Engineering Internship Final Report

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“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.”
Executive Summary

During their last year of University, two final year students studying Engineering at Murdoch University were given the opportunity to complete a 16 week internship at the BHP Billiton Worsley Alumina Refinery in Western Australia’s South West. The students were a part of the Process Control Group at the refinery who is responsible for maintaining the sites Process Control System. During the span of the internship a number of projects were assigned to each intern to allow a diverse range of engineering tasks to be experienced. These projects coincided with the student’s major Engineering degree components, Industrial Computer Systems Engineering and Instrumentation and Control Systems Engineering. This report will detail the projects taken on by intern Matthew Ray and the knowledge he gained throughout the internship as a result of project work.

Before any project work could take place a thorough understanding of the refinery’s operations and more importantly a comprehensive familiarisation of the refinery’s control system had to be acquired. This included study of the system architecture, engineering tools and standard engineering practice used on site. This knowledge is detailed in preliminary sections of this report.

The projects worked on during the placement are discussed thoroughly including background information relevant to the project and the technical methods utilised during project work. The project work covered in this report is listed below

- Alarm Configuration Management Trial Server
- Experion Development Test Network
- SCOM C300 Monitoring Implementation
- Facility 24B Efficiency & Growth Commissioning
- Valve Stroking Control Module

During the course of the internship, the majority of time was spent completing project work some of which was carried out with fellow intern, Elliot Payne.

Additional tasks completed throughout the internship are also covered including descriptions of Morning Meetings, Weekly Key Performance Indicator Meetings and Monthly Safety Meetings.

The internship has proven to be a worthwhile learning exercise not only as a result of project work but also having the opportunity to interact with technical professionals in an industrial environment.
Disclaimer

All work discussed within this report is solely the work of the author unless otherwise referenced.

All project work carried out during the internship was completed with the consent and under the supervision of members from the Process Control Group at BHP Billiton Worsley Alumina Pty Ltd.

I declare the following to be my own work, unless otherwise referenced, as defined by the Murdoch University’s Plagiarism and Collusion Assessment Policy.

Matthew John Ray

18th of November, 2011
Acknowledgments
I would like to thank BHP Billiton Worsley Alumina Pty Ltd for giving me the opportunity to complete an Engineering internship at the Worsley Alumina Refinery. The safety culture and professionalism present throughout all departments on site assisted me during my initial weeks at the refinery. The supportive and approachable manner of my colleagues during this time made my initial experiences less daunting.

A huge thank you needs to be given to the entire Process Control Group at the Worsley Alumina Refinery. The amount of assistance provided during the internship was immense and was greatly appreciated. Even when I was heavily bombarding members of the group with questions they were more than happy to answer. Their overall friendliness and attitude towards me and each other have made the entire internship at the refinery an enjoyable and worthwhile experience. A special thanks to Arnold Oliver, Rob Duggan, Ben Marler and Julian Leitch for the amount of time they have invested in me during the course of the internship. Their vast technical knowledge and level of professionalism has helped me develop my technical and professional skills as a developing Engineer and will hold me in good stead for my future career as an Engineer.

I would like to thank the Murdoch University Engineering Department, in particular Associate Professor Graeme Cole, Professor Parisa Bahri and my Academic Supervisor, Dr Gareth Lee. Their efforts in teaching me over the past 4 years have seen me develop professionally and personally. Their passion for teaching continues to motivate me and is responsible for my technical knowledge of Engineering.

I would lastly like to thank my family and girlfriend. Without their continual support over the past 4 years there would be no way I would have made it this far through my Engineering degree. I am forever in their debt for everything they have done for me.
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1 Introduction

For the past 6 years a select number of Murdoch Students studying Industrial Computer Systems Engineering and Instrumentation and Control Systems Engineering are given the opportunity to complete a 16 week internship at the Worsley Alumina Refinery. This helps fulfil the requirement of 500 hours of engineering practicum as per Engineers Australia’s requirement. The internship also provides students with the opportunity to take what they have learnt in the previous three years at university and apply it to “real world” situations and to build on their practical engineering knowledge. This provides great benefit throughout the initial period of their engineering career.

The Worsley Alumina Refinery has a variety of control systems for monitoring and controlling the refinery’s process. The central system is the Experion’s Process Knowledge System which is recognized as one of the world’s most advanced process control systems. Because the refinery runs continuously, it has essentially never been taken offline. It is for this reason that upgrades to the system are carried out online. This practice has resulted in a diverse range of system components existing within the refinery’s process control system. These range from legacy components from former years to modern technologies. Since the refinery was commissioned in 1984 it has utilised Honeywell brand control systems. With the diverse range of technology utilised at the Worsley Refinery, it allowed for varying knowledge to be gained throughout the duration of the internship.

During the internship a number of projects were assigned to the intern to undertake. These projects related strongly to the engineering degree majors, Industrial Computer Systems Engineering and Instrumentation and Control Systems Engineering currently being completed. This allowed for a methodical approach when completing the projects to be developed based on prior knowledge obtained from university studies. The projects assigned coincided strongly with the engineering program offered at Murdoch University, this made the familiarisation period of assigned projects a lot more efficient. As a part of university requirements, a Project Plan and Project Progress Report were developed to communicate with Academic Supervisor, Dr Gareth Lee the background, preliminary scope and progress on the assigned projects.

During the placement the intern worked as a member of the process control team which consists of a range of knowledgeable and friendly professionals who develop and maintain the Refinery’s Control System. This provided a great opportunity not only to query technical information but to develop communication skills within a professional environment. As a member of the process control team the intern was expected to attend and participate in Key Performance Indicator (KPI), Safety and regular morning meetings all of which were a valuable learning experience.

This thesis report aims to provide an in-depth account of the project work completed during the internship period at the Worsley Alumina
Refinery. The assigned projects are diverse in nature and have provided a wealth of experience in many areas of Engineering. Table 1 - Internship Project Summary lists the tasks worked on during the internship placement accompanied by a brief description of each project. Projects are listed in order of commencement date.

Table 1 - Internship Project Summary

<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm Configuration Manager Trial Server</td>
<td>Alarm mismatches between system components can cause various problems for control systems. Alarm Configuration Manager (ACM) Software is used as an automated solution to locate alarm parameter mismatches, generate notifications and change alarm parameters based on a central alarm database. The ACM software needed to be trialled and documented upon a test server before implementation on to the refinery’s control system.</td>
</tr>
<tr>
<td>Experion Development Network Test System</td>
<td>An existing development network is used at the refinery that was created to emulate the actual Process Control Network. This system is used to develop and trial new control schemes before implementation on to the live system. This network needed to be configured to represent a true Fault Tolerant Ethernet to allow for more advance applications to be trialled and to test control hardware.</td>
</tr>
<tr>
<td>SCOM C300 Monitoring Implementation</td>
<td>The Process Control Group use Systems Centre Operations Manager (SCOM) software from Microsoft to notify certain members of the Process Control Group of abnormal operating conditions of system components. A SCOM Server exists which communicates periodically to various system components their current status information. If an anomaly is found a notification is raised by either SMS or Email. Currently there is no way of monitoring Honeywell’s C300 Controller. A solution has to be developed to notify members of</td>
</tr>
</tbody>
</table>
the group when a C300 encounters a fault to allow it to be corrected in a timely manner.

**Facility 24B E&G Commissioning**

As a part of the current refinery expansion the bauxite bin shuttle system is being overhauled to cater for a fourth bin. This new equipment had to be commissioned before hand over to operators. Migration from PLC to the new C300 controllers required new control code to be developed by the vendor. This code had to be Factory Acceptance Tested (FAT) off site and then commissioned on site by Worsley Alumina Process Control Engineers.

**Valve Stroking Coding**

Inactivity of control valves can lead to increased scaling and premature valve failure. By manipulating valves away from their normal operating conditions periodically valve scale can be reduced, this is known as valve stroking. Code did exist to stroke various valves throughout the refinery. The code existed on an older control system which cannot communicate to the new Control Execution Environment (CEE) environment implemented on site. A solution to valve stroking has been implemented within the CEE.

The time allocated at the beginning of each project had to be revised constantly throughout the internship. There were varied reasons for this including unavailable equipment, construction delays, human resource availability and scope adjustments as a result of an increased understanding of the projects. This was a beneficial learning experience and made time management a crucial aspect throughout the entirety of the internship.
2 Background
A refinery overview, refinery process description, area descriptions and a process control system overview will be given to provide context to the write ups for the aforementioned projects. Tools and applications will also be described as knowledge of them is a prerequisite of the following sections of the report. General knowledge of the refinery was required prior to starting project work and was essential in understanding the scope and circumstance for each of the assigned projects preceding their launch. A thorough understanding had to be developed not only prior to starting project work but before full participation in regular meetings could take place.

2.1 Refinery Overview
The Worsley Alumina Refinery was constructed in 1984, 20 kilometres northwest of Collie in Western Australia. The project is a joint venture with 86% owned by BHP Billiton, 10% owned by Japan Alumina Associates Pty Ltd and 4% owned Sojitz Alumina Pty Ltd. An aerial picture of the refinery can be observed in Figure 1 - Aerial Refinery Overview (BHP Billiton Pty Ltd.).

![Aerial Refinery Overview](BHP Billiton Pty Ltd.)

The refinery produces Alumina which is extracted from the bauxite provided by the Boddington Bauxite Mine. The bauxite used is transported from the mine by one of the world’s longest overland conveyors. The refinery uses a modified Bayer Process to produce the Alumina which once calcined, is transported to the Bunbury Port by rail. This alumina is stored until it is loaded onto transport vessels and shipped worldwide to customers. (BHP Billiton Pty Ltd.)
The refinery has undergone a number of upgrades since it was initially commissioned with each upgrade providing an increased alumina production rate.

