to trip the motor if the current does not drop after a suitable amount of time.

Arduino works through the use of “three main components” (Blum, n.d.); the Arduino board, external hardware and the Arduino software.

A very important aspect to the protection of the motor is fault analysis, in order to gain this fault analysis some kind of interface between the user and the fault data must be achievable. With Arduino a LCD screen can be utilised in order to present the basic running data of the motor and the alarms/trips. However, for proper analysis of the faults LabView can be utilised, by utilising this existing trips/alarms can be documented to provide data that could lead to the correct fault diagnosis on the motor.

The only real limitations that this solution contains is the need for a small regulated voltage on the Arduino board which can be difficult to find within, industrial substations; therefore, a regulator may be needed. Also Arduino boards are known to develop problems and the protection on the motors needs to be as reliable as possible.

Due to the simplicity of the Arduino software it can be seen within the log 7, that a basic prototype was developed that had 3 alarms at different currents, a potentiometer was utilised to alter the current in order to trigger each alarm. The circuit and example of alarm 1 can be seen within Figure 6 & Figure 7 – Arduino prototype.

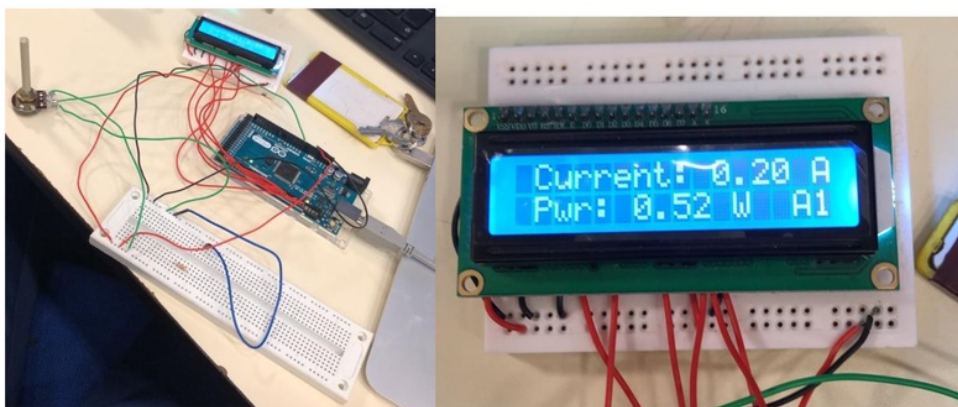


Figure 6 & Figure 7 – Arduino prototype

Good argument supported by a demonstration and test.

Good image.

4.2 Solution 2

The second solution is to utilise a microprocessor in order to provide the protection for the motor. The microprocessors program is developed utilising MPLAB IDE and HITECH C compiler, once the program has been developed it is then downloaded to the PIC chip. The program is then run through the use of proteus.

The microprocessors program Figure 8 is coded through the use of C-programming this allows for complex programs to be coded with relative ease. This can allow for the FLC and in rush current to be analysed throughout the code, depending on the arithmetic values alarms/trips can then be activated from the program. The microprocessor can be re-programmed as many times as desirable this will be helpful if the motor size is changed in the future.

The limitations of the microprocessor are how complicated the circuits can become, also there will be a need for a large CT which will reduce the accuracy of the current readings and could therefore cause discrepancies and allow the motor to run under fault conditions.

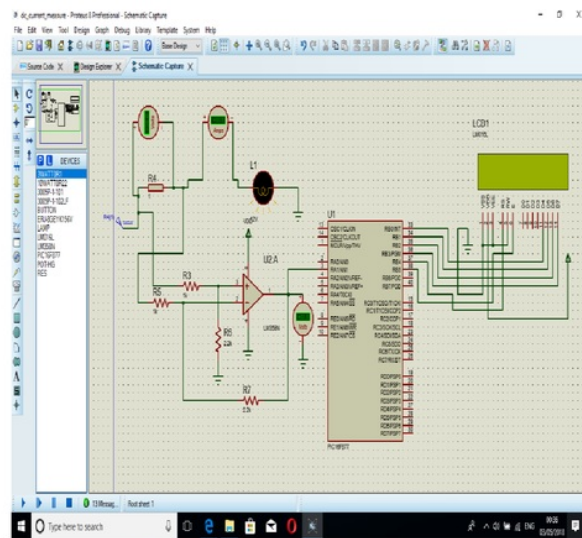


Figure 8 - Microprocessor example program

Good image and argument for this solution.

4.3 Solution 3

The final solution is the use of a gemstart for the protection of the motor. The gemstart is programmed through utilising gemstart software on a laptop, the laptop allows for all the protection settings to be set up accordingly to the motor that the protection is for. The gemstart operates through the use of a CT on each of the motor phases, this allows for many other protection types to be undergone. The in rush current and overload can be protected however by having a CT on each phase phase imbalance can also be analysed, this protects the motor from potentially single or double phasing when one phase is down. The gemstart 5 has 3 CT's built into its processing module.

The gemstart has an LCD display which is utilised in order to display the running conditions of the motor, it can also give a small display on the faults that occur. This is important in

providing the user with information on the faults, the good thing about a gemstart is the historical data that is available. Through the use of a laptop all the historical data of the gemstart can be analysed, this can be helpful in understanding any re-occurring faults with the motor and can allow for diagnosis of the fault to be made easier.

The limitations with the gemstart is the severe cost to install to begin with however due to the extensive protection that is provided this cost is repaid. Another limitation is the need for a laptop for the best communication, due to regulations upon site the laptop would be very expensive as it would need to be certified to be utilised within hazardous areas (ATEX).

A good argument for the drive especially since it has built in CT'S for each phase. This would have to be done as external ccts using microprocessors.

5. Final Solution and Implementation

For this section all three of the solutions can be compared and the most viable option can then be chosen.

5.1 Comparing all three solutions

Installation time

From analysing all three of the possible solutions it was decided that the gemstart would be the quickest to install. This is due to the ease of installation with the current switchgear compared to the development time and installation time of the other two solutions. The motor starter itself would have to be remodelled so the LCD displays are appropriately displayed. Also the board would have to be mantled to the starter appropriately and a supply would have to be installed into the starter for the circuits. All of these modifications will take time and will also require more tests to ensure the modifications made are appropriate.

Cost

The overall estimated cost of all 3 solutions can be seen within the log 8. It can be seen that the cost of the gemstart solutions is much greater than the other two solutions. The only parts that will be different between each solution is the protection device therefore the gemstart is going to be much more expensive due to the capabilities it supplies.

Availability of parts

All the solutions have been compared with the availability of the parts required for the particular solution. This also accounts for the time that it will take for the parts to be sourced and delivered.

From analysing the availability of parts for each solution it can be deemed that each of the solutions have very available parts, there should be no parts with excessive delay. This is also desirable as spares could be sourced and delivered with short delay, this can be important if faulty parts require changing.

