ENG470 Engineering
Industrial Project Final Report

Construction of a Human Machine Interface For the Clampton Gold Recovery Mine-Site

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Industrial Project final report submitted to the school of Engineering and Information Technology, Murdoch University, in partial completion of the ENG-470 Honours Project.

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Abstract

This report outlines the design, construction and commissioning of a Human Machine Interface for an operational gold recovery processing plant. The HMI was deployed in accordance to the Clampton Process Control Philosophy developed by various different professions of engineering and metallurgy.

The project is now complete, with the processing plant being fully operational utilising the HMI for visualisation of the current process control operations. The software that was initially used was Rockwell’s Factory Talk View Site Edition, however it was later decided by the client that Schneider Electrics’ Vijeo Citect 7.30, should be the software environment in which the HMI is developed.

The system was constructed so that it was accessible to operators of various abilities and skills. Success of the project can be judged, in part, by the positive feedback provided by the client.

This report also covers the extensive amount of documentation and manuals for instruments that were used within certain phases of design and implementation of this project.
Acknowledgements

The author would like to thank the following Murdoch staff for their continued support throughout this project:

Professor Parisa A Bahri, Unit Coordinator

Associate Professor Graeme R Cole, Lecturer

To Brad Hanson and Adam Foster, the author owes a huge debt of gratitude for their teachings throughout the entirety of this project.

And finally on a personal note, the author would also like to sincerely thank his family and friends for their incredible guidance throughout this learning journey.
# Abbreviations

<table>
<thead>
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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AI</td>
<td>Analogue Input</td>
</tr>
<tr>
<td>AO</td>
<td>Analogue Output</td>
</tr>
<tr>
<td>DI</td>
<td>Digital Input</td>
</tr>
<tr>
<td>DMM</td>
<td>Digital Multimeter</td>
</tr>
<tr>
<td>DO</td>
<td>Digital Output</td>
</tr>
<tr>
<td>DOS</td>
<td>Disk Operating System</td>
</tr>
<tr>
<td>FAT TEST</td>
<td>Factory Acceptance Test</td>
</tr>
<tr>
<td>GENSET</td>
<td>Generator Set</td>
</tr>
<tr>
<td>HMI</td>
<td>Human Machine Interface</td>
</tr>
<tr>
<td>I/O</td>
<td>Input/Output</td>
</tr>
<tr>
<td>MCC</td>
<td>Main Control Centre</td>
</tr>
<tr>
<td>NC</td>
<td>Normally Closed</td>
</tr>
<tr>
<td>NO</td>
<td>Normally Open</td>
</tr>
<tr>
<td>OPC</td>
<td>Open Platform Communications</td>
</tr>
<tr>
<td>P&amp;ID</td>
<td>Piping and Instrumentation Diagram/Drawing</td>
</tr>
<tr>
<td>PFD</td>
<td>Process Flow Diagram</td>
</tr>
<tr>
<td>PID</td>
<td>Proportional Integral Derivative</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable Logic Controller</td>
</tr>
<tr>
<td>SCADA</td>
<td>Supervisory Control and Data Acquisition</td>
</tr>
<tr>
<td>VFD</td>
<td>Variable Frequency Drive</td>
</tr>
<tr>
<td>VSD</td>
<td>Variable Speed Drive</td>
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Background

The location of the Clampton mine site is approximately 140 km’s north of Bullfinch in rural Western Australia. It is a small processing plant, however the same rules of safety that larger companies utilise still apply. Safety was held as the upmost importance as was made apparent before and after the author arrived on site. Unfortunately, due to the company’s information confidentiality policy, certain technical aspects of this project cannot be disclosed in this report.

Murdoch University is well known for having a very hands-on teaching method, especially within the Engineering school. The intern found that the material covered in previous third and fourth year units are extremely helpful in understanding and then working on this specific industrial project. The units such as ENG305 (PLC systems), ENG306 (Real Time and Embedded Systems) and ENG345 (Instrument and Communication Systems) played a crucial role in the success of this project. In particular, the foundational understanding of PLCs as well as some knowledge of industrial instrumentation made the entire project, from design to commissioning, significantly easier to work upon.

The interface between humans and machines is of vital importance to the overall growth and development of the industrial sector. This relationship is reliant upon the design and testing of the Human Machine Interface (HMI) as a portal between operator and instruments in the field. Throughout this project, the author was able to follow in the path of Murdoch University’s teaching method and benefit in the participation of teamwork to successfully design, test and deploy a HMI within a gold recovery process plant.

The HMI software development environment initially chosen was FactoryTalk View Site Edition *(Rockwell Automation, 2015)*. This was later changed to Vijeo Citect
(Schneider Electric, 2015) at request of the client. The reasoning behind this was due to licencing issues, in which the client was utilising certain hardware that was easier to establish communications to the latest version of Vijeo Citect (7.30) than it was to the older versions of Factory Talk Site Edition.

The current recovery system for the Clampton mine site utilises size reduction and screening. No chemicals are used within this system. Dirt is initially loaded into a jaw crusher, the discharge of which is screened and any oversize particles are sent to a hammer crusher for further size reduction. Undersize particles are sent to a stockpile. The discharge from the hammer crusher is then conveyed to be screened, the oversize is recirculated through the hammer crusher and the undersize is sent to the stockpile. These process steps are referred to as the initial size reduction.

From the stockpile, dirt is loaded into a vibrating hopper via a front end loader and then conveyed to a ball mill for further size reduction. The discharge from the mill is screened, then pumped into a gravity feed tank. This tank feeds the gravity concentrators that collect the gold as a concentrate which is then taken offsite for extraction.

Many different types of instruments aided in the recovery of gold at the Clampton gold recovery mine site. Drives, pumps, gravity concentrators, electromagnetic flow meters, valves, density meters and level indicators are some of the main devices that are utilised in this project.
Project Objectives

The overall objective of this project is to create a unique, well designed, efficient and robust HMI for a client mine site, which allows operators of various levels of ability to successfully run the gold recovery process system. The HMI would have to go through certain phases of design and testing, and perform successfully through a Factory Acceptance Test. The final step of the project is the deployment of the tested HMI at the Clampton gold recovery processing plant.
1. Project Documentation

The technical dossiers that were utilised throughout this industrial project will be the main focus of this section. These documents are used throughout every project (irrespective of size) and are absolutely vital as they explain every detail of how the entire system is expected to function. All individual dossiers’, Instrument list, PLC I/O list, Process Flow Diagram (PFD) and Piping and Instrument Diagram (P&ID) stem from the Process Control Philosophy. The following sub-headings are relevant to the overall scope of this project as they are the very foundations for almost every project.

