University of Southern Queensland
Faculty of Engineering & Surveying

Electrical Training Package for Mining Area C

A dissertation submitted by

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in fulfilment of the requirements of

ENG4112 Research Project

towards the degree of

Bachelor of Electrical Engineering

Submitted: October, 2007
Abstract

Training is of significant importance within the Australian mining industry and is affected by many factors including the ageing workforce, high levels of employee turnover and the current skills shortage, enhanced by the global commodities boom fuelling the mining industry.

This dissertation outlines the design, development, implementation and evaluation of an electrical training package for the Mining Area C Iron Ore deposit operated by HWE Mining in Western Australia. This involved research into training within the Australian mining industry and HWE Mining as well as stakeholder consultation to identify and select the components of the electrical training system.

The development, implementation and evaluation of selected training material highlighted the effectiveness of a site specific training system comprised of on-the-job and simulated theoretical and practical components. The continuation of this process to develop the remaining material will provide significant benefits to the mining operation and its employees in the form of reduced plant downtime, reduced turnover, ongoing employee development and positive reinforcement of a training culture within the organisation. The potential for this training package to be adapted to other disciplines within the organisation has been identified and the ongoing evaluation process will provide a strong basis for such projects.
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I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

M. McKay

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Acknowledgments

I would like to extend my thanks to my supervisor, Mrs Lyn Brodie from the University of Southern Queensland for her guidance and support throughout the year.

Thank you also to my supervisor Mr Gary Waldron and to Mrs Anna Chemello for her assistance and insight into training within HWE Mining.

I would like to thank the electrical department, engineers and management of HWE Mining at Mining Area C for allowing me the time and resources to develop an electrical training system for the site. A special thank you is extended to all the individuals within HWE Mining who provided input and feedback on the training material.

Overwhelming appreciation is extended to my family and friends whose patience and support throughout my studies has not gone unnoticed.

M. McKay

University of Southern Queensland
October 2007
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<td>Australian Institute of Mining and Metallurgy</td>
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<td>AQF</td>
<td>Australian Qualifications Framework</td>
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<tr>
<td>DEST</td>
<td>Department of Education, Science and Training</td>
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<tr>
<td>DET</td>
<td>Department of Education and Training</td>
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<td>DOIR</td>
<td>Department of Industry and Resources</td>
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<td>EEO</td>
<td>Equal Employment Opportunity</td>
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<td>FIFO</td>
<td>Fly In Fly Out</td>
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<td>GDP</td>
<td>Graduate Development Program</td>
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<td>LEO</td>
<td>Learning and Education Online</td>
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<td>MIS</td>
<td>Minerals Industry Survey</td>
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<td>NCVER</td>
<td>National Centre for Vocational Education Research</td>
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<td>NTF</td>
<td>National Training Framework</td>
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<td>Resources and Infrastructure Industry Skills Council</td>
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<td>RTO</td>
<td>Registered Training Organisation</td>
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<tr>
<td>TAFE</td>
<td>Technical and Further Education</td>
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<td>SCADA</td>
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Chapter 1

Introduction

1.1 Overview

HWE Mining is a contract mining company with diversified operations across Australia including Iron Ore, Gold, Nickel, Silver, Lead and Zinc. The company can provide total mining solutions across both surface and underground operations, including processing, handling, rehabilitation and mine infrastructure. HWE Mining became a subsidiary of Leighton Contractors Pty Limited in February 2006.

HWE Mining provides contract mining services to BHP Billiton at the company’s Area C Iron Ore deposit in the eastern Pilbara region of northern Western Australia. This operation involves blasting, digging and haulage operations as well as crushing, processing and train loading facilities. The plant and infrastructure is operated and maintained by HWE Mining. The mine has been operational since late 2003 and has been designed using advanced communications, control and monitoring technology. Consequently, a high level of technical knowledge and proficiency is required to maintain, troubleshoot and upgrade the electrical and control system at the mine.
1.2 Aim

This project aims to investigate and develop a training system that is relevant to electrical plant and systems at Mining Area C. This system will be compatible with existing HWE Mining systems and provide structured in-house electrical training for technicians and engineers. Training material will also become a useful reference tool for electrical maintenance, design and troubleshooting.

The project will involve research into current training systems and trends in the Australian mining industry and investigating the systems currently in use within HWE Mining. Consultation with stakeholders will identify the requirements of the training system and this information combined with the project research will form the basis for developing a suitable training system. Training system materials will then be designed, created and presented to stakeholders for review and evaluation.