Currently the refinery is going through an expansion project named Efficiency & Growth (E&G). This expansion will see the refinery go from producing 3.55 million tonnes per annum to 4.6 million tonnes per annum of calcined alumina. The construction of this expansion is currently 70% completed with commissioning of some areas currently taking place. The Process Control Group is heavily involved in the commissioning duties. The details of the commissioning process and the Process Control Group’s involvement will be discussed within the Facility 24B Commissioning Project. Much of the project work completed during the internship was directly related to the E&G project. (BHP Billiton Pty Ltd.)

2.2 The Refinery’s Process
The bauxite fed into the refinery is 30% alumina (mainly gibbsite) with approximately 70% impurities consisting of quartz, sulphates, kaolinite, reactive silica and iron oxides. To produce aluminium, alumina with extremely low levels of iron and silica is required. The refinery uses The Bayer Process which exploits the fact that alumina readily dissolves in hot caustic solutions leaving behind the non-soluble materials. This property makes it relatively easily to remove unwanted impurities from the dissolved alumina solution using a clarification system. The alumina is precipitated out of the green liquor (alumina enriched caustic) by seeding which results in alumina hydrate crystal growth. The refinery includes an additional step of removing the three chemically bonded water molecules by heating the alumina crystals to temperatures in excess of 900°C, this is known as calcination. (BHP Billiton Pty Ltd.)
The refinery is divided into 6 major areas that house key parts of the process. These areas are Raw Materials, Area 1, Area 2, Area 3, Area 4 and the Powerhouse. These process areas can be observed in Figure 2 - Area Refinery Overview (BHP Billiton Pty Ltd.)

![Area Refinery Overview](image)

**Figure 2 - Area Refinery Overview (BHP Billiton Pty Ltd.)**

Each of these areas is then divided into specific facilities, each with its own particular functionality. Throughout the area outlines, functionality of the fundamental facilities will be described in detail with the less significant facilities being omitted.

### 2.3 Raw Materials Outline

The Raw Material area accounts for the bauxite and coal entering the refinery. Many conveyors exist which are interfaced by the DCS. The Raw Materials area is one of the most crucial areas in the refinery as it is responsible for delivering bauxite into the process. The Raw Materials area also looks after lime and caustic unloading and alumina train loading.

#### 2.3.1 Facility 420 Overland Conveyor

An overland conveyor is used to transport crushed bauxite from the Boddington Bauxite Mine to the refinery. The conveyor is one of the largest in the world spanning over 50 kilometres. The conveyor’s speed is approximately 23km/h which equates to approximately 2700tonnes of crude bauxite per hour. Over the course of one year the overland conveyor will transport 12.7 million tonnes of bauxite to the refinery which is deposited onto the bauxite stock piles of Facility 15 Bauxite Reclaiming. The conveyor is powered by a number of electric motors which are controlled by high power Variable Speed Drives (VSD).
2.3.2 Facility 15 Bauxite Reclaiming

Upon reaching the refinery via the overland conveyor, the bauxite is then transported by the two stacker conveyors to one of four 200,000 tonne bauxite stockpiles totalling approximately 800,000 tonnes of bauxite. This amount of stored bauxite can provide the refinery with feed for up to 20 days, in the situation of no bauxite transfer from the mine (conveyor belt rip or other equipment down time). (BHP Billiton Pty Ltd.)

The bauxite is stored on the stock piles in a chevron pattern and then reclaimed at a 90 degree angle to the stacking angle. This ensures that the diverse grade of bauxite present in the stockpile is evenly mixed when being fed into the process. (BHP Billiton Pty Ltd.)

The bauxite is reclaimed from the stockpiles by two bucket wheel reclaimers which reclaim at approximately 1600 tonnes per hour. The two reclaimers are attached to a rail system which allows them to move parallel to the stock piles. A rake exists in close proximity to the bucket wheel to break the surface of the bauxite before being reclaimed by the bucket wheel. A diagram representing the bucket wheel reclaimer can be observed in Figure 4 - Cross Section of Bucket Wheel Reclaimer (BHP Billiton Pty Ltd.)
The reclaimer system is controlled by the refinery’s DCS. A noteworthy feature of the reclaim conveyor control system is the inclusion of a digital video manager system which allows central control room operators to view video feed of the live reclaimer system from their operator stations. (BHP Billiton Pty Ltd.)

The reclaimer deposits the bauxite on to the transfer conveyor which transports the bauxite to the bauxite bin shuttle system of Facility 24B Bauxite Bins.

### 2.3.3 Facility 24B Bauxite Bins

Facility 24B consists of 3 bauxite bins which feed 4 downstream mill circuits. A shuttle system exists on top of the bauxite bins along with flop gates to allow any bin to be fed with bauxite by either of the two transfer conveyors. The shuttle system moves east or west on top of the bauxite bins depending on which bin has been selected to be filled. Many VSDs and drive controllers exist to position the shuttle system and to run the conveyor belts. Various proximity switches allow the DCS to locate and control the position of the bauxite shuttles. The control room operators are responsible to ensure that the bins remain at reasonable levels to ensure that the mills have constant bauxite feed. The bauxite bins are located directly above the 4 mill circuits and rely on gravity to force the bauxite contained within the bins into the milling circuits of Area 1.

During the internship an extensive amount of time was spent on the upgrade of the Bauxite Shuttle Bin system. This included FATs and commissioning work which will be defined in Facility 24B Bauxite Bin E&G Commissioning chapter of this report.
2.3.4 Facility 11 Coal Unloading, Storage and Reclaiming
Coal is delivered to the refinery by rail and unloaded into the coal storage pit. The coal is used to feed the Powerhouse which is responsible for generating steam and power for the refinery. Facility 11 provides approximately 2000 tonnes of coal a day to the powerhouse to ensure enough utilities exist for the refinery’s process. (BHP Billiton Pty Ltd.)

The coal contained within the storage pit is reclaimed and conveyed to the powerhouse for utility generation.

2.4 Area 1 Outline
2.4.1 Facility 24 Bauxite Grinding
Facility 24 consists of 4 mill circuits each comprising of: a rod mill; a ball mill; dust collectors; DSM (Dutch State Mines) Screens and classifier feed pumps. The normal operation of these circuits is that 3 are active and 1 is offline as a spare. Upwards of 450 tonnes per hour of bauxite is fed through each of the mill circuits. The bauxite is mixed with spent liquor to form slurry which is milled to achieve a size of 1.2mm or smaller. The product of the mills is then fed in to the desilicators of Facility 26 Desilication. (BHP Billiton Pty Ltd.)

2.4.2 Facility 26 Desilication
After being reduced in size the bauxite slurry stream is fed into the desilicat or circuit which comprises of 5 desilicator tanks. The slurry is heated for up to 9 hours in an effort to make the reactive silica convert to desilication product. The reactive silica needs to be converted as it can lead to increased scale build up in the downstream heat exchangers. From the desilicators the product stream is transported to the digester system. (BHP Billiton Pty Ltd.)

2.4.3 Facility 30 Digestion
Before entering the digestion vessels the product stream is transported to the digestion feed tank where it is combined with a certain amount of spent liquor in order to achieve a specified alumina to caustic ratio. From the digestion feed tank the slurry is then passed through a number of heat exchangers and flash vessels to heat the stream from 90°C to 175°C. After slurry passes through the numerous heat exchangers it is fed into the digestion tanks. At this increased temperature and pressure the alumina readily dissolves into the caustic. Nearly all of the alumina is dissolved into the caustic with the remaining solids despatched back through the flash vessels passing on heat to the incoming slurry stream. (BHP Billiton Pty Ltd.)

2.5 Area 2 Outline
2.5.1 Facility 33 Clarification and Caustic
From the digestion tanks the slurry is transferred to the clarification
facility where the alumina rich liquor is separated from the bauxite residue. The bauxite residue (mainly mud and sand) is allowed to settle in the large settler tanks where it is then expelled into the bauxite residue disposal area. The overflow from this tank is the clarified alumina enriched liquor which contains very fine particulate matter left over from the bauxite residue. This solution is subsequently transferred to the polishing filters in Facility 35. (BHP Billiton Pty Ltd.)

2.5.2 Facility 35 Polishing Filters
The fine particulate matter within the alumina enriched liquor stream is removed by cloth filters before it is transported to area 3 for further processing. This ensures minimal impurities are present during precipitation. (BHP Billiton Pty Ltd.)

2.6 Area 3 Outline
2.6.1 Facility 41 Green Liquor Heat Interchange
The green liquor (alumina enriched) from area 2 is cooled by plate heat exchangers from 103°C to 85°C. This heat is transferred to the spent liquor stream which is heated from 60°C to 80°C and recycled to area 1 where it is used to create the slurry mixture. The cooled green liquor stream is then transported to Facility 45 to begin precipitation of alumina hydrate. (BHP Billiton Pty Ltd.)

2.6.2 Facility 45 Precipitation and Heat Interchange
The green liquor passes through 5 agitated tanks combined with clean seed from Facility 46 in an effort to precipitate the alumina out of the saturated green liquor stream. The presence of the clean alumina hydrate seed acts as a nucleation point which draws the alumina out of the green liquor. After most of the alumina has precipitated out of the green liquor solution the alumina hydrate crystals settle to the bottom of the last two agitator tanks and are harvested to obtain alumina hydrate solid green liquor slurry. (BHP Billiton Pty Ltd.)