1.1. Process Control Philosophy

The Process Control Philosophy commonly referred to as the Functional Specification describes how the process operates. The document is created by a team of people bringing different areas of expertise with the objective being to describe the optimal way in which the project is to function. This is an exceptional task as every detail of every part of the project must be included. As mentioned above, several other documents are found within the Process Control Philosophy which can be seen in Figure 1.
From Figure 1, it can be seen that many different areas of engineering work are combined to produce a Control Philosophy for an industrial project. The Process engineers and Metallurgists in this project worked together to design a way in which the alluvial gold found at Clampton could be recovered to a high percentage yield.

The metallurgists considered the size of the rock found as well as the size of the particles that are needed for the gravity concentrators to recover gold effectively. The Process engineers studied and reviewed how the process plant should function to achieve this desired rock size reduction. The Mechanical Engineers made decisions the appropriate choice of hardware for the process design. For example, the conveyor that would feed the gold rich dirt into the mill needed to rotate at a certain speed with a certain load. The Mechanical Engineers studied and adjust the angles of the conveyors as well as motor size to meet the numbers that the metallurgists had
produced. The Piping Engineers inspected how much water was required in the mill for the correct amount of size reduction of the rock. The electrical engineers calculated how much power the system required. The control system engineers designed a system that would automate the entire system while letting operators adjust for optimal set-point conditions. All of these different areas of expertise worked together to create a document that would outline every detail in how this gold recovery plan would run.

The reason this document is so relevant to the scope of this project is that besides being the foundation for the entire project, this document outlines the desired way in which the HMI is to function. The control system engineers work with the client to generate a base idea for how the HMI is to look and function. This will be marked as revision 0 and will then be included into the Control Philosophy. Although this could be thought as the only relevant for this report, without the rest of the document, it would be incredibly unpractical to just look at the base HMI design. In order to create a functional, well thought out HMI design, the entire Control Philosophy must be utilised and understood.

The Process Control Philosophy can be broken down into plant description, process description, system parameters, sequences, permissives and interlocks, equipment overview, control loops, alarm handling and alarm responses, operator and maintenance functions. The HMI is what the operator will see and therefore the design must be thought out as to what the operator can alter or look further into. For instance, the Control system engineers might not want the operators to be able to change an interlock into a permissive as this might cause hardware damage. However the operator must be able to see what the permissives and interlocks are. Finally, it is the Control systems Engineer’s job to bring all of the workings together to create the final system functionality.
Post commission, another Control Philosophy is written up to explain exactly how the system has been implemented and tested. This document explains, in greater detail, how the entire system is to function. Various tests are completed after the system has been implemented and are documented in this dossier as well as all of the results. This is to explain the optimum set-point values for the process.

The Clampton Control Philosophy could not be included in this report for as it is commercially confidential.

1.2. Process Flow Diagram (PFD)

The Process Flow Diagram (PFD) or flow-sheet is a visual overview of the design for the processing plant. In accordance to the ISO 10628 standards \(\textit{ISO, 2016}\) it is designed to show the relationship between the major components of the overall process. The PFD usually shows process piping, connections, major valves, equipment along with operational data such as pressure, mass flow rate, temperature, density as well as the names of different process streams.

This dossier is created to provide a visual overview of the entire project, as it only shows the major components. The difficulty only lies within the understanding foundations of the overall process. After reading through the entire Control Philosophy several times, the PFD becomes much easier to understand. The PFD is an extremely helpful tool when designing pages for the HMI. It allows for the Engineer to have a basis of visualisation for how the system is to be designed.

For the Clampton gold recovery process, the exact PFD diagram cannot be published within this report as the information is commercially confidential. However, below is an example of a typical PFD for an Amine treatment process.
The Piping and Instrument Diagram (P&ID) is a comprehensive drawing which outlines the interconnections of the entire industrial process. The instrument symbols used within this drawing must adhere to the International Society of Automation Standard S5.1 *(ISA, 2016)*. Knowing the connections between process equipment and instrumentation used for control is absolutely critical within an industrial project. The P & ID also typically outlines, flow directions, valves, process piping, vents/drains, mechanical equipment, instruments in addition to control inputs, outputs and interlocks. All of these items would have an associated name, symbol and reference for identification.

Throughout this project, the author occasionally struggled to learn some of the abbreviations used throughout the P & ID. As the names and symbols are based on
the ANSI/ISA S5.1 (ISA, 2016) and the ISO 14617-6 standards (ISO, 2016), the author was advised to read the standards and then construct a table to better understand the naming system. Past ENG 345 notes also assisted in recognising certain symbols. The result of this learning activity was the ability to recognise most symbols and names within the P&ID. This was important for the HMI as the project’s entire Control system could be visually understood using various pictorial representations. Understanding and being able to read the PFD and P&ID helped in assisting Engineers throughout the design phase of the HMI.

For instance, a Flow Indicator Transmitter would be labelled as FIT-001 and a Flow Indicator Controller would be FIC-001. Understanding the differences as well as being able to recognise the abbreviations and symbols was a key learning task throughout this industrial project.

For confidentiality reasons, the Clampton P&ID cannot to be published in this report, however an example of a P&ID can be seen in Figure 3.
1.4. Instrument/Equipment List

The Instrument List is composed of the most recent instruments being used (or planned to be used) on site. An example of a typical Instrument List can be found in Figure 4.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Tag</th>
<th>Type</th>
<th>Location</th>
<th>Function/Service</th>
<th>Measure</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FIT-xxx</td>
<td>Electromagnetic Flowmeter</td>
<td>Feed to Mill</td>
<td>Measure Water feed to Mill</td>
<td>Flowrate</td>
<td>Process Water</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size</th>
<th>Engineering Units</th>
<th>Manufacture</th>
<th>Model</th>
<th>P&amp;ID Line number</th>
</tr>
</thead>
<tbody>
<tr>
<td>50mm</td>
<td>M³/h</td>
<td>Endress + Hauser</td>
<td>Proline Promag 50P</td>
<td>200-14 - PG-DC1-001</td>
</tr>
</tbody>
</table>

Figure 4. Example of an Instrument List
As can be seen from Figure 4, almost all the information about an instrument is found within this dossier. Typically this list would also include a reference to a file in which any data sheets/manuals could be found on the instrument in question as well as the communication protocol, e.g. Modbus, Profibus or Ethernet. This list helps the design of the HMI as it details exactly what each instrument is used for and where it is located on site. The HMI must display this information to the operator if requested and therefore it is vital to have a list as such as this one pre-prepared.

Most of these instruments can be seen visually within the Process Flow and Piping & Instrument Diagram, however the specifications of each are found via the Instrument/Equipment list.

