ENG450: Engineering Internship

Boddington Gold Mine Expansion Project

Internship Report

A report submitted to the School of Engineering and Energy, Murdoch University in partial fulfilment of the requirements for the degree of Bachelor of Engineering.

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INDUSTRY AND ACADEMIC SUPERVISOR ENDORSEMENT PRO FORMA

We are satisfied with the progress of this internship project and that the attached report is an accurate reflection of the work undertaken.

Signed:
Roger Wingett – Principal Instrumentation Engineer.
Industry Supervisor

Signed:
Professor Parisa Arabzadeh Bahri
Academic Supervisor

Abstract

The purpose of this document is to provide an overview of the projects undertaken with Aker Solutions in an industrial placement at Boddington Gold Mine as a requirement for the instrumentation and controls engineering internship unit at Murdoch University.

This report looks into the objectives of the internship and the documents and drawings to be used and understood, along with all the relevant field instrumentation to be used on site. This report also covers the projects undertaken during the period of the internship including the Reverse Osmosis (RO) Plant Number 1 and the detailed engineering review undertaken on all vendor supplied packages. As I will be continuing to work on the Boddington Gold Mine Expansion Project after the culmination of internship period this report will go through some of the other projects that are upcoming within the next couple of weeks.

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1. Acknowledgements

My appreciation to Aker Solutions as a company and in particular Francis Norman and Jeni Watson for making this internship placement possible. Without their time and effort I would not have had this wonderful opportunity to gain invaluable experience in the field of instrumentation engineering.

I would also like to thank Roger Wingett for all his help and patience. He understood my position and explained everything clearly and in great detail aswell as having a tremendous amount of patience with all my numerous questions. I extend grateful acknowledgements to the rest of the instrumentation team, along with the E&I supervisors for their help through out this internship. I have learnt a tremendous amount in the past 4 months, and without all their help this would not have been possible.

I would also like to extend my appreciation to the Murdoch School of Engineering and Energy staff for allowing me to complete my degree in an industrial intern placement. I would also like to thank Professor Parisa Arabzadeh Bahri who was my academic supervisor during my internship placement.

2. Introduction

The purpose of this document is to provide an overview of the projects undertaken with Aker Solutions in an industrial placement at Boddington Gold Mine as a requirement for the instrumentation and controls engineering internship (ENG450) unit at Murdoch University.

This report covers the work done to fulfill the objectives for this unit, as explained in Section 3 of this report. The work done to complete these objectives includes the Reverse Osmosis (RO) Plant Number 1, then the detailed engineering review of ten sets of vendor documents within the dry area of the plant.

For the first part of the project, the tasks for the RO plant includes marking up of all relevant drawings to show the ‘as built’ conditions of this plant. The list of drawings included all P&ID’s, termination diagrams, telemetry drawings and instrument location drawings. After all drawings had been revised to represent the ‘as built’ conditions of the plant they were signed off and added to the other drawing deliverables for hand over to the client.

For the second part of the project, the vendor document review consisted of a detailed engineering review of all vendor instrument engineering drawings. The review started with the largest vendor package on site which is Conveyor Engineering Inc (CEI). Under supervision, my tasks included a detailed engineering review of construction drawings such as electrical single line diagrams, Piping and Instrumentation Diagrams (P&ID’s), termination diagrams, cable schedules and the control system’s input/output list (I/O list). My tasks also included checking and revising cable and ferrule numbers, power supplies to non-loop powered instruments and revising the safety issues involved with mixed voltages in field junction boxes. The task of hand marking up vendor controlled documents requires the use of an AKCMR status stamp, to control the use of uncontrolled vendor documentation during the construction period. Installation Contractors on site require controlled drawings checked and issued for construction. These are controlled drawings. Uncontrolled drawings are those being revised by engineers prior to being “issued for construction” to the installation contractors. The relevance of this stamp is explained further into this report. Once the CEI vendor package had been revised the next priority was to review the vendor packages installed in the primary crushing area. The primary crushers consist of approximately 16 different vendor packages. Under supervision, the tasks were to review the primary crusher vendor packages using the same disciplined procedures as CEI.

3. Gold Extraction Process

The process employs primary crushing, closed circuit secondary and tertiary crushing, ball milling and hydro cyclone classification to generate a milled product of 150µm at a slurry density of 34% solids. Flash flotation facilities are provided to treat a portion of the mill discharge stream. The flash concentrate is delivered to the gravity concentrator and the resulting concentrate is refloated in a flash cleaner flotation cell.

The milled product (cyclone overflow) is treated in a flotation circuit that produces a copper-gold concentrate for export. The treatment of the concentrate includes regrinding and cleaning to achieve an acceptable grade. The final concentrate is thickened and filtered then trucked to the port.

The cleaner scavenger tailings stream is thickened and leached in an elevated cyanide leach circuit, and the flotation scavenger tailings are thickened and leached in a conventional leach/adsorption circuit. The leached slurry from the cleaner scavenger tailing leach circuit is delivered to the flotation scavenger tailings carbon-in-leach (CIL) adsorption circuit for recovery of gold.

Leach residue is pumped to the residue disposal area, and residual weak acid dissociable cyanide (CNwad) is maintained below a targeted level by a detoxification plant treating the decant water.

Carbon from the scavenger tailings CIL circuit is treated by conventional split-AARL elution and reactivated in horizontal regeneration kilns. Gold recovery is by electrowinning, cathode sludge filtration and drying, and smelting.

(Engineering, Procurement, Construction Management (EPCM) Agreement,2006).

3.1 COMMINUTION

The Comminution plant comprises 3-stage crushing followed by single-staged closed circuit ball milling. Both secondary and tertiary crushing stages operate in forward or regular closed circuit with dedicated screens, in which unscalped ore, that is feed containing fines from the previous crushing stage, is fed to the crushers.

Primary crusher product is delivered to the coarse ore stockpile, from which it is apron fed and conveyed to the secondary crushers. The secondary crushing product is conveyed to the scalping screens, the screen oversize joining the new feed to close the circuit, and the undersize product is conveyed to the high pressure grinding rolls (HPGR's).

The bin feed conveyors to both secondary crushing and HPGR have overhead magnets for removal of tramp metal, while the belt feeders to the crushers and HPGR's have metal detectors for ultimate tramp metal protection. From a production point of view, the removal of tramp metal is a high priority. Tramp metal is a hard material like iron ore which looks like a spear. It often slips through crushers to then be poured onto a rubber conveyor belt surrounded by tonnes of crushed rock. As it lands on the conveyor below it is capable of spearing through the conveyor, lodging itself between structure above and below. The electric motors continue to drive the conveyor belt past the tramp metal spear which splits the belt causing production downtime in repairs.

HPGR product is conveyed to the fine ore storage bins. Ore is drawn from the fine ore bins and delivered to the wet sizing screens. Screen oversize is returned to HPGR's feed, closing the circuit, and the undersize slurry flows to the mill sump from which it is pumped to classifying cyclones. Cyclone underflow gravitates to the ball mills, which discharge to the mill sump, closing the circuit. The ball mill discharge stream passes through a trunnion magnet that removes undersize balls and ball fragments from the slurry.

For each of the four mills, a portion of the mill discharge stream is pumped to a flash flotation cell. Flash flotation tailings gravitate to the mill sump, while concentrates gravitate to a gravity concentrator circuit, the resulting concentrate is pumped to a flash flotation cell.

Cyclone overflow, the final ground product, gravitates through trash screens to the flotation plant.

(Engineering, Procurement, Construction Management (EPCM) Agreement,2006).

3.1.1 Primary Crushing

Run-of-mine (ROM) ore is trucked from the open pits by rear dump haul trucks and tipped into a dump hopper above each of the two 1000kW primary crushers. The dump hopper is designed for the initial expected truck dump size of 218 tonne, but can accommodate a maximum truck dump size of 345 tonne. The dump hopper has a nominal capacity of 1¼ trucks to provide some tipping/reclaim overlap.

Tipping is controlled by 'traffic' lights that are in turn controlled by dump hopper and discharge bin level signals. An image analyser on each dump hopper is used for monitoring of ROM ore sizes. Oversize and shabby ore is handled by a mobile excavator fitted with a rockbreaker.

Crushed ore is withdrawn by a variable speed 2.2 meter wide electro hydraulically driven apron feeder below each primary crusher and transferred onto the acceleration conveyor. The acceleration conveyor in turn transfers the ore onto the overland conveyor, after passing under a tramp metal magnet. A belt scale on the downstream of each transfer point allows monitoring and control of each reclaim feeder.