2.6.3 Facility 46 Seed Separation, Filtration and Hydrate Classification
The main function of Facility 46 is to separate the heavier alumina hydrate crystal particles from the finer particles. Product cyclones are used with the lighter materials expelled out the top and the heavier particles being deposited from the bottom. The fine particle streams are then separated into fine and coarse seed, filtered and washed before being charged back to the precipitators. The heavier particle stream is transported to area 4 to commence calcination. (BHP Billiton Pty Ltd.)
2.7 Area 4 Outline
2.7.1 Facility 50 Filtration
The underflow of the product cyclones of Facility 46 are filtered to remove the liquor from the slurry. A hydrate cake is formed at the top of the first stage filters which is scraped from the top, mixed with wash filtrate and then transported to the second stage filters. The hydrate is washed with clean condensate to remove the remaining caustic soda and other impurities. (BHP Billiton Pty Ltd.)

The washed alumina is transported to a venturi driven drier to commence the first stage of calcination. The hydrate is subject to hot waste gas and is driven towards the electrostatic precipitator (ESP). During travel the chemically bonded water molecules are driven from the hydrate which is heated to approximately 170°C by the waste gas. 80% of the alumina in the gas stream is deposited by gravity into a chute before reaching the ESP. The remaining 20% is captured by a high voltage negatively charged grid of wires. The grids are regularly knocked, dislodging the deposited alumina into chutes below, to be combined with the previously obtained alumina. (BHP Billiton Pty Ltd.)

The alumina is then driven through the second stage where it is subject to 900°C waste gases. Most of the water molecules are driven off during this stage of calcination. The hydrate stream is then fed through a cyclone to separate the hydrate and waste gases with the alumina leaving the cyclone via the cyclone underflow. (BHP Billiton Pty Ltd.)

The underflow stream is fed into the calciner furnace where it is mixed with a natural burning gas mixture and a recirculating stream of fluidised alumina. The fluidised alumina is forced from the top of the furnace by convection and enters a recycle cyclone where the alumina is separated from the hot gases. These hot gases are introduced into a second stage venturi. The underflow of the recycle cyclone contains the fully dehydrated alumina which is conveyed by secondary air to the storage facility. During this transport much of the heat from the dehydrated alumina is transferred to the conveying air which is then used by the furnace for combustion with natural gas. (BHP Billiton Pty Ltd.)

2.7.2 Facility 51 Alumina Storage and Shipping
The alumina enters the storage silo after it has been cooled during transport from Facility 50. The storage silo is capable of holding up to 100,000 tonnes of calcined alumina which equates a live capacity of 85,000 tonnes. Transportation from the storage silo is done by 24 pneumatically driven slides which are spaced throughout the bottom of the silo to enable reclaiming from different sections. When reclaimed the
Alumina is sent to the shipping silo which is used during rail load out. (BHP Billiton Pty Ltd.)

Alumina is dropped into rail wagons beneath the shipping silo through 10 parallel chutes. Upon loading, the 10 chutes are lowered into the hatches of the first two rail wagons. Along with the 5 chutes entering each wagon, a flexible air duct also enters the wagon which vacuums the air out allowing alumina hydrate to enter more evenly and also provides alumina dust collection which is very important given the abrasive nature of calcined alumina. The shipping silo has a 10,000 tonne capacity with approximately 7,500 tonnes of live capacity. There are usually 6 trains loaded each day with 36 wagons attached to each train. The loading sequence is partially controlled by the DCS with input from the control room operator also taking place. (BHP Billiton Pty Ltd.)

2.7.3 Facility 44 Liquor Burner
The main function of the liquor burner is to clean spent liquor of Total Organic Carbons (TOC) and Sulphates. Once these two impurities are removed the remaining sodium aluminate is recycled back to Area 1. (BHP Billiton Pty Ltd.)

2.8 Powerhouse Outline
2.8.1 Powerhouse
The refinery’s steam and primary power source is the powerhouse which is used for most of the unit operations required on site. The powerhouse contains 3 coal fired boilers combining to produce 207 t/hr of 10MPa, 515°C steam. The steam is transported to one of three Mitsubishi Double Extraction, Condensing Turbines and one Siemens Back Pressure Turbine. These turbines are capable of producing 34 mega watts at 11.5 kV. The coal used by the powerhouse is transported from the coal stockpile pit via a transfer conveyor system. (BHP Billiton Pty Ltd.)

2.8.2 Co-Generation Plant
An externally owned Co-Generation Plant exists in close proximity to the Powerhouse. This facility utilises natural gas to produce supplemental steam for the refinery and power for separate customers. (BHP Billiton Pty Ltd.)

2.9 Control Systems Overview
The refinery’s control systems are a complex combination of legacy and new equipment most of which is manufactured by Honeywell. The continuous and intricate nature of the refinery’s process only allows for parts of the control system to be offline for short amounts of time before damage is done to the live process or process equipment (tank product solidification etc.). Special actions and change management procedures must be adhered to when installing new control system components onto
the network. This makes a complete control system overhaul almost impossible.

The refinery has always preferred Honeywell Control Systems as their preferred control system equipment vendor. Much of the Honeywell equipment is catered towards process control orientated applications therefore this is an obvious choice of control system manufacturer for the refinery. Honeywell control equipment is recognised by industry as one of the most advance Distributed Control Systems in the world. Worsley Alumina has an excellent relationship with Honeywell International including development work which will later be described in the C300 SCOM Monitoring Project section.

As Honeywell DCS upgrades have been rolled out to the refinery throughout the last 30 years, parts of existing Honeywell control infrastructure have been left behind. This has allowed for the connection between the refinery’s different control system components to be accomplished relatively easy and the combination of different communication interfaces achievable.

The refinery was first commissioned with TDC2000 (Honeywell International Inc. TDC2000) which was the current Honeywell Control System at the time of implementation and was one of the first Distributed Control Systems available to industry. The TDC2000 system comprises of 2 main nodes, which are a Basic Controller and a Process Interface Unit. These nodes could be loaded with process control algorithms which could execute based on the analog inputs read by I/O cards present on the controller. The nodes communicated between each other via a Data Hiway connection (Honeywell International Inc. Data Hiway) which had a maximum transfer rate of 256kb/s. This was considered fast at the time of implementation. The TDC2000 was upgraded to TDC3000 (Honeywell International Inc. TD3000) which included the addition of the Local Control Network (LCN) (Honeywell International Inc. Local Control Network) which coexisted with the Data Hiway network. The LCN uses two coaxial cables for communication, one primary and one secondary. This allows for redundancy to be achieved and eliminates a single point of failure within the network similar to Fault Tolerant Ethernet.

The first major upgrade to the refinery’s control systems was from TDC3000 (the follow up to TDC2000) to the Total Plant Solution (TPS) which was Honeywell’s current offering at the time. One of the major additions during the upgrade was the Process Control Network. The Process Control Network is built on an Ethernet connection which allows for a much more diverse range of products to be incorporated and higher transfer rates to be achieved (100Mb/s). New High Performance Manager
(HPM) and Advance Performance Manager (APM) Controllers were introduced taking the place of some of the older Basic Controllers and Process Interface Units. The Plant Historian Database (PHD) was also implemented as the new Historian server with the TPS upgrade.

The most recent upgrade to the Refinery’s control system was from TPS to Experion Process Knowledge System (EPKS). This upgrade includes the installation of a number of Fault Tolerant Ethernet Networks (Honeywell International Inc. Fault Tolerant Ethernet) throughout the refinery. This upgrade also involves a number of new controllers to replace various legacy controllers still present. Many of the more advance control strategies have been implemented on Advance Control Environment (ACE) Nodes.

The new controllers being implemented are Honeywell’s C300 controller (Honeywell International Inc. C300 Controller) which executes the CEE. The C300 Controller is considered to be one of the most advanced industrial controllers on the market.

Numerous Schneider Quantum PLCs (Schneider Electric. Quantum Programmable Logic Controller) also exist throughout the refinery, many of which are being migrated to C300s as a part of the E&G Upgrade.

2.10 Tools and Applications Review
A number of different tools and applications were used during the course of the internship. A summary of the main applications used during engineering project work will be given. This will allow a better understanding of work described in following sections of the reports to be developed. Most of the applications listed are used by Process Control Engineers on a daily basis at the refinery.

2.10.1 Configuration Studio
This program is used to perform most configuration tasks with regards to EPKS DCS components. Many configuration tasks can be executed from the Configuration Studio interface including user access permission configuration, trend configuration, history archiving and various other EPKS settings. Other EPKS applications such as Control Builder and HMIWeb Display Builder are launched from Configuration Studio

2.10.2 Control Builder
Control Builder is a Honeywell application used on a daily basis by Process Control Engineers to configure and monitor process control strategies. Control Builder gives a graphical representation of the Control Execution Environment (CEE) housed in various Honeywell controllers including C200s, C300s and ACEs. This software allows control modules
to be developed using a graphical function block, drag and drop style approach. Configuration and monitoring of both online and offline controllers can be performed from control builder, which is extremely useful for debugging purposes. This feature was used extensively during the parameter interrogation for the SCOM C300 Controller Project. Control Builder was used for most project work especially when creation or configuration of control modules took place.

2.10.3 HMIWeb Display Builder

HMIWeb Display Builder is used to construct Human Machine Interface (HMI) graphics for process interaction by control room operators and for testing conducted by Process Control Engineers. The Worsley Alumina Refinery has adopted the Abnormal Situation Management (ASM) (Abnormal Situation Management Consortium) which is a Human Factors Engineering standard that dictates how the environment within the Central Control Room is configured. Part of the ASM approach is to have a defined set of process shapes and graphics to be used on operators HMIs. This includes a grey on grey colour system which only results in colour when an abnormal situation arises. The graphics created by this program are coded in Hypertext Mark-up Language (HTML) which is hidden from the user. The shapes can be configured to execute custom script to alter functionality of shapes during run time; this script engine uses the Visual Basic Syntax. The graphics created within HMIWeb Display Builder are accessed by Experion station clients on console stations within the Central Control Room.