1.5. PLC I/O List

The I/O list is essential in the design phase as it summarizes what is connected to each PLC channel on each rack.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Tag</th>
<th>Digital In</th>
<th>Digital out</th>
<th>Analog In</th>
<th>Analog Out</th>
<th>PLC Rack</th>
<th>PLC Slot</th>
<th>PLC Channel</th>
<th>Sig Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mill Discharge Hopper Level</td>
<td>LIT-001</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>4-20mA</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5. Example of a PLC I/O list

Figure 5 is an example of the typical information that could be found in an I/O list. Having this information is absolutely critical when designing pages for the HMI, as the Process engineer must program Vijeo Citect to read information from the correct channels in the PLC. This list is tested throughout the FAT test and then again on site.
to make sure the correct signals are being received by the correct channels of the PLC.

Throughout the design phase, this document was mainly used to set up tags within the system. Those tags would refer to the specific channel, on the specific rack within the specific PLC and all of this information is found within this list. The Clampton PLC I/O List is commercially confidential and cannot be published in this report.
2. HMI Software

The HMI is the portal via which the operator is able to gain insight and control the industrial process therefore the design of such an interface is crucial for the overall success of the operation. In order to generate a robust and versatile HMI, a software development package must be chosen in accordance to the client’s needs. The initial software chosen by the client was Rockwell’s Factory Talk View Site Edition (Rockwell Automation, 2015). However, before the FAT test was to be undertaken, the client requested the HMI to be developed using Schneider Electrics’ Vijeo Citect. The following sections will discuss the way in which these two software packages are configured and installed correctly. Learning how to navigate and create HMI pages within both software packages was a great learning experience for the author.

2.1. Factory Talk View Site Edition (SE)

FactoryTalk View Site edition is an integrated software package developed by Rockwell. It was created to simplify the way in which humans can interact with machines and is extremely dependable, robust and versatile. FactoryTalk allows for not only the development of HMIs but also allows for applications to be run and distributed over a network. The software package has many helpful tools and is a very in depth users guide, however a lot of time must be spent learning the way in which this program communicates with a PLC.

2.1.1. Factory Talk View Site Edition (SE) Installation

Throughout this section, the six Major steps that must be completed in order to successfully install Factory Talk View Site Edition will be discussed. These are listed below (Automation, 2015). This installation is extremely important as it is the
foundation for the HMI. If the HMI software environment is not configured correctly, the consequences could be problematic.

Step 1: Plan the Layout of the network

The structure and layout of the network is vital for how the overall system will perform and therefore must be taken into account before the necessary software is installed. By planning the layout it is possible to determine whether a network domain controller is required or what role host computers will play (e.g. servers running as redundant back-ups). The Clampton project had a network consisting of less than 10 computers and therefore it was possible to use a Windows workgroup.

Step 2: Install FactoryTalk Services Platform

This step is dependent on the application the software is being used to develop. The FactoryTalk Network Directory as well as the Local Directory is set up by Rockwell to install onto the computer automatically.

Step 3: Install FactoryTalk View SE

Once at this step, the components can be installed onto one computer or split into individual parts and distributed over separate computers within the network. This is important as it allows certain parts of the software to be allocated to different computers. For example users might only want computers used by operators to receive the FactoryTalk View Client software as to not be able to alter the application. However, if a local application is needed (e.g. the operators are able to alter the fundamental appearance of the HMI), then all necessary software must be installed and configured on just one computer.
Step 4: Select the connectivity options

This is by far the most important step: connectivity issues are difficult to fix and can often cause issues throughout the application itself. Throughout this project, a connection issue did arise with an Allen & Bradley PLC, in which the wrong make and model of the PLC was selected in the connection setup. The Factory Talk (Rockwell Automation, 2015) software was unable to register that the PLC was successfully communicating. This problem was resolved after much deliberation, with a change in the setup options.

FactoryTalk View has two different methods of communication with logic controllers: RSLinx Enterprise (Rockwell Software, 2016) and RSLinx Classic (Rockwell Software, 2016):

- **RSLinx Enterprise (Rockwell Software, 2016)** is a Live Data server that has the ability to run on multiple platforms depending on the client’s needs. For communications with Allen-Bradley PLCs (especially the Logix5000 controllers), RSLinx is appropriate as use of the data communications software for the FactoryTalk View Applications.

- **RSLinx Classic (Rockwell Software, 2016)** is used to communicate data through Data Highway (industrial bus protocols developed by Rockwell (Belden, 2015)) networks. It is not the preferred choice for data communication, however it can support complex bridging (assigned IP address that is part of the physical Ethernet subnet) and routing (using its own subnet) (VPN, 2015). The developer is also able to create alias topic shortcuts in which the user is able to upload and download RSLogix 5000 files online.
These two methods of communication are dependent on the developer’s needs and are associated with Allen-Bradley logic controllers. To communicate with a third party remote or local device that is not an Allen-Bradley, FactoryTalk View Site Edition supports Open Platform Communications (OPC), which is used to connect to communication devices via vendor specific OPC servers *(Automation, 2015).* OPC masks FactoryTalk View as a client from the other vendor specific OPC server. This allows for successful communication between the two OPC servers (e.g. to retrieve tag values from a Siemens logic controller).

In this project RSLinx Enterprise was chosen as the communications software for reasons being that it is a simpler software package for developers to setup.

**Step 5: Install the necessary activation keys**

Without the correct activation, the software, although installed, will not run. A count of displays, global objects, tags, graphics, run time and network size should be considered to determine the required activation for the project.

**Step 6: Set up the FactoryTalk Directory**

This is the final step in the installation process for FactoryTalk View SE. The FactoryTalk Directory consolidates access to all of the components, such as tags and global objects, for all of the FactoryTalk products in the development stage of a Control system. There are two types of Factory Talk Directory:

- Local Directory, manages the components and resources that are assigned to a singular computer. This directory is used for local application projects.
- Network Directory, manages the components and resources that exist shared between multiple computers connected over a network.
Both directories are automatically set up on the computer when FactoryTalk View Service Platform is installed (step two). As a pre-configured setting, if the project is local then no further set up is required. However if the Network Directory is needed, then all the computers that participated in the project must be set up reference a single computer as their network directory (Automation, 2015).

The setup for the installation of FactoryTalk View SE is somewhat tedious and special attention must be spent setting up communication connections. However, for industrial projects to be successful, the appropriate software must be properly installed and configured to the needs of the developer and client.

2.2. Working within FactoryTalk View SE software

FactoryTalk View Site Edition requires at least one HMI server. The HMI server stores all the projects components and provides these components to the clients. The server also contains all the information of tags, manages the data (logging) and performs alarm detection (Automation, 2015). The following section describes the working environment for the Factory Talk View software. Knowing each part of the working space is vital in the design phrase of this industrial project.
2.2.1. FactoryTalk View Studio

FactoryTalk View Studio, a feature of the software package is used for developing, testing and running FactoryTalk View SE applications. Once FactoryTalk has been opened, the user may select the application type to which matches the developer’s needs.