The distinction between an apron feeder and a conveyor is the former is a steel catapillar style "belt" running over flat idlers with sides to the infeed lined with hardened metal tiles, whilst a conveyor is a steel cable reinforced synthetic rubber belt running over troughed idlers supported between large section channel steel structures known as stringers.

Dust control measures include water sprays at the truck tip points and baghouse dust collection from the reclaim area. Collected dust from the baghouse is transformed into a paste in a plug mill and discharged onto the burden on the overland conveyor.

(Engineering, Procurement, Construction Management (EPCM) Agreement,2006).

3.1.2 Acceleration and Overland Conveyors

Primary crusher product withdrawn from the surge bins by the apron feeders is discharged onto the tail end of the acceleration conveyor, which in turn transfers the ore onto the overland conveyor that delivers the ore to the coarse ore stockpile at the process plant.

An overhead self-cleaning magnet located at the head end of the acceleration conveyor is used for removal of tramp ferromagnetic material referred to in previous paragraphs of this report. The feeders and conveyors are protected by belt rip detectors in addition to the normal belt drift, blocked chute, under speed, take up position and statutory pull-wire switches protect personnel working near operating conveyors.

The conveyor is approximately 2.4km long, with a total lift of 139m and an operating speed of 4.6m/s. Fogging water sprays are used for dust suppression at the discharge onto the coarse ore stockpile, and a belt washing station is located at the head end of the conveyor.

(Engineering, Procurement, Construction Management (EPCM) Agreement,2006).

3.1.3 Coarse Ore Stockpile

Primary crusher product is delivered by the overland conveyor to a conical stockpile with a live capacity of 40,000 tonnes.

Three variable speed apron feeders withdraw the ore from the bottom of the stock pile and discharge onto the secondary crusher feed conveyor. The feeders can be used for blending purposes to regulate the sizing of the feed to the crushing circuit, and any two feeders can supply the full plant feed capacity.

A belt scale on the secondary feed conveyor downstream of the last feeder loading point is used to monitor and control the feed rate to the crushing plant. The feeders and conveyors are protected by belt rip detectors in addition to the normal belt drift, blocked chute, under speed, take up position and statutory pull-wire switches as appropriate.

A belt scale is a dynamic weighing machine using either load cells or nuclear level measurement which weighs the net product on top of a conveyor belt as the conveyor moves at production speeds of between 2 and approximately 4.5 metres per second.

Dust control is by a reclaim tunnel pressurising fan and fogging sprays at the feeder loading points.

(Engineering, Procurement, Construction Management (EPCM) Agreement,2006).

3.1.4 Secondary Crushing and Scalping Screens

New feed for the coarse ore stockpile is conveyed to the secondary crusher feed bins and delivered by variable speed belt feeders to the crushers. The feed conveyor includes an overhead magnet for tramp metal removal, and each belt feeder has a metal detector for ultimate tramp metal protection. A detection event causes the feeder to stop, and manual retrieval of the metal object is required before the feeder can be reset and operations resumed.

Choke feeding is maintained using the variable speed feeder drive and a level detector in the crusher feed chute. Alternatively, a power-based control function may be used whereby the feeder speed is controlled by the power draw of the crusher motor. This is a more appropriate method of control if the crushers are power limited rather than volume limited. The control system has been configured to allow either mode of control, or a combination of the two.

The crusher modules are automatically started and stopped according to their respective feeder bin levels.

The crusher product is conveyed to the scalping screen feed bins and delivered by variable speed diverging pan feeders to the screens. Screen oversize returns to the secondary crusher feed conveyor, closing the circuit, and the undersize discharges to the HPGR feed conveyor.

(Engineering, Procurement, Construction Management (EPCM) Agreement,2006).

3.1.5 High Pressure Grinding Rolls (HPGR's)

New feed to the HPGR's (scalping screen undersize) is conveyed to the HPGR feed bins and delivered by variable speed belt feeders to the HPGR's. The feed conveyor includes an overhead magnet for tramp metal removal, and each belt feeder has a metal detector for ultimate tramp metal protection. A detection event causes a gate at the feeder head to open and bypass the contaminated ore around the HPGR to the product conveyor.

Choke feeding is maintained using the variable speed feeder drive and a level detector in the HPGR feed hopper, while the variable speed drives of the HPGR's are used to control feed bin levels.

If the feed bin level continues to fall with the HPGR at minimum speed, the module is shut down automatically; the system will restart when the bin level reaches a higher level. Likewise if the bin level continues to rise with the HPGR at maximum speed, feed to the HPGR operation is reduced by stopping one or more scalping screen modules.

The HPGR's are arranged in a back-to-back pattern in which alternating units are located north-west and south-east of the feed bins respectively. This is necessary to accommodate the HPGR unit geometry in which the motors and drive trains are offset to one side of the machine and occupy the adjacent building bay. The alternating pattern avoids difficulties with the feed bin arrangement, but does require product transfer conveyors from on of the two banks.

HPGR product is transferred onto the fine ore bin feed conveyor and delivered to the bins using a tripper.

(Engineering, Procurement, Construction Management (EPCM) Agreement,2006).

3.1.6 Milling

The milling plant comprises four modules, each with a 14.5MW mill (each mill has 2 X 7.9MW drives) for a nominal total capacity of 35.2Mt/a. No special provision is made in the layout for additional milling lines for debottlenecking, although the space does not preclude this in the future.

For each milling line, mill feed is drawn from the fine ore bin by two variable speed belt feeders and delivered to the sizing screens. Pulping water is added to the screen feed box and spray water to the screen deck. Additional water required for the milling circuit is added to the mill discharge sump.

Mill balls are stored in bunkers at the west end of the mill building, and delivered on demand to the automatic dosing system using a rotary feeder. The balls are elevated to the cyclone floor level using a pocket conveyor that discharges onto the horizontal transfer conveyor. Balls are discharged from the transfer conveyor into the appropriate mill feed chute using pneumatically actuated deflector gates. The deflector gates are controlled by an automatic dosing program. Dosing may be time, tonnage or power based at the operator discretion.

Screen oversize is conveyed to the crushing and screening plant where it is transferred onto the HPGR feed conveyor. To accommodate the different utilisation factors of the milling and crushing sections of the plant, a second, parallel conveyor is provided to transfer screen oversize to the coarse ore stockpile when the crushing plant is inactive. Stockpiled ore is reclaimed along with new feed to the crushing and screening plant.

Sizing screen undersize material falls into the mill discharge sump, from which it is pumped to the cyclones. Cyclone underflow, comprising the new feed and the mill circulating load, gravitates to the mill.

The mill discharge stream passes through a trunnion magnet that removes tramp metal and ball/ball fragments from the slurry. The ferrous metal is discharged onto a conveyor delivering to a tramp metal skip, located at the west end of the mill building for easy access outside the main process area.

The mill discharge slurry flows into the mill sump via a static grizzly that protects the sump and pump from balls ejected from the mill during upset conditions and not retrieved by the trunnion magnet.

Cyclone overflow gravitates through the trash screen to the flotation section. Trash screen oversize is dewatered on a single vibrating screen and collected in a skip for removal.

Each trash screen underflow stream is sampled by a multi-stage cross-cut and rotary sampling system to provide a shift sample of each mill stream for metallurgical accounting purposes.

For each milling module, a portion of the mill discharge slurry stream is pumped to a flash flotation cell. Flash flotation tailings fall into the mill sump, while the concentrates gravitate to the gravity concentrators, concentrate is pumped to a flash cleaner flotation cell.

(Engineering, Procurement, Construction Management (EPCM) Agreement,2006).

3.2 CONCENTRATE RECOVERY

Ball mill cyclone overflow, after passing through the trash screens, is delivered to the rougher/scavenger flotation circuit, comprising two parallel banks of ten cells with two milling lines dedicated to one flotation line with no provision for cross-over between lines. The first four cells in each flotation bank are fitted with dual froth launder outlets so either a high grade or rougher concentrate may be produced. The high grade concentrate can be directed to the concentrate thickener. A combined rougher/scavenger concentrate from the two flotation banks is reground to 80%

(20µm) and refloated in a 3-stage cleaner circuit to produce a final copper concentrate for export.

The combined high grade rougher concentrate and the final cleaner concentrate are thickened and filtered, using a pressure filter, to product a dewatered product that is trucked to the port for export to a smelter.

Scavenger flotation tailings gravitate to a thickener and the thickened slurry underflow is pumped to the leach/CIL circuit, comprising two parallel trains and supplemented with two additional leach tanks per train.

