Australian Engineering Excellence Awards 2018 (2018)
Energy, Water and Resources Projects

Astaxanthin Project - Stage 2

wgnKvqYk

Entry details

Full Name of Project	Ayr Astaxanthin Production and Concentration Project.

Address of Project

Trent Road
Alva Beach 4807
Queensland
Australia

State/Region of entry (Division)	QLD
Name of Submitting Organisation	Norwood Technologies Pty Ltd trading as The Project Office

Address of Submitting Organisation

110 Glen Park Road
Eltham North 3095
Victoria
Australia

Role of Organisation Submitting Entry

The Project Office performed Engineering, Procurement and Construction Management for the entire project including detailed engineering design and equipment specification for power, instrumentation, distributed control and communications systems, pump and piping hydrology, tanks, mechanical layout, 3D piping layout, walk-throughs, HAZOP's, PLC and HMI software, construction management, commissioning and ongoing support.

Name of Primary Contact Person	John Norwood
Mobile Number	0418 325 891
Phone Number	03 9017 3144
Primary Email Address	norwoodj@projectoffice.com.au

Please provide a short description of the project.

> Astaxanthin (Asta) is a highly valuable red pigment and anti-oxidant which is extracted from fresh water alga Haematococcus Pluvialis (HP). It is used to produce high-end nutraceuticals and aquafeed. HP is extremely fragile, easily destroyed by biological predators, competitors, bacteria, and shear stress.
>
> Laboratory bred HP inoculums are transferred to 260 sterile and fully automated growth columns and 18 raceway ponds designed to maximise photosynthetic growth and control biological infection.
>
> Complete automation of loading, nutrient dosing, air and carbon dioxide, pH, sampling, cooling, transfer and hygienic CIP systems allow the complex systems to remain sealed prior to concentration and packing.

Please accept and acknowledge all the following terms and conditions to continue	1, 2, 3, 4, 5, 6
Signature (Printed Full Name)	John Norwood

Executive Summary

> Asta Project History
>
> MBD Industries originally developed the Asta process biology and engaged a multinational engineering consultant to project manage a commercial scale plant near Ayr Qld. Their initial estimate for the project was $47M against an available budget of $13M. In a bid to recover project feasibility, MBD engaged The Project Office (TPO) to review and reduce the scope of work to a bare bones infrastructure, with no automation or process redundancy. The consultant's estimate reduced to $35M. At this stage the project was not going to proceed, and the consultant was let go.
>
> In a last bid save the project, MBD asked TPO to completely rescope the entire process and estimate as if TPO was the primary consultant and contractor (in keeping with TPO past practice). TPO had complete freedom to innovate, reduced the estimate to $15.5M, and retained full automation and process redundancy. A project budget was agreed at $13M with no contingency and the project was successfully completed early 2018 for $15.5M.

Which element of the project is being assessed?
How has the project achieved engineering excellence?

> Innovation and Reduced Costs
>
> The Asta project only commenced beyond the laboratory because TPO was able to innovate and be certain of its convictions that the project could be built and perform as designed. The primary cost saving innovations include:
>
> Pump and Pipe Hydrology (one example)
> It is common engineering practice to install short suction lines for pumps. This minimises cavitation, but it also places pumps adjacent to the source. The Asta project included eight 150kL and ten 700kL raceway ponds that could be routinely filled and drained in 4 to 6 hours. In order to have pumping redundancy the raceways required 36 large food grade pumps located remotely amongst the raceways. TPO demonstrated that the entire system could be technically achieved with four very small centrally located pumps and very long suction lines. The pump and energy costs were reduced by 90%, and the cabling and infrastructure cost were reduced by 95%. The low power pumps were also selected to have very low shear and negligible product degradation.
>
> CubeLink Commercial Scale Trial
> Part of the Asta project included 260 highly controlled and hygienically sealed vertical growth columns (VGC). The independent control, monitoring and data logging of each VGC included:

 Automatic filling of inoculum, water or chilled water and simultaneous dosing of any mass ratio of four nutrients.

 Automatic sampling of pH, ORP, tank level, and temperature.

 Automatic % ratio of CO2 and Air, Blanketing and Anti-vacuum Valves.

 Automatic emptying and transfer to Raceways.

The cost of conventional Instruments and PLC infrastructure to read so much data and automatically control over 1,500 valves would have crippled the project. TPO installed its own distributed control system called CubeLink as a large-scale trial of this home grown system. One Cubelink module was mounted under each of the 260 tanks to control the equipment. The CubeLink modules only require a common three-wire data cable and a common power cable for the valves. In this way PLC costs were reduced by 80% and cabling costs were reduced by 90% because the average cable run length was reduced from 35m to 1.5m. TPO installed 450 CubeLink modules in the project to monitor and control 3,200 devices. CubeLink and CubeHMI are capable of winning awards on their own.

Engineering Design
Since 1988 TPO has developed computer-based technology for use far beyond the reach of conventional engineering organisations. TPO has linked its modelling, engineering design and procurement systems in a way that it can predict process behaviour, select optimum equipment, produce detailed design documentation and procure equipment in a remarkably efficient manner. TPO can turn over a very large project with a fraction of conventional engineering and CAD manhours. Typically 80% of the drawings and schedules are produced entirely and error free by computer.

Reduced Supply Chain
TPO performed the design, supply, programming and commissioning of the entire process control infrastructure including Instruments, Pumps, Valves, PLC, CubeLink, Motor Control Centres, Control Cubicles and Air Control Cabinets, SCADA and HMI. This avoided multiple levels of added profit and risk costs associated with conventional client - consultant – primary contractor – sub contractor – supplier – wholesaler channels. The smart TPO design systems also select detailed part numbers that feed through to procurement systems so suppliers simply price and supply. After dealing for 30 years with TPO, suppliers don’t price sales, engineering or risk costs in their products. TPO was able to resell industrial equipment between 30% and 50% below conventional end user cost which reduced Asta equipment costs by over $2M in the $13M budget.

Actual or potential contribution of the work to the economy

The work undertaken by The Project Office (TPO) has enabled its client (MBD) to develop the first commercial scale algae cultivation and processing facility in Australia, for the production of natural Astaxanthin.

Astaxanthin is fed to farmed salmon, trout, and prawns to provide their pink-orange colour as they do not have access to their normal ocean diet (e.g. krill). Whilst synthetic astaxanthin is predominantly used in the aquaculture industry, the market is progressively shifting towards a natural version of the pigment, which imparts added health benefits such as disease resistance and increased immunity. There is also a growing market for natural astaxanthin in the nutraceutical (dietary supplements) and cosmeceutical industries, where its strong anti-oxidant properties have human health benefits.

Natural astaxanthin is extracted from algae, and since biomass growth is powered by the sun (photosynthesis), very little raw materials come into production of the valuable pigment. Displacing synthetic astaxanthin off the market to replace it with a natural alternative is therefore a step towards sustainability in the aquaculture industry.