![Product Type Selection](image)

Figure 6. FactoryTalk View Studio Front Page; RSVIEW Studio Site Edition

Figure 6 above shows the front page of FactoryTalk Studio View and the three application types. Factory Talk Software can be utilised for different types of projects such as standalone or distributed and different types of machines such as panel (touchscreens) or desktops. Site Edition (SE) is primarily used for desktop screens and depending whether it is distributed over a network will be unique to the individual’s project network layout. Machine Edition (ME) is used for touch panels, it can be used for desktops but a machine edition run time licence is required and this
is already built in when using Panel-View. Apart from a few tools, the software environment is almost identical for all three configurations. Figure 7 shows the main development window for the FactoryTalk View Studio. After an application area is created and the HMI server is added, the working space for HMI development will appear as shown.

Figure 7. Main window Factory Talk View Studio; Automation
The Explorer window is found inside of the application tab. This window allows the developer to access the majority of the components found within FactoryTalk View Studio’s software environment. The workspace is the blank area to the right of the screen and is where displays, global objects and parameter files can be created. The communications tab shows the devices on the network that are available for communication through the connectivity settings that were set up during installation. For this specific project, RSLinx Enterprise *(Rockwell Software, 2016)* was chosen as the data server for communication and thus the communications tab is where a developer would find the Allen-Bradley logic controller in which information between HMI and PLC can be exchanged.

2.3. CitectSCADA

CitectSCADA *(Schneider Electric-CitectSCADA, 2016)* is another software environment that was used within the project as a tool to create a HMI for site monitoring. Similar to FactoryTalk View Studio, CitectSCADA was also developed to create HMIs and is able to communicate with various third party vendor logic controllers via OPC servers. The following sections discuss the way in which Vijeo Citect was utilised for this project.

2.3.1. CitectSCADA Background

Citect was developed and released in 1987 for Microsoft’s Disk Operating System (DOS) *(MS-DOS, 2016)* as a tool to help with the very limited range of interfaces for operators to use. As the Windows operating system (OS) became more popular, Argyle Diamonds decided to upgrade their original system to use Citect *(Argyle Diamond Mine CitectSCADA, 2016)* and so Citect for Windows, Version 1, was released in 1992. Citect became ever more popular due to its feature of Cicode. Cicode is a programming language that is very similar to the programming language, Pascal.
This allowed for sophisticated tasks to be achieved. Due to the versatility of Cicode, the BHP Iron Ore project in Port Hedland upgraded its operator interface to use CitectSCADA. This however required some limitations (such as the Citect Graphics system) in version 1 to be updated and so version 2 was released in 1993. Versions 3 and 4 were released to increase functionality of the software, such as providing alarm indication of a communications failure to any device displaying real time data (Schneider Electric-CitectSCADA, 2016). Versions 5 and 6 were aimed at keeping the functionality and features ahead of other rivalling companies and version 7 was released in 2007, as the first version to support the Microsoft Windows Vista OS (Windows Vista, 2016). The version which was used for this project is Vijeo Citect (CitectSCADA rebranded) 7.30 which was released in 2014. The history of the software environment being used in this project was researched to gain a better insight into licensing issues. For instance, older Citect SCADA versions are not compatible with Vijeo Citect 7.20. However, version 7.30 allows for compatibility with older Citect SCADA versions as well as previous Vijeo Citect versions (such as 7.20 and 7.10). It is important to have an understanding of which versions are adaptable and which aren’t.

2.3.2. Vijeo Citect Installation

Schneider Electric Australia decided to rebrand CitectSCADA to the globally recognised, Vijeo Citect, with the release of version 7.30 (Electric, Schneider Electric). The change was superficial to create a global product name and just as with Factory Talk View Site Edition, the installation process was extremely important.

Step 1: Setup network layout and select which software to install

Once the Installation disc is inserted, the developer is able to choose which software environment they want to setup (Viejo Citect, 2015).
The desired network layout must be contemplated by developers, when working through the installation process. To provide the OPC Factory Server (OFS), Vijeo Citect must be installed first in order for all of the components of the software to be covered under the same license key. The OFS, similar to RS View Studio, is based upon the OPC protocol. Once “Next” is selected, the installation documentation for that specific choice will appear and it is highly recommended to download and read this before moving onto the next step.
Step 2: Installation Profiles

This step allows the developer to specifically choose what core components of Vijeo Citect are to be installed onto the PC.

Figure 9 outlines the component installation options for Viejo Citect 7.30. This part of the installation will be specific to individual project needs.
If “All Components” was selected in the previous dialogue box (Figure 9), then the following dialogue box would look like Figure 10. This step involves deciding what core components will be installed.

Figure 10. Step 2 Vijeo Citect Installation core components; Electric, Vijeo Citect, 2015
**Step 3: Installation Add-ons**

This step is crucial as it involves the way in which tag values can be exchanged between Vijeo Citect and the logic controller.

![Vijeo Citect Setup](image)

*Figure 11. Step 3 Vijeo Citect Installation; Electric, Vijeo Citect, 2015*

The DBF add-on is for Microsoft Excel and stands for Database File. Tag information is stored within the DBF in Excel and if the right setup is configured, Vijeo Citect is able to read and write values to those tags via the HMI into the logic controller. The Web server IIS (Internet Information Services) uses the Internet as a platform for reading and writing values to tags. This option comes with risk from viruses and external sources gaining access to secure information. The next few dialogue boxes from this step are concerned with setting up the file location for Vijeo Citect and a summary before installation is provided (Figure 12).
Step 4: Communication Driver Installation

Installation of the communication drivers lets Vijeo Citect software know which drivers the software is likely to be in communication with. The most common drivers are selected by default and any drivers that are limited or not supported by the OS will deliver an error message.
Figure 13 displays some of the default drivers that have been selected for communication purposes between the software and the logic controller. For example, ABCLXRELASE Driver (highlighted driver in Figure 13) is the driver for Allen-Bradley Control Logic devices (current version, 2015, 3.20). By having this selected, the Vijeo Citect setup will be configured in such a way that information (such as Tag values, alarm detection and trending) between Allen-Bradley PLCs and Vijeo Citect can be successfully established.