Lime slurry is added at the pre-leach thickener to raise the pH, and cyanide is dosed to the leach feed. Loaded carbon is pumped from the first CIL tank, via a screen, to the elution column. Where there is one column per leach train. Both acid washing and elution of the loaded carbon are conducted in the same column after which the stripped carbon is transferred to the regeneration kilns. Two kilns per leach train are located above the final CIL tank.

The cleaner flotation tailings are refloated in a scavenger stage. The cleaner scavenger concentrate is recycled to the regrind mill where the tailings are thickened and leached. The leached cleaner scavenger tailing slurry is pumped to the scavenger tailings CIL circuit for gold recovery.

Electrowinning and smelting is performed in a central gold room facility to produce gold bullion bars.

(Engineering, Procurement, Construction Management (EPCM) Agreement,2006).

3.2.1 Flotation

The flotation system consists of two parallel banks of rougher/scavenger flotation cells. Each bank comprises of three 100m^3 rougher cells with individual level control and ten 200m^3, 220kW rougher/scavenger tank cells grouped in pairs with dart valves between each pair for level control. The first four cells in each bank are provided with dual outlet froth launders allowing a high grade concentrate to be produced when feed grade allows. The high grade concentrate is pumped directly to the concentrate thickener using a horizontal 150mm froth pump. The concentrate from the remaining cells in each bank comprises a combined rougher/scavenger concentrate that gravitates to a common regrind section.

The flash rougher/scavenger concentrates are combined with the regrind mill discharge in the regrind cyclone feed sump and pumped to the classifying cyclones. The cyclone underflow gravitates to the regrind mills and the overflow, with a grind size of 20µm, is directed to cleaner flotation. The regrind circuit is comprised of four VTM 1500 tower mills, two clusters of 22 250mm cyclones and two 550mm, 400kW horizontal cyclone feed pumps.

Regrind cyclone overflow gravitates to the feed box of the first stage cleaner bank comprising four 100m^3, 150kW tank cells. The first stage concentrate is pumped with a 250mm horizontal froth pump to the head of the second cleaner stage, comprising five 30m^3, 45kW cells. The second stage concentrate is pumped to the head of the final stage, comprising three 8m^3, 15kW cells. The cleaner cells are arranged such that the tailing from the second and third stages gravitate to the feed to the first and second stages respectively. The final concentrate is pumped to the concentrate thickener.

The first stage cleaner tailings are pumped with a horizontal 400mm centrifugal pump to a cleaner scavenger bank, comprising seven 100m^3, 150kW tanks. The cleaner scavenger concentrate is returned to the regrind cyclone feed sump. The cleaner scavenger tailings are pumped to a thickener.

Each flotation bank scavenger tailings stream is sampled by a multi-stage cross-cut and rotary sampling system to provide a shift sample for metallurgical accounting purposes.

(Engineering, Procurement, Construction Management (EPCM) Agreement,2006).

3.2.2 Scavenger Tailings and CIL

The cleaner scavenger tailings, mentioned above, from the flotation section are pumped to a 19m diameter thickener. Thickener underflow at 45% solids is pumped to the leach circuit. The seven existing 175m^3 supergene plant leach tanks are re-used, with the addition of three new 300m^3 leach tanks to provide 12 hours leach residence time.

The slurry from the final leach tank is pumped to the scavenger tailing leach circuit for additional leaching and recovery of the leached gold.

Scavenger tailings from the individual flotation banks gravitate to a single thickener, 75.5m in diameter. Lime is added to the thickener feed for pH adjustment prior to leach, and flocculant is used to promote settling of the solids and produce a clear thickening overflow. Thickener overflow gravitates to the process water tank.

Thickened underflow is pumped by individual 300mm, 475kW horizontal centrifugal pumps to each of the leach trains.

The two existing leach/CIL trains are re-used with the addition of two 3150m^3 leach tanks at the head of each train to provide a total of 14 hours residence time in four leach tanks followed by seven CIL tanks. The reused tanks have been refurbished and ‘banded’ to provide the structural strength required for the increased leach slurry density.

The first leach tank in each train has provision for oxygen injection into two parallel static mixers. Provision has also been made for the future injection of air into the remaining leach tanks should this prove necessary. Cyanide and lime additions can be made down the train.

Carbon advance up the CIL train is by recessed impeller pumps submerged in each tank. Loaded carbon from each of the first CIL tanks is pumped to the 15m^3 loaded carbon screen mounted above the tank. Slurry return to the tank and carbon gravitates to the acid wash/elution column. Regenerated carbon is returned to the final CIL tank from the horizontal rotary regeneration kilns mounted above the tank.

(Engineering, Procurement, Construction Management (EPCM) Agreement,2006).

3.3 GOLD RECOVERY

Acid washing and elution of the loaded carbon is conducted in a single rubber liner column, one per leach/CIL train, using a split-AARL elution sequence. Two strip per day are conducted, each of 13t capacity. Individual soft water, pre-soak and intermediate eluate tanks are located at each elution column together with gas fired elution heaters and heat exchangers.

Stripped carbon is transferred to horizontal gas fired regeneration kilns each of 650kg/h capacity. Two kilns are located above the final CIL tanks in each train so minimising the carbon transport distance and number of transfer events. Regenerated carbon is screened and quenched then returned directly to the CIL tank.

Pregnant solution from the elution circuits is treated in an electrowinning circuit comprising 1m^2 wire mesh cathode electrowinning cells. Two batches of solution are treated daily. The powder gold deposit is washed from the cells, filtered and smelted to produce bullion bars. Barren electrolyte is pumped back into the leach circuit.

The electrowinning and smelting facilities are contained in a secure building that contains a vault for storage of the gold bars prior to shipment.

(Engineering, Procurement, Construction Management (EPCM) Agreement,2006).

3.4 RESIDUE DISPOSAL

Leach residue from the final CIL tank in each train gravitates through 25m^2 Delkor carbon safety screens into an agitated residue surge tank. From the surge tank the residue slurry is pumped to the relevant storage impoundment.

Two trains of pumps are provided for each leach train, each comprising three pumps in series. The first stage is fixed speed, while the second and third stages are variable speed.

(Engineering, Procurement, Construction Management (EPCM) Agreement,2006).

4. Objectives

The initial project undertaken was concerned with the dry (crushing and grinding) area of the Boddington Gold Mine Expansion Project (BGMEP). The dry area includes all instrumentation for the primary crusher, secondary crusher and the high pressure grinding rolls (HPGR), along with all the associated conveyors, feeders and shuttles.

As time progresses, these personal projects may extend to the wet area of the plant which involves the leaching and metal extraction process as described in Section 2.

The objective of the internship project is to gain a fundamental understanding of field instrumentation engineering, design and construction. The internship is structured to provide detailed experience and an understanding of the following areas:

➢ Design:

Preparation of all Drawings for use by the Construction Teams to install all instruments including in-line control valves, flowmeters, pressure and temperature switches and transmitters, cabling, junction boxes, marshalling panels and their interface to the Process Control System (PCS).

➢ Site Works:

Preparation, checking and understanding of all instrumentation drawings which are issued to the E & I construction team. These Include:

- Piping and Instrumentation Diagrams - P&ID's.
- Cable schedules.
- Terminal connection diagrams.
- Loop drawings.
- Instrument indexes.
- Field instrument data sheets.
- Instrument location drawings.
- 3D Plant Model for location of main structures which contain piping, field instruments, field junction boxes, cable trays.

➢ Understanding the types of instruments and their applications, to be specified and installed for the function of large mechanical packaged equipment and skid mounted smaller packaged plant.

- Conveyor Monitoring Instrumentation:
    - Belt drift switches.
    - Pull wire switches (including Australian Standards for statutory safety requirements).
    - Bulk solids profile monitoring instruments.
    - Dust monitoring (environmental monitoring instrumentation).
    - Conveyor belt rip detection instruments.

  - Under speed switches.
  - Ferrous metal detection (tramp iron) to protect the conveyor belt.
  - Bag droppers for locating tramp iron after detection.
  - Magnets for removing tramp iron from bulk solids on conveyor.
  - Belt take up equipment including limit switches.
  - Shuttles for extending conveyor discharge points to a number of bins or hoppers.
  - Apron feeders for transporting bulk solids from bottom of large bins onto conveyors.