Reliability

All the solutions' reliability has been compared, due to the gemstart being utilised within many applications before upon site it must be considered the most reliable as no real problems have been accounted as of yet. Through research it has been found that Arduino board and microprocessors do tend to become less reliable over time and therefore would probably require more maintaining.

Chosen Solution

Having analysed each of the three solutions, it has been ultimately decided that the solution 3 is the most desirable solution. There are several reasons that have made this solution the most preferable; the installation time is one of these reasons, being able to install the protection with complete assurance of the operation of the system is extremely important and by utilising this solution this assurance can be fulfilled. The gemstart also provides far further protection of the motor than the other two solutions and also provides the most analytical historical data upon the motor. Although the cost of the gemstart solution is the

Your arguments are logical and valid. It is probably worth mentioning that the codes of practice with Valero insist on the GEMSTART drive.

highest it is believed that the advantages off this solution far outweigh this and therefore make the solution worth the cost.

5.2 Designing chosen solution

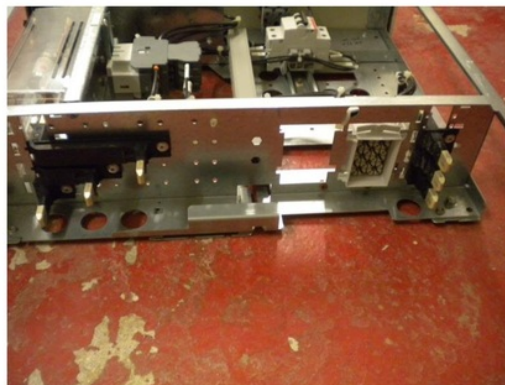
Having decided upon the chosen solution, the design stage for the solution must be now undergone. The first part of the design stage was to determine where the motor will be located, this therefore allows for the most desirable supply for the motor to be located.

Having had the location of the motor confirmed by the Mechanical department the supply can be confirmed, from the location of the motor the most desirable supply was confirmed to be within substation 6. A route for the cable between substation 6 and the motor was then produced. This cable route can be seen within Appendix B.

It can be seen within the drawing that the cable will be ran upon existing cable tray. The cable way for within the substation can also be seen within the design seen in Appendix C. The cable is drawn so that it goes to a spare starter slot in the switchgear. The board that the supply is taken of is 30-MCC-6-1, this is a motor control centre (MCC), therefore many motors are fed from this board.

The next part of the design is to distinguish the cable connections for the motor, the motor also has control wiring therefore the cable connections are not as simple as they may seem, there is also a need to use existing cables from old substation six to allow remote control of the motor from the control room. The cable connections that were derived can be seen within Appendix D.

The next step of the design was to construct the starter for the motor, the motor starter that was to be used was a spare galaxis motor starter (Figure 9) the first stage in wiring the starter was to get all the control wiring in place. Once this had been complete the components could then be mounted and the cable could then be terminated appropriately.



Good image to support explanation

Figure 9 - Spare motor starter

Therefore, in order to complete the starter; fuses, a contactor, a gemstart 5 (and processing module), the cabling for gemstart and an isolator, must all be installed. The completed motor starter can be seen within (Figure 10), the wiring within the starter has since been tidied however no pictures have been taken of this.

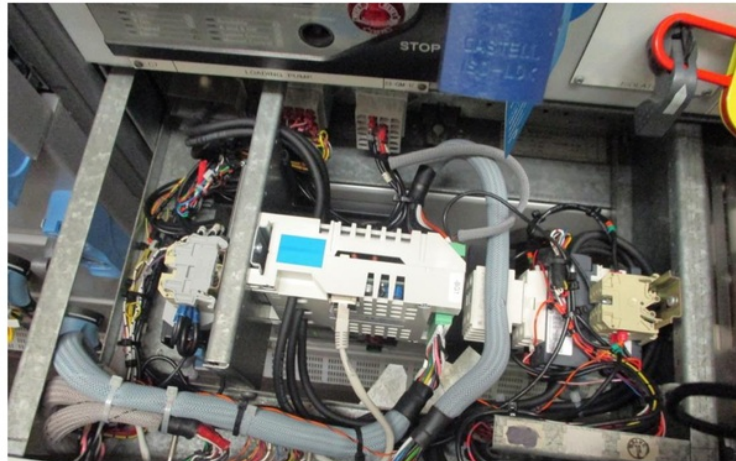


Figure 10 - Completed starter

The quote for the gemstart can be seen within Appendix H, there was also a quote for the re-wiring of the motor starter, however this was carried out as part of the project so this was disregarded.

The component list can be seen below;

Stop/Start station - (£229) (Crouse-Hinds, n.d.)

Cable - (£339) (Components, n.d.)

Contactors - (£87) (contactors, n.d.)

Fuses - (£40) (Bussman, n.d.)

Motor - (£785) (TECO, n.d.)

Isolator - (£45) (FUSERBLOC, n.d.)

Gemstart - (£4150) (Comeca, n.d.) (Appendix H)

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Once the motor was chosen the details could be used in order to derive the gemstart parameters that needed to be set. The settings are derived from the motor curve, this curve is effected by many factors, a few of these are; the FLC of the motor, the wiring of the motor eg. Star/Delta, and many other factors. The amount of settings that are available on the gemstart are substantial, the settings that have been chosen can be seen within Appendix E. Within Figure 11 the CT settings of the gemstart can be seen these settings are notable as they show that all three of the CT's are utilised in order to analyse the running current of each phase.

Phase CTs			
CT Input Type	Primary		
Number Of CTs Used	3		
External CT Primary Rating	Speed 1	Speed 2	
Primary Turns Through CT	Speed 1	Speed 2	
Turns	1	1	

Figure 11 - CT settings



Figure 12 - Motor details plate

6. Testing and Results

Once the solution had been put together, the next step was to carry out a test run. Also the starter requires fault testing. Thorough testing has to be carried out before the system can be deemed operable.

6.1 Starter testing

The first stage in testing the starter was to carry out an insulation resistance test to ensure that there is no breakdown in insulation within the starter. This also confirms no shorts between phases or phase to earth.



Figure 13 - Settings being updated in GEMSTART

Image is appropriate to support your explanations.

In order to test the starter then certain fault conditions must be simulated, this is achieved through the use of a primary injection tester, this tester will allow for a current that exceeds the overload to be injected through the starter, this will then test the response of the gemstart as it should trip the motor. The imbalance trip can be simulated by removing one of the phase' fuse and then injecting the correct current upon the other two phases.

The second test of the starter is too insert the starter into the carriage of the switchgear into the test position and too carry out a control circuit test.

Through carrying out these tests it was found that the gemstart suitably protected the circuit. When injecting the correct running current, the starter operated correctly, and after increasing the current to above the 110% FLC the gemstart tripped. Following the successful first test the second test could now be carried out.