The development has generated significant employment opportunities in the Burdekin Shire of North Queensland (creation of 18 new full-time positions), and its operating cost is being directly injected into the local/regional economy. It has brought a new rural based industry to the Shire, diversifying and broadening its economic base. In addition, a majority of the finished product will be exported overseas, qualifying the operation as a GDP export earner.

Impact of the work on the quality of life of the relevant communities

> The development has dramatically increased the economic value of the land; 20 hectares previously used for low-value grazing were upgraded for use in higher value algae cultivation and concentration, including a modern food-grade processing facility.
>
> The establishment of a new sustainable and emerging rural industry provided an alternative to traditional activities in the area (eg. cane farming and cattle grazing). It created business opportunities for the local economy (material suppliers, service contractors, catering businesses...), attracted qualified people from diverse backgrounds, and enriched the local culture.
>
> The facility being the first of its kind, it also attracts many national and international visitors which enhances the profile of the Shire and the State.

Significance of work as a benchmark of Australian Engineering

> The microalgae cultivation process holds a tremendous amount of inherent complexities. To prevent the ingress of predators and competitors, maintaining a high level of sterility was paramount. As such, a lot effort went into the design of hygienic pipework (eliminating dead legs, careful selection of valves and fittings etc), positive pressure control of sealed inoculation vessels, and systematic sanitization and rinsing of all systems between transfers. The selected algae strain is also extremely fragile and whilst gentle handling in a large-scale process can be quite difficult and/or costly, detrimental shear stress was prevented by the specification of cost effective, low-shear pumps, as well as the minimization of pipe friction through careful hydrology modelling and clever design. Furthermore, the need to control pH, salinity, temperature, flows, levels etc, as well as to accurately dose nutrients, CO2, cleaning agents and to recycle water and chemicals were only some of the process constraints adding to the overall project complexity.
>
> Safe and timely management of such a large, intricate, and sensitive operation would have been virtually impossible without a high level of automation. Indeed, minimising manual intervention was critical to reduce labour intensity, and most importantly to limit the introduction of pathogens and eliminate operational error. The great level of automation&control implemented by TPO also enabled to optimize transfer quantities, timing and energy input, resulting in minimum operational cost and increased yields.
>
> Implementing conventional control hardware was simply incompatible with the capex budget. Thankfully, the Cubelink technology developed by TPO's sister company Enesys was key to make automation affordable, and ultimately to make the project viable. Cubelink is a low-cost, modular system comprising a suite of interface processors, I/O modules, and proprietary communication protocols allowing distributed control over long distances, without interference, and using conventional cabling. Such intelligent communication infrastructure allowed to centralise PLC's, eliminate power in the field and reduce cabling cost. The Cubelink package also comprises a user-friendly HMI, running on a windows platform and without license fees, which was greatly appreciated by the client. With both TPO (design and construction) and Enesys (technology development) being operated by Norwood Technologies, the integration of Cubelink in the electrical and software design was seamless and cost-effective.
>
> Another key factor which helped to bring the design cost down is TPO's unique database systems which links all equipment data (eg. specifications) with engineering models and drawings. In this highly integrated system, all manual data entry is performed in only one unique location and distributed to associated databases to prevent duplication error. With this automatic data management system, production of drawings, document registry and equipment procurement are only some of the tasks which can be managed for a fraction of the time and cost compared to most engineering firms. A high-level schematic describing the system is attached to this submission (Appendix A).

Extent to which the work represents world best practice

> TPO was honoured to be appointed as the exclusive EPC contractor for a "first of its kind" project, thus playing a major role at the forefront of an emergent industry. Numerous technical challenges made this project even more

exciting: product sensitivity to biological contamination, shear stress and environmental factors; the requirement to recycle water and chemicals; to produce within tight food-grade specification etc. TPO takes pride that all these challenges were tackled through best practice engineering design. The level of automation involved (eg. 105 connected devices, 16 sub-networks, 3,414 configured I/O points, 130,759 lines of code...) in an algae production facility was very novel and in fact, a world first. The fact that this project was successfully developed on a greenfield remote site, within a tight budget, and operating 24/7 makes this achievement ever so outstanding, and represents engineering best practice.

Other considerations

The development does not cause adverse impact on coastal resources and other areas of ecological significance. The adjacent waterways, wetlands and ground water system were protected by the lining of algal growth ponds, appropriate land grading and earthen levees, as well as adequately lined and bunded areas for chemical storage.

High water recycling rates reduce the fresh water input to a minimum, and all surplus Process Water is pumped to irrigation for improved pastures. Nutrient loads are diminished by the algae and any living organisms present in the Process Water will be naturally occurring in aqueous communities, be non-toxic, be non-invading and therefore not pose any threat to the environment.

The development size and location are compatible with the surrounding agriculture (mainly cane farming and cattle grazing) and aquaculture use and does not have any adverse impact beyond the site in terms of air, water, noise, light and land.

The site being in sunny North Queensland, there is a high potential for future solar panel inclusion and the provision of 100% renewable electricity for the plant. Finally, current R&D efforts are focused on the algae CO2 capture efficiency, to further improve the environmental footprint of the project.

Please include any confidential information here

The owner of this process plant, MBD Energy Ltd, wish to remain anonymous for commercial confidentiality purposes. No information in this submission that displays the MBD name or logo may be released to the public or any unauthorised third party.

The following OneDrive link will allow read only access to pdf's copies of most of the technical drawings produced by TPO relating to the project. There is no access to the various databases and engineering models as they cannot adequately be represented in a pdf file.

https://1drv.ms/f/s!AosKhD-4pDUehdlJbs_vlMv7LNXZVA

Please contact TPO if this link does not function correctly.

Please upload a video explaining project features (optional)

MP4 Flyover Rev C (3 Mins).mp... (155.8 MiB download)

Additional Comments

Please note that in all drawing and documents, the green text indicates that the data is derived from an engineering model or database. The database hierarchy is such that no single element of data is entered in two places which eliminates the possibility of duplication errors. Also, large systemic changes that effect whole of project, process areas or equipment data can be implemented instantly without the need to redesign any technical drawings or documents. eg. If the project decided to switch from one electrical equipment manufacturer to another, every electrical part number would be automatically selected and every referenced document would automatically

change.

Note that the TPO automated design process is also linked to TPO equipment procurement systems to Enquire, Quote, Order, Invoice and Deliver thousands of part numbered items from design through to commissioning. eg In PID's there are symbols describing the procurement status of all equipment to assist site managers with the logistics of their task to locate, identify and install delivered equipment on site.

Similarly, the TPO procurement system can automatically report procurement or installation progress based on any combination of the 80+ fields of data within the Equipment List. eg. Process Area, Equipment Types, Part Numbers, Duty, Vendor, Physical Location etc.