- Instrumentation used in this project includes:

  - Flow meters (mostly electromagnetic flowmeters).
  - Thermal flow switches.
  - Positive displacement flowmeters.
  - Pressure switches and transmitters.
  - Temperature switches and transmitters.
  - Modulating control valves using air or electric actuators.
  - On/off valves using air or electric actuators.
  - Load cells and weight transmitters.
  - Level switches and transmitters.
  - Hydrogen Cyanide environmental analysers.
  - Blocked chute instruments.
  - Bin level instruments.

- A detailed description of the two personal projects undertaken during the internship period follow in the coming sections.

5. Reverse Osmosis Plant Number 1 – Project One

5.1 BACKGROUND

The first of two Reverse Osmosis (RO) plants has been built on site and is currently in use to supply all potable water around site as well as to the village accommodation located 13 kilometres from the construction site. The RO Plant was one of the first infrastructure projects for the mine site. Several changes have occurred to the required potable water usage during the current two year construction period.

As the potable water usage requirements are now mature all associated construction drawings are required to be issued 'as built'. This process ensures that all alterations and changes that occurred during the construction period are captured. All 'as built' drawings are then CAD revised, checked, signed off with wet signatures (ink signatures of the reviewing engineer and line manager), then issued through Document Control to the client as one of the plant hand-over packages.

5.2 PROJECT WORK

As this project was almost finished by the time the internship started, the only involvement was in the 'as built' deliverables for the client.

Due to the continuously changing and temporary conditions often experienced during the early stages of a construction site, there have been numerous progressive changes to the original design that must be captured accurately on all the relevant drawings.

The first of numerous changes was the change of raw water supply that originally came from the D4 dam. Over the 2 years of construction this dam has slowly been emptied and thus alternative sources were required. The raw water supply was moved from the D4 dam to the North Clear Water Ponds. For this change to occur several documents needed to either be created or revised. These drawings included the P&ID's for the raw water supply to the RO plant, the telemetry system drawings such as termination diagrams and layout diagrams.

Other changes that occurred during construction were the addition of a safety shower next to the RO plant. This shower was removed from the P&ID's during the construction period, however, as required by mine site regulations it was built as per the original design and thus the safety shower needed to be reinstated on the P&ID's to reflect the 'as built' condition of the plant. The mark up of the P&ID showing the safety shower is shown below in Figure 1.

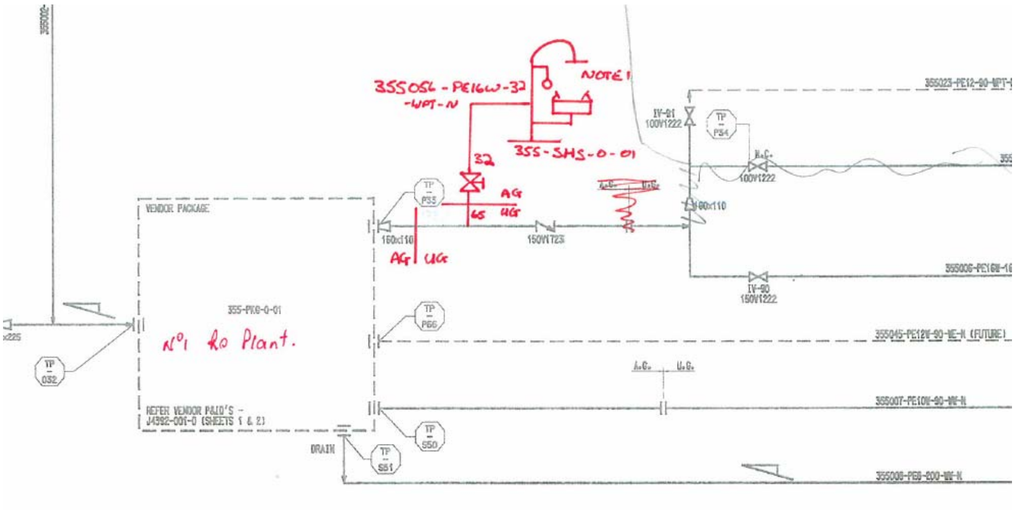


Figure 1: Mark Up of Safety Shower on P&ID.

Several piping routes from the RO Plant that were created for various early stages of construction have either been revised or demolished. One of these routes included a secondary line pumping RO Plant potable water directly into the plant's potable water ring main pipeline and later the fire water ring main line during the completion of the potable water storage tank on Comm's Hill. This allowed early construction access to potable water during maintenance of the storage tanks located at Comm's Hill.

Once these changes had been captured on the relevant drawings they were stamped 'as built' and filed in the master folder under infrastructure. Red line mark ups were then CAD revised and issued 'as built' and signed off with wet signatures by myself, my supervisor, and the area supervisor. These drawings were then added to the remaining deliverables for the RO plant for hand over to the client.

6. Detailed Engineering of Vendor Drawings – Project Two

This task started out as a review of vendor documents as it was noted that the vendor cables did not appear on the AKCMR engineered area cables schedule and that the vendor cable schedules were either missing or unacceptable. This led to a lot of questions being asked regarding the status of all other vendor packages and it was soon realised that no detailed engineering had been completed on any vendor packages by the original, overseas design team. A senior management decision was made to use the site engineering team to complete the detailed design of the vendor packages.

The detailed engineering of vendor documents involves the checking of all vendor document deliverables to ensure they complied with all AKCRM standards and procedures. This includes checking all instrument tag numbers, cable numbers and ferrules, instrument power supplies, instrument by instrument, wire by wire, from every field instrument all the way through field junction boxes to the substation marshalling panels and finally to the control system address cards. The various drawings were also checked against the control system I/O list, field junction boxes and also marshalling cabinet termination diagrams and the area cable schedule to ensure every field instrument was monitored by and/or controlled by the process control system.

6.1 CONVEYOR ENGINEERING INC.

The first vendor package to be checked was Conveyor Engineering Inc. (CEI) who are supplying 35 conveyors, shuttles and feeders throughout site incorporating 23 different types of instruments. Due to the large volume of CEI documents (over 300 drawings), the task was split between numerous engineers. I was given the areas 611 (Primary crushing), 612 (2.3 kilometre conveyor), 621 (stockpile), 622 (secondary crushing), 623 (screening) and 624 (high pressure grinding rolls). These areas include 9 conveyors, 2 shuttles and 9 feeders in total.

The first process was to add the CEI vendor cables to the AKCMR area cable schedule in terms of their cable number, number of cores, cross sectional area of each core, the number of pairs per multipair, whether the cables are individually screened and/or overall screened, earthing cores, external sheath colour to differentiate between instrumentation cables and electrical power cables. It was also noted that the cable numbers did not comply with the AKCMR numbering convention. Further, the ferrule numbers also followed the wrong naming convention. Therefore the first step in the detailed engineering process was to determine the correct numbering convention from the instrumentation design criteria, then red line mark up all of the cable and ferrule numbers throughout the vendor documents. Putting that task into perspective, my package included over 100 CEI vendor wiring diagrams which each required over 100 red line mark ups – totalling over 10,000 revisions.

The next process was to cross check that the vendor supplied instruments were noted on the instrument equipment list in terms of tag number, instrument type, function description, status of delivery to site, process connection type & size, power supply, inclusion in the field junction box and marshalling panel termination schedules, cable schedules and also the process controls I/O list. This extensive cross checking procedure highlighted many issues including vendor supplied instruments which had not been included in the wiring diagrams, cable schedules, instrument index and more.

The next design review procedure was to check the terminal connections and power requirements of each instrument against each data sheet. Being a design from the USA, we also discovered that the 240VAC power supply to some of the instruments was terminated in their 24VDC signal field junction boxes. The practice of installing 240VAC and 24VDC power supplies in the same terminal strips inside the same field junction box is an unsafe practice unless installed as per the Australian Wiring Rules AS3000. The US design did not include such AS3000 requirements so the decision was made to revise the junction box layout designs to 24VDC power supplies only. The 240VAC instrument termination diagrams were re designed to be wired directly from the nearest 240VAC Distribution Board to each instrument. The capacity of each 240VAC Distribution Board and the number of available circuit breakers were checked via their respective Electrical Single Line Diagrams before adding the new local instruments to those drawings. 24VDC signal wires from each instrument were then connected to the 24VDC field junction box – resulting in a safe design which conforms to the Australian Standards: AS3000 Wiring Rules.