The second test sees the starter be taken down to the substation and inserted into the relevant carriage within 30-MCC-6-1. The starter was inserted into the test position and then the control circuitry could be tested, by pressing the start button it can be confirmed that the contactor is pulled in and the running light comes on the gemstart. By then stopping the gemstart it can be confirmed that the contactor opens back up and the stopped light illuminates.

*Test
expla
nation
is
clear
and
gets
to the
point.*



Good image

Figure 14 - Starter inserted into carriage

It can therefore be seen that the starter is in working order.

6.2 Motor light run test

In order to ensure the motor and cabling from the substation are in working order an insulation resistance test and a balance test will be conducted upon the motor. The results from these tests have been documented within Appendix F.

In order to confirm the working of the motor both remotely and locally a light run was carried out. A light run of a motor is when the motor is running with no load. In this case the coupling between the motor and the pump is removed, this therefore means the motor has no load.



Figure 15 - Control at motor

By doing this and then running the motor the running current will be much lower than if the motor had a load upon it, however it allows for the control circuitry to be tested. The running current is expected to be around 40% of the FLC when being ran light. The current on each phase can then be tested by using a clamp meter in the phases at the back of the board (Figure 16), these values can also be compared to the displayed current on the gemstart. The results from this test can be seen within Appendix G.

Good explanation and reference to the appendix.

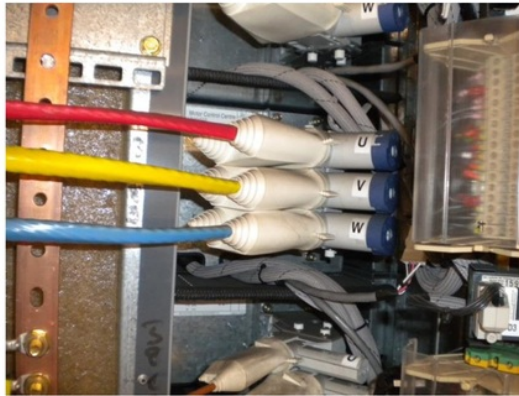


Figure 16 - Phases in the back of the board

Good images showing the implementation and shows the coupling removed for the test with no load.



Figure 17 - Motor being ran with coupling dropped

Thirdly the control of the motor from the substation was tested. This test was carried out through the use of a radio, the motor was started and then stopped from the substation successfully, secondly the local control station was tested. Once again the motor was successfully started and then stopped.

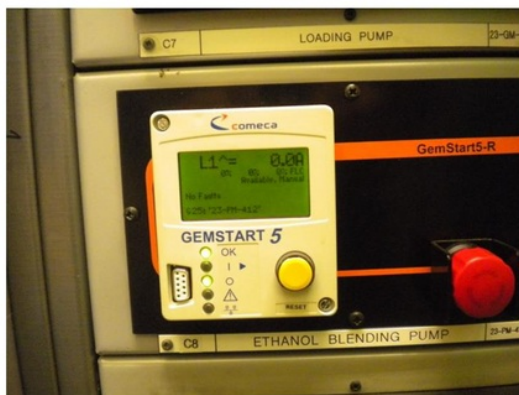


Figure 18 - Gemstart display (not running)

Finally, the remote control of the motor was to be tested. In order to test this an operator who understands the operating system within the control room is required. When this operator started and stopped the motor from the panel within the control room the motor functioned correctly.

It can therefore be deemed that all control circuitry works correctly.

6.3 Motor full load test

The final test for the motor is to have the mechanical department fit the coupling between the motor and the pump and to have a final on load test (Figure 19). The motor will be allowed to run for several hours in order to ensure everything operates correctly. Once this test has been completed the final commissioning of the motor can be undergone.

Having carried out the final test run it was deemed that the motor was fit for operation, this therefore means that the motor is ready for commissioning.



Figure 19 - Motor being ran with coupling installed

However, whilst carrying out the final tests before commissioning it was found that the local start button seen within Figure 19, ignores the interlocks in place and therefore allowed the motor to start even when no lorry was connected. Therefore, it was decided that the local control be removed for now and this problem be amended at a later date.

*Important to highlight
this problem here.*

7. Discussion, Conclusions and Recommendations

7.1 Discussion

In this section the results from the testing will be concluded. In order to do this the results from testing will be compared to the initial specification.

The first part of the specification states that the drive must be as efficient as possible, this can be proven to be true due to the capabilities of the gemstart. The gemstart utilises analytical data to ensure that the motor works in the most efficient way possible.

The next section of the specification states that the motor must be operable 24 hours a day and must operate for two years without any maintenance issues. It can be confirmed that the motor would be operable for 24 hours a day however in order for the two years without maintenance point to be confirmed then 2 years after the commissioning of the motor would have to pass.

The specification states that the motor must be purchased from a company that will provide spare parts for at least 6 years. This is achieved through the use of a Brooke Compton motor, this company is a well known supplier to the industry and therefore is extremely reliable and provides spare parts for at least 10 years.

The specification states that the drive must cost no more than £8000, it can be seen within the log 22; that the overall cost of the solution is £6025 for parts, and due to the installation cost being little to none it can be confirmed that this specification is met.

Within the specification it states that the motor must be suitable for a cowl to be installed and must have a safe means of isolation. Through utilising a Brooke Compton motor it is known that a cowl will be supplied on the motor, and the safe means of isolation is found on the starter within the substation. On the isolator there is a slot for a lock to be installed which will prevent the supply from being turned back on.

The next section of the specification states that the motor must be suitably tested, it can be seen within 6.2 Motor light run test and 6.3 Motor full load test that the motor is thoroughly tested both with and without a load.

The specification also states that the motor must have local and remote control, it can be seen through the tests carried out within 6.1 Starter testing that both of these motor control types have been achieved. However, after conducting final testing before commissioning it was found that the local control within the substation overrode the interlocks in place and therefore this had to be removed.

The specification states that the motor must be suitably atex rated and the wiring must be in line with current BS 7671 regulations. The motor that was selected was ensured to be suitably rated through the use of the hazardous area drawings for the area in which the motor is being installed, also the wiring was appropriately carried out under the current regulations.

Codes of practice are followed here.

7.2 Conclusion

For the conclusion of this project several different aspects of the project are to be looked at, these include the timing plan and the budget.

The first thing to be studied will be the project plan, it can be seen that the project was planned to be completed by the 30/04/19.

Ultimately although several set backs within the project such as wrong parts being delivered the project was a success and also the final test was carried out before this completion date. Although the commissioning of the motor has not been undergone yet due to factors causing other departments on the project problems.

The budget for the electrical installation of the project was capped to £8000, it can be seen in the log 22 that the final component spend list is well below the £8000 mark. Therefore, this means that the budgetary conditions of this project have been satisfied.