1.3 Justification

The electrical and engineering departments at HWE Mining Area C have identified the need to design and implement an electrical training solution for Area C aimed at technicians and engineers. The following factors have influenced this requirement:

- High levels of staff turnover continues to erode the level of technical knowledge and plant specific experience at the operation.
- Lack of technical proficiency that can be directly recruited due to the resources boom and consequent labour shortage of highly skilled workers.
- Excessive time for employees to develop the required technical and plant electrical experience.
- Lack of documentation and electrical training for plant equipment.
- A vulnerable reliance on a select number of key experienced and skilled personnel.
• The imminent expansion of the project to increase production capacity resulting in electrical and technician numbers increasing by 100%.

1.4 Objectives

The project objectives are outlined below:

• Research the current training systems and trends in the Australian mining industry.

• Investigate current HWE Mining training systems.

• Liaise with relevant stakeholders and identify the user requirements for an electrical training system at Mining Area C.

• Identify and develop an electrical training system that meets the requirements identified.

• Design and develop a range of electrical training materials.

• Present completed material to stakeholders and gain feedback on the design and implementation of the system.

• Evaluate and review the developed electrical training package.

1.5 Overview of the Dissertation

This dissertation is organised as follows:

Chapter 2 provides a literature review of training systems and trends within the Australian mining industry.

Chapter 3 outlines the methodology adopted to research, design, implement and evaluate the electrical training system for Mining Area C.
Chapter 4 presents a case study of current HWE Mining training systems and policies.

Chapter 5 outlines the identification of stakeholders, examines the stakeholder requirements and identifies the components selected for the training system.

Chapter 6 outlines the design of the electrical training system for Mining Area C.

Chapter 7 discusses the implementation and evaluation of the training system into the HWE Mining Area C electrical department.

Chapter 8 concludes the dissertation with a discussion of achievements and suggestions for further work.
Chapter 2

Literature Review

2.1 Overview

The Australian mining industry is a well established industry primarily concerned with the exploration and extraction of minerals, oil and natural gas and the associated services provided to these operations. The mining industry contributes significantly to the economic prosperity of Australia and high levels of consumer demand in recent times (Resources and Infrastructure Industry Skills Council 2005). Some of the major mineral resource deposits in Australia include coal, copper, iron ore, gold, aluminium, lead, diamonds, silver, nickel and zinc among others. In terms of training expenditure the Australian mining industry has the highest average annual expenditure per employee, reported as $1643 in 2001/2002 (Resources and Infrastructure Industry Skills Council 2005, p. 72).

Employers in the mining industry are bound by the requirements of the Mines Safety and Inspection Act 1994 and an important component of this act refers to the general duty of care of employers and employees on a mine. The act requires employers to provide information, instructions and training to enable them to perform their work in such a manner that they are not exposed to hazards. The Western Australian Department of Industry and Resources (Department of Industry and Resources 1999) publishes guidelines to the general duty of care in Western Australian mines as they
2.2 Training Trends

relate to the Mines Safety and Inspection Act 1994. This act is relevant across Australia and hence such a guide may be considered an indicator of what is required across the Australian mining industry. The Western Australian Department of Industry and Resources (1999) guidelines state that training should take into account the functions required of each employee and should include:

- Safety and health induction training.
- Industry based training (such as accredited or certified courses).
- Hazard specific training.
- On-the-Job training.
- In-house programs.

2.2 Training Trends

The increasing costs of industrial accidents and incidents along with occupational health and safety (OHS) compliances has seen a strong focus on training in these areas. The priority and trend towards OHS training in the mining industry will remain high, especially with employee turnover and mobility within the industry remaining high (Department of Industry and Resources 1999). Training to meet legislative and OHS safety requirements in the mining industry accounts for a large proportion of training budgets and this may have an influence on the provision of training in other areas.

The technological advancement of the resources industry is ongoing and will continue to support improvements in productivity and workforce rationalisation. Changing technology results in continuous changes in the skills required in the mining industry and the Resources and Infrastructure Industry Skills Council report (2005) reveals that many mining companies are utilising more technically qualified people with TAFE certifications in their operations rather than degree qualified professionals. Training in the use of upgraded technology is costly and many smaller companies do not have the resources and/or capacity to provide adequate training in this area. The nature of
technical skills is that they become obsolete or require updating at a faster rate than generic skills and Dutneall, Hummel, Ridoutt & Smith (2002) argue that the return on investment will tend to be lower than for other types of training.