There is a compilation of typical drawings called "AEEA Sample Drawings" online. The following OneDrive link will allow read only access to pdf copies of most of the technical drawings produced by TPO relating to the project. There is no access to the various databases and engineering models as they cannot adequately be represented in a pdf file.

https://1drv.ms/f/s!AosKhD-4pDUehdlJbs_vlMv7LNXZVA

Please contact TPO if this link does not function correctly.

Title of the project	Asta Project
Organisation Name	The Project Office
Contributing organisation 1 (if applicable)	Enesys

Project Summary for Promotional Purposes

The Project Office, a long established Australian engineering design and construction organisation, completed an innovative aquaculture process plant in Qld involving growing and processing a fragile but valuable astaxanthin rich algae. Against all technical and financial odds, TPO was reduced the original design and construction estimate by 70% while increasing process redundancy and automation.

"We were able to fully utilise our automated design and procurement systems on the Asta Project which significantly cut engineering and project management time and costs, but more importantly our smart modeling systems were able to extensively rework the process hydrology to cut 90% of the pumping costs from the project."

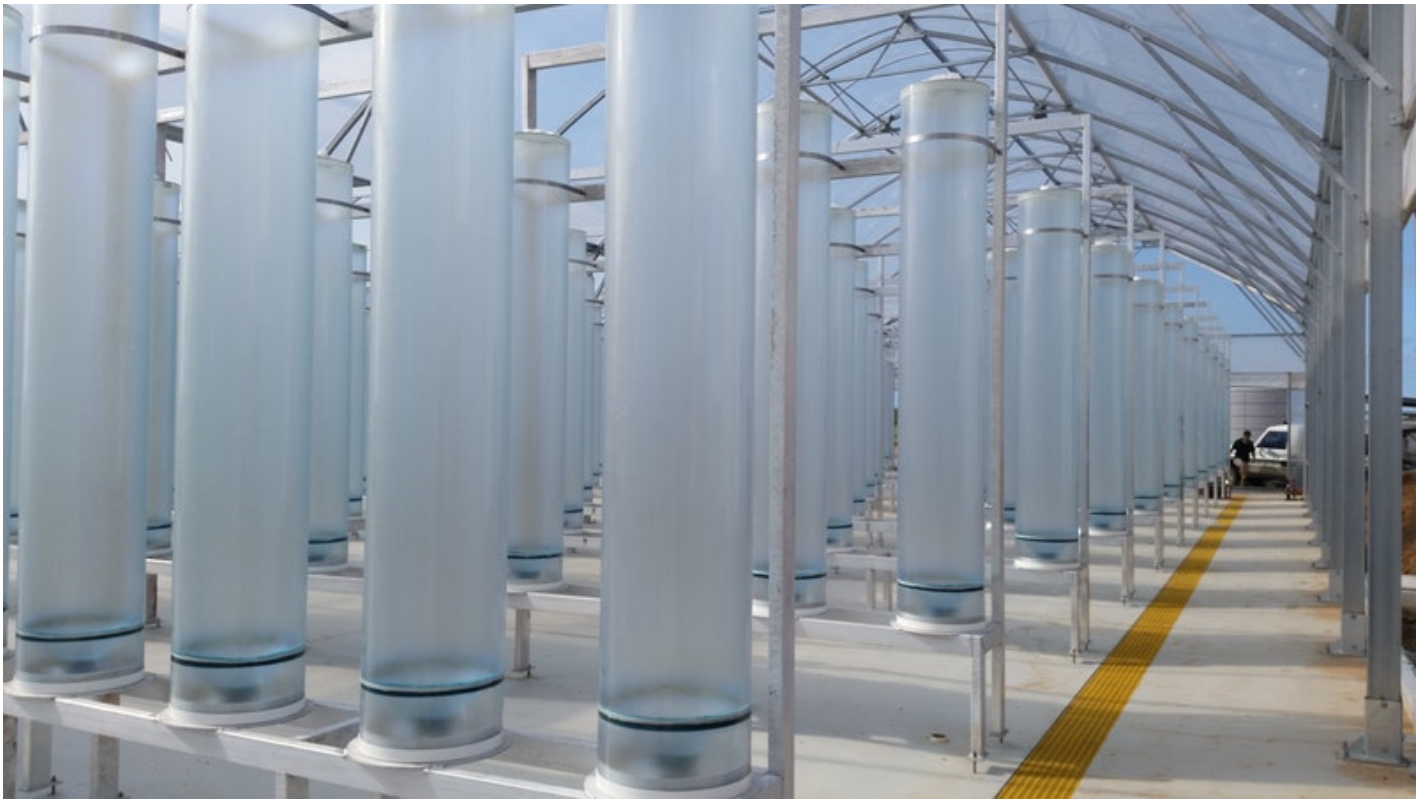
"We also installed a commercial scale trial of a new distributed process control system CubeLink, and the IoT capable supervisory control system CubeHMI and this cut process control equipment costs by 85%."

CubeLink and CubeHMI have been newly developed by TPO's sister R&D organisation Enesys.