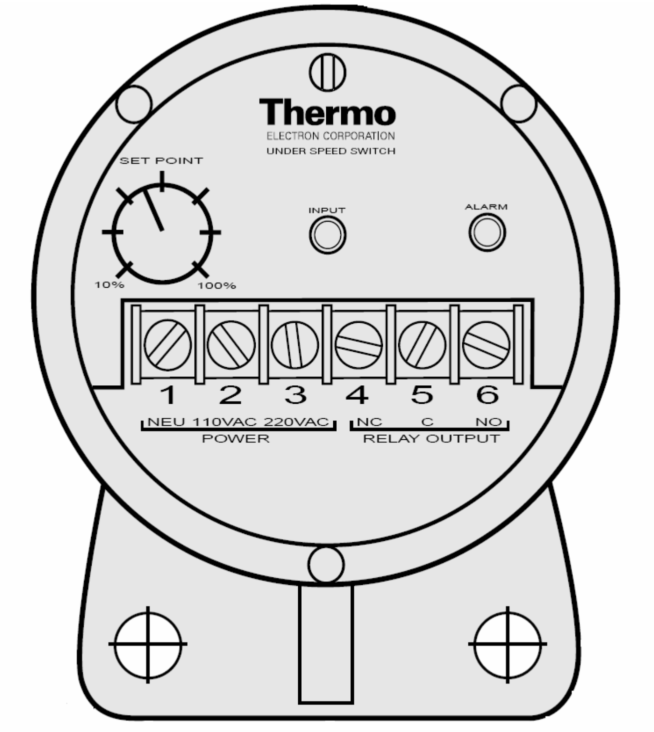


Figure 2: 240VAC Powered Instrument.

Figure 2 shows the connection terminals for a 240VAC power instrument, an under speed sensor, where the 240VAC is connected to terminals 1, 2 and 3 with the 24VDC signal connected to a combination of terminals 4, 5, and 6. Figure 3 shows the marked up CEI wiring diagram, where previously the 240VAC power ran from the junction box via a 5 core cable. The mark ups now show the power running directly from the 240VAC distribution board to power the instrument and a single pair running back to the junction box for the return signal.

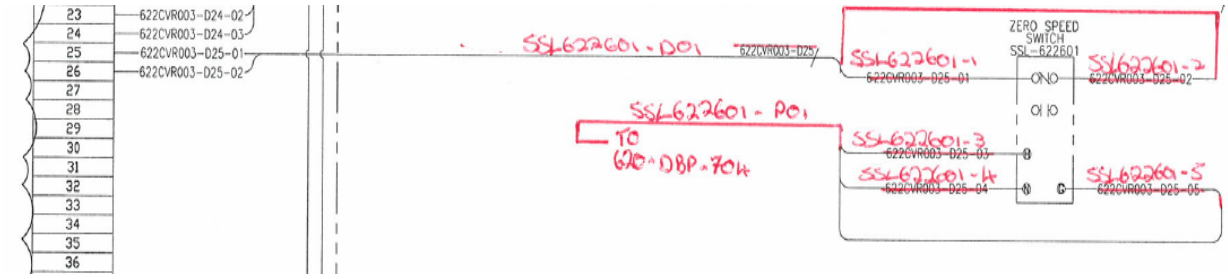


Figure 3: CEI Wiring Diagram for 240VAC Powered Instrument.

Figure 4 Shows the single line diagram for 620-DBP-704, located in one of the switchrooms, from where the under speed switch is powered.

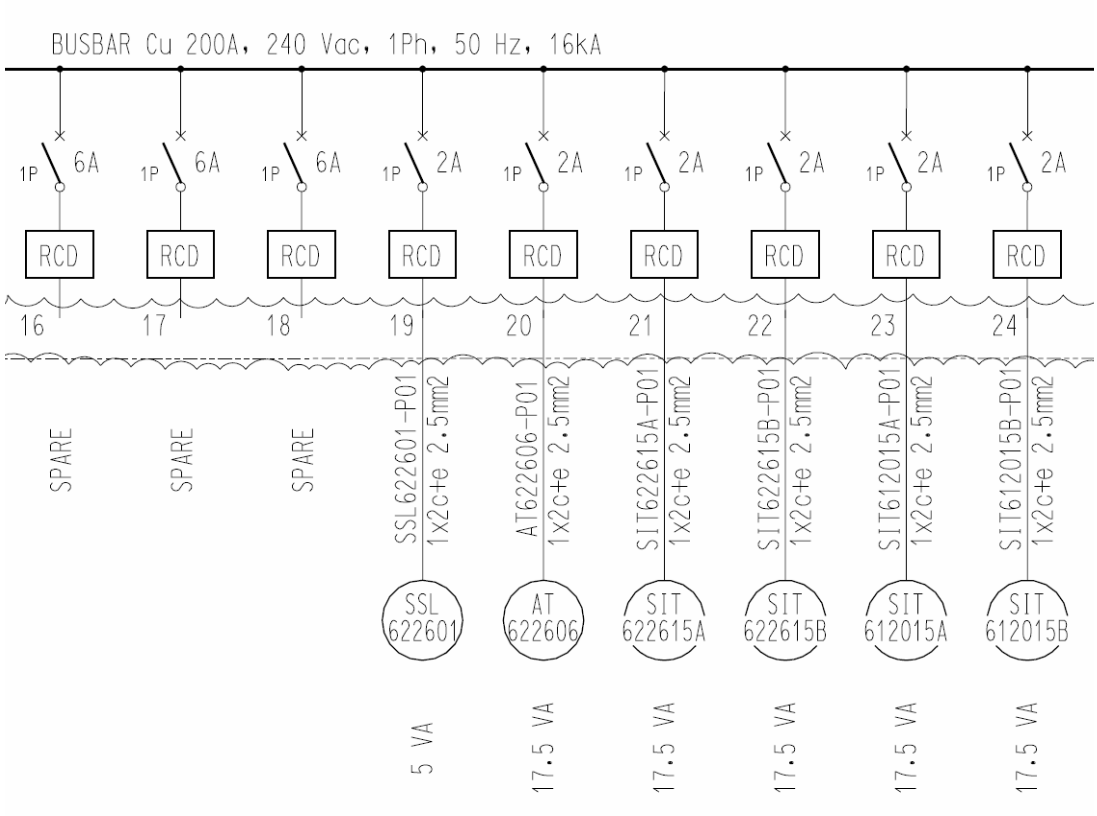


Figure 4: 620-DBP-704 Single Line Diagram.

6.1.1 Ferrule Numbers

Ferrule numbers conform to the 'Instrumentation Design Criteria' referred to previously, which is a detailed specification written specifically for each project by the Principal Instrument Engineer as the detailed instrumentation design requirements to be followed throughout the project – see Appendix D. Ferrule numbers consist of the instrument tag number followed by a suffix to differentiate between the cores in a cable. All instrumentation signal wiring consists of twisted pairs containing a white core and a black core. Each core is multi stranded twisted copper wire of various cross sectional areas. Each core is PVC covered and colour coded. PVC insulated multi pair cables can consist of up to 50 black and white pairs, each pair is numbered one to 50 on each core pair by the manufacturer. On the design drawings, each core is numbered with suffix, whereby -1 indicates a positive current from the PCS on all white cores. The negative black core uses the suffix of -2 to indicate the return signal.

Figure 5 shows the ferrules for both the field wiring and the PCS wiring, at a terminal strip in one of the marshalling panels located within the sub station. The point of doing all this detailed engineering is to ensure the wiring from the PCS matches up with the field wiring to the field instrument.