Figure 13

Figure 14 displays the final dialogue box for the installation of Vijeo Citect. Once the installation is complete, the developer can upgrade to updated versions of Vijeo Citect by downloading and installing service packs provided by Schneider Electric. This feature is important as it allows the developer to modify, repair or remove certain components no longer required. Network communications are set up automatically and can be changed afterwards. During installation it was discarded.
that Vijeo Citect requires both “Vijeo Citect FTP server” and “Vijeo Citect Runtime” to communicate through a Windows Firewall (*Electric, Vijeo Citect*). If a computer has a particular network profile, then the developer must manually add an application to the necessary firewall exception list. This is an important issue as communication problems are often hard to narrow down to a specific point. Everything within the hardware and software might appear to be working however the information could be stopped by the firewall.

### 2.3.3. Communication Setup Vijeo Citect

Setting up communications within the network between the field I/O devices and the main I/O server is the most crucial step after the installation of the appropriate software. This step can be setup via ‘Express Communications Wizard’ (*Communications Wizard, 2016*), which is a tool provided by Schneider Electric. However, throughout this project, to gain a better understanding of what was involved, it was decided to manually configure the communications. At the time, this process was somewhat tedious, however the lessons learnt in hindsight were well worth the time spent. If communication is not configured correctly, the I/O server will not be able to communicate with the field devices and the clients will not receive any readings or have any control. This section will discuss how to configure these communication settings in order to successfully exchange tag data between a PLC and a HMI.

**Step 1: Define an I/O server**

This step involves specifying a name for the main I/O server and it is this name that will be used as a reference. In order for redundancy (e.g. a backup I/O server), a database record for each server must be setup in order for a backup to take over communications between clients and field devices and the event of a system crash.
**Step 2: Complete Port Properties**

Most computers have several communication ports available. In order for successful communication, a port must be specified. If a modem is used, it must also have a unique port name. Virtual ports also exist and could be assigned to physical ports. This must also be taken into account when setting up communications. The properties of the ports are dependent on the boards that have been installed on both the I/O server/s as well as the I/O device/s connected to the port/s. Each port must have a specific port name, port number, board name (found in step 2), baud rate, data bits, stop bits, parity and any other special options.

**Step 3: Complete I/O Device Properties**

This step involves specifying the I/O device that Vijeo Citect will be communicating with in addition to the protocol. When configuring an I/O device it is important to note the specific properties and configurations made to the device for record keeping. The I/O device will have to a have a field Name, field Number, address, protocol, port number (from step 3), a start-up mode (primary, standby or standby write) will have to be selected, priority and field memory allocation must be configured in this step. Start-up mode is where redundancy is specified, a backup I/O server will be configured to have a standby write start-up mode, which allocates a channel of communication to remain unused until the I/O device (configured to have a start-up mode of Primary) becomes inoperative. There are many more extended properties that can be configured for I/O devices, however these properties would only be used for very specific purposes.

The steps described above are extremely important when it comes to configuring the right communications between I/O server and I/O field device. However, if there is
no data to read or write, Vijeo Citect will not communicate with the field device, even if it has been configured and defined.

2.4. Working within Vijeo Citect

Vijeo Citect graphic displays are extremely capable, versatile and robust. The graphics have to be easy to use and quick to develop to allow a successful interface between the operator and the HMI to be created efficiently. The following section will describe how the graphics within the Vijeo Citect software environment can be utilised.

2.4.1. Vijeo Citect Graphics

Vijeo Citect graphics are based on a simple set of objects, such as rectangles and circles *(Schneider Electric, 2015)*. With these objects, a set of properties is associated that allow the behaviour and characteristics to be linked to a variable. The goal is to mimic real life situations, so movement such as rotation, size and fill can be added to graphics. Touch properties and commands can also be assigned so as to make the objects interactive and informative, specific to the operator’s needs. Figure 15 shows the different states of the filling of a tank to demonstrate some of the graphics within Vijeo Citect.

Figure 15. Tank example; Clampton, 2015
The graphic design in Viejo Citect is extremely versatile, with the ability to somewhat zoom in on (to the pixel level) on what is being drawn. This is extremely useful when moving objects around the page and making sure the smallest details are correct. Viejo Citect has an extensive library of objects, shapes and pop-up windows that can be used throughout the project.

The HMI screen resolutions that Vijeo Citect is able to produce are up to 4096 x 4096, which allows for the highest quality of images to be added into the project. The default symbol library that is automatically installed during setup is vast and packed with various symbols and graphics. The most commonly used items are pumps, drives, tanks, crushers, motors and valves.

2.4.2. Vijeo Citect Genies and Super Genies

Vijeo Citect libraries are numerous and can be built upon in order to use on different projects. Genies (Genies and Super Genies, 2016) act as a macro within the project and consist of multiple graphics put together. For example a Pump Genie might consist of an image of a pump, an alarm indication, an auto/manual switch and a set-point input. All of these grouped together will make the one Genie that can be used over and over again throughout the project.

![Image of a Vijeo Citect Genie example](image)

Figure 16. Common Genie example; Clampton, 2015

Figure 16 shows a classic example of a Vijeo Citect Genie for a pressure indicator controller (PIC) and is taken from Clampton HMI front page. It shows the set point,
the process variable (PV) level (in this case the pressure), the units that the PV is measured in and whether the control loop is operating in manual or remote (auto) mode. However, instead of making the same box for every necessary I/O, it is easier to draw and configure an object (Genie) with the ability to bring up a pop-up window for entering values and then reuse the object (Genie) throughout the project. The reasoning behind this is that it is easier and more time effective. If the Genie is created in an appropriate way, the process engineer simply needs to add the tag name to the above rectangle and the tags found inside is populated throughout

Vijeo Citect Super Genies *(Genies and Super Genies, 20016)* are most commonly used for popups of device control. A Super Genie is comprised of one or more individual configured objects that have been grouped together as a page or a pop-up. Parameters of Super Genies are set up as to be assigned to a certain tag or value, allowing for reuse through the entire project. Titles, display information or logging can be set up through the use of Cicode allowing the user can set up the Super Genie to read certain string texts. Figure 17 shows a common example for a trend display popup Super Genie.
It can be seen that a popup with the ability to be reused throughout the entire project is extremely helpful. The individual objects such as the numeric inputs for the alarms are all configured objects that have been grouped together. Vijeo Citect also provides libraries of pre-configured Genies and Super Genies for use within projects. This ability to group objects and make them universal without projects is one of the reasons that Vijeo Citect is widely utilised for HMI design. Figure 17 shows the settings in where a tag can be added and then the data with that tag would populate the Super Genie. In between ‘ %Tag% ’, a tag value can be added, this super genie would then read the value (e.g. Level Indicator Transmitter 100/LIT100, would give a reading of the level in the tank, the set points for the alarms as well as a description of the tag itself.
2.4.3. Trending within Vijeo Citect

Trending is extremely important when it comes to processing large amounts of data or large numbers of different variables in a way that maintains data integrity. Vijeo Citect offers trending capabilities (Vijeo Citect Technical Overview, 2015) that combine historical as well as real time data on the same page. An operator can bring this page up and configure it to read certain tag values or select the tag they wish to inspect the trend data of. This task is set up in the initial construction phase of the project. Operators scroll through the trend data and adjust input set point values to achieve the optimum system performance. For this project, the client wished to trend the amount of water going in and out of the system. Various flow meters have been then setup to send pulses to the PLC when a pre-configured amount of water passed through the pipe (e.g. one pulse for every $10 \ m^3$ of water). These pulses were then accumulated every ten minutes and displayed as a trend while also being logged to maintain a count on water usage. The trending page was an extremely useful tool for displaying information such as water usage. This allowed a visual inspection of performance rather than displaying a number with nothing to compare it to.