High Definition Image

High Definition Image 2

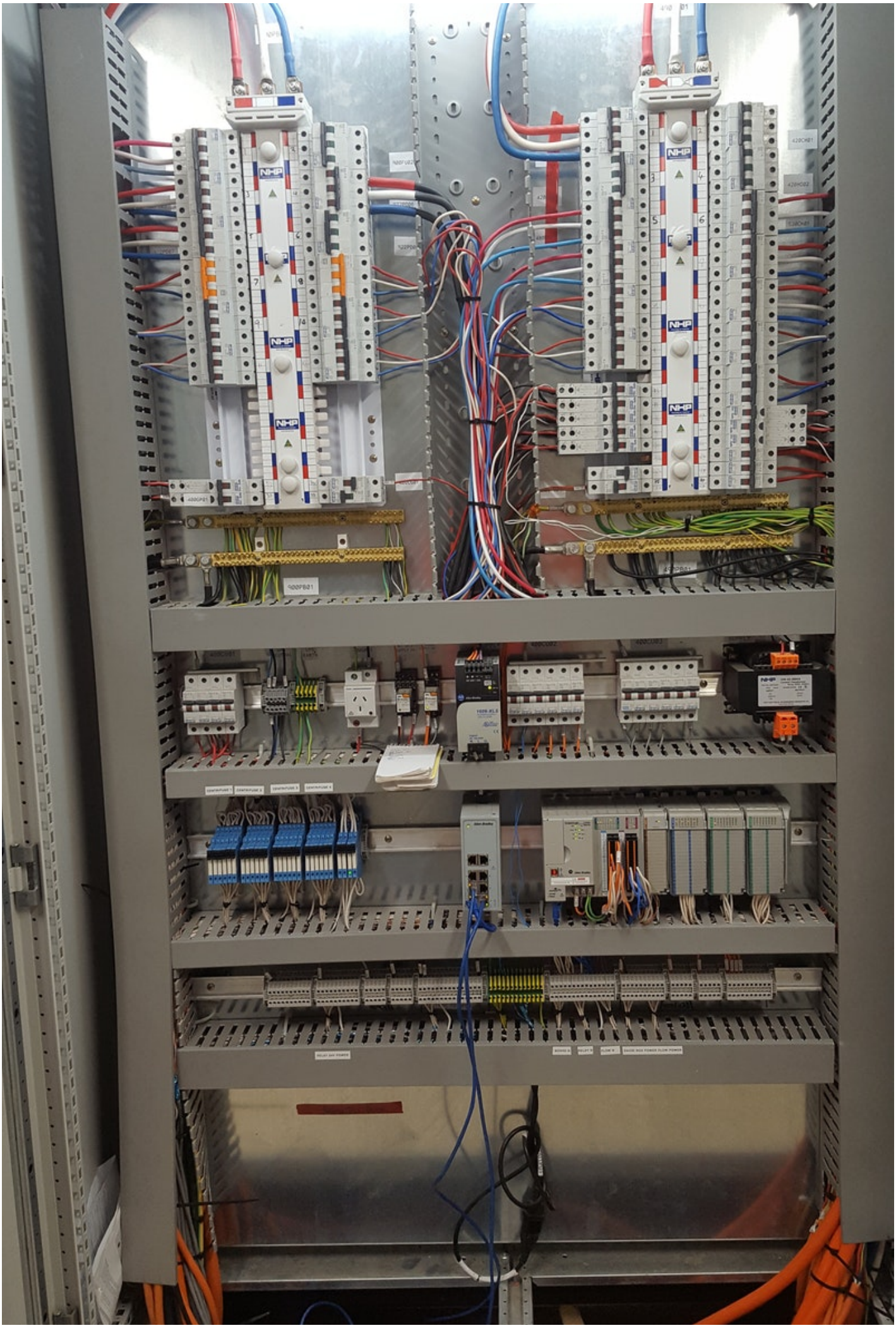
High Definition Image 3



High Definition Image 4

High Definition Image 5