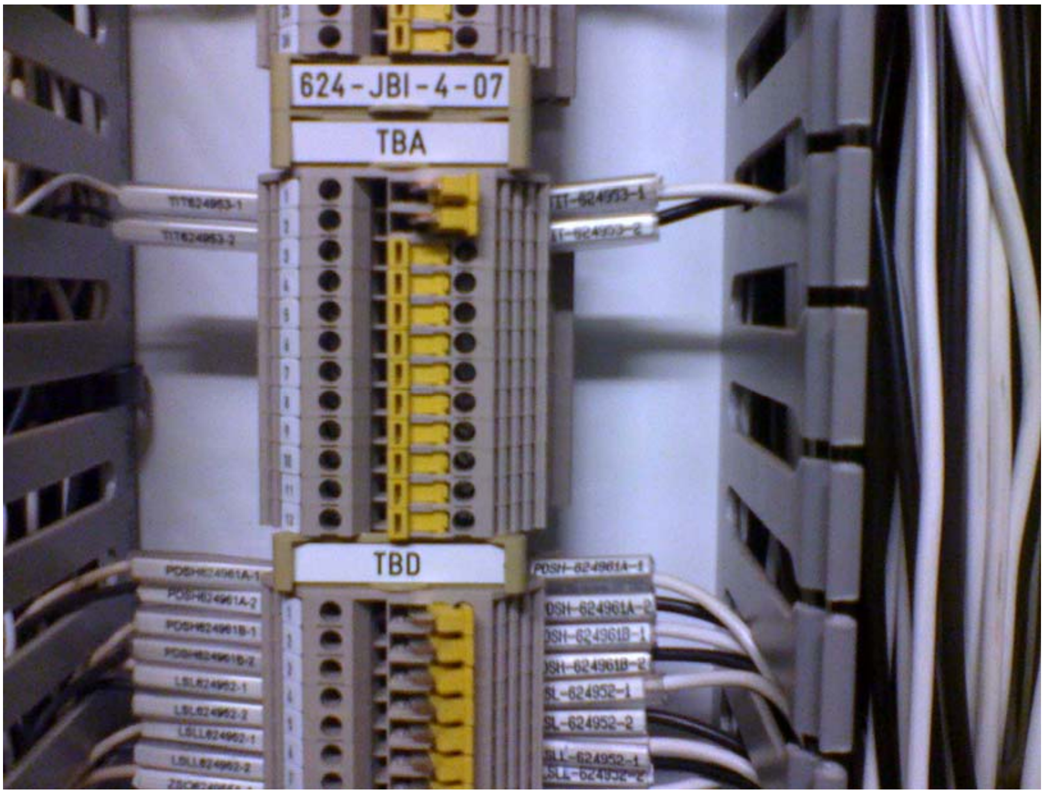


Figure 5: Physically ferruled cables

Figure 6 shows marked up ferrules on a differential speed sensor supplied by CEI. The signal pair has the predefined suffixes while the 240VAC power has been given the next consecutive suffix as these cores do not have any relevance to the PCS.

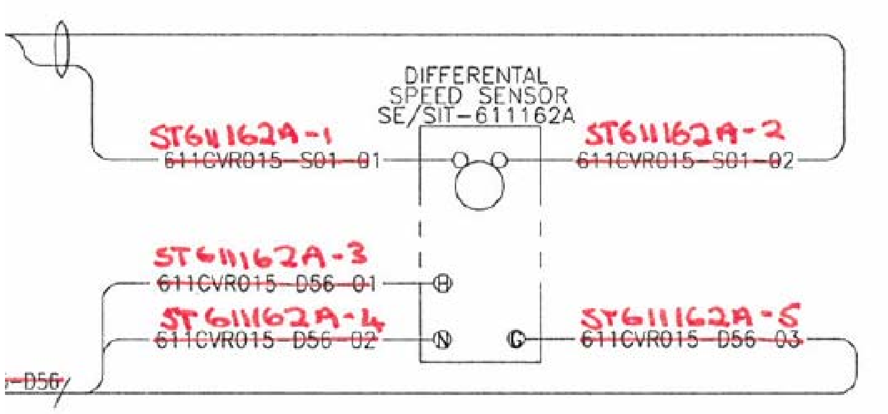
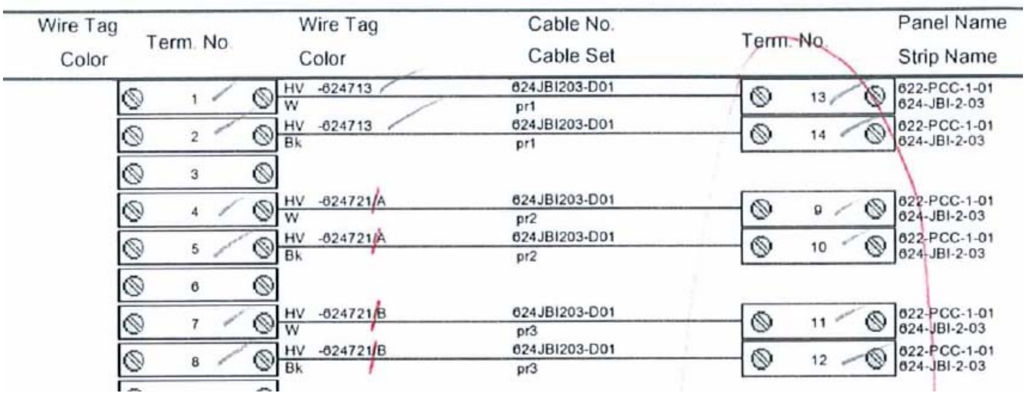


Figure 6: Mark Up of Ferrule Numbers

The ferrule numbers were also checked against the termination schedules as shown in Figure 7, where the PCS input addresses are shown on the right hand side, going out to the field junction box terminal block on the left hand side. These termination schedules will also be expanded to include the wiring to every field instrument. That wiring will be located on the left of the junction box terminal block. Loop drawings for each and every field instrument are created from these attached drawings. Putting the volume of design work into perspective, there are over 8,000 field instruments on this project. Every instrument requires a PCS address and all individual wiring from the PCS cabinets to the marshalling cabinets which are located inside the area substations (or equipment rooms). From marshalling cabinets, multipair cables are run out to their respective field junction boxes (JBI's) located in the process field area via cable trays and conduits, then terminated onto the terminal blocks. From there wiring continues via similar cable trays and conduits to each field instrument. My responsibility was also to create the routing for all of the cable trays and conduits to the field junction boxes located up to 800 cable metres through the process plant from the marshalling panel.



Wire Tag Color	Term. No	Wire Tag Color	Cable No. Cable Set	Term. No	Panel Name Strip Name
	1	HV -624713 W	624JBI203-D01 pr1	13	622-PCC-1-01 624-JBI-2-03
	2	HV -624713 Bk	624JBI203-D01 pr1	14	622-PCC-1-01 624-JBI-2-03
	3				
	4	HV -624721/A W	624JBI203-D01 pr2	9	622-PCC-1-01 624-JBI-2-03
	5	HV -624721/A Bk	624JBI203-D01 pr2	10	622-PCC-1-01 624-JBI-2-03
	6				
	7	HV -624721/B W	624JBI203-D01 pr3	11	622-PCC-1-01 624-JBI-2-03
	8	HV -624721/B Bk	624JBI203-D01 pr3	12	622-PCC-1-01 624-JBI-2-03

Figure 7: Termination Schedule

6.1.2 Cable Numbers

The AKCMR numbering convention is made up of the instrument tag number followed by a suffix which indicates the type of cable. The suffixes use:

- -D for a digital signal.
- -S for an analog signal.
- -P for all power cables, either 240VAC or 24VDC.
- -R for communication cables, such as profibus.

The cable number tags are made from 0.5 mm thick etched stainless steel as per the instrument design criteria. Figure 8 shows some of these cable tags ready for placement on the multipair cables being run from the sub station.

Figure 8: Cable Tags for Multipair Cables

Figure 9 shows the red line mark up of the cables for a differential speed sensor. It shows the instrument tag number followed by the relevant suffix. As these instruments are not loop powered from the PCS they require a separate 240VAC power supply, ST611162A-P01, easily identifiable by the power suffix.

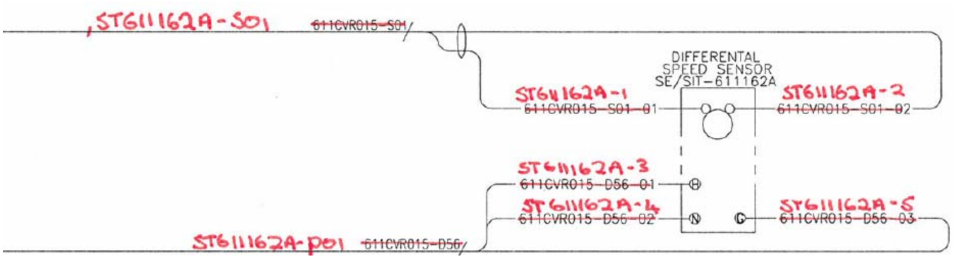


Figure 9: Mark Up of Cable Numbers

None of these vendor cables have been captured in the AKCMR cables schedule. As all cables designed by AKCMR or by vendors will be supplied and installed by the site Electrical and Instrument Installation Contractors, (E & I Contractor) all of the above marked up vendor cables were transferred to the AKCMR cable schedule, then the vendor cable schedule voided. The AKCMR area cable schedule together with the voided vendor cable schedule was then issued to the E & I Contractor via Document Control.