2.5. Overview of the HMI Software

It was decided that the installation requirements of the appropriate software were so important that it should be added to the thesis rather than as an appendix. The reasoning behind this is that throughout the design phase of this project, so much emphasis was placed on the installation of the software. HMI software development environments, if installed incorrectly, can be found to not function when commissioned or integrated into an existing system. These errors can occur with different versions of the same software, for example, Viejo Citect version 7.20 is not compatible with earlier versions.
3. HMI Hardware

The hardware that is used for HMIs for industrial purposes is dependent on a variety of factors: budget, size of the pages, software choice and resolution required are just some of the variables that need to be taken into consideration before a choice is made.

As this project was of small scale, it did not need to be distributed over many different servers and clients. Therefore to save time and money, only a few desktop computers were used to maintain, control and monitor all processes throughout the site. One computer acted as the I/O server and the control client and a second was a View client. A third PC was also added as a dedicated backup I/O server; in case of a crash, the backup would take over the communications between the PLC and the View only client until the main I/O server was back up and running. Once the main I/O server was up and running again, the backup server would backfill its information and then the main I/O server would take over. If it was a planned shutdown, the backup would take over immediately otherwise it took an average of a few seconds to switch from a crashed I/O server to the backup. The need for a master station which would usually be composed of multiple servers and distributed software licenses would have been for what was required for this project.

The major factors for this project, when selecting the appropriate hardware were cost and time. Throughout the early stages of design, hardware choices were made and presented to the client, who in turn had the final say. The client approved of limiting the hardware to drop the level of complexity of the overall system.
4. Factory Acceptance Test

Also known as the Operational Acceptance Test (OAT), Black-box Test or Field Acceptance Test, the Factory Acceptance Test (FAT) is a test conducted to determine whether the design of the overall system is working to a satisfactory level. This is the final step in the design phase and allows the Engineers to resolve any issues that arise as well as uncover design flaws that would need to be altered. The FAT test acts as an electrical signal simulator for the entire system, with the overall objective being to test the design of the HMI as well as the functionality of the PLC.

Figure 18. FAT test MCC panel; Clampton

Figure 18 depicts one of the control panels for the Clampton project in which an Allen Bradley PLC is housed. Hardware, software, electrical drawings, I/O list, equipment list and electrical wiring were put together in order to test whether the design met the expectations of the client. Any issues that arose had to be documented and adjusted, so that the system would be easily integrated in the field. The goal of the FAT was for the switchboard technician to close contacts and inject currents into the appropriate channels to mimic real world I/O devices.
4.1. FAT Test Problems Encountered

The problems described here all affected the way in which the HMI performs, each issue that arose needed to be repaired which takes time. However, the time it takes to fix any issues pales in comparison to the time it could take if the same issue arose during commissioning.

Slight differences between the I/O list that was provided by the client and the Electrical drawings caused disruptions to the testing procedure. This particular type of problem was hard to narrow down as a cause of receiving no signals on a certain channel. It was first thought to be an issue with the wiring (e.g. a loose connection). Once traced and tested it was thought to be an issue within the PLC code. The signals were being seen by a different channel on the PLC and that the I/O list disagreed with the electrical drawings for that particular input. This did not have such a large impact on the HMI, however it was necessary to update the I/O list and that in turn meant an update to some of the variable names within the HMI. This could be quite easily changed within the Cicode and it is this flexibility and robustness that made Vijeo Citect an excellent choice for HMI software development.

The HMI indicated that a belt drift for one of the conveyor belts was constantly being tripped. This led to alarms being displayed in the HMI which affected the entire system. This sounded like a simple issue to resolve, however when looking through the Cicode there were no apparent problems. There were no errors in the wiring and the electrical drawings had been drawn correctly. A digital multimeter (DMM) was used to determine that a signal was being sent from the relay for the belt drift alarm was a normally-open (NO) relay had been used instead of a normally-closed (NC) relay. If not for the HMI design working correctly, this problem could have gone unnoticed and led to a costly altering.
It was discovered that a thermo overload relay needed to be added to a drive. This was necessary as it would allow the PLC to have control over the drives and indicate to the operators if there was an issue. This update of the HMI would also allow for proper indication of the thermo overload fault. Although this was not a major revision, it did take time to create the images for indication as well as to add I/O to the PLC and then write the Cicode to read signals from the recently added channel and finally update the drawings.

One of the cards on the Allen Bradley PLC had been formatted to communicate using differential mode whereas the wiring was for an analogue input with a signal of 4-20mA. As a result, the card should have been configured with a single ended format. This error led to strange signals being read on the HMI from the current injection. The process to troubleshoot was to look over the wiring and the drawings first to check if these were similar, check the Cicode, check the current injection DMM for bad wiring and then finally check the communication settings of the analogue input card on the PLC. If the PLC gave the same analogue readings as the HMI then this would indicate to the engineers that problem might be within the PLC. The HMI therefore could be used as a tool to diagnose where the errors troubleshoot.

The faults detected in the FAT were often time consuming to locate and difficult to correct. This is the reason for the FAT test: it is to find any issues so that, during the commissioning phase in the field, the instalment of the control system will effectively meet the requirements of the client.
4.2. **Communication at the FAT test**

The FAT test was an excellent opportunity to explore a way in which process engineers, control system engineers, electrical engineers, electricians, operators and technicians all communicate to one another. It was clear from the start that each of the different professions had their own way of communication, especially when there was an issue. Being able to communicate with everyone was one of the most vital lessons learnt throughout the entirety of this project. If an issue arose, the electrical engineers were looking towards the electrical drawings for a problem while the Process engineers were looking within the code of the PLC and the electricians were collaborating with the electrical engineers and testing whether the wires had loose connections and were trying to find the appropriate electrical signal. Witnessing this, allowed the author to get an outside perspective into how the different professions communicate and collaborate with one another to find a solution.