High Definition Image 6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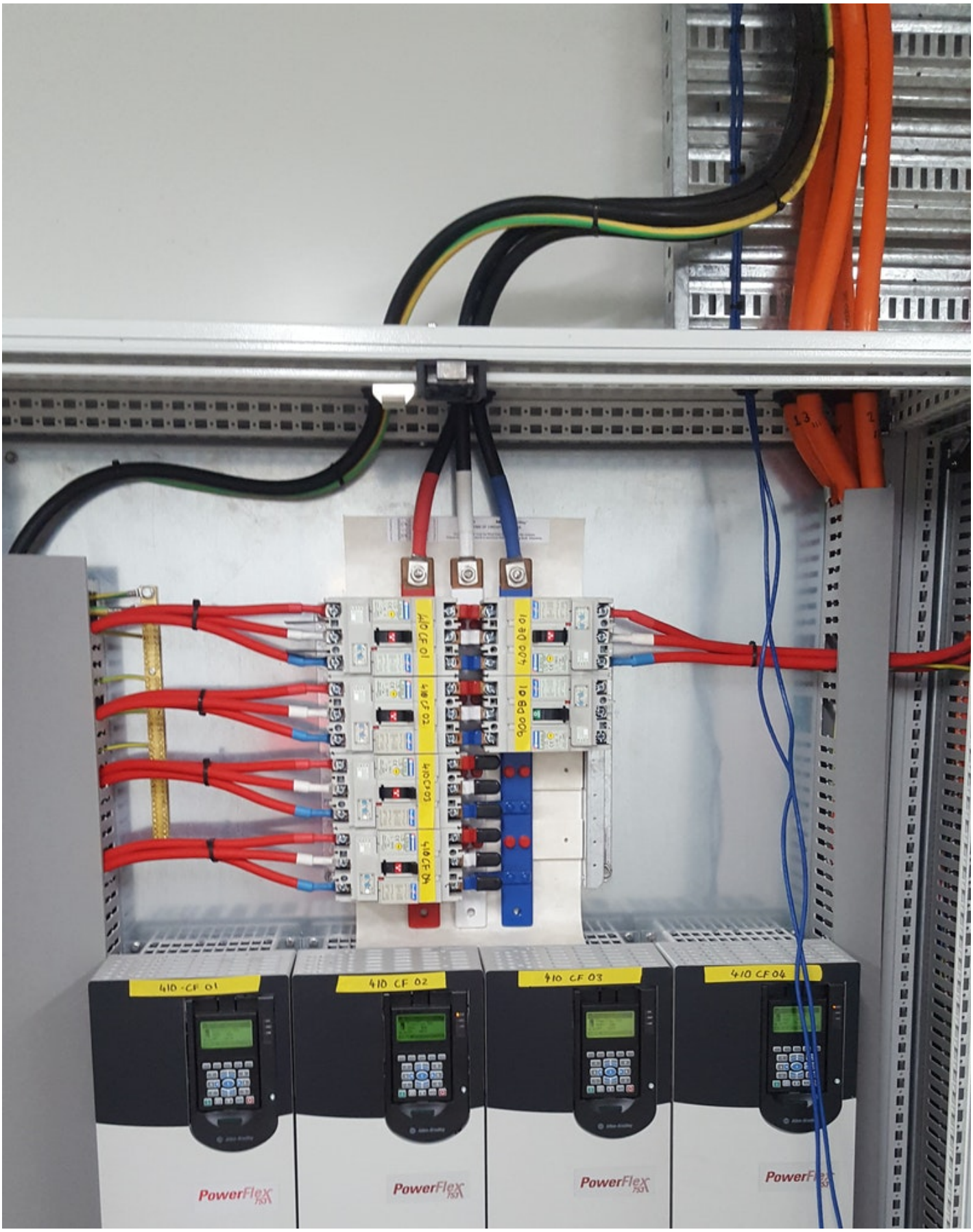
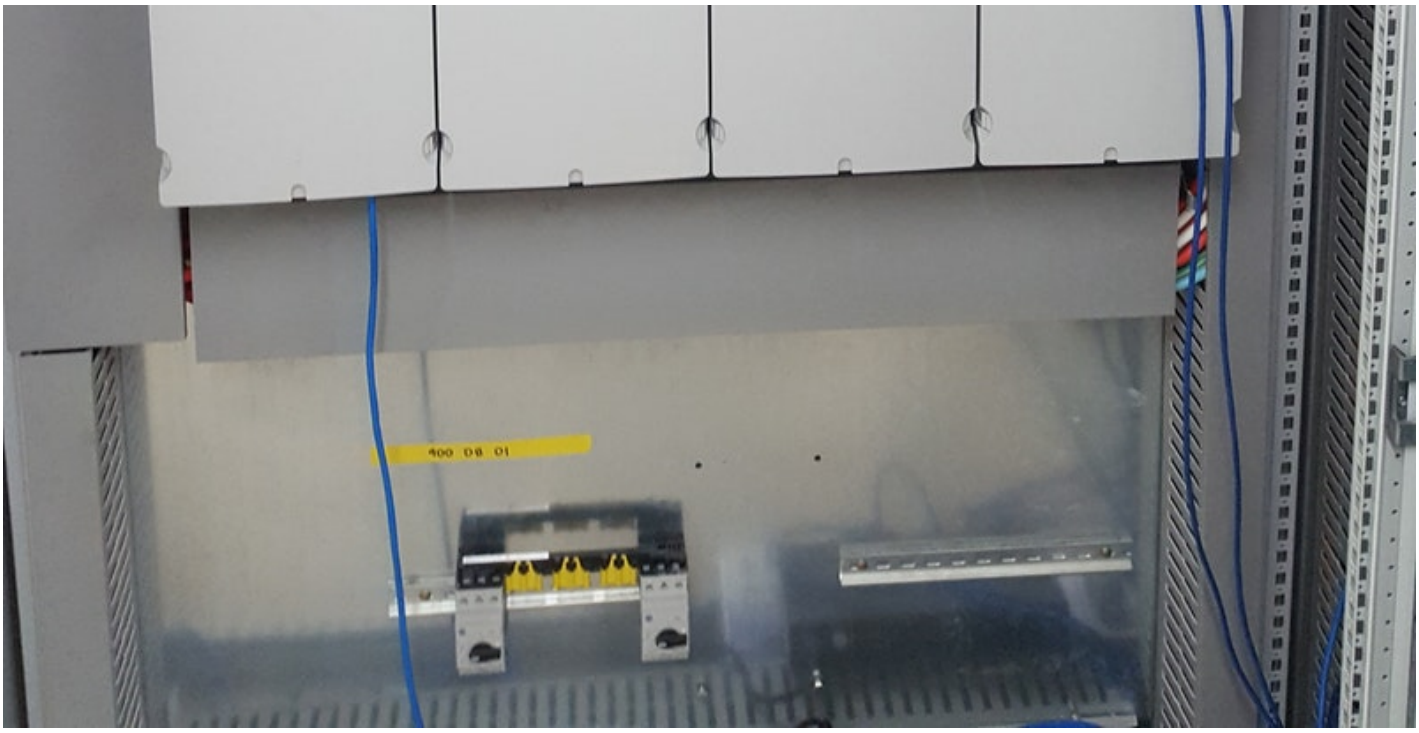
High Definition Image 7