2.10.4 Quick Builder

Quick Builder is a configuration utility used for point building within Experion’s SCADA system. A point is Experion’s way of holding variable information throughout system components. A point can be a Boolean, numeric, text or a custom defined parameter. Many Programmable Logic Controller (PLC) variables are ported through to the Experion DCS all of which need to have a point built in quick builder. Each PLC variable read by the DCS references a memory location within the PLC. These points, once configured can then be used inside control modules within Control Builder for signals such as digital I/O interfaced by the PLC. Points can also exist for Experion components including C300 Points. Trending, alarming and state descriptors can all be configured within in Quick Builder. Script can also be performed for specific points which can include execution of advanced calculations.

2.10.5 Station (Experion)

Experion Station is Honeywell’s HMI Display software used by operators to interface with the process. Station provides customisable alarm summaries of specific areas, trending of selected variables and most
importantly, control of the process via process graphics. As alluded to previously, graphics displayed on station are configured within HMIWeb Display Builder by Process Control Engineers.

2.10.6 Station (PlantScape)
An older version of station exists on all of the workstation PCs on site. This version interfaces with the PlantScape (Experion R201 SCADA) server which is a view-only system configured by the Process Control Group. This allows employees other than operators to view live process information and configure trends as they see fit. From PlantScape, historical data can be copied and used in report making, which is common practice for many Senior Managers, Production Engineers and Process Engineers.

2.10.7 Microsoft Terminal Services Client (Remote Desktop)
Microsoft’s Terminal Services Client (MSTSC) is used to remotely access Windows machines over the Process Control Network. This program is used extensively during most engineering tasks performed on engineering consoles and control system servers. The main benefit of using this application is that access to a targeted machine can be accomplished via the engineer’s workstation computer located at their desk. Some virtual machines that exist on control system do not have peripherals such as monitors, keyboards and mice plugged in therefore MSTSC is the only way to access such machines. A Terminal Services Server exists on the Process Control Network which acts as a gateway between the site’s corporate network and the Process Control Network. This server can also be used to remotely login from home if tasked with weekend duty. Stringent security present on the Terminal Services Server prevents unauthorised access to the Process Control Network through this interface.

2.10.8 VMware VSphere Client
VMware VSphere client is an application which allows configuration of Virtual Machine Servers remotely over Ethernet. VSphere can also be used to remotely access a virtual machine’s desktop in similar fashion to MSTSC. The VSphere remote access can be used without Windows services being loaded compared to MSTSC which requires background services to be running in order to function. This feature allows operating system installations to be completed remotely. A noteworthy feature of this software is physical drive emulation over a network interface which will be discussed in more detail during the ACM Trial Server Project description.
3 Intern Projects

As mentioned in previous sections of this report, during the entirety of the internship many projects were assigned to the intern. These projects were not only substantial in size but were also diverse in terms of learning outcomes. This provided an excellent opportunity to apply theoretical knowledge developed at university to practical engineering scenarios at the refinery. The next section of this report will cover in detail the various projects including a background of each project, required research, methodology used during work carried out and concluding remarks including any lessons learnt during the project work.

3.1 ACM Trial Server

3.1.1 Background

As a part of the continual improvement of the refinery’s Process Control System it had been proposed that a software package from Honeywell known as Alarm Configuration Manager be trialled and assessed on a virtual machine. ACM is used to compare the alarm settings to the settings on the live control system. This ensures that mismatches between control system components do not exist. ACM can be made to run an alarm comparison manually or can be scheduled to run at specified intervals. The results from this can be recorded and viewed or can be made to enforce the change of inconsistent alarms to match the MAD (Master Alarm Database). This functionality is performed by the Enforcer Server which can be hosted on the ACM Server. The intern was tasked with implementing an ACM Trial Server in order to comprehend the feasibility of implementing such software to the Process Control Network. This included installation, configuration and documentation of the ACM software. Upon completion, recommendations could be made to decide whether the ACM software could be used as an alarm analysis tool on the Process Control Network at Worsley.

3.1.2 Required Research

Alarm Configuration Manager is a Honeywell Process Solutions software package that can be configured to monitor alarm parameters across multiple control systems components. It can then compare these parameters in order to generate notifications for mismatches. It can communicate with an Enforcer Server (also part of the ACM package) to make alarm changes to match a specified system component.

VMWare ESXi (VMWare Esxi) is an operating system used to host virtual machine guests. It allows the resources of a physical machine to be divided up between a number of virtual machines in order to save on hardware costs and physical space constraints. This approach has been adopted by the Worsley Alumina Refinery with many of their control
system servers existing as guests hosted on VMWare ESXi Server Installations. Figure 5 - VMware Architecture Visual Representation shows a Visual Representation of the VMware architecture used on site.

Figure 5 - VMware Architecture Visual Representation

3.1.3 Method
In commencing the project a conversation with Process Control Consultant, Rob Duggan took place to discuss an overview of the ACM software and current status of the installation. During this discussion, physical media was supplied which contained the ACM Software Package, along with the EPKS Supplemental Software required to complete the installation. Also on the installation media is documentation including an installation guide, user guide and software guide for the ACM software which were studied prior to installation tasks.

The ACM trial server has been created on a virtual machine which is hosted as a guest on a VMware ESXi 4.1 installation. This machine is housed in a virtual environment which provides the ability to snap shot the current machine settings. This allows for system roll backs which aids in problematic software installations. This assists with installations that are extremely fragile in terms of configuration and helps immensely when a rebuild of the machine is required. The time consuming installation and configuration of a Windows Server Operating Systems can be avoided with the use of regular system snap shots.

The first stage of the project was to complete installation of ACM which had been partially installed on the virtual machine. A difficulty faced during this stage of the project was the requirement of physical installation media being read from an optical drive (DVD-ROM Drive) of the server. This is challenging as the Windows 2003 installation present on the virtual machine does not have a physical optical disk drive installed, relying on network communications for file transfer and
installation of software. The primary style of interface to the server is using MSTSC which does not support optical disk emulation over an Ethernet Interface. A solution to this issue is to use VMware’s VSphere Client software (VMWare VSphere) which allows an interface with the VMware ESXi Server from a remote desktop connected to the same network. Although VSphere can be used to remotely manage and configure the ESXi Server it can also be used to provide a gateway into guest machines in a very similar fashion to MSTSC. A major difference between the VSphere and MSTSC is the ability to emulate physical drives and communications ports over the Ethernet Connection. VSphere has functionality which allows the local PC’s optical drive to emulate the optical disk drive on the virtual machine over an Ethernet connection to the ESXi Host Server. This functionality allows the use of installation media remotely and hence finalization of the incomplete installation of the ACM Server software was completed.

VSphere Administration access to the machine in question had to be configured by a System Administrator which can be accessed through the management interface on the VSphere Client software. This had to be done using a user login which has administrative privileges across all guest machines and on the ESXi Server system.

Installation tasks carried out on the ACM Trial Server Include installation and configuration of an SQL (Structured Query Language) server on the ACM machine; this is used to host the Master Boundary Database and other system critical information. Care is required when configuring SQL Databases on server installations especially with multiple user accounts requiring permission to access specific databases. This problem was encountered multiple times with user accounts automatically created during Honeywell installations being denied access to databases required by the ACM Server. Specific user permissions can be configured using the Microsoft SQL Server Management Studio Program which provides an efficient way to configure aspects of the databases being held on a specified machine. Configuration of databases must be executed from a Windows User Account with sufficient privileges to the database being configured. The permissions can be managed by a global administrator.

Other tasks performed on the ACM Trial Server include configuration of DCOM (Distributed Component Object Model) account security on the Windows 2003 Server and configuration of local user accounts used by the ACM software services and their associated permissions. This required a particular procedure from the installation guide to be carried out. The DCOM account settings allow a specific process to be executed automatically by users with sufficient permissions. This allows the Honeywell Server Services to be started automatically after the machine has booted. These services are activated by the Honeywell Administrator.
account automatically created during ACM installation. This account is used for starting all the required Honeywell services for the server.

A required step for the ACM installations was to install the Experion Application Framework (EAF) to allow communication to Experion Servers contained within the refinery. This permits the ACM to view the Enterprise Model which holds information about the assets configured for EPKS. This allows ACM to generate tags for a given asset and eventually be made to monitor these tags through the OPC gateway on Experion servers. At this stage of the project a problem was encountered with the installation of EAF. Experion Servers require a suffix after their machine name which is a reference to their redundancy role. A “-A” had to be appended to the computers name to allow the installation of EAF to proceed. Initially it was thought that the only adverse effect this would have on the machine was with the references to the machine’s name in the SQL ACM database. To combat this, the necessary changes were made to the SQL database with help from Systems Engineer, Andrew Curtis. The SQL server logins were also made to comply with the name change of the machine. A problem however with the ACM software services arose which references the computers name in the ACM service start-ups. This caused an error in the ACM software when trying to configure ACM using the ACM Administration Client. After trying numerous fixes the only work around was to complete a rebuild of the server, including a fresh install of Windows 2003 Server Enterprise Edition and the ACM Software. This was done in a similar fashion to the ACM installation using VSphere to virtualise the Windows Installation Disc but instead, mounting an .iso disk image from a network file share store rather than using physical installation media on a local desktop.