The project itself was successful, this can be deemed as the brief that was provided was achieved. The motor has been installed with the most efficient protection as reasonably practicable. The motor has both remote and local control which allows for the panel man to operate the motor and also the field man.

Throughout the project a lot of inter work relations with other departments was required, this was clear within the testing of the motor as communication with operations personnel was required. It was therefore important that a professional approach was taken throughout this project to ensure the communication between different departments was clear and precise.

7.3 Recommendations

For the recommendations to the project improvements will be suggested.

The improvement that was identified for this project would be the improvement of the gemstart settings in order to ensure that local control of the motor is not available when certain interlocks are not satisfied. It was identified through testing that the local control overrode the interlocks on the system, these interlock are; tanker being connected and sufficient ethanol available for blending in the tanks. Therefore, the local control has been fully removed from the system for now, however if the problem was overcome local control could still be available.

In order for this improvement to be undergone the interlocks would have to be taken into account before allowing a local start, this is possible through adjusting the settings within the gemstart through the use of Gempro software.

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[pl file/Barrett_Ch1.pdf](https://www.morganclaypool.com/doi/suppl/10.2200/S00522ED1V01Y201307DCS043/suppl_file/Barrett_Ch1.pdf)

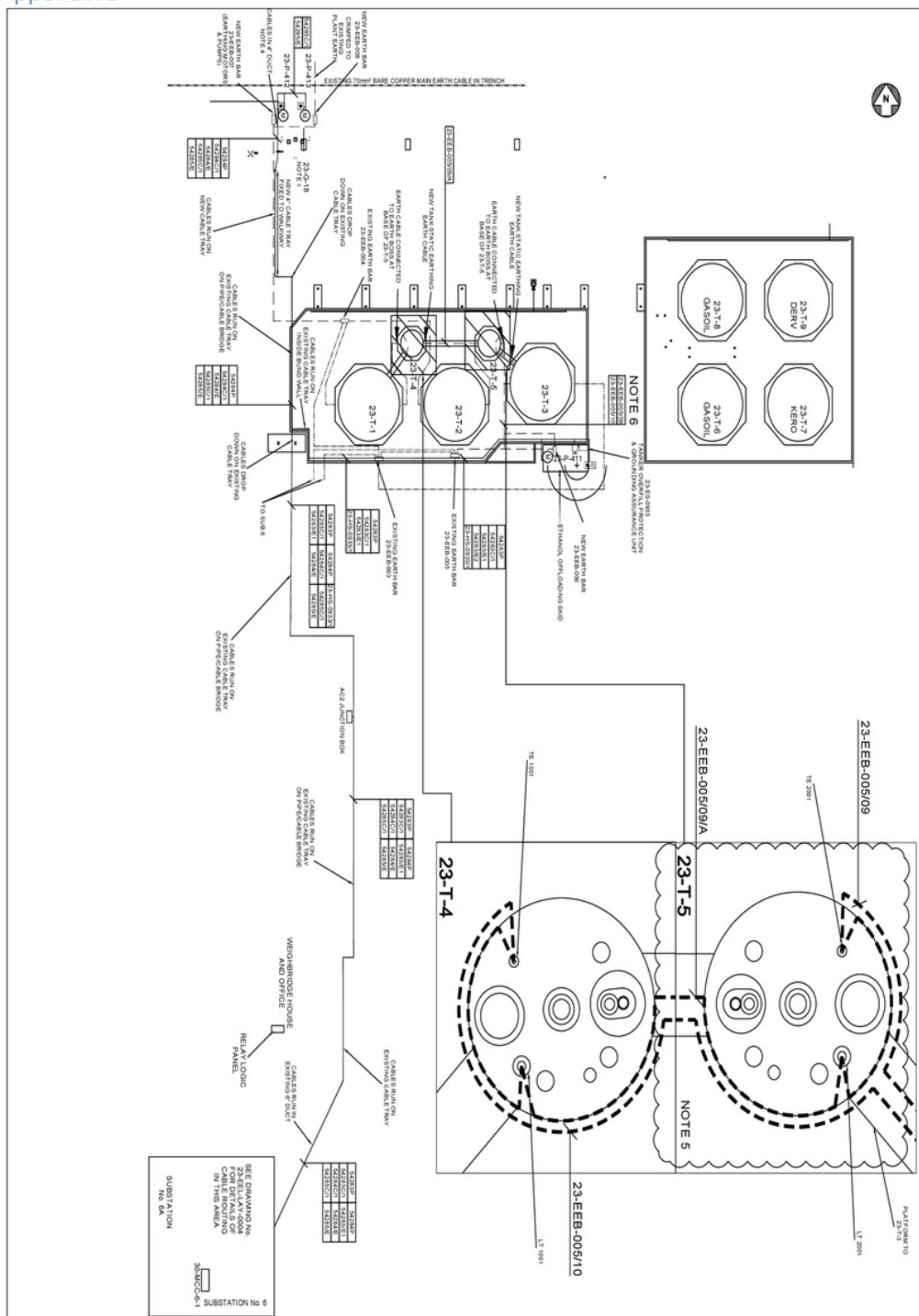
[Accessed 2 January 2019].