The termination schedules were issued to site engineering showing only the multipairs from the PCS out to the field junction box terminal block. None of the vendor wiring from field junction boxes to field instruments had been captured. As engineering had been designed from both sides of the field junction boxes (i.e. from the PCS to JBI and also from the field instrument to the JBI), my tasks included manually matching every wire from both sides of the JBI terminal blocks.

6.1.3 Mixed Voltages in Junction Boxes

This section is in addition to the mixed voltages noted above.

As the instrument junction boxes (JBI's) supplied by CEI were designed with both 24VDC and 240VAC a number of changes were required for these junction boxes to conform to AS3000 standards concerning mixed voltage power supplies. It was established that a design change was required. There were two options available to revise the JBI designs to conform to Australian Wiring Rules, AS3000.

The first option involved retaining the 240VAC power wiring inside the JBI, by redesigning terminal strips and internals of the junction box. First, the terminal strips containing the 240VAC terminals would be separated from the 24VDC terminal strips. Then the 240VAC trunking, terminals and cables would need to be entirely covered or boxed by Perspex (or equivalent) to prevent any human finger or screwdriver ingress to 240VAC. This would be a more costly and time consuming process to other options, as it would involve a redesign of the JBI's, delays in procuring added materials, a significant increase in installation time and the prospect of several additional weeks delivery time – at a time in this project where all engineering and materials deliverables are on critical path.

The second option was to remove the 240VAC entirely from the JBI. It is common practice to run the 240VAC power supplies directly from instrument distribution boards (DBI's) to each instrument bypassing the junction box. This solution was a much simpler option, and quickly agreed upon. Another issued faced was that the instruments only contained a single cable entry point to accept both the instrument power and signal cables. Our design included a small 3-entry CCC posibox with a small terminal strip, located adjacent to each AC powered instrument. Two of the cable entries allowed for separate power and signal cables, then the third hole used as an exit for the 5 cores of power/signal cable to the instrument via a short flexible conduit. The AC posiboxes labelled Danger 240VAC are readily available through the E&I

contractors and simple to install, as well as complying with AS3000. Therefore provide lower cost, readily available alternative to the mixed voltages in junction boxes.

6.1.4 AKCMR Status

All vendor documents are received by AKCMR Document Control Department. Document Control stamps every vendor document with a vendor status stamp, shown in Figure 10, to track all changes to vendor documents from the AKCMR engineers as they transfer to and from the vendor designers. The vendor designers are responsible for revising their designs and drawing layouts to conform to AKCMR drawing and design standards and red line markups by AKCMR engineers. Doc Control Vendor stamps contain the purchase order of the vendor package, along with an AKCMR document number and revision number which provides a tracking system for the ten's of thousands of drawings from all disciplines each at various revisions throughout the various phases of a large project from concepts, pre-feasibility, feasibility, detailed design through to construction and commissioning to 'as built'.

AKCMR

BODDINGTON GOLD MINE EXPANSION PROJECT

Equipment Tags:

Purchase Order No. 699-55MR-010A-P016

AKCMR Doc Type: B051

Sequential No. 737

AKCMR Rev. 3

Status Code 2

Prime Reviewer (Engineer)

Date 9.9.08

11981

Comment Status Code

1 Reviewed and Accepted as Final Certified. Manufacture May Proceed

2 Reviewed and Accepted as Noted. Review and Resubmit. Manufacture May Proceed

3 Reviewed and Returned. Correct and Resubmit. Manufacture Should Not Proceed

4 Review Not Required. For Information Only. Manufacture May Proceed

Acceptance of this document by AKCMR ABN 33 691 568 923 does not relieve the vendor of any responsibility therefore, nor for compliance with the terms and conditions of the Agreement or Contract

Figure 10: AKCMR Status Stamp.

There are four different status codes for vendor documents as indicated in the stamp above, which are:

1. The document has been reviewed by an engineer, and accepted as correct and to the proper regulations. This means that no more changes are required and the vendor may continue to manufacture or install the apparatus to the documentation specifications.
2. The document has been reviewed by an engineer, but changes have been red line marked up. The vendor is then required to revise the document with these changes and resubmit to AKCMR as the next revision. Vendor manufacturing may proceed including the engineers markups.
3. The document has been reviewed by an engineer and deemed unacceptable for construction, and thus the manufacturer may not proceed. This will usually require a redesign of the equipment by the manufacturer.
4. The document is no longer essential, and thus only for information. Usually occurs if a certain drawing or document has been voided or superseded.

The CEI documents relevant to the internship tasks are status code 2 for all the wiring diagrams as they have been reviewed and require changes before final acceptance, and status code 4 for the cable schedules these drawings have been voided since the cables now appear on the AKCMR cable schedule. Once these drawings have been revised and resubmitted by the vendor to AKCMR the AKCMR engineer marks status code 1 as the final acceptance. Status Code 1 drawings are returned to the Vendor who then issues their drawings as “Issued for Construction”

6.2 PRIMARY CRUSHING VENDOR DOCUMENTS

The next priority for construction was the primary crushing area as a coarse ore stockpile is required by Christmas and thus construction is on a tight schedule to try meet this deadline. The primary crushing area is made up of approximately 10 different vendor packages servicing the two primary crushers, the crushers themselves, rockbreaker, two apron feeders and acceleration and overland conveyors covered previously in the CEI review. These large pieces of equipment have a wide variety of lubrication and hydraulic skids, greasing systems and numerous different types of field and control instrumentation.

The primary crushing area is made up of numerous individual vendor packages that make up different systems themselves including:

- Rockbreaker.
    - Transmin.
- Primary Crushers.
    - Bosch Rexroth, FFE Minerals, Spider and CSE Uniserve.
- Apron Feeders.
    - Tomlinson and Hagglunds.
- Instrument Air.
    - Ingersoll Rand and Jemaco.
- Acceleration Conveyor.

    - CEI, P&J Law Pty Ltd, Svendborg.
- Overland Conveyor.
    - CEI, Svendborg, CSE Uniserve.
- Dust Suppression System.
    - T&T projects, TRC Group
- Cooling Water.
    - Matsu.
- Water Systems.
    - Dynapumps.
- Marshalling Cabinets.
    - Yokogawa.

All these vendor documents need to be reviewed in a similar manner to the CEI vendor package which includes:

- Checking that the ferrule, cable and instrument tag numbers conform to the AKCMR Instrument Design Criteria.
- Cross checking tags with I/O list, instrument index, data sheets and P&ID's.
- Cross checking tags with termination schedules.
- Ensuring all cables are captured on the AKCMR cable schedule.
- Designing the cable routes of cable trays and conduits from marshalling panels to Instrument junction boxes (JBI) to each field instrument.
- Ensuring all vendor packages conform to this mine site and Australian Statutory regulations.

Most of the vendor packages supplied to site are made up of numerous different sub-packages from other manufacturers. These sub-vendor packages come together as a unit and thus all the detail engineering should have already been done by an engineer through the manufacturer, and thus only need a quick check by site to ensure all apparatus will operate correctly. Once this review has been completed then a detailed review of then entire package can commence. This detailed review, as mentioned earlier, is similar to the process taken for the CEI vendor package in terms of checking numerous key documents such as P&ID's, instrument indexes, termination schedules, cable schedules, loop drawings, location drawings, single line diagrams, installation hookup drawings and the control system I/O list.

6.2.1 Instrument Air

All instrument air for the primary crushing area is provided by a single setup consisting of a compressor, filter, dryer and 3 air receivers located throughout the primary crushers. The system also contains a differential pressure switch across the filter, to ensure the filter is not blocked as well as pressure transmitters on each of the air receivers to warn of over or under pressure in terms of the rating of the pressure vessel – again by mine regulations statutory regulations. The Ingersoll Rand air compressor has a MODBUS converter installed at its controller electronics allowing the control system to monitor and control the air compressors via its local human machine interface

(HMI), whilst also allowing more control over the compressor compared to the hard wired option which only allows for remote start/stop and the monitoring of an alarm signal and running signal contacts. The Jemaco dryer only allows for the monitoring of the alarm and running contacts as it has a local on and off switch for operation.

6.2.2 Rockbreaker

The rockbreaker has been manufactured by Transmin and comes self contained with its own hydraulic power pack. Due to the location of the rockbreaker within the primary crushers it needs to be remotely operated from the control room and this is achieved through radio communication to a receiver located at the base of the rockbreaker. The rockbreaker also contains local manual solenoid activated controls via control levers connected to each solenoid which open and close to allow/stop hydraulic oil flowing to the relevant actuations required of the actuated arm with its spear like rock breaker attachment.