Growth in labour hire and contract employment has been rapid in Australia and now constitutes over 3% of employment (Liu & Richardson 2006, p. 2). This is supported by the RIISC Industry Skills Report (2005) which identifies a growing trend towards contracting in place of direct employment in the mining industry. Contractors and labour hire employees generally receive lower levels of employer provided training and hence the burden of training is shifted from the employer. The trend towards implementing new technology in the resources industry may be detrimental to contractors and casual workers due to the high cost of training and low levels of training provided by the client (Resources and Infrastructure Industry Skills Council 2005).

Research by Jackson & Mawer (2005) reveals that many small to medium sized Australian companies utilise unaccredited, structured and semi-structured training to a greater extent than accredited training. Statutory and OHS training requirements often involve accredited training although informal training such as on-the-job training is preferred where possible. This same research indicates that the major drivers for formal accredited training consisted of factors external to the company such as OHS, contractual and statutory obligations. This type of training is also driven by licensing requirements such as those relating to tradespeople, mobile equipment and other licensed and controlled skill sets.

In general, Lilly (2006) suggests that there are increased levels of training taking place in the workforce and there is strong indications that employers will be increasing their training effort in the near future.

2.3 Factors Affecting Training

Significant factors that are of relevance to training in the Australian mining industry include:
2.3 Factors Affecting Training

- The ageing Australian and minerals industry workforce.
- The Australian resources and economic boom and the associated skills shortage.
- The accounting view of training as a cost.
- High levels of employee turnover.

2.3.1 Ageing

The Australian demographic is shifting towards an ageing population and the mining industry is reflective of this change. The mining workforce is comprised of a cross-section of employees such as older workers (>45), middle aged workers returning to the industry as well as young inexperienced workers (Kowalski et al. 2001).

Kowalski et al. (2001) reveals that there is very little research into the levels of training and education experiences that are most effective for the ageing mine worker. Similarly, there is little known as to the best way to prepare younger employees for a career in mining. There is no broadly accepted model for transferring experience and knowledge from older to younger workers. Hartley (2006) also expresses concerns relating to the practical knowledge and experience that retiring workers will take with them.

2.3.2 Skills Shortage

The skills shortage influencing the mining industry has been driven by major investments and expansion of mining operations in Australia. This investment has been fueled by the global commodities boom that has increased Australian mineral exports by 32% to $91.8 billion in 2005/2006 (Price Waterhouse Coopers 2006, p. 8). The rapid expansion in production and exports highlighted by a 19% increase in mining employment to 82,588 in 2005/2006 and is expected to grow by a further 4% in 2007 (Price Waterhouse Coopers 2006, p. 9). The medium term employment growth has also been strong with mining employment growing at a rate of 11.0% pa over the past 5 years (SkillsInfo 2006).
2.3 Factors Affecting Training

The increased demand for skilled workers has been partially dealt with by poaching and increased wages within the mining industry (Larkin 2006). This suggestion is supported by the Minerals Industry Survey Report (2006) figures showing labour cost increases of 14% across the mining industry in 2005/2006. Continuous upward pressure on wages is unsustainable in the long term in a competitive global resources industry. Kowalski et al. (2001) suggests that organisations reduce training and under-invest in employee training due to a perceived decrease in the return on investment caused by expected poaching and high turnover. The under-investment in skill development along with weaknesses in available training systems has been identified by the National Centre for Vocational Education Research (NCVER) as a strong contributor to the Australian skills shortage.

The practice of poaching skilled staff and reducing training by mining companies exasperates the industry skills shortage and is an unsustainable and unproductive policy in the long term. Richardson (2004) supports the view that current skills shortages are due to a combination of under-investment in skills development, rapid structural change with low levels of unemployment, surge in mining employment and weaknesses in the available training systems.

2.3.3 Accounting Practices

Human infrastructure is not often viewed as an investment but is recorded and treated as a cost in the general mining industry. Kowalski et al. (2001) argues that treating training in the mining industry as an investment may provide improved performance in regards to safety, productivity and profitability. Treating training as a cost may reduce the overall level of training in an organisation, especially in smaller companies and at mining operations that operate on tight profit margins.

2.3.4 Turnover

Workforce turnover in the mining industry is a major factor affecting the provision of training. Beach, Brereton & Cliff (2003) state that the mining industry experienced
average turnover of 21% annually in 2001/2002. The obligation of employers to provide OHS and statutory training in the mining industry results in a large proportion of training resources being allocated to this requirement, especially when turnover is significant.