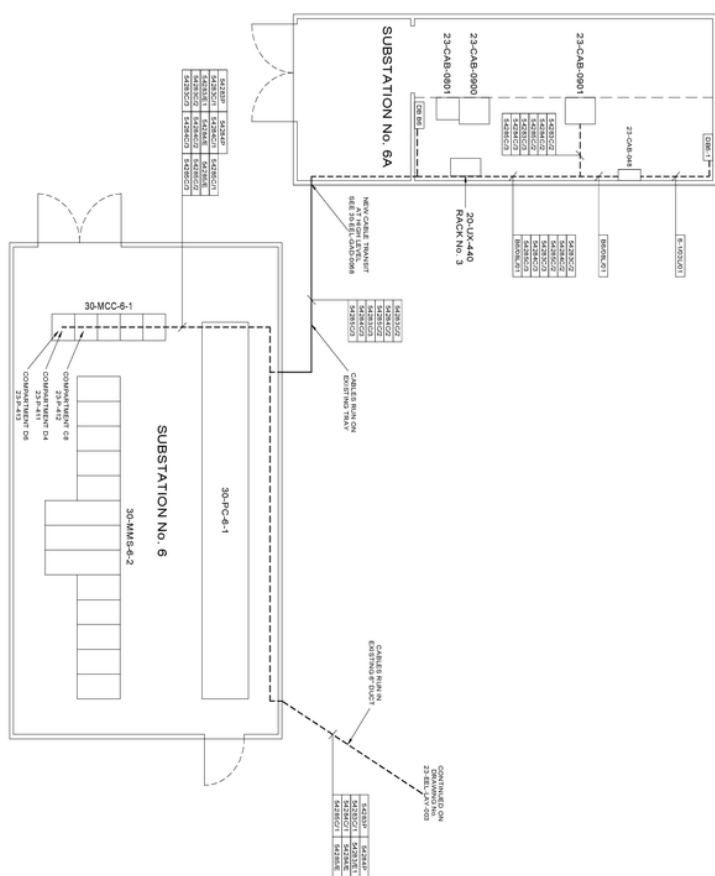
9. Appendix

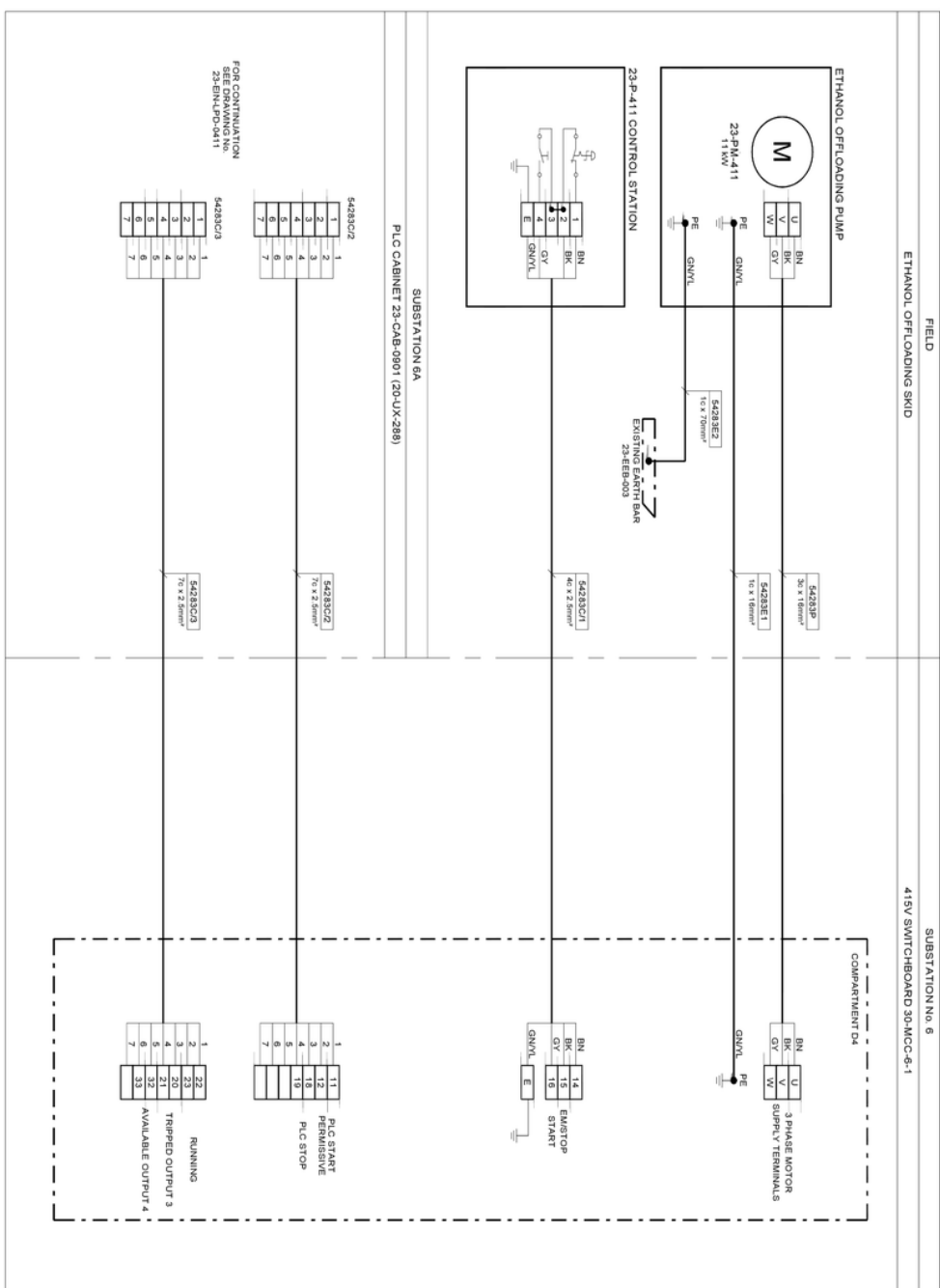
Appendix A

[illegible]

Appendix B







GEMSTART 5 Configuration Sheets

Project File (c:\..\xxxx.gcf)	
Project Name	RTW Ethanol Blending
Comeca Project Number	621895
Valero Project Number	PM17-0210

Unit Summary	
Gemstart Type	Gemstart 5.4
Connector Type	DOL-E
Schematic	30-P6S-531 - Sheet No.13
Motor Tag	23-PM-411
Link Name	N/A
Firmware Build	5450
Firmware Issue	H20

Configuration CRCs	
Overall (all Settings)	
Factory Settings CRC :	
Commissioning Settings	

Notes :

- The overall CRC is the CRC for all configuration items.
- The configuration data on page 2 has been set up and tested during manufacturing. These parameters define the functionality of GEMSTART 5.
- The configuration data on page 3 must be set up during commissioning according to the characteristics of the motor/equipment and the different protection functions required.



GEMSTART 5 Configuration Sheets

Factory Settings CRC :

DIGITAL AND PROTECTION APPLICATION			
Voltage Setting	415V	Monitor Voltage	340 V
Motor Voltage		Monitor Phases	Phases 1 to Neutral
Number of Phases	3	Inputs Supply Voltage	No
Frequency	50Hz		
Breaker / Over Voltage	Yes	Severity	Warn
Active		Pre Warn at	Off
Protected in Start	-		
Phase Reversed	Yes	Severity	Latched Trip
Active			
Disabled in Start	-		
Reset Through	Yes	Auto Restart	Off
Ready / Fail / Recovery	65, 80%	Maximum Trip Time	Off
	200ms	Restart Delay	Open 1s

FUSES AND CONTACTOR			
Contactor Type	DOL-E		
Contactor Model	None		
Contactor Protection	Speed 1	Speed 2	
Cont. Rating (W/LC)	1000% FLC (P15.00 A) 100% FLC (P15.50 A)		
Start Blow Time	1 s	1 s	
Contactor / IP A	Source	Source	
Contactor / IP B	Input 1	Normally Closed	
Contactor / IP C	Disabled	Normally Closed	
Contactor / IP D	Disabled	Normally Closed	
HW OP 1	Source	Source	
HW OP 2	Cont. A	Normally Open	
HW OP 3	Tripp	Normally Open	
HW OP 4	Available to Manual	Normally Open	
Check Analyses	Yes		
Charger Allowed	No		
Min Start Time	1s		
Max STOP Time	Off		
Slow Down Time	0s		
Contactor Setting Time	< 0.5s		