During installation of Windows Server 2003 network settings had to be configured. This included domain configuration that allows access to the domain controller and therefore permits login through APAC accounts to the Process Control Network. After this was complete the ACM installation procedure was repeated with the new machine name which allowed the EAF installation to proceed. Upon completion of this another problem arose with the EAF installation. Configuration of EAF is done through Honeywell’s Configuration Studio however this requires an Experion “mngr” account login to configure user access for the first time. This “mngr” account is also used to communicate to other Experion Servers and therefore has to be consistent throughout the Experion Server architecture. The “mngr” password on the ACM machine was not known and therefore user access could not be granted onto the ACM Experion Server through Configuration Studio. This meant that the ACM Experion Server could not be configured. With help from Honeywell personnel this problem was overcome by using a password change tool (PWDUTIL.EXE) provided with the EPKS package. With security access to Experion
Server, user access was configured for the ACM Server and also added to the Enterprise Model Database (EMDB) to enable the importation of the Enterprise Model from the Enterprise Model Server.

3.1.4 Current Status
The ACM Trial Server is currently unable to connect to a specified Experion Server due to an error encountered referencing a communication error with an ActiveX component. Contact with Honeywell Support is currently taking place which will ideally result in a rectification of this error and completion of the project.

3.1.5 Lessons Learnt & Conclusion
It was made apparent throughout the progression of the ACM Trial Server Project that communication to multiple technical personnel is an effective way of acquiring information on particular queries in respect to project work. During the project contact was made with upwards of four technical staff each with their own specific knowledge of system management, configuration and installation of software. This was found to be an effective way to source solutions and to gain knowledge relating to issues that arose during this project.

Similar experiences encountered with installation of Labview components in the Instrumentation and Control System laboratory made some of the configuration tasks easier to perform during the project. A vast quantity of learning outcomes were achieved as a result of the ACM Trial Server Project including experiences with Virtual Machine Environments, Windows Server configuration and SQL Database management.

3.2 Development Network Test System

3.2.1 Background
A test process control environment was developed at the Worsley Alumina refinery to simulate, as close as possible, the actual process control system. The main reason for the development network is to allow Engineers to test changes on the process control system without implementing the change to actual online systems, which is the current common practice. With a fully functioning test system, engineers can test system and application changes without jeopardising the refinery’s process control system. The development network needed to be configured to include two new fiber optic switches, that would act as head switches for the development network. This will allow the development system to be configured with a true Fault Tolerant Ethernet (Honeywell International Inc. Fault Tolerant Ethernet) to ensure that the test systems and process control systems are as close as possible to allow an accurate test environment to be utilised. The new head switches needed configuration along with a number of system components to ensure all could communicate on the development network. Various
other tasks were performed on the development network including support tasks for Process Control Engineers with various problems using the development system.

### 3.2.2 Required Research

**SFP (Small Form-factor Pluggable Transceiver)**

An SFP is a transceiver used for industrial communications between network switches. SFPs are inserted into empty slots on industrial switches which result in a physical connection to the switches motherboard. These SFPs can then be used as a communication port to interface other switches and computers similar to a normal network switch. SFPs are available for copper Ethernet and fiber channel, this allows many options in terms of switch port configuration to be utilised which is one of their main benefits.

### 3.2.3 Method

To start the project a thorough review of the current system configuration had to be completed. This included observing what physical and virtual machines were present on the network and tracing any network cables from switches to ensure they are connected to the correct port. This was made easier by network architecture diagrams and switch connection diagrams created for the development network. Current versions of these diagrams edited by the intern can be observed in Appendix C and Appendix D.

One of the initial tasks completed on the development network was to fix the simulated C300 controllers hosted on the system. The controllers in question are emulated on a dedicated simulation server housed on a Windows 2003 Server implementation. The controllers had lost communication with the Experion server, rendering the development network unusable and the execution of the CEE impossible. After reviewing the settings on the C300 simulation machine it was found that the simulation host computer was configured with the wrong IP addresses for both the controllers and the host computer. After a remote desktop connection was made with the host server the machine IP address was changed along with the C300 IP addresses. A restart of the host machine was also completed to ensure that memory leaks were not effecting the performance of the server. Changing the server’s and C300’s IP address along with a restart of server solved the communication issues allowing for control of the simulated C300s to be accomplished.

Upon establishing communications to the Simulated C300 server a new controller was built to test the functionality of the simulated environment. This new simulated C300 was also used for control module
development for other projects, this did not affect other controllers utilised by other Process Control Engineers on the development network.

An update of the network and switch configuration diagrams to represent the current system was completed to convey accurate information to systems personnel during discussions relating to the development network. A meeting took place with systems personnel to discuss the next steps in completing the network. A discussion detailing the configuration exercise for the two new head switches made it apparent that the currently unused head switches would be configured and a fiber channel link would be established between the two equipment rooms where the head switches are located. A member of the IT department participated in the meetings and described how the existing connection to the APAC (Asia Pacific) network would cease to exist and be replaced by a connection into the Process Control Network through the Juniper Core Network Switches. This would allow access to the development system through the Process Control Network’s Terminal Services server which is the same practice used by Process Control Engineers accessing Engineering Consoles on the actual Process Control Network. This would create a more accurate representation of the current Process Control Network and is likely to lead to more use of development system for application programming. Connection to the development network is currently routed through the Information Management (IM) domain and hence is on the “dirty” side of the network as opposed to the “clean” Process Control Side.

Configuration of the head switches was performed using a serial link from a Laptop PC to the physical port on the switch. This allowed the Cisco iOS (Operating System on the Switch) to be remotely managed. From the iOS, settings for each physical port could be configured including machines names, allowable traffic, communication interface expected on each specific port and general security settings including switch administration passwords. This was completed on each switch.

The following step was to plug in and configure SFPs and to connect fiber cables which were already pulled through to the required cabinets. When trying to complete these connections it was discovered that the wrong cable type had been pulled between the cabinets. The new head switches make use of a new LC type connection for the fiber cable whereas the Fiber Optic Breakout Terminal uses the older style SC Type Connection. The cable that was installed between the required cabinets were SC to SC type cables which meant connections could not be made between switches. Upon learning this, the network switch diagrams were updated to include cable type and cable length required to make the connection. This was then used to create a list of cables required which was sent to a vendor for quotation and ordering.
3.2.4 Current Status
The project is currently on hold as the new cables are required to complete the fibre connections between switches. A plan is being developed to carefully migrate the network to incorporate the new switches that will lead to minimum downtime of the network. This will ensure it can still be used during the upgrade and that a roll back contingencies are in place to guarantee that the network can be reconfigured to the old setting upon any errors that prevent the upgrade moving forward.

3.2.5 Lessons Learnt & Conclusion
Documentation is a necessity when configuring networks that contain multiple components such as switches and servers. At times during the project confusion existed regarding connections between actual physical ports and links detailed on network diagrams. From this project it is apparent that up to date documentation can make configuration and connections work a lot easier, as opposed to laboriously checking physical connection and tracing communications over networks. As the project carried on, more emphasis was placed on keeping relevant documentation up to date and adding more information to these documents in order to make configuration tasks easier to accomplish. This lesson can be carried to other projects as well with change management and thorough documentation playing a big role in most of the project work carried out during the internship.

During this project the intern was exposed to switch configuration, network management and infrastructure and support tasks all of which were valuable experiences. The network architecture studied at University proved to be vital knowledge when initially understanding the architecture of the development network. The complexity of network switches was underestimated when initially understanding the project as experiences previously had only been with non-configurable Ethernet switches and not with fiber channel switches that run their own operating system.

3.3 SCOM C300 Monitoring

3.3.1 Background
The Worsley Alumina Process Control Department have implemented Systems Centre Operations Manager (SCOM) software to monitor their Process Control Servers. SCOM is used to monitor critical parameters that can jeopardise the refinery’s control system, more specifically server malfunctions. This allows technical staff responsible for the servers to receive SMS and email notifications when systems are threatened while personnel are present or away from the refinery (after hours). Currently the Process Control Network has no way of automatically observing
status of controllers and their Peer Control Data Interface (PCDI) Links. The current way of observing the status of controllers and their associated PCDI links is to manually check them when performing a change or maintenance on that specific controller using Experion’s Control Builder.

The intern was tasked with finding a solution that will involve acquiring data in SCOM from the controllers and PCDI Links in order to generate notifications from SCOM in the event of a threatening situation. This would alert the required engineer rather than waiting for an operator to raise awareness of the malfunctioning controller.

3.3.2 Required Research

SCOM

Systems Centre Operation Manager is the monitoring software utilised by the refinery to keep track of the health of process control system components. SCOM is a Microsoft product which can be installed on a Windows server operating system. Monitoring clients are installed on the machines which require monitoring, the client scans up to date system information and relays this back to a central SCOM server periodically. The SCOM server can then raise notifications based on conditions configured by systems personnel on the SCOM server; this can be executed in a number of ways including SMS and Email notifications. Companies that wish to support SCOM often provide management packs which, once installed on the SCOM server, give extra functionality to monitor their products. Custom script can also be utilised to monitor non-standard components. The script used for this is written in Visual Basic.

3.3.3 Method

The first step taken was to research the SCOM software in order to gain an understanding required to define the scope and required tasks. This was done by holding discussions with Systems Engineer, Andrew Curtis and Process Control Engineer, Ben Marler. Shortly after these discussions, Andrew Curtis hosted a presentation where he gave an insightful overview of SCOM including capabilities of the software.