There is limited evidence of the turnover rate stabilising at a natural level in the mining industry. Rather it appears that mining employee turnover is affected by site-specific factors. These include:

- Type of roster - shorter roster rotations appear to reduce turnover.
- Level of management commitment to employee training and skills development.
- Creating and maintaining a positive workplace culture.
- Perception of inevitability that current turnover will continue.

Young and new entrants to the mining industry want training to be provided but are often highly mobile within the industry due to high wages and poaching, resulting in increased levels of turnover and reduced return on investment (Resources and Infrastructure Industry Skills Council 2005). Turnover trends also show professionals and management appearing to have higher turnover rates than maintenance and processing workers (Beach et al. 2003).

The costs of high turnover are considerable and involve direct recruitment and training costs. Loss of productivity during the exit and replacement phases of an employee leaving is another cost to consider. In addition, the loss of knowledge and experience as well as the possible interruption to work teams, orientation by existing workers and stalled projects are indirect costs of employee turnover (Beach et al. 2003).

High turnover and continuing instability may contribute negatively to the workplace culture on mine sites, with stressed and under-functioning existing employees affecting new recruits. New employees also take time to reach their full productive capacity. Consequently, high turnover results in the mining operation continually performing below its potential productive capacity. Dutneall et al. (2002) argues that training
that is highly specific, rapidly accomplished and related to new technology or work patterns will be beneficial to an employer, even under tight market conditions with high employee turnover.

Beach et al. (2003, p. 31) estimates that for an open-cut fly in fly out (FIFO) mining operation with 300 employees, turnover costs will exceed $2.8 million annually. Organisations that fail to offer comprehensive training opportunities often experience higher turnover rates.

2.4 Types of Training and Learning

The context of learning is an important factor in developing skills as the majority of adult learners want to know how they will apply what they are learning to the workplace. Kowalski et al. (2001) identifies three learning styles that provide alternatives to traditional models of passive, instructor led training. These include:

Action Learning takes place in the process of finding solutions to problems and hence constitutes a problem solving context.

Situated Learning taught in the contexts in which the information will be used in real life situations.

Incidental Learning embedded in the employees actions and incorporates learning by doing or from mistakes.

Liu & Richardson (2006) suggest that informal learning may provide a greater contribution to the available stock of worker skills than formal instruction undertaken as part of an accredited course.

2.5 Professional Training and Development

The Australian Institute of Mining and Metallurgy (AIMM) report on building professional staff capability in the mining industry (2001) reveals that cost pressures in the
competitive mining industry has resulted in a reduction in professional development programmes due to cost constraints. Further barriers to professional development in the mining industry include limited opportunities due to remoteness, limited numbers of like-disciplined colleagues and limited access to professional seminars, universities, workshops and meetings.

There is little indication that the current shortage of engineers and other skilled professionals will be alleviated in the foreseeable future (Hartley 2006) and hence the limitations on professional development in the mining industry is concerning.

2.6 The Future of Training in the Mining Industry

The RIISC Industry Skills Report (2005) suggests a range of recommendations that the resources industry should adopt in regards to training and include:

- Implementing mentoring partnerships to aid the transfer of skills and knowledge to new entrants and existing employees.
- Introducing paid or subsidised training in and out of work time.
- Treating contractors as permanent employees for training purposes.
- Up-skilling of workers within the industry.
- Increased succession planning and the development of training plans for all employees.
- Using simulators where possible to reduce the impact of on site training that may utilise productive and expensive equipment.
- Develop specific training programs to fit individual organisational or site requirements.
- Increasing on-the-job training and developing more internal training and professional development.
Dawe (2003) provides insight into what factors contribute significantly to successful training practices in Australian firms. The main factors identified include an organisational culture that supports learning, mechanisms to link training to business strategy and mechanisms to link training to workplace change. These findings are particularly relevant to the mining industry due to the rapid technological and structural changes that are typical of this dynamic and competitive global industry.

Other factors identified by Dawe (2003) that should be considered by the mining industry to improve training practices moving forward include:

- Increasing the diversity of training and learning approaches.
- Sourcing formal training from within the organisational itself.
- Adopting accredited training, possibly linked to the National Training Framework.
- Increasing the use of informal training.
- Decentralising the training within the organisation.
- Responding to the needs of the individual.
- Evaluate the training provided.
Chapter 3

Methodology

3.1 Overview

This chapter outlines the methodology adopted to research, develop and implement the electrical training package at Mining Area C. The following sections provide a brief overview of how each stage of this project was undertaken.