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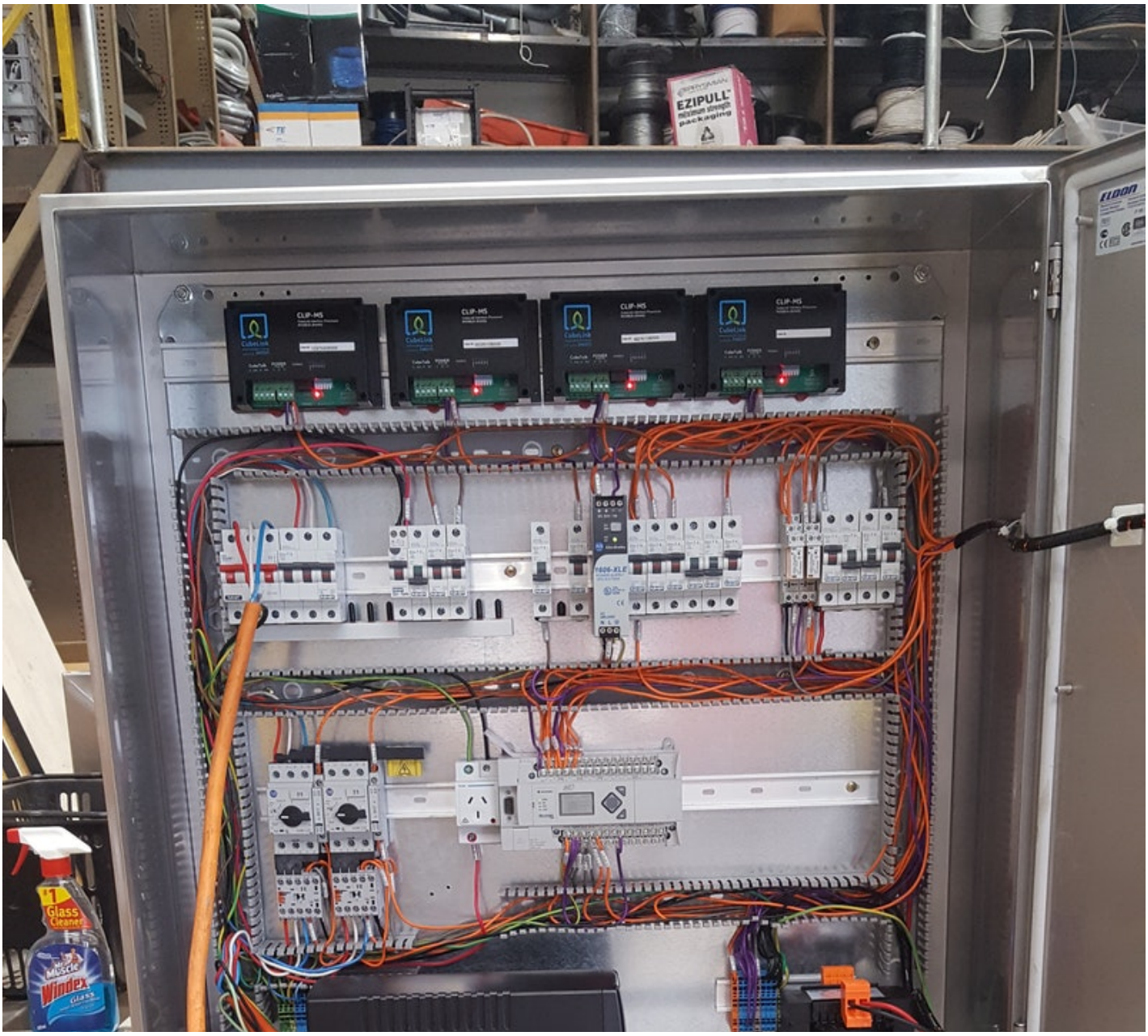
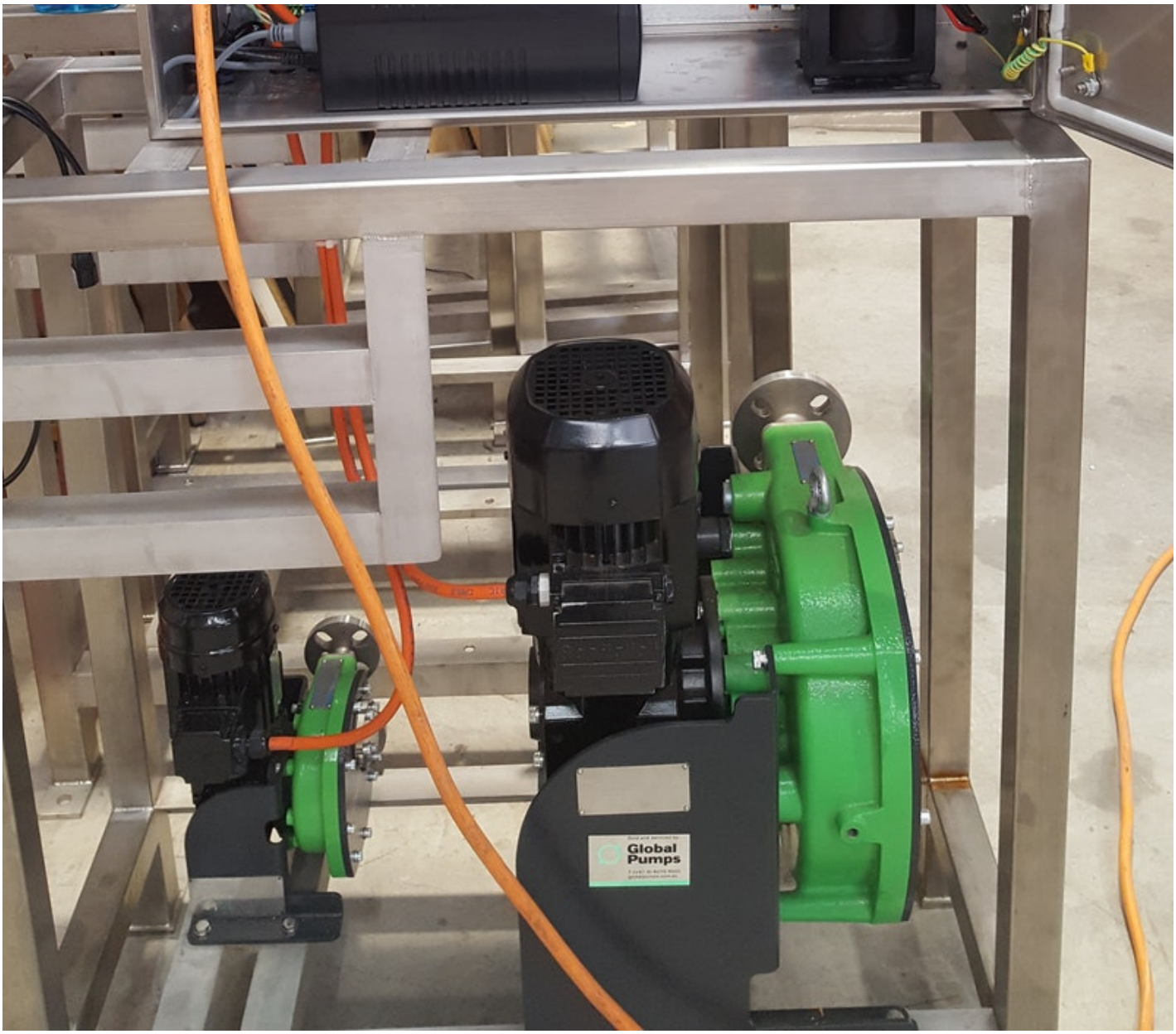
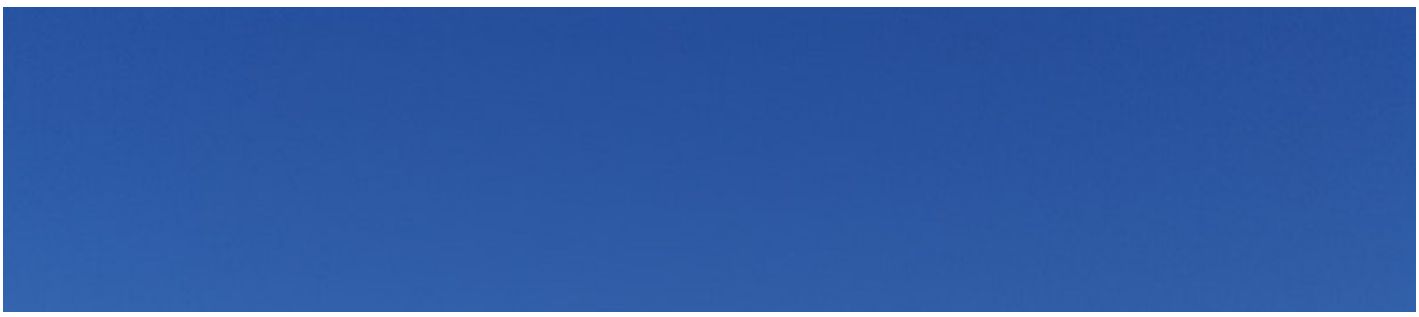