It was clear from the discussions about the project that one of the first tasks that would need to be completed was to produce an initial list of parameters that would need to be monitored. This included filtering all non-essential system parameters leaving a list of the most critical monitoring parameters that will eventually be monitored by the SCOM software. This was completed by using the monitoring functionality of Control Builder to build a list of parameters available in the online monitoring tab of the asset tree. After discussions with colleagues many of the parameters could be disregarded as they were seen as insignificant and not system critical. The OPC (OLE for Process Control) tags
generated by each C300 asset were also interrogated in order to find any hidden parameters not available from the monitoring tab. This list was extensive and much research had to be done in order to find the function of each tag.

After completion of the refined list, a copy was sent to stake holders for approval. This list was then relayed to Honeywell development personnel for their input and possible advice in achieving the desired outcome. The Final SCOM Parameter List can be found in Table 2 - SCOM Parameter List

Table 2 - SCOM Parameter List

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Variable Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>State Information</td>
<td></td>
</tr>
<tr>
<td>Controller Status</td>
<td>C300STATE</td>
</tr>
<tr>
<td>Redundancy Roll</td>
<td>RDNROLESTATE</td>
</tr>
<tr>
<td>Synchronization State</td>
<td>RDNSYNCSSTATE</td>
</tr>
<tr>
<td>Battery State</td>
<td>BATTERYNOTOK</td>
</tr>
<tr>
<td>Soft Failures Present</td>
<td>SOFTFAIL</td>
</tr>
<tr>
<td>CPU Statistics</td>
<td></td>
</tr>
<tr>
<td>CPU Free (%)</td>
<td>CPUFREEEAVG</td>
</tr>
<tr>
<td>Minimum CPU Free (%)</td>
<td>CPUFREEMIN</td>
</tr>
<tr>
<td>Time Since Power up</td>
<td>UPTIME</td>
</tr>
<tr>
<td>Hardware Temperature</td>
<td></td>
</tr>
<tr>
<td>Current Temperature (degC)</td>
<td>CTEMP</td>
</tr>
<tr>
<td>Peak FTE Traffic</td>
<td></td>
</tr>
<tr>
<td>LAN_A (Yellow) Failed</td>
<td>LANAFailed</td>
</tr>
<tr>
<td>LAN_B (Green) Failed</td>
<td>LANBFailed</td>
</tr>
<tr>
<td>InterLAN Comm Failed</td>
<td>INTERLANFailed</td>
</tr>
<tr>
<td>Crossover Cable Failed</td>
<td>XOVERFAILED</td>
</tr>
<tr>
<td>Soft Failure</td>
<td></td>
</tr>
<tr>
<td>Battery State Warning</td>
<td>BATTERYNOTOKSFTAB</td>
</tr>
<tr>
<td>Device Index Switches Changed</td>
<td>BCDSWSTS</td>
</tr>
<tr>
<td>Factory Data Error</td>
<td>FACTDATAERR</td>
</tr>
<tr>
<td>ROM Application Image Checksum Failure</td>
<td>ROMAPPIMGCHKSFAIL</td>
</tr>
<tr>
<td>ROM Boot Image Checksum Failure</td>
<td>ROMBOOTIMGCHKSFAIL</td>
</tr>
<tr>
<td>WDT Hardware Failure</td>
<td>WDTHWFAIL</td>
</tr>
<tr>
<td>WDT Refresh Warning</td>
<td>WDTSWFAIL</td>
</tr>
<tr>
<td>Critical Task Watchdog Warning</td>
<td>TASKHLTHMON</td>
</tr>
<tr>
<td>Uncorrectable Internal RAM Sweep Error</td>
<td>RAMSWEPPER</td>
</tr>
<tr>
<td>Correctable Internal RAM Sweep Error</td>
<td>RAMSCHRUBBERS</td>
</tr>
<tr>
<td>Uncorrectable User RAM Sweep Error</td>
<td>BACKUPRAMSWEEPER</td>
</tr>
<tr>
<td>Corrected User RAM Sweep</td>
<td>BACKUPRAMSCHRUBERRS</td>
</tr>
</tbody>
</table>
During the Honeywell User Group Demo a contact was made by Andrew Curtis with a member of the Honeywell Development team who seemed eager to provide assistance with the possible implementations of C300 monitoring through SCOM. Emails were exchanged which resulted in a teleconference being scheduled. The teleconference consisted of members from the Honeywell Development team and Worsley Alumina’s Honeywell Account Manager along with Process Control Group members from the refinery. All parties seemed eager to engineer a solution with Worsley members communicating to Honeywell Developers the capabilities of SCOM and the desired outcome of the project. Andrew described to the Honeywell developers that a management pack could be developed which would enable Honeywell’s customers to install an add-on to their SCOM installation which would allow C300 Monitoring. All parties agreed that a project with input from both parties would be the best approach to move forward. The only problem was an intellectual property issue from Honeywell’s side. Worsley Staff assured Honeywell that any code developed would be Honeywell’s intellectual property and that Worsley Alumina was only interested in the solution and not developing a marketable product.

The customised SCOM script is written in Visual Basic to monitor non-standard components within industrial networks. The process control group have developed numerous custom scripts to monitor various servers throughout the Process Control Network. With an example of Visual Basic code used to poll C300 controllers various other specified parameter communications will be developed.

3.3.4 Current Status

The project team currently have another teleconference to communicate to Honeywell Engineers their progress. This has been scheduled in the near future. An email was also received verifying that the Honeywell legal department have agreed to sharing code with the Worsley Refinery enabling the project to move forward during the scheduled teleconference.
3.3.5 Lessons Learnt & Conclusion
The SCOM monitoring project has given an insight into the development environment within a large corporation. Experience with communication of project details across different companies has been a beneficial learning exercise. Intellectual property is an issue that development companies take very seriously which is understandable given the competition between vendors to engineer practical solutions for their customers. From the communications received, it is apparent that the Worsley Alumina Refinery has no interest in the marketing or sale of a C300 SCOM solution but instead are interested in optimising the monitoring of control hardware on site only.

3.4 Facility 24B Bauxite Bin E&G Commissioning

3.4.1 Background
The E&G Expansion construction is being finalised in many areas of the refinery. Commissioning of newly installed controllers along with new code is required before handover to the refinery to ensure the process control equipment is working correctly. Commissioning exercises during the internship included the bauxite shuttles (Facility 24B). The bauxite shuttles are used to feed 3 bins which provide 4 mill circuits with bauxite. The E&G expansion will see a fourth bin be commissioned to feed a 5th mill circuit. This upgrade also included migration of the current PLC control to C300 control. During the stages of commissioning, code will be migrated from Ladder Logic housed in Quantum PLCs to Control Code housed in the new C300s. A number of stages have been defined for the commissioning, the first of which started on the 22nd of September 2011 and saw partial migration of shuttle travel drive and shuttle conveyor code. Factory Acceptance Testing had to be carried out for all code before loading onto controllers on site. This includes testing all functionality of the code to ensure that no errors exist during commissioning before handover.

3.4.2 Required Research
Bauxite Bin System
The bauxite bin system contains 3 bins which feed the 4 downstream mill circuits. Two rail systems exist above the bins which deposit crude bauxite reclaimed from the stockpile yard into the bins via a sequence of conveyors. Depending on the bin levels, the two shuttle systems can feed any of the three bins. Proximity switches relay back to the control system the position of the shuttle allowing for the control of the shuttle position. The shuttle system can be run manually by operators or can be run automatically. Automatic mode allows the control system to perform a calculation which determines which bin should have top priority for bauxite feed. This calculation takes into account, bin levels, milling rates
and various other parameters. Upon assigning priorities the control system moves the shuttle to feed the top priority bin.

Figure 6 - Pre E&G Bauxite Shuttles (Bin 1), Figure 7 - Pre E&G Bauxite Shuttles (Bin 2) and Figure 8 - Pre E&G Bauxite Shuttles (Bin 3) show the three possible positions of the shuttle system prior to the E&G upgrade.
After the E&G upgrade is complete a fourth bin will be used to feed a fifth mill circuit. An extra shuttle conveyor will exist on each rail system to provide feed to the fourth bin. This shuttle conveyor will make use of a locking pin which will engage when the shuttles are in the correct position. Upon engaging the lock pin, the shuttles will move as one to a location where they can provide bauxite to bin 5. Figure 9 - Post E&G Bauxite Shuttles (Bin 3), Figure 10 - Post E&G Bauxite Shuttles Transition and Figure 11 - Post E&G Bauxite Shuttles (Bin 5) show the 3 steps to change bauxite feed from bin 3 to bin 5.
The ABB MNS iS Drive Controller is a piece of hardware used to interface a VSD to a control system. The MNS iS provides various benefits over interfacing VSDs directly to the control system. These include more detailed alarming of fault conditions, open loop thermal modelling of motors, a standardised approach to controlling drives from the control system and minimal downtime due to the loading of configuration through a HMI interface. The MNS iS can also be configured to house its own logic localized within the actual device. All of these features result in a less complex way to interface drives which lead to decreased engineering costs. Part of the E&G upgrade has been to implement MNS iS switch gear into the new Electrical Distribution Centres (EDC) across site for drive control.
3.4.3 Method

To initially understand the bauxite shuttle system along with the changes being made to it, both the facility functional description (FFD) and the control system functional description (CSFD) were studied meticulously. The FFD provided a general overview of the bauxite shuttle process and the process changes that were being made as a part of the E&G upgrade. The CSFD went into more detail about the control system and the expected functionality of control system during and after the completion of the upgrade. These documents were created by Bechtel Corporation, who is an Engineering, Procurement, Construction and Management (EPCM) Company. Bechtel were tasked with completing the E&G Upgrade by the Worsley Alumina Refinery.