PHASE CTs			
CT Load Type	Primary		
Number Of CTs	3	Speed 2	
External CT Primary Rating	Speed 1	Speed 2	
CT Range			
Primary Turns Through CT	Speed 1	Speed 2	
Turns	1	1	

DIGITAL INPUTS			
Interlock	Source	Source	Severity
Interlock	Interlock	Normally Closed	Self-Clearing Trip
Interlock	Disabled	Normally Closed	Self-Clearing Warning
Overload Relay	Disabled	Normally Closed	Latched Trip
Thermistor Relay	Disabled	Normally Closed	Latched Trip
ELCB Relay	Disabled	Normally Closed	Latched Trip
Device Status	Disabled	Normally Closed	Self-Clearing Warning
Test Position	Disabled	Normally Closed	Self-Clearing Warning
Input Counter 1	Disabled	Normally Open	
Input Counter 2	Disabled	Normally Open	
Input Counter 3	Disabled	Normally Open	
Reset Input 1	Input 8	Normally Open	
Reset Input 2	Disabled	Normally Open	
Speed Sense	Disabled	Normally Open	
Reset Action On Reset Input (Input 1 / Input 2)	Yes / -	Applc	Yes / -
Interlock	Yes / -	Motor	Yes / -
LOCKED Start	- / -	Overload	Yes / -
User Text	Source	Source	Severity
User Text 1	Disabled	Normally Closed	Latched Trip
User Text 2	Disabled	Normally Closed	Latched Trip

MANUAL CONTROLS			
Manual Select	Source	Source	Severity
Remote Select	Active	Normally Closed	
Local Select	Disabled	Normally Open	
Input Stop	Input 7	Normally Open	Stop (No Fault)
Process Stop A	Input 3	Normally Closed	
Process Stop B	Input 2	Normally Open	
Manual Start A	Disabled	Normally Open	
Manual Start B	Disabled	Normally Open	
Emergency Start A	Disabled	Normally Open	
Emergency Start B	Disabled	Normally Open	
Test Mode Start	Disabled	Normally Open	
Leave Trigger at Power On	No		
Manual Start A Trigger	Edge Only		
Manual Start B Trigger	Edge Only		

PARAM			
PARAM Meaning Action	Use Backup Data		
PARAM On	Self-Clearing Trip		
PARAM Off			

COMMUNICATION CONFIGURATION			
Protocol	Generic	Link Number	0
Modbus Plus	Auto	Gateway Number	20
Time Out	2.5 s	Control Group	Off
Link Fail Action	Self-Clearing Warning		
Priority Enabled	Yes		
Priority Emergency Start Enable	No		
Host Resets	OPERATOR	SUPERVISOR	
Alarm	Yes	Yes	
Lock	-	Yes	
Application	-	Yes	
Monitor	-	Yes	
Overload	Yes	Yes	
Link Data	Source	Source	
Status Bit 1	Disabled	Normally Open	
Status Bit 2	Disabled	Normally Open	
Group 10 Word Sources	FLC Current (% FLC)	Profilos Current/Power Multiplier	No
Word 1	Thermal Current (%)	Current x100	No
Word 2	Interlocks (%)	Power x100	No
Word 3	Current Current (%)		
Word 4	Interlocks ID		
Word 5			

Main Voltage Inputs			
Interlock	Input Side Through Trips		
Input 1	High Range (115220V)	Input 5	20ms
Input 2	High Range (115220V)	Input 6	20ms
Input 3	High Range (115220V)	Input 7	20ms
Input 4	High Range (115220V)	Input 8	20ms
Input 5	High Range (115220V)	Input 9	20ms
Input 6	High Range (115220V)	Input 10	20ms
Input 7	High Range (115220V)	Input 11	20ms
Input 8	High Range (115220V)	Input 12	20ms

OPERATION			
LCD	English		
Character Set	Standard Character Set		
Line 1 Display	Highest Amps		
Line 2 Display	3 Phases %FLC		
Line 3 Display	Status		
Motor Tag	23-999-411		
Over test 1	Test 1		
Over test 2	Test 2		
FUNCTION	Running	COOLDR	
ED 2	Running	Auto	
ED 3	Running	Auto	
ED 4	Test	Auto	
ED 5	Start Mode	Auto	



GEMSTART 5 Configuration Sheets

Commissioning Settings

GEMPRO			
Key Required	Not Required		
Alarm Config. Via Front Panel	Allowed		
Reset Actions			
AI	-	Action	-
Alarm	Yes	Motor	-
Block	-	OL	-
Stop	Yes		
THERMAL			
Overload		Gemstart	
Current Type	Speed 1	Speed 2	
Overload	19	19	
Curve	Unknown	Unknown	
Active	Yes	Severity	Trip Therm Alarm
Disabled in Startup	-	Pre Warn at	90%
Reset Inhibit	Yes	Severity	Trip
Active			
Thermal Reset Delay	Off	Severity	Tip
Delay	-	Severity	
PTC Input	-	Severity	Warm
Active			
RTD Group 1	-	Severity	Warm
Group 1 Description	xxxx		
Product rds as group	xxxx		
RTD 1	-	Severity	Warm
Limit	105°C	Pre Warn at	Off
RTD 2	-	Severity	Warm
Limit	105°C	Pre Warn at	Off
RTD 3	-	Severity	Warm
Limit	105°C	Pre Warn at	Off
RTD Group 2	-	Severity	Warm
Group 2 Description	xxxx		
Product rds as a Group	xxxx		
RTD 4	-	Severity	Warm
Limit	105°C	Pre Warn at	Off
RTD 5	-	Severity	Warm
Limit	105°C	Pre Warn at	Off
RTD 6	-	Severity	Warm
Limit	105°C	Pre Warn at	Off

MOTOR			
FLC	Speed 1	Speed 2	
Range	10 - 100 A	10 - 100 A	
Value	21.5 A	21.5 A	
Start Current Limit	Speed 1	Speed 2	
Limit	800% FLC (172.0 A)	800% FLC (172.0 A)	
Active	Yes	Severity	Latched Trip
Disabled in Startup	-	Pre Warn at	90%
Start Time Limit	Speed 1	Speed 2	
Time	00 min 15 s	00 min 15 s	
Active	-	Severity	Latched Trip
Disabled in Startup	-	Pre Warn at	90%
Preloadance	Speed 1	Speed 2	
Limit	10% FLC (21.5 A)	Off	
Time	0.5S	0.5S	
Active	Yes	Severity	Latched Trip
Disabled in Startup	-	Pre Warn at	90%
Storage Preload Time	0.1 s		
Limit	Yes	Severity	Latched Trip
Active	-	Pre Warn at	Off
Start in hour	Off		
Limit	-	Severity	Trip
Speed Sense	Off		
Limit	-	Severity	Latched Trip
Active	-	Pre Warn at	90%