3.2 Mining Research

Research into existing training and trends within the Australian mining industry was undertaken to establish a broad overview and understanding of the scope and utilisation of training within the industry. The identification of trends and influences as well as the future direction of training in the industry was the primary focus of this research. It is expected that this information will provide a benchmark to evaluate HWE Mining’s training systems and assist in the development of an electrical training system at Mining Area C.
3.3 HWE Mining Case Study

The evaluation of HWE Mining’s current training systems involved a number of steps. Reviewing current documentation and training policies available on the company intranet and forming a broad understanding of the facilities, tools and policies constitutes the initial stage. The second stage involved consolidating this information and seeking greater depth and clarification from HWE staff within the training department through research interviews. This also helped identify the future direction and development of training within the company. A research interview guide was developed to assist with this process and is provided in Appendix B. The final stage involved evaluating the company’s training systems overall and drawing comparisons to the previous research outlining the Australian mining industry in general.

3.4 System Requirements

The system requirements were identified by assessing the electrical training needs of the minesite and consulting with stakeholders within the company. These stakeholders included electrical and engineering staff, the maintenance superintendent, operations manager and site training coordinator. A training need analysis was undertaken which addressed areas such as business objectives, training justification, task analysis and content analysis. Once these system requirements were finalised the components, materials and delivery methods were identified, reviewed and selected for development. The selection process also involved the relevant stakeholders.

3.5 System Design

The design of the training system materials involved the planning and creation of each component selected for inclusion as a result of the system requirements identification process. This involved determining the structure of each component, considering assessment and delivery methods, selecting the detailed content to be included and developing a training plan for potential trainees.
The materials consisted of templates, assessments and training aids. All the training material and simulation equipment was designed, written, built and tested by the author of this thesis and these materials needed to adhere to HWE Mining document standards. The material was then reviewed by stakeholders and submitted to the HWE Mining training department and quality assurance officer as required by the HWE Mining Training and Skills Development Policies and Procedures Manual.

3.6 System Implementation

Once approved for use by the training department the training material was presented as a package to the electrical, engineering and management stakeholders. This presentation provided an overview of what had been developed, how the training system would be utilised and outlined how the system would be implemented and evaluated. The training system was then implemented and training provided to a number of electricians and engineers.

3.7 System Evaluation

HWE Mining training evaluation forms (Appendix C) were used to capture feedback from trainees. Specific feedback was sought on the effectiveness of each system component, trainee satisfaction, training content and whether trainees felt they had benefited from the training. This feedback was evaluated and a number of conclusions and recommendations were made in respect to the strengths, weaknesses and possible improvements of the training system.
Chapter 4

Case Study: HWE Mining

4.1 Company Overview

HWE Mining is a contract mining company operating within the Australian and New Zealand mining sector. The company employs over 1800 people across its iron ore, gold, nickel and coal mining operations. Mining services delivered by HWE Mining include:

- Surface and underground mining.
- Processing and handling.
- Closure and rehabilitation.
- Mine infrastructure.

4.2 Methodology

This case study aims to provide an overview of HWE Mining training policies, systems and programs. The company’s approach to training and professional development will be highlighted and compared to the mining industry trends and recommendations identified from the previous literature review.
This case study has been developed through a review of the HWE Mining Learning and Skills Development Policies and Procedures Manual (2006), HWE Mining SiteSafe Training Manual Guide, HWE Technical Training Policies and Procedures Manual and the HWE intranet. Research interviews with the HWE Training Superintendent, Staff Development Officer and Training Coordinator enabled a broad understanding of training within the organisation to be developed and this enhanced the information obtained through reviewing company documentation. The research interview guide developed for these interviews is provided in Appendix B.

The final stage of this case study compares the direction of the HWE Mining training system to the general training trends identified within the mining industry and assesses to what extent the company has implemented the training recommendations identified by the literature review.

4.3 Training Overview

The HWE Mining Learning and Skills Development Policies and Procedures Manual states that the company 'is committed to developing and recognising the skills of all its employees' and believes that 'learning is all about providing employees with skills, knowledge and understanding of a job task in order to satisfy the competency standard and job requirements'.

HWE Mining has developed and is currently implementing an integrated training system to manage training within the business. The following key elements of the HWE Mining training system have been summarised from the Learning and Skills Development Policies and Procedures Manual:

- Delivery and assessment of training that supports the operation of a safe, productive and efficient workplace in accordance with Occupational Health and Safety (OHS), Mining Acts, Regulations, Code of Practice, Advisory Standards and other relevant legislative requirements.
- Nationally endorsed competency standards and course curricula to enable HWE
employees to meet agreed industry standards and ensure they are appropriately qualified and trained to operate safely, productively and competently.