Shortly after reading these documents Factory Acceptance Testing of stages 3 and 4 of the bauxite shuttle upgrade was completed at the Honeywell Facility in Burswood. These stages were mainly concerned with code migration to C300 therefore the newly developed control modules were the main focus of the FAT. The tests involved completing the FAT procedure, developed by the responsible Honeywell Programmer that they had developed from the CSFD. All interlocks, alarms and logic were tested during the FAT procedure plus any additional tests that were not covered in the FAT document.

One particular case that arose in the FAT was the loop speed at which the control modules were running. The control modules had been set to run at 500ms loop times as opposed to the site standard 1000ms loop time. This discrepancy was noted as a potential threat to the functionality of the code (specifically timing critical operations for shuttle movements and under speed checking) and therefore prior tests were redone using the site standard loop speed. Some timing functions had to be altered as a result of the loop speed change. Another issue encountered during the FAT procedure was a bug found in the code that resulted in the shuttle moving in the wrong direction if a sequence start was initiated while holding in a local directional hand switch. This could potentially result in a trip of the bauxite shuttle system from an activated over travel limit switch which is activated when the shuttle reaches its limits on the shuttle rails. This bug was not picked up in a specific test but was found when testing additional functionality of the code. Picking up bugs such as these during the FAT procedure ensures minimal problems are encountered during commissioning and ensures that the systems safety is not compromised as a result of unproven code.

Before commissioning, a specialised test was conducted to ensure that the travel drive responsible for powering the motor that moves the shuttles was going to stop in time after receiving a stop signal from the control system. This was a critical investigation to ensure that the shuttle
would not over shoot the specified bin when a bin change command was initiated. For the check a test drive and motor were setup and connected to the DCS to mimic the movements of the current travel drive. Because the new travel drive was going to receive signals from the C300 a large delay may have existed between the proximity switch activations read by the PLC and the travel drive stop controlled by a C300. This was largely due to the MNSIS Drive Controller adding an extra communication pathway between the proximity switch and a drive stop. The comparisons of the communication can be seen in Figure 12 - Pre E&G Travel Drive Communication Architecture and Figure 13 - Post E&G Travel Drive Communication Architecture.

**Figure 12 - Pre E&G Travel Drive Communication Architecture**

**Figure 13 - Post E&G Travel Drive Communication Architecture**
The test was conducted with a spotter to relay back information of the various movements to engineers on an Experion Console. A stop time could be measured between the DCS and the actual drive stop allowing the team to verify that the delay was no greater than 2 seconds which was considered the limit for the drive to stop over the bin. 2 seconds was found to be conservative during commissioning as the shuttle over shot the bin in some cases. Extended striker plates to activate the proximity switches earlier had to be constructed to combat this.

An initial problem found during the commissioning test was the communication interface where the ABB drive controller was skipping commands sent by the C300. It was concluded that the drive controller was receiving too many commands in a short period of time and therefore could not process them all. The solution to this was to send null commands in between each command being sent from the C300 which allowed more time for the drive controller to process previously received commands. This fix solved the drive communication problem but does increase the delay between the C300 sending movement commands and the drive controller executing these commands. Because the delay for the drive to start is not a priority and the stop command to actually stop the drive has precedence over all other commands no additional delay exists between the shuttle movement stop signal and the shuttle physically stopping.

Upon completing commissioning, a problem that caused the Drive Controller to intermittently fault after receiving a start command was added as punch list item to be completed promptly after handover. It was thought by Commissioning Engineers that the C300 could be sending a stop command shortly after sending a start command to the drive controller. Commissioning Engineers insisted that the control system be thoroughly checked to prove the C300 was not sending a stop command. A viable solution to testing this was to use a Modbus scanner which allows the logging of communications to specific registers on the Modbus Link to be logged. The Modbus scanner was configured to log the register of the MNS iS that the C300 writes commands to. After logging numerous start commands it was verified that the C300 was not sending a stop command. Upon relaying this information to the commissioning team it was found that a loose neutral wire existed between the connections from the VSD to the travel drive which would trip the drive controller out upon start up. Upon rectifying this problem the stop issue has not been encountered again. Figure 14 - Modbus Scanner Installation provides a representation of where the connection was made when monitoring the Modbus link using the Modbus Scanner.
During the project numerous meetings relating to the commissioning have been attended. Topics covered in the meetings include procedure, hand over reporting, schedules and shutdowns.

3.4.4 Current Status
The first stage of the commissioning has been completed with all punch listed items (items found to be non-critical and rectified outside of the commissioning schedule) also completed. The second stage will commence shortly which is identical to the first stage only on the opposing shuttle system.

3.4.5 Lessons Learnt & Conclusion
The commissioning exercises completed during the internship were a very rare opportunity to gain a vast range of hands-on engineering exposure. Many of the problems encountered during the commissioning required on-the-fly engineering solutions to be developed and documented within a short period of time. Although pressure is placed on engineers to commission as quickly as possible this pressure should not compromise the tests to be completed as a part of commissioning. Safety of the system is top priority which was made very apparent by Engineers during the commissioning work.

3.5 Valve Stroking Control Module
3.5.1 Background
Control valves that are inactive for an extended period of time can suffer from particulate matter build-up on their internal parts. This is known as valve scale. Valve scale can lead to decreased performance and premature valve failure. By exercising the valve away from its normal
operating level, scale build up can be minimised which result in reduced maintenance cost. This is known as valve stroking.

Code had previously been developed by the Worsley Process Control Team to periodically stroke control valves with the intention of preventing scale build-up. This program was executed on HPM controllers within an Application Module. Previous attempts to use this code with CEE referenced points were unsuccessful. The intern was tasked with engineering a viable solution for valve stroking within the CEE. The control module developed includes configurable parameters to allow the characteristics of the stroke to be manipulated. This will allow a common module template to stroke many valves with only the configurable parameters differing from valve to valve.

3.5.3 Method
The initial step taken to complete the Valve Stroking Project was to gather background information on the required functionality of the control module code. This was done by discussing with Process Control Engineers the expected outcomes of the code. During these discussions it was found the previous code was contained within a CAB. The refinery is trying to minimise the use of CABs due to difficulty understanding and debugging the Visual Basic code contained in them. The CAB however did provide a good starting point for defining the functionality required for the control module.

A simulated C300 on the development network was used during the development of the control module. Initial development made use of a RampSoak function block which is a standard Honeywell function block within control builder. The RampSoak block allows numeric profiles to be configured over a specific time period after receiving a start signal. It was initially thought that this block could be used for the valve stroke profile. After extensive coding it was found that this block was inadequate for the required application as configuration of the profile could only be done by accessing the control modules property form which results in a more difficult configuration interface than is necessary. The difficulty of storing the output level after commencing a stroking profile was also difficult to implement when using the RampSoak block. This is required as the control module needed to return the valve output level to the output level prior to commencing a stroking profile.

Upon deciding that the RampSoak block was not the right block to use for the stroking profile an alternative solution was trialled. This solution was to use a combination of math function blocks to manipulate the stroking signal dependant on how the function blocks were configured from their face plates. After completion of this code a timed on-off signal using a delay and pulse block in series was created. By configuring the
delay and pulse time respectively on these two blocks a period on-off signal was generated. These timing parameters are used to configure the hold time of each valve manipulation. On a rising edge (off to on) the step size is either added or subtracted from the stroking signal depending on a bit stored within a flag function block which is used as a memory location for the count status (whether the count is going up or down). Upon reaching a limit, the signal is capped at the specific level which results in the count status flag being inverted. With the count status now inverted the valve stroking continues opposing its previous direction.

The code was developed and was placed into a System Control Module which allows code to execute in similar fashion to a normal control module with multiple function blocks but allows the control module to be executed within a parent control module. This creates a “black box” type scenario with the code encapsulated within a faceplate in Control Builder. The configurable parameters can be altered on the faceplate which was created to include the parameters likely to be changed as a part of configuration. The Sequence Control Module developed can be found in Figure 15 - Valve Stroke System Control Module Faceplate. This displays the face plate with all configurable module parameters.

![Figure 15 - Valve Stroke System Control Module Faceplate](image)

When the valve stroking start signal is deactivated the stroking profile will continue to manipulate the valve until the output level is within the upper and lower stop band to avoid a large change of valve position instantaneously. The upper and lower stop bands are configurable to allow customisation of the module for the required valve. This functionality prevents a hammering of the valve from taking place which can lead to valve damage. An example of a stroking profile being output from the Control Module can be observed in Figure 16 - Valve Stroking Profile Output. The configurable parameters are also displayed. This
screenshot was taken using the Experion station client’s trending functionality.

Figure 16 - Valve Stroking Profile Output

A screen shot of the control module code can be observed in Appendix B of this report.

Throughout the coding of the control module numerous HMI graphics were created for testing purposes using HMIWeb Display Builder. This provided a convenient view and control of the control module from a station client.

3.5.4 Current Status
The system control module code is complete with documentation being finished before handover to the Process Control Group. Peer review and testing are currently underway.

3.5.5 Lessons Learnt & Conclusion
The valve stroking project provided a large amount of exposure to programming within Honeywell’s CEE. CEE knowledge and coding experience had been developed at university prior to commencing the internship and was extended during project work completed on the valve stroking control module. The emphasis on efficient coding practice to allow understanding of the code by other Engineers was a major focus during the coding of the control module. This practice was also beneficial when attempting to understand code which has not been altered or viewed for an extended period of time; a common situation during the control module development. Clean coding is greatly beneficial for projects with large amounts of code and when a team environment is involved in the development as is evident during university studies and also throughout the course of the internship.
4 Additional Tasks

Over the duration of the placement the intern was required to perform additional tasks including various meeting and process control related events. These additional activities are commonly performed by Process Control Group members. This provided an excellent insight into the extra activities Engineers are expected to fulfil on a week to week basis as opposed to only being exposed to technical work which was the expectation. The participation within these activities proved to be a valuable learning experience with exposure to group discussions on critical control system issues proving to be invaluable knowledge during the course of the internship.