6.2.3 Primary Crushers

The primary crushers are supplied by FFE Minerals, however of all the vendor packages on site it contains the most sub-vendor manufactured packages. The primary crushers cover four different levels and each level contains an assortment of different equipment. Thus the instrumentation on each level are wired to their respective junction boxes on that level. Therefore some of the field instrumentation signals from a piece of equipment may terminate in one junction box while other field signals may terminate in a different junction box on a different level for the same piece of equipment. And thus a lot of different drawings need to be cross referenced to ensure all field signals have been captured.

The lubrication skids for the primary crushers are provided by Bosch Rexroth and come pre-wired to a junction box located on the large skid. This makes the review a lot simpler in terms of cross reference checks, requiring termination schedules, I/O list and cable schedule to be checked. It is a similar situation with the CSE Uniserve Secondary Liquid Resistance Starters (LRS) for the electrical drives and the Spider Greasing skid, although the Spider system uses PROFIBUS protocol as opposed to being hard-wired I/O. PROFIBUS is a high speed industrial protocol for transporting field instrumentation signals – something similar but more precise than ETHERNET. Precision is required as the loss of a part of a signal would cause the process control system to output an incorrect control signal.

6.2.4 Apron Feeders

The apron feeders are manufactured by Tomlinson, and include field instrumentation such as the statutory pull wire switches, underspeed switches and differential speed switches. These instruments are pre-wired by the vendor to an instrument junction box

(611-JBI-1-05 and 611-JBI-1-07) located on the apron feeder, and thus termination schedules, I/O list, single line diagrams, instrument location drawings, loops drawings and the cable schedule need to be reviewed to ensure all components are captured.

The drives for the apron feeders are provided by Hagglunds and consist of the hydraulic drives as well as the hydraulic power packs. The hydraulic power pack contains the majority of all the field instrumentation connected to a panel (611-PNL-1-04 and 611-PNL-2-04) located within the skid's control panel. This system also contains a local HMI panel and smart controller, allowing the plant's process control system to communicate through PROFIBUS DP.

6.2.5 Cooling Water

The cooling water used throughout the primary crushers is generated from two MATSU water chillers. They have an incoming supply from the potable water ring main. This potable water is then pumped through the gearboxes and other equipment as required for cooling to optimum operating temperatures.

6.2.6 Acceleration Conveyor

As a review of the actual conveyor has already been completed, and covered in the previous section 5.1, it will not be covered again although all other equipment not covered before will be included. Some of the other major pieces of equipment include the tramp iron magnet and the conveyor braking systems.

The tramp iron magnet is located at the head end of the acceleration conveyor, just before the transfer bin to the overland conveyor. The purpose of this large magnet is to try and extract any tramp iron within the bulk ore, as the tramp iron often splits the conveyor belt during a transfer. This magnet by itself contains a variety of different components that need understanding in order to complete this review and include the cooling system required as well as the festoon cabling needed to allow the magnet to be moved in order to dump the tramp iron down a chute.

The Svendborg braking system for the conveyors is fairly complex within itself and requires fail closed contactors to ensure the conveyor will not slide in any situation. Conveyor brakes look like large diameter disc brakes similar but much larger than a motor vehicle.

6.2.7 Overland Conveyor

As with the acceleration conveyor the large overland conveyor review has previously been completed and thus this review covers those components that were not covered previously. These components include the secondary liquid resistance starters (LRS), and the Svendborg brake system.

6.2.8 Dust Suppression System

The dust suppression system for the primary crushing area is understandably a fairly critical component to the process as it is a dry process and therefore will create large quantities of dust. The majority of the dust control is required on the top of the primary crushing area in the dumping areas as well as at the bottom round the apron feeders as these two areas are open and with such a large and continuous volume of dirt and ore so the dust is a lot harder to contain.

6.2.9 Potable and Fire Water Systems

The potable and fire water systems are fairly simple in terms of instrumentation as they are only really concerned with the levels in each of these tanks, and the flow rates though the relevant pipes as the water needs to be pumped from comms hill. These systems also contain chlorination skids for the potable water, to ensure the potable (drinking specification) of the water.

7. Further Tasks

As construction is so far advanced, there is great pressure on engineering to produce the outstanding packages as soon as possible. This means all projects have high priorities and often other unexpected 'interruption' projects will take priority, meaning other projects may have taken priority over initial projects. As I will be continuing with Aker Solutions, at the Boddington Gold Mine Expansion Project, work will continue on some of the projects initially intended for this internship.

7.1 Detailed Review of Vendor Documents

As Mentioned in the previous section the review of vendor documents in the primary crushing area has not been fully completed. As this area is in full construction, the documents for this area are urgently required. The review of this area is almost complete, with a few remaining details being marked up on the termination schedules and cable schedules. Due to the urgency for these documents, they are issued as soon as possible as an Site Transmittal memorandum (STM) to the E&I contractor as redline mark ups. Construction cannot wait for the vendor to revise their drawing using CAD, and therefore once all vendor documents have been marked up for this area they will be sent back to the relevant vendors for revision via document control.

The next area to be reviewed will be the secondary crushing, coarse ore screening and high pressure grinding rolls. Again this review will follow the same process as those done previously, although the HPGR's have been reviewed previously and therefore most aspects of the package should have been captured.

7.2 Design of Small Infrastructure Projects

This design process would involve several smaller infrastructure projects that are required around site. The process group will issue P&ID's for these projects and from there I will be supervised to design the instrumentation, while still interacting with the other disciplines. From the P&ID's it will be expected to obtain:

1. Create an instrument index listing all the instruments shown on the P&ID's.
2. Design loop diagrams.
3. Create I/O list for the Process Control System (PCS).
4. Design interconnection diagrams for field junction boxes and marshalling panels using the I/O list and loop diagrams.
5. Create an instrument cable schedule.
6. Design a Material Take Off (MTO) for all cables.
7. Create data sheets for all instruments.
8. Write installation scope of works for the E&I contractors.
9. Submit all created documents to document control.

i) Issue revision A to relevant inter discipline engineers for comments eg mechanical, piping and electrical engineering disciplines.
ii) Incorporate all comments from rev A and other updated information into rev B. For issue to the client for comments.
iii) Incorporate all comments and revised information, then issue rev 0 as Issued for Construction (IFC).

10. i) Advise procurement department to obtain quotes for all instruments and materials.
ii) Evaluate quotations.
iii) Procurement to buy instruments and materials, advise engineering delivery dates, then expedite timely delivery of all items to site stores.

7.3 FURTHER GENERAL TASKS

These involve continuing to assist the area electrical and instrument supervisors with any design issues, as well as answering any Technical Queries (TQ's) that are generated by the E&I contractors regarding any construction issues will be continued.

8. Bibliography

Instrumentation Design Criteria 11147-699-70DC-005

The purpose of this document is to identify and define the basic requirements for the instrumentation design criteria and design guide for use on the Boddington Gold Mine Expansion Project (BGM).

This document identifies the criteria for the design, purchase and installation of the instrumentation and control systems for the project. It also identifies the Australian Standards, and applicable International Standards, for all instrumentation and equipment supplied.

Electrical and Instrument Cable Coding - DOP4.70.514

Document detailing the format required for ordering all electrical and instrumentation cabling through the AKCMR procurement tracking software package (VPRM).

Wiring Rules AS/NZS3000.2000

This standard sets out the minimum requirements for the design, construction and testing of electrical installations, including the selection and installation of electrical equipment forming part of such electrical installations.

The requirements are intended to protect persons, livestock and property from electric shock, fire and physical injury hazards that may arise from an electrical installation that is used with reasonable care and with due regard to the intended purpose of the electrical installation.

Engineering, Procurement, Construction Management (EPCM) Agreement

This document contains the agreement between BGM Management Company Pty Ltd and Aker Kvaerner Australia Pty Ltd and Clough Projects Australia Pty Ltd trading as Clough Murray and Roberts for the Boddington Gold Mine Expansion Project. The agreement is comprised of the formal instrument of agreement and the annexed documents being; special conditions, general conditions, scope of services, compensation and schedules, exhibits and appendicies.

Due to the nature of the work completed during the internship period, this bibliography may seem fairly limited. The instrumentation design criteria is a fairly comprehensive document, and covers most issues that have arisen during the vendor review process constituting the majority of the projects undertaken during the internship period. There were also a number of issues that were not contained in any documentation that had to either be discussed between the other instrumentation engineers on the team, interdisciplinary engineers, procurement department and the QA/QC department.

9. Appendices

For all appendices please refer to the attached disc.