- Training priorities based upon business goals, identified skill shortages and the commitment of all employees to on-going, relevant skills development.

- Quality assurance measures that support the sharing of training material, delivery and assessment resources to minimise the duplication and/or unnecessary re-training of employees between sites.

- The flexibility to recognise and respond to organisational constraints, provide for differing individual learning preferences and the varied training requirements of diverse and remote locations.

- Cost effective training delivery and assessment utilising existing HWE infrastructure, resources and expertise for the design and delivery of training where possible.

- The contracting of Registered Training Organisations (RTO’s) for the delivery of technical, safety, professional and industry training package qualifications as required.

- The capacity to respond to the identified training priorities at a regional and site level.

In general, HWE Mining management appears to support the development of a strong training culture and the company’s policies and procedures are reflective of such an aim. The development of such a culture and the degree to which training is implemented within the workforce varies between sites however and is dependant upon the willingness of site based management at all levels to drive and support such a culture.

Technical, vendor and development training at any specific HWE operation is directly related to the site management’s support for training and whether such training is relevant to business needs. Contract mining is highly sensitive to operational profits and cost pressures have a large influence on training provisions on a site-by-site basis.

Operational and maintenance employees are generally provided with on-the-job training
that relates specifically to the tasks required of their job. Site based procedures, training
and assessment materials are used to provide this training. The majority of site based
training and assessment materials focus on mobile equipment with minimal structured
or formal training for maintenance and technical employees. This is an area of potential
improvement within the HWE Mining training system.

HWE Mining sub-contractors and employees employed on a contract basis such as
labour hire employees must have the relevant qualifications, training and experience
before beginning employment with the company. The Learning and Skills Development
Policies and Procedures Manual stipulates that HWE sub-contractors must undertake
training at their own expense. This generally applies to external or accredited training
only as HWE Mining has a statutory obligation to provide relevant operational and
OHS training such as inductions, equipment assessments, company procedures and
other safety based training to all employees, including contractors.

4.4 Centralised Training Database

HWE Mining has implemented a centralised training database system to store and
record employee training information. The SiteSafe Safety and Training Database
provides all HWE operations with access to historical and current information on all
employees within the organisation. The database is accessed using the company intranet
and can provide the following reports:

**Individual Training Plans** compare what skills a person has against the skills re-
quired for a particular job and can be used to identify training gaps or require-
ments for individuals.

**Training Certification** identifies which employees are certified to operate a piece of
equipment or undertake a specific mining activity.

**Training Course Listing** lists all training activities both internal and external that
is registered on the database.

**Training Licence** provides a list of employees with licences over a given period of
4.5 Training Delivery

A variety of delivery methods are used to provide training across the organisation and include internal training, external training, on-the-job training and e-learning applications. The internal training undertaken by the company consists of both formal training such as development workshops and theory assessments as well as informal training such as on-the-job instruction and learning. External registered training organisations (RTO) are contracted to deliver specific training and assessment to meet nationally accredited qualifications where applicable.

A number of e-Learning programs are being utilised to provide online learning and assessment to employees in regards to workplace relations and statutory compliance. The ongoing development and implementation of e-Learning within HWE Mining is a highly effective means of standardising training across a large number of remote locations within Australia and New Zealand.

HWE policy requires that only qualified workplace assessors and/or trainers who are competent in the tasks being assessed may deem a trainee competent. The company provides relevant training towards the Certificate IV Training and Assessment qualification to those people utilised as workplace trainers and assessors.

4.6 Professional Development

HWE Mining demonstrates a commitment to improving the leadership and technical performance of its employees. Training needs of staff are identified through regular performance reviews and development strategies within HWE Mining include mentor-
ing, providing on-the-job training, self education support and training and development programs.

Training and development initiatives being implemented within the company include:

- Graduate development program.
- Safety leadership program.
- Leading effective teams program.
- Human resources management program.
- Time and self management program.

Each of these development programs is outlined in the following sections.

### 4.6.1 Graduate Development Program

The company views the graduate development program (GDP) as a key recruitment and development initiative to provide an ongoing selection of professionally qualified people to meet the needs of the business. The program aims to provide graduates with opportunities to acquire the knowledge, skills and judgement to manage the human, information, financial and physical resources of the company. The program is similar in scope and implementation to other GDP’s in use within the Australian mining industry.