EARTH FAULT			
Earth Fault Method	Residual CT		
Earth Fault CT Primary Rating	Speed 1	Speed 2	
Range	1.0 - 10.0 A	1.0 - 10.0 A	
Value	8.00 A	8.00 A	
EF Protection	Speed 1	Speed 2	
Ignore EF at start for	0.4 s		
Enable Remote Resets	No		
EF Trip Current	1.0 - 10.0 A	1.0 - 10.0 A	
EF Trip Current	8.00 A	8.00 A	
EF Trip Current	8.00 A	8.00 A	
Delay to Sense EF	0.1 s	0.1 s	
Lockdown Delay to Trip EF	0.7 s	0.7 s	
Active	Yes	Severity	Latched Trip
Disabled in Startup	-	Pre Warn at	90%

EXTERNAL MODULE			
Communication Unit Severity	Protection Off		

APPLICATION			
ALC	Speed 1	Speed 2	
Range	10 - 100 A	10 - 100 A	
Value	Same As FLC (21.5 A)	Same As FLC (21.5 A)	
Under Current	Speed 1	Speed 2	
Limit	Off	Off	
Time	00 min 10 s	00 min 10 s	
Active	-	Severity	Latched Trip
Disabled in Startup	-	Pre Warn at	Trip
Instant ALC	Speed 1	Speed 2	
Limit	Off	Off	
Active	-	Severity	Latched Trip
Disabled in Startup	-	Pre Warn at	90%
Continuous ALC	Speed 1	Speed 2	
Limit	Off	Off	
Time	00 min 10 s	00 min 10 s	
Active	-	Severity	Latched Trip
Disabled in Startup	-	Pre Warn at	Trip

POWER			
Motor Power Rating	Speed 1	Speed 2	
Range	10 - 100 kW	10 - 100 kW	
Value	Disabled	Disabled	
Power Factor Low	Speed 1	Speed 2	
Limit	Off	Off	
Active	-	Severity	Warn
Disabled in Startup	-	Pre Warn at	Off
Power Factor High	Speed 1	Speed 2	
Limit	Off	Off	
Active	-	Severity	Warn
Disabled in Startup	-	Pre Warn at	Off
Under Power	Speed 1	Speed 2	
Limit	Off	Off	
Time	10 s	10 s	
Active	-	Severity	Latched Trip
Over Power	Speed 1	Speed 2	
Limit	Off	Off	
Time	10 s	10 s	
Active	-	Severity	Latched Trip
Disabled in Startup	-	Pre Warn at	100%



Appendix F

	Pembroke Plant	Engineering Form	TEC/SPI/017 Appendix 45
TR 646: 7128	Electric Motor Test Form		Form No: EEL-FRM-0009
Revision: 3.0			Procedure: PP-ENG-PRO-0027
Date: 01/05/2013			Originator: S. O'Keefe
Status: Active			Approver: M. Carroll

Project Title:	Ethanol Blending Project	PJN / WR No:	PM17	/	0210
		Contract No :			

MOTOR TAG NO	23-PM-412	SCHEMATIC DIAG. NO	30-PBS-532
MANUFACTURER	SIEMENS	DATA SHEET NO	/
MODEL / TYPE	LOHER DNGW 160MR-02A	RATING (KW)	11KW
SERIAL NO	L0X30025439	VOLTAGE (V)	415V
SPEED (RPM)	2955	FLC (A)	20.5A
FRAME SIZE	IM B3	FREQUENCY (HZ)	50HZ
ROTATION FROM DE	CW	OVERLOAD SETTING (A)	20.5A
HAZ AREA CERTIFIED	EX DB E IIC T4 GB	CONNECTION	STAR
			DELTA
			/

WINDING RESISTANCE TEST

TESTED BETWEEN	L1-L2	L1-L3	L2-L3
RESISTANCE (Ω)	1	1	0.9

POLARISATION INDEX

IR AFTER 1 MINUTE (M Ω)	>550 M Ω
IR AFTER 10 MINUTES (M Ω)	>550 M Ω
TEST VOLTAGE	>550V

INSULATION RESISTANCE TEST

TESTED BETWEEN	L1L2L3 - E	TEST VOLTAGE
IR (M Ω)	>550	550V

BEARING INSULATION RESISTANCE

IR (M Ω)		TEST VOLTAGE

CONTROL FUNCTION TESTS

(Y/N)		(Y/N)	
CONTROL CIRCUITS PER SCHEM. DIAG	Y	RTDS / T COUPLES CALIBRATED	
LOCAL AND REMOTE CIRCUITS TESTED	Y	INSTRUMENT INTERFACES TESTED	Y
ALL TRIP CIRCUITS TESTED	Y	ANTI-COND'N HEATER TESTED	
ALL ALARM CIRCUITS TESTED	Y	MOTOR 4 HOUR TEST RUN COMPLETED	Y

TEST EQUIPMENT USED	EQUIPMENT NO.	CALIBRATION CERT NO.	CALIBRATION DATE
FLUKE MULTIMETER	46-WS-4085	SMG-8-6	7-6-19

MANUFACTURER / SYSTEM CERTIFICATION

CERTIFICATE TYPE	Y / N	CERTIFICATE NUMBER
MANUFACTURERS MOTOR TEST CERTIFICATE AVAILABLE	Y	
SYSTEM FEEDER CABLE TEST CERTIFICATE AVAILABLE	Y	
SYSTEM CONTACTOR/STARTER TEST CERTIFICATE AVAILABLE	Y	
MOTOR 4 HOUR TEST RUN CERTIFICATE AVAILABLE	Y	EEL-FRM-0034 (23-PM-412)

CERTIFICATION

THE ABOVE TESTS WERE PERFORMED ON THE LISTED MOTOR.				
CERTIFICATION	COMPANY	SIGNATURE	PRINT NAME	DATE
COMPLETED BY:	VALERO ENERGY		THOMAS WOOD	2/4/19
WITNESSED BY:	VALERO ENERGY		GARY GWYTHYR	2/4/19
ACCEPTED BY:	VALERO ENERGY		ROB HAYWARD	2/4/19

Appendix G

	Pembroke Plant	Engineering Form	TEC/SPI/017 Appendix 67
TR 646: 7128	Title Electric Motor 4 Hour Run Test Form		Form No: EEL-FRM-0034
Revision: 3.0			Procedure: PP-ENG-PRO-0027
Date: 01/05/2013			Originator: S. O'Keefe
Status: Active			Approver: M. Carroll

Project Title:	Ethanol Blending Project	PJN / WR No:	PM17	/	0210
		Contract No :			

MOTOR TAG NO	23-PM-412	~~SCHEMATIC DIAG. NO~~	30-P6S-532
MANUFACTURER	SIEMENS	DATA SHEET NO	/
MODEL / TYPE	LOHER DNGW 160MR-02A	RATING (KW)	11KW
SERIAL NO	L0X030025439	VOLTAGE (V)	415V
SPEED (RPM)	2955	FLC (A)	20.5A
FRAME SIZE	IM B3	FREQUENCY (HZ)	50HZ