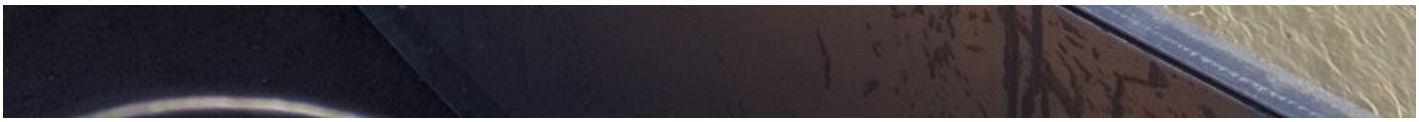


High Definition Image 9

High Definition Image 10

High Definition Image 11





High Definition Image 12

High Definition Image 13

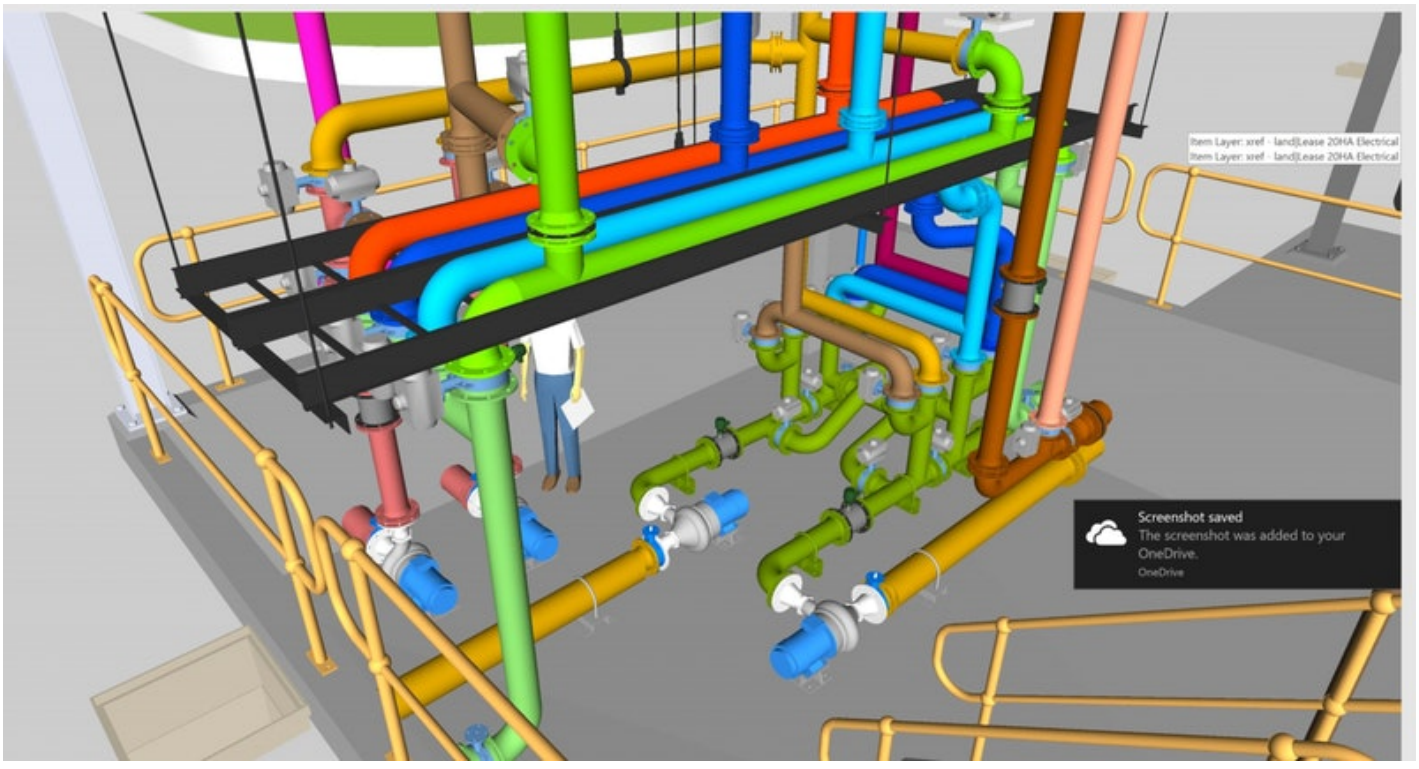
High Definition Image 14

High Definition Image 15

High Definition Image 16

High Definition Image 17

High Definition Image 18



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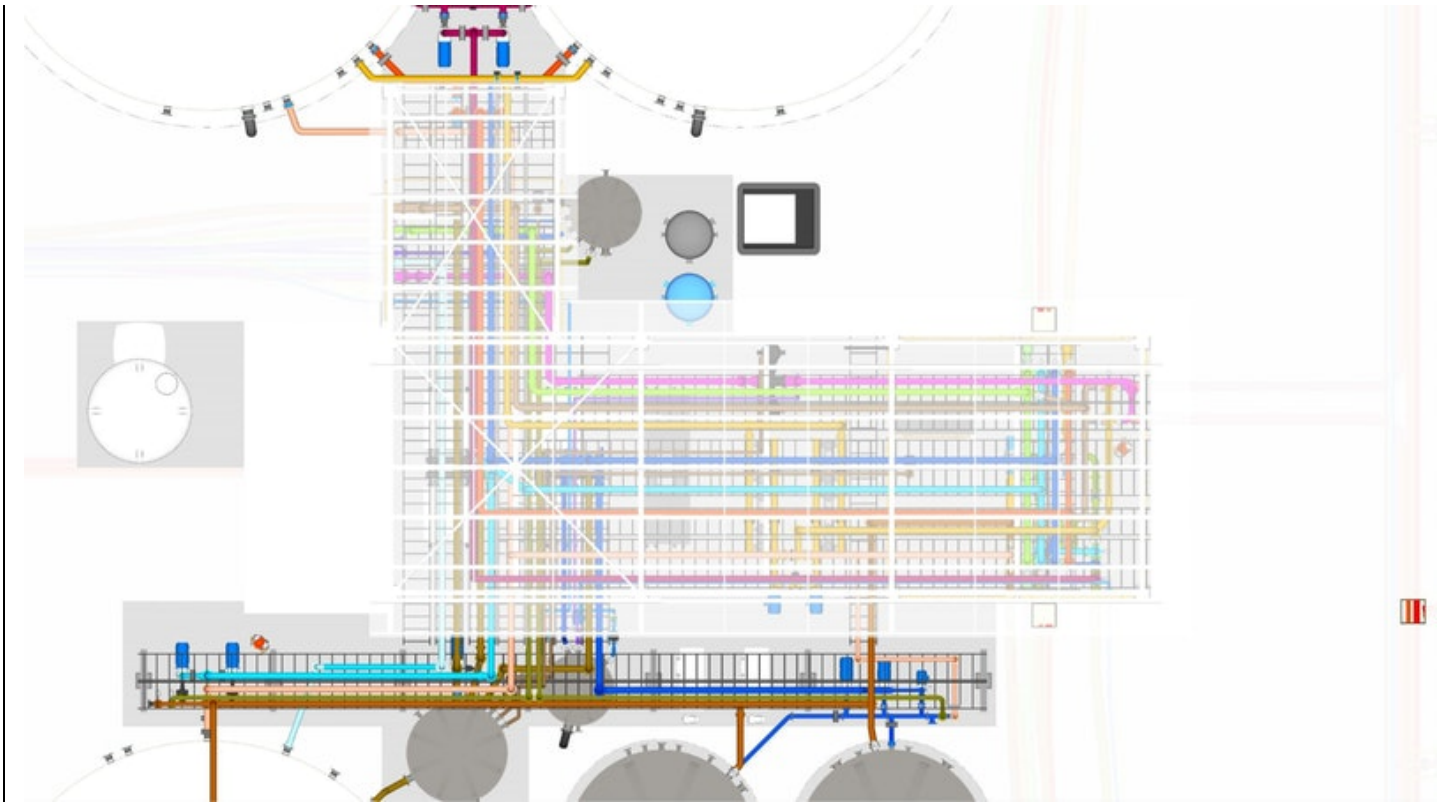