### 4.6.2 Safety Leadership Program

The safety leadership program developed by HWE Mining aims to prepare and provide HWE employees with the skills and knowledge to effectively manage safety and safety systems in the workplace. It has been designed to meet three units of competence from the Metalliferous Mining Training Package (MNM05) and relationships with RTO’s ensure that participants are issued with Statements of Attainment for the following competencies:
4.6 Professional Development

- MNMG325A Apply Risk Management Processes
- MNMG327A Communicate Information
- MNMG326A Conduct Safety and Health Investigations

4.6.3 Leading Effective Teams

This program is another leadership program designed by HWE Mining to support professional development and is linked to one unit of competence in the Certificate IV Frontline Management qualification. Once again, a Statement of Attainment is issued to participants in the following recognised competence:

- BSBFLM512A Team Effectiveness

4.6.4 Human Resources Management Program

Similar to the safety leadership program, the HR management program was developed by HWE Mining to provide employees with the skills and knowledge to manage people and systems in the workforce. This program focuses on tools, strategies and company systems that can be used on the frontline in day-to-day operations and has been aligned with two units of competence from the Certificate IV Frontline Management qualification. Statements of Attainment are issued by RTO’s for the following nationally recognised competencies:

- BSBFLM503B Effective Workplace Relations
- BSBFLM514A Manage People

4.6.5 Time and Self Management Program

This program is another leadership program designed by HWE Mining to support professional development and is linked to one unit of competence in the Certificate IV
Frontline Management qualification. Once again, a Statement of Attainment is issued to participants in the following recognised competence:

- BSBCMN402A Develop Work Priorities

4.7 Training Initiatives

In addition to the professional development programs developed and implemented, HWE Mining currently has a range of training initiatives and policies in place to enhance training and recruitment in the organisation. These are outlined briefly below.

4.7.1 Safety Trainee Coordinator Program

HWE Mining recently initiated a new program that recruited ten employees to become trainee safety coordinators. These trainees were selected from existing positions within the organisation and will be provided with an opportunity to gain skills in OHS, communication and leadership. Individual training plans are prepared for each participant to ensure program goals and development objectives are achieved.

4.7.2 Self Education Policy

The self education policy in place within the organisation provides the opportunity and support to employees who wish to develop themselves in line with organisational needs. Education assistance is available for courses that lead to a nationally recognised qualification under the Australian Qualifications Framework (AQF).

4.7.3 Apprenticeships and Traineeships

HWE Mining employs apprentices and trainees across a range of disciplines and the administration of these programs is based upon the HWE Mining Technical Training
Policies and Procedures Manual. The policies presented in this document also address the utilisation of post-trade training for senior tradespeople and team leaders within the organisation.

**4.7.4 Learning and Education Online Program**

Learning and Education Online (LEO) is an online learning and assessment tool that HWE Mining utilises to provide employees with training in workplace relations to ensure that company policies and procedures are understood and that employees are aware of the legal obligations and best practice principles of the business. Areas of online training using this system include performance management, union right of entry, workplace relationships, EEO, Harassment, Discipline and Termination.

**4.7.5 Self Administered Legal Training Program**

This program is an online legal compliance training program that HWE Mining uses to provide staff with information on compliance issues within the workplace and enables an employees understanding of these issues to be monitored through testing and reporting. Online sessions may be accessed at a convenient time to the employee and also serves as evidence that HWE Mining employees are being trained and understand compliance issues relating to the workplace and the mining industry. This program addresses areas such as sexual harassment, discrimination, workplace investigations, workplace bullying, harassment, email and internet use.

**4.8 Training Evaluation**

HWE Mining implements a training evaluation process as outlined in relevant training policies and procedures. Evaluations are undertaken randomly on both internal training and external training and serve to provide the trainee and trainer with feedback in terms of the quality of training received and areas for possible improvement.
HWE leadership programs such as the Human Resources Management and Safety Leadership programs require daily evaluation forms to be completed to provide continual assessment of the course effectiveness and to gather general comments. The e-Learning programs also provide a mechanism for feedback and participants are encouraged to take advantage of this functionality.

4.9 Comparison to Research Recommendations

HWE Mining has developed a number of strategies that positively align with the recommendations identified through research into training in the mining industry. Many of these training initiatives and policies have been implemented recently and the contribution and effectiveness towards building a successful training system and culture is hard to assess.