1 HOUR TEST RUN

TEST RUN START TIME	11:30	PHASE CURRENT READING		
		L1	L2	L3
STARTING INRUSH CURRENT		89	99	95
START TIME PLUS 15 MINUTES		9.4	9.2	9.2
START TIME PLUS 30 MINUTES		9.2	9.4	9.2
START TIME PLUS 1 HOUR		9.2	9.4	8.9
START TIME PLUS 1 HOUR 30 MINUTES		9.4	9.2	9.2
START TIME PLUS 2 HOURS		9.2	8.9	9.4
START TIME PLUS 2 HOURS 30 MINUTES		8.9	9.1	9.3
START TIME PLUS 3 HOURS		8.8	9.2	9.4
START TIME PLUS 3 HOURS 30 MINUTES		9	9.2	9.4
START TIME PLUS 4 HOURS		9.2	9.2	9.2
TEST RUN FINISH TIME	3:30			

MANUFACTURER / SYSTEM CERTIFICATION

CERTIFICATE TYPE	Y / N	CERTIFICATE NUMBER
MANUFACTURERS MOTOR TEST CERTIFICATE AVAILABLE	Y	
SYSTEM FEEDER CABLE TEST CERTIFICATE AVAILABLE	Y	
SYSTEM CONTACTOR/STARTER TEST CERTIFICATE AVAILABLE	Y	
SYSTEM MOTOR TEST CERTIFICATE AVAILABLE	Y	EEL-FRM-0009 (23-PM-412)

CERTIFICATION

THE ABOVE TESTS WERE PERFORMED ON THE LISTED MOTOR.				
CERTIFICATION	COMPANY	SIGNATURE	PRINT NAME	DATE
COMPLETED BY:	VALERO ENERGY		THOMAS WOOD	2/4/19
WITNESSED BY:	VALERO ENERGY		GARY GWYTHYR	2/4/19
ACCEPTED BY:	VALERO ENERGY		ROB HAYWARD	2/4/19

COMMENTS:

--

SYSTEM NAME / NUMBER

--

EQUIPMENT TAG NUMBER

23-PM-412

VARIATION COST PROPOSAL

Date : 05/11/2018
 SWB Tag No : Valeo WWTP DE-NITRIFICATION PROJECT
 Project No : 171201

V/C N° : 3
 Additional Equipment
 VENDOR PO N° : 4504277457

REQUEST DESCRIPTION	TECHNICAL PROPOSAL / MODIFICATION	
ITEM 1 Scope Change VSD Feeder to Gemstart 5 equipped Motor Starter Install and wire, Gemstart 5, fit new front panel & Gemstart 5 display Configure PAMM Tag settings and Gemstart config database. Modify Drive Data Sheets Modify schematic diagrams for VSD Feeders add Control Fuse & Link & Remote Stop		
COMMENTS	VARIATION COST	
	Materials	£4,150.00
	Engineering & Documentation Change	£1,200.00
	Labour - Deconstruct, Construct & Test	£1,450.00
	TOTAL :	£6,800.00

PSDE 4033 Project Report

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

68/100

PAGE 1

PAGE 2

Text Comment. Good summary.

PAGE 3

PAGE 4

Text Comment. Good list of contents. The sub-divided headings looks professional.

PAGE 5

Text Comment. Figures have appropriate nanes and are easily identified.

PAGE 6

Text Comment. Good graph to support the explanation and from a good source.

Text Comment. This is good background information.

PAGE 7

Text Comment. Good argument for the Arduino which is more than capable of monitoring multiple analogue signals and controlling outputs.

Text Comment. The argument for the Arduino is supported by further test and implementation further in the report.

PAGE 8

Text Comment. Good argument which is backed up further in the report with some testing.

PAGE 9

Text Comment. Good argument for this PLC with more information to support this further in the report.

PAGE 10

Text Comment. Sustainability here

PAGE 11

Text Comment. Spec is good but seems it only includes the motor and drive. There should also be a controller as discussed in the research. This should not be specific to a drive.

PAGE 12

Text Comment. Good explanation and supported by good use of Gantt chart which has comparative timeline.

PAGE 13

Text Comment. Good image.

Text Comment. Good argument supported by a demonstration and test.

PAGE 14

Text Comment. Good image and argument for this solution.

PAGE 15

Text Comment. A good argument for the drive especially since it has built in CT'S for each phase. This would have to be done as external ccts using microprocessors.

PAGE 16

Text Comment. There would be extensive interface circuitry needed in comparison for MCU's

Text Comment. MCU's are cheap in comparison but the cost in time to design and build the interface circuitry would increase the cost.

Text Comment. Your arguments are logical and valid. It is probably worth mentioning that the codes of practice with Valero insist on the GEMSTART drive.

PAGE 17

PAGE 18

Text Comment. Good image to support explanation

PAGE 19

Text Comment. This costing list should be in the appendix.

PAGE 20

PAGE 21

Text Comment. Image is appropriate to support your explanations.

Text Comment. Test explanation is clear and gets to the point.

PAGE 22

Text Comment. Good image

Text Comment. Good explanation and reference to the appendix.

PAGE 23

Text Comment. Good images showing the implementation and shows the coupling removed for the test with no load.

PAGE 24

Text Comment. Important to highlight this problem here.

PAGE 25

Text Comment. Codes of practice are followed here.

PAGE 26

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GRADING FORM: CSG-RUBIC

THOMAS WOOD

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RESEARCH-INFORMED LITERATURE



The research and sources are relevant to the project. However there should be more academic sources included. There is evidence of extensive background research in the report but not enough refs.. 5.5/10 The number of references is not appropriate for the report. 5.5/10

11/20

KNOWLEDGE AND UNDERSTANDING



The specification is explained well. Sustainability and environmental issues are covered as part of the company policy . 6/10 Solutions considered shows a good comprehensive understanding of what is needed for the system and alternative methods. The effort made here is very good with images of tested solutions to support. This should have been rounded off by a table of comparison. 7 /10

13/20

ANALYSIS



Testing and results are explained well with visual evidence to back up the explanation claims. Tables could have been used for comparison against the spec. 7/10 Conclusion and recommendations are good and good ref to appendix used. You have evaluated the performance of the system against the spec and included some good recommendations including wireless operation. 8/10

15/20

PRACTICAL APPLICATION AND DEP.



The planning using Gant chart is good and there is a comparative timeline. The deployment explanation is good. 4/5 There solutions considered have been researched and there are good arguments for all the alternatives which includes tested evidence. 7/10 Implementation is good and there is evidence to support this including the PLC program and HMI. 7/10

18/20

SKILLS FOR PROFESSIONAL PRAC.



The report is good. Good use of appendices to contain relevant data which is referenced from main report. 11/15

11/15