4.1 Process Control Meetings

The Process Control Group has regular meetings throughout the week. These meetings allow Process Control Group members to communicate any work that may be of interest to other members. Safety concerns are also raised in these meetings along with any important announcements that need to be made. Weekend duty is discussed with any outstanding issues from the weekend being discussed on the Monday and any potential threats communicated to the responsible engineer on Friday.

On Thursdays the group meets for a Key Performance Indicators (KPI) meeting to assess personal performance of the previous week. Any overdue items and outstanding issues are also discussed. The weekly plant performance statistics are presented at KPI meetings.

4.2 Monthly Safety Meeting Chair

Every month the Process Control Group holds a meeting to discuss a safety topic. A chair person is responsible for organising and presenting material on a safety issue that they have chosen. Some of the topics that have been experienced during the internship include ladder safety and fire precautions within a hotel. These have been beneficial learning exercises with a large amount of safety knowledge learnt as a result of the topics discussed.

4.3 Honeywell Users Group Demo

The Process Control Group attended the Honeywell Users Group Demo which gave the Worsley Process Control Group an opportunity to gain knowledge of the new Honeywell hardware and software currently on offer in development. A large amount of networking also takes place which can provide great benefit when support is required for Honeywell manufactured products at the refinery.
4.4 Engineering Open Day
The engineering departments at The Worsley Alumina Refinery in association with Engineers Australia hosted an open day for South West Australian year 12 students. The open day gave the students an opportunity to understand the work that engineers are involved in and to understand the life of both a student (University) and an Engineer in industry. Students were given tours of the central control room and were exposed to some of the equipment used on site. Many questions were asked in regards to University work load which the intern was more than happy to discuss.

4.5 Plant Support
During the placement the intern was involved in plant support activities as they arose. This included fixing the development network when issues were encountered, configuring area equipment rooms with fibre optic keyboard, video, monitor (KVM) extenders and providing input into technical discussions on coding challenges.
5 Internship Review

BHP Billiton’s Worsley Alumina Refinery is one of the largest and most efficient alumina refineries in the world. Part of the high efficiency can be credited to the Process Control Group who maintains one of the most advanced control systems in industry. The nature of the process only allows for partial upgrades to the control system at any one time. This requires a well thought out process including backup contingencies when performing changes to the Process Control System. The conglomeration of systems that the intern was exposed to was vast and a hugely rewarding experience. Not until the intern worked at the refinery did he realise the cross communication possible between legacy and new control system hardware.

The internship has resulted in an immense number of learning outcomes including commissioning knowledge, system and server administration, technical development, project management, technical communication, documentation techniques and code development. All the learning outcomes that have been achieved are hugely beneficial experiences and provide an on the job learning style when compared to university studies.

Throughout the internship many noteworthy experiences created unexpected learning outcomes. This included the pressures of commissioning which was completed for the bauxite shuttles. As a part of the night shift commissioning team the exposure to on-the-fly engineering of technical solutions provided a different style of engineering to the typical practice completed during normal working hours. Normally many Process Control Engineers are present within the same room which is not the case during commissioning. More emphasis is placed on engineering a solution in a timely manner which increases pressure upon the Process Control Engineer.

Documentation was a key factor throughout the internship. Up to date documentation can lead to increased efficiency when performing specific engineering tasks. The reverse is also true with poor documentation resulting in decreased work output. This was discovered early in the internship and hence documentation was a focus for much of the project work carried out.

Time management throughout the internship has been a key factor in ensuring that the required tasks were completed within a timely manner. With the parallel nature of the projects the intern’s schedule had to be constantly revised to ensure that the most effective use of time was being utilised. This is common practice within the Process Control Group with many members relying on detailed schedules to divide up their time between different tasks.
Not only has the internship been beneficial because of technical knowledge gained but also experiences in communicating to technical members of the refinery. This was a new experience as most communications relating to control systems previously experienced occurring among people with the same level of knowledge. Regular meetings with the Process Control Group have created an understanding of areas of the refinery not covered by project work and the general feel for engineering tasks completed by other Process Control Engineers.

The internship has resulted in a vastly diverse range of learning outcomes which is hugely rewarding in terms of career progression.
6 Conclusion

As can be seen from the diverse range of projects that the intern is involved with, the internship placement has proven to be a great experience. Being part of a team-orientated environment has helped immensely with any queries that arose during project work. The helpful nature of the process control group members has resulted in a consistent progression through the projects that were initially assigned.

The intern’s work load has slowly ramped up as the intern has become more familiar with the process control system, the assigned projects and the engineering practice used at Worsley. The intern views the placement as a huge success and extremely beneficial due to the technical knowledge gained through diverse range of technical tasks completed at the Worsley Alumina Refinery.

The safety culture present at the refinery and in particular, exhibited by the Process Control Group had not been observed before completing work at the Worsley Alumina Refinery. The Process Control Group have dedicated themselves to the safety of others and themselves in order to reduce, as much as possible, the safety risks that they have control over. This realisation has affected the intern’s outlook on safety not only at work but in life outside of work.

All the experiences gained during the placement are credited to the professionalism and willingness of the Process Control Team who helped throughout the entirety of the placement. The intern was made to feel like an active member from day one of the internship and has embraced this opportunity with efforts to actively contribute to the Process Control Group, both at meetings and when completing engineering work on assigned projects.

The intern owes the Process Control Group a great amount of gratitude for the opportunity to complete an internship at the BHP Billiton Worsley Alumina Refinery.
7 References

An approach to HMI graphics used at the Worsley Alumina Refinery

This resource gave a functional overview of the bauxite grinding facility. This document was read meticulously prior to any E&G work on Facility 024 to ensure that a thorough understanding of the facility was achieved.

This resource was studied to gain an understanding of the control system functionality of Facility 15C/D. This document was also used during FAT procedures to ensure that the tests completed were aligned with this document.

This resource was studied extensively to gain an understanding of Facility 24B -Shuttle Conveyors. This document was used during FATs for any queries that arose.

This document provided a thorough understanding of the Bayer Process used at the Worsley Refinery. This document also contains descriptions of each facility which has been of great benefit during the internship.

This document was used to perform the installation of the ACM software on the ACM Trial Server. It provides details and procedures for various installation and configurations of the ACM software.

This document provided information regarding the addition of control systems and tags into the ACM system. The procedure contained within this document was used extensively during the configuration of the ACM Trial Server.

This document describes the use of a complete ACM configuration from a user perspective rather than an administrative perspective. This was document was used during the ACM installation.

This program is used to perform most configuration tasks with regards to Experion
Servers. This program is used on a daily basis to configure servers that relate to the intern projects. Additional Honeywell software is launched from Configuration Studio.

Honeywell International Inc. *Control Builder (Software)*. 2007. Control Builder is used to configure process control strategies that execute within the Control Execution Environment housed in various Honeywell controllers. This software was used program control modules for projects such as the Valve Stroking


Honeywell International Inc. *Experion Station (Software)*. 2007. Experion Station is Honeywell’s HMI Display software used by Engineers to test process graphics and by operators to interface with the process. This software was used extensively during commissioning duties and during control module development.


Honeywell International Inc. *HMIWeb Display Builder (Software)*. 2010. HMIWeb Display Builder is used to construct HMI graphics for testing purposes and for operator interfacing. This software was used during the development of control modules to allow convenient testing.


Honeywell International Inc. *TDC2000 (Software)*. http://hpsweb.honeywell.com/Cultures/en-
Legacy Honeywell DCS still in use at the Worsley Alumina Refinery


Legacy Honeywell DCS still in use at the Worsley Alumina Refinery


Programmable Logic Controller used throughout the Refinery


Virtual Machine Operating System used at the Worsley Alumina Refinery


Virtual Machine Operating System remote management tool used at the Worsley Alumina Refinery


This document provided an understanding of the Experion System. Contained within this document are the Worsley specific standards used during coding and graphic constructions.


This document details the refinery’s control system and the various hardware and software present throughout the site.


This work instruction is used during the restart of Experion Servers. The intern uses this procedure during restarts of Experion Servers including the Development Network.
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<thead>
<tr>
<th>Glossary</th>
<th>Description</th>
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<td>Advanced Process Manager</td>
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<td>Abnormal Situation Management</td>
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<td>Latest Honeywell Controller</td>
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<td>Calculated Algorithm Block</td>
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<td>Control Execution Environment</td>
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<td>New type fiber optic connector (small)</td>
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<td>Local Control Network</td>
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<td>Master Alarm Database</td>
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<td>MNS iS</td>
<td>ABB Drive Interface Device</td>
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<td>Microsoft’s Terminal Services Client</td>
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Appendices

9.1 Appendix A – Industry and Academic Endorsement

ENG450 Engineering Internship

Industry and Academic Supervisor endorsement pro forma

This is to be signed by both the industry and academic supervisor and attached to the final report submitted for the internship.

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

Signed: [Signature]

Industry Supervisor

Signed: [Signature]

Academic Supervisor

16/11/2011
9.2 Appendix B – Valve Stroking Control Module CEE Code
54
9.3 Appendix C - Development Network Architecture
9.4 Appendix D - Development Network Switch Diagram