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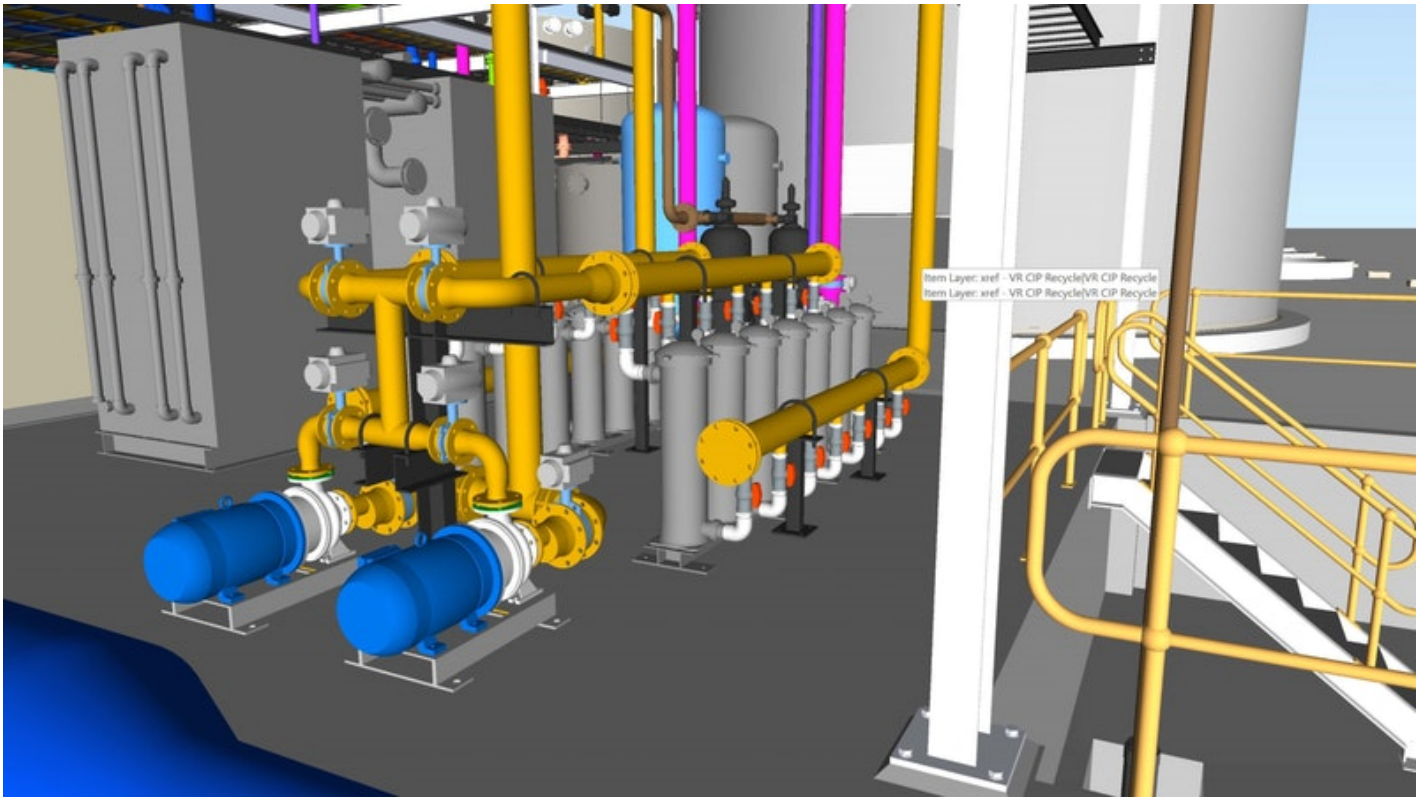

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Engineers Australia for the Australian Engineering Excellence Awards (all except material uploaded under "Confidential" tab).

I certify that the copyright covering all material included in this submission and supporting illustrative material is held by:	Norwood Technologies Pty Ltd
Signature (Printed Full Name)	John Norwood

Log in to aeea.awardsplatform.com to see complete Entry attachments.

PDF

Attachment name
000FD001 Engineering Design and Modelling Data Flow Diagram - Process Plant
Description
When TPO preforms design and construction of a Process Plant, this is a diagram to describe how engineering modelling and data flow automation efficiently creates detailed drawings, schedules and also links to TPO procurement systems.

000FD001 Engine.. 1.7 MiB

PDF

Attachment name
330CP012 General Arrangement - SR Feed Services Panel
Description
This is a pilot valve control panel general arrangement drawing. Note the abnormal quantity and quality of detail to assist panel builders and maintenance personnel, including tag numbers and technical details, allocation for future equipment and device lists to be placed within the panel.

330CP012 Genera. 811 KiB

PDF

Attachment name
410CP01 Schematic Diagram - Centrifuge 1 Control Panel
Description
This drawing is able to link control inputs and outputs common to a centrifuge control panel. Note the absolute detail referring to PLC I/O address, full process control description, I/O module type, slot address, PLC tag and physical location. A general arrangement is also included to assist the panel builder.

410CP01 Schema.. 489 KiB

PDF

Attachment name
400MC012 General Arrangement - Process Building MCC

PDF

Attachment name
410PI001 - Centrifuge PID
Description
This is a typical TPO process

PDF

Attachment name
922PD01 SLD - Site Overall
Description
This is a master site Electrical

Description
This is a general arrangement drawing to assist the panel builder. Note the dimensional accuracy of the equipment (chassis and VSD's) and technical detail for each device. This level of design detail reduces the builders technical risk, cost of manufacture and site installation errors.

400MC012 Gener.. 530 KiB

control PID that is linked to TPO models and databases (all green text is a data link). Note uncommon detail in PID's includes actual pipe flows and pressure drops, and detailed equipment data.

410PI001 - Centri.. 412 KiB

Single Line Diagram. Note it defines the detailed equipment part numbers, cable sizes, types, installation method and maximum demand. This drawing also defines the procurement status at a point in time in the project.

922PD01 SLD - Sit. 422 KiB

Attachment name
922PD043 General Arrangement - Switchroom
Description
This is a typical switchroom and cable route general arrangement. Note that each distribution panel and MCC is defined by tag number, description and a physical general arrangement to assist installers and reduce major site errors.

922PD043 Genera 1.0 MiB

Attachment name
950PL01 CIP Effluent Ocean Outfall Pipe Hydrology
Description
This is a report extract from the Pipe List, that overlays four pipeline performance curves with three pump curves to determine the optimum pipe and pump hydrology. It also details, pump pressures, hydraulic and electrical power and an indicative cost of the pipeline to assist engineering selection.

950PL01 CIP Efflu.. 237 KiB

Attachment name
MA-M-310-GA-002_1 Pumping Station GA
Description
This is a typical mechanical general arrangement drawing. The CAD iso drawing behind this drawing also form the components for the 3D pipe clash analysis and rendered 3D drawings and video walkthroughs.

MA-M-310-GA-00.. 255 KiB

Attachment name
MA-P-310-GA-010_2
Description
This is a mechanical general

arrangement of recycle pump filters. Not that the drawing includes the isometric drawings and a 3D view to assist installers.
MA-P-310-GA-010. 282 KiB

Attachment name
https://1drv.ms/f/s!AosKh..