4.3. **FAT test and the HMI**

Overall the HMI design was well-thought out and the client was satisfied with the proposed pages. The FAT test saw some issues arise within the indication of high or high-high alarms within one of the tank’s water levels. This problem was written down and then the design was adjusted to make sure that the operators were aware of these alarms for that tank. The problem ended up being within the Cicode, a ‘;’ was missing at the end of a line of code and was getting skipped as the high and high-high conditions were met. Most of the time that was spent on the HMI involved re-designing certain pages to include more objects at the client’s and operator’s request.
The switchboard technician also showed great insight into the electrical drawings and how to understand and navigate through them. This was an extremely important learning curve as to be able to read and draw electrical schematics from a switchboard perspective in an important skill to have. The FAT test was a success and only a few minor problems arose, which were adjusted and documented.
5. Pre-Commissioning

Pre-Commissioning refers to the workings of the Clampton gold recovery system that was setup prior to the arrival of the team of Engineers from Power and Control WA. The basis of design of the control system is to minimise the manpower required to operate the gold processing plant, increase the gold recovery and minimise the operating costs. Due to the remoteness of the location, reliability and equipment interchange ability had to be considered before arrival. On arrival, Clampton had a team of mechanics, electricians, drivers, operators and a fully functional gold recovery processing plant. The plant could be run, however without a control system, it would require an extremely large number of people, all working on different parts of the plant as well constantly looking over values from flow-meters, density meters, torque, voltages, currents and water pressure variables.

Several desktop computers, software licences (and backups on HASP keys) as well as backups of the projects were taken to the Clampton mine site to provide redundancy. Licenses can be difficult to setup throughout the network and without backups, if a problem occurs it would be could cost a lot of time to figure out.

5.1. Pre-Commission Testing

The project was set up to exchange data through the network and several tests were undertaken to make sure that the appropriate I/O had been wired correctly into the MCC.

The first test was to toggle certain bits through the HMI to check if the appropriate actions would occur within the field. For example, different valves were tested to see
if they would actually open and close as a result of opening and closing them on the HMI. This indicated that the valves had been wired into the appropriate channels on the PLC and coincides with the I/O list provided by the client. Water was introduced into the system so that flow meters could be checked if they had been calibrated correctly and were sending data back to the PLC on the right channel.

This kind of test also checked that the appropriate motors on the pumps and pipes were in place for the amount of liquid that was flowing. This became apparent when a small motor had been used in an attempt to move more liquid than it could pump, as it began to overheat the HMI displayed a thermo overload fault had been tripped and the motor was replaced for a more appropriate version. This was demonstrated clearly why FAT tests are so important. This particular drive was not missing the thermo-overload relay found during the FAT test, however it was a perfect example of what could happen if information on the health of the drive is not sent back the PLC and then displayed via the HMI. As the drive experienced a thermo-overload fault, an error message popped up indicating what had happened and the drive started flashing in the appropriate colour to display a fault. This issue was able to be dealt with quickly and then the testing could continue. If the design of the HMI was not well thought-out, the fault might have gone undetected and a motor could have burnt out.

Once water was introduced into system, the next tests were for the conveyor belts and then finally the mill. The conveyors had no issues and all belt drifts, lanyards and thermo-overload faults were checked and the HMI reacted as expected. This meant, displaying an error message to the operator, logging the error and indicating on the appropriate pages that an error had occurred as well as the type of error. The final I/O test was for the mill, and when started via the HMI, the current spiked up and yet nothing would move. The Variable Speed Drive (VSD) was checked and found
that had been calibrated incorrectly and needed to have a higher starting torque. The author was told to assist the Instrument Technician on this problem. This meant, looking through the equipment list for a manual on how to calibrate the VSD and then documenting the changes made.

The current readings were able to be read clearly from the HMI and this indicated that the issue was with the mill itself rather than from the PLC. The source of this issue could have taken a much longer time to locate had it not been for the visuals of the VSD controlling the mill’s current readings being displayed on the HMI.

These tests were to check whether the I/O list provided by the client matched the I/O that the Process engineers had coded the PLC to read and write values to. This also tested that the correct methods of error detection could be checked for certain I/O within the HMI. The tests during commissioning of the site include the overall control of the system as well as testing of the sequencing during the start-up and shutdown phases. Once the I/O had been checked, it was documented what channel on the PLC it was located on, if the HMI reacted correctly to values, if errors were detected and specified and if the I/O trended correctly.
6. Commissioning

Commissioning is the final step in this project. It occurs after all of the I/O are tested, properly work and are well documented. Commissioning involves the testing of the control loops as well as the sequences. Once the commissioning of the site is complete, various tests are performed to guarantee the system is fully functional to the specifications of the Control Philosophy. Various documents, such as the I/O list, performance of the system as well as a full functionality report are then handed to the client as they take control of the system. All of these documents are kept as insurance and are strictly confidential.

6.1. Start-up Sequence

This involves setting up the sequence in the PLC as well as setting up a page within the HMI to show the interlocks and permissives as well as any errors that occur. The client wished for a popup to occur that would show the operator the steps involved in the start-up and shutdown sequencing as well as what step the sequence was completing in order to move onto the next.
Figure 20 shows the Start sequence pop-up for the Clampton mine site. It can be seen that each step has an indicator next to it to show if it is ready for the sequence to begin. If the interlocks and permissives are not healthy, then the orange indication signifies that the sequence will not begin. Only once the system is healthy (e.g. all permissives and interlocks are healthy) then the sequence may start. It can also be seen from the right hand side of Figure 20 that each step of the sequence can be seen. Once the sequence starts, each step will highlight an appropriate colour to symbolise what step the sequence is up to, as well as if an error has occurred.

Figure 21, on the following page, displays the start sequence that would be considered healthy. This could also be considered a Super Genie pop up window.
Figure 21. Start Sequence Ready; Clampton

Figure 21 might look simple, the work that it does in the background is immense. The testing of the sequences is also quite time consuming, as if one part of the sequence does not work in the provided time period, it will stop the entire sequence. For example, Conveyor 1 was a piece of equipment that moved the gold filled dirt from a vibrating hopper to the next conveyor. It was found the belt was too strained from the weight of the dirt, and as a result the motor could not rotate. This led to further testing of the start sequence. The conveyor belt was loosened and the dirt began to flow smoothly.

6.2. Shutdown Sequence

The shutdown sequence was almost exactly opposite to the start-up sequence except that it had to be more precise in timing. This was due to the fact that the Clampton gold processing plant utilized enhanced gravitational concentrators to separate the gold particles from the dirt. This process heavily relied on maintaining a certain water pressure as well as a certain speed. If one of these two variables fluctuated then the gold would be lost through to the tailings. During the shutdown
sequence, the two gravitational concentrators had to be ramped down in speed and water pressure so that gold would not be lost during the water dump (water dumped through the gravitational concentrators) for cleaning. The client requested a visual representation of this ramping down of speed and water pressure so that the optimum conditions could be found (e.g. how quickly should each variable ramp down). The shutdown sequence then had to be programmed to focus around the gravitational concentrators. If the shutdown sequence did not work correctly, the water dump that was to clean out the gravitational concentrators would also flush out all of the gold. By creating the visual representation of the water pressure and speed inside these concentrators, it allowed the client to adjust values within the rest of the process accordingly. The timing for the ramp down condition’s optimum value was found after a testing the shutdown sequence a few times. The sequences were then tested repeatedly until the team was satisfied that they worked and were displayed on the HMI correctly.

6.3. Control Loops

The final step would be to make sure that the control loops were correctly worked to the specifications of the Control Philosophy. This was mentioned briefly in the previous paragraph as the speed and water pressure of the gravitational concentrators must remain constant. However this was just one control loop but a complex project of control loops. These were vital to create a process plant that would maximise the gold recovery. The speed of the mill (rotations/min) was another factor, as the gold could be crushed into such a small particle that even the gravitational concentrators could not separate it from the dirt. However if the mill moved too slowly then the concentrators would clog up with too many large heavy particles of dirt and the gold would wash straight through them.
The amount of water to dirt ratio inside the mill was another variable that needed to be controlled. If there was too much water the mill would not produce the correct size reduction. This involved creating a control loop around the conveyor speeds as well as the flow rate into the mill. Each of these control loops was displayed on the HMI to show the operators which variables were being controlled (when in auto mode). There was also a page created to show the trends and how each of the variables reacted to a step up or step down in the system. For example, a step-up in the speed of the conveyor indicated that more dirt was added to the system and therefore the control loops would be required to adjust the level of water being fed into the mill.

The control of loops could be set up in either the PLC or the HMI, however it is very uncommon for a HMI to manually control any variables. This is due to the fact that what is shown on the HMI might not be the raw value. The raw value read by the PLC could be adjusted and then sent to a tag which is read by the HMI. Therefore it is the PLCs role to perform anything control related (at least in this project). Once the client was satisfied that the control loops were functioning at their optimum set points the final tests were undertaken.

6.4. Instrument Technician Work

Whilst on site, the client requested that a water totalizer page be set up within the HMI to allow for the demonstration of water being used within a certain part of the site. With the use of Genies from the Vijeo Citect library, this task relatively quick to complete, from the control systems perspective.

The instrument technician had to install a new flow-meter that was able to be calibrated to send a pulse to the PLC for every \( x m^3 \) of water that flows through it. This meant communicating with different areas as well as filling out the appropriate
documentation to isolate and make sure the pipe was safe to work on. Once the flow-meter was installed, the Instrument list was used to locate the manual. This instrument was then calibrated; this required a meeting with the Process engineer to discuss the pulse width that would be appropriate for the PLC. If the width was too wide, the PLC would always read this pulse as high. Figure 22 shows the manual that was utilised in order to assist the instrument technician in calibrating a flow meter instrument whilst at the Clampton site.

![Figure 22. Manual for Flow-meter](image-url)
6.5. Electrical work

The high voltage electrician demonstrated how the cables would need to be run in order to introduce an air compressor into the system. The goal being to send a receive signals between the PLC and the air compressor and then demonstrate these to the operator’s via the HMI. This meant updating the existing electrical drawings.

Figure 23 is an attempt at introducing an electrical drawing draft of adding an air compressor to a part of the mine site.

![Air Compressor Electrical Drawing DRAFT](image)

This drawing was only a draft and was inspected by the electrician to check its validity. Once the electrical drawings were updated, the HMI was required to have a compressor entered onto the front page of the HMI. This can be found in Figure 24, below.
6.6. Final Tests

A final test was performed to run the process system from the HMI. This involved operators starting the sequences, monitoring and maintaining the run time of the processing plant. The gold recovered by the system was favourable and indicated a high yield due to the control system set point parameters within the HMI. Several entire start-ups and shutdowns were then performed to assess the overall performance of the control system. Supporting documentation for the project is written and produced to the client. This documentation includes an updated Process Control Philosophy and overall system performance summaries. At this point, the client is now in control of the systems performance as well as any alterations to the set points via the HMI.
7. Conclusion

The Clampton mine site is currently using the implemented control system and the client is satisfied with the process results. Although the initial HMI software environment (FactoryTalk View Site Edition) was not used, the fundamental understandings of objects and global objects, helped in the aid of developing skills within the environment that was, Viejo Citect 7.30. The HMI design was robust, efficient and was easy to use by operators. The exposure to both software environments has meant a greater understanding into the development of HMIs for industrial projects. Viejo Citect was utilised as the final decision and this allowed for significant time to grasp the components. As this is a leading software development package that many companies utilise, it is positive to be able to design and implement a HMI within them.

Whilst at the Clampton mine site, time was spent with instrument technicians and high voltage electricians. Although this was only from an observing standpoint, the lessons taught were very practical.

The project’s success can be judged, in part, by satisfaction from the client. The HMI is now implemented at the Clampton mine site and is delivering favourable results.
Works Cited


Appendix


The documentation provided by Rockwell is vast and incredibly detailed. This document was used at the beginning of the project as Factory Talk View, Site Edition, was to be utilised as the HMI Software Development Environment.


This documentation covers the installation and configuration of Schneider Electrics, Vijeo Citect. This dossier was utilised a great deal within the design phase of the project. Its most useful chapters are 3-6 as they cover the requirements and explanations of different steps of installation.


Throughout the design phase, certain phrases such as Genies, Super Genies, Tags and object editing were used by the Process engineer. This document was provided as a reference in case the author did not understand a phrase. This is the technical overview for Vijeo Citect, it is detailed enough to understand parts of the Software but not overly technical that someone reading it would get confused.

This is the follow on from Technical overview dossier. This document outlines to greater detail certain areas of the software environment as well as more in depth details of communication setup.


This is the most in depth document for Vijeo Citect. Totalling nearly 1100 pages, this dossier is provided by Schneider Electric as in depth, incredibly detailed description of the entire Viejo Citect Software. It also explores to a much full extent; networking, communications, hardware and graphics.


This manual was used for the Gravity Concentrators, In order to create the sequencing various details about the ICON gravity concentrators was required. This document was used to calculate the ramp down speed in which the water pressure and speed of the icons was needed to be.


This is the manual that was used for calibrating the Endress+Hauser Flow-meter on the Clampton mine site. It details various ways in which the flow-meter can be configured in order to gain the desired outcome.