The development of formal training programs from within the business and the alignment of this training to the national training framework are positive strategies. The ability to evaluate the training provided to employees is also an important feature of the HWE Mining training system. The increasing diversity of training and learning approaches enhances the company’s training flexibility and effectiveness. The mix of formal, informal, internal, external, online and on-the-job training offers significant potential for the company to provide training and systems that meet business needs.

The centralised training database appears to conflict with research recommendations to decentralise training within organisations. This is deceiving however as training requirements and delivery is organised individually by each mining operation. The training database, policies and procedures are used to standardise the training practices and records of any training that each site undertakes.

The needs of individual employees are addressed through regular performance reviews and the development of training plans. Performance reviews provide an opportunity for employees to express their development and training aspirations and for the company to match these to business needs. HWE Mining provides self education support to individuals and this strategy aligns itself to the research recommendation of providing
4.9 Comparison to Research Recommendations

paid or subsidised training in and out of work time.

There are a number of areas where HWE Mining could make improvements in line with research recommendations. The development of specific training programs to fit individual site requirements is undertaken to some degree for operations although site based maintenance and technical training programs are minimal. The development of such internal training programs may provide valuable upskilling to existing employees at a minimal cost to the company. These programs may also be utilised to train sub-contractors where appropriate, allowing contractors to fulfill business requirements more effectively while contributing to the overall knowledge base of employees within the industry.

Another recommendation involves utilising simulators where possible to reduce the impact of site based training on using productive equipment. There is currently minimal training of this type within the business and this strategy may have high potential for specific applications such as plant control systems and mobile equipment.
Chapter 5

System Requirements

5.1 Overview

Identification of the electrical training system requirements involved consultation with the relevant stakeholders and the development of a basic training needs analysis for the electrical department. The criteria was developed with input from the following stakeholders:

- Electrical Supervisor.
- Electrical Technicians.
- Electrical Engineers.
- Maintenance Superintendent.
- Ore Handling Plant Manager.
- HWE Training Coordinator.

The electrical training system was also required to be compatible with the existing HWE Mining training system and have the flexibility to be adopted across a range of HWE Mining operations as required.
5.2 Training Needs Analysis

Training needs analysis is undertaken on an individual basis within the company through the use of regular performance reviews. This method of training identification is limited in that it may identify training requirements and future development needs for individual employees but does not provide an outline of the overall training requirements for the electrical department.

The general training needs analysis undertaken for the electrical department addressed a number of criteria including:

- Business objectives.
- Justification.
- Task analysis.
- Content analysis.
- Training suitability.

5.2.1 Business Objectives

HWE Mining aims to provide a total mining solution to clients while maintaining the highest standards of safety, quality and environmental behaviour. The overall quality of service provided to clients is the determining factor in the ongoing success of the company. The company’s operational revenue and professional reputation relies upon the effectiveness of its employees and management to meet client requirements.

The efficient and productive operation of the processing plant at Mining Area C is an important factor in the ongoing fulfillment of HWE business objectives. Optimal plant availability and utilisation is achievable through maintaining a highly motivated and competent workforce. The objective of the HWE electrical department at Mining Area C is to develop and maintain a highly skilled, motivated and competent work
5.2 Training Needs Analysis

5.2.2 Justification

Justification for the development of an electrical training package for Mining Area C has been presented earlier in this thesis. The main points have been summarised below:

- High levels of staff turnover continues to erode the level of technical knowledge and plant specific experience at the operation.
- Lack of technical proficiency that can be directly recruited due to the resources boom and consequent labour shortage of highly skilled workers.
- Excessive time for employees to develop the required technical and plant electrical experience.
- Lack of documentation and electrical training for plant equipment.
- A vulnerable reliance on a select number of key experienced and skilled personnel.
- The imminent expansion of the project to increase production capacity resulting in electrical and technician numbers increasing by 100%.

5.2.3 Task Analysis

The task analysis outlines the general tasks undertaken by specific groups within the electrical department. Table 5.1 has been developed to identify the electrical skill set relating to plant and systems at Mining Area C and the depth of training required for electrical employees.
<table>
<thead>
<tr>
<th>Skill Description</th>
<th>Employee</th>
<th>Frequency</th>
<th>Training Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide technical support to technicians and electrical supervisors.</td>
<td>Engineer</td>
<td>Frequent</td>
<td>High</td>
</tr>
<tr>
<td>Provide technical support to operations and maintenance personnel.</td>
<td>Engineer / Technician</td>
<td>Frequent</td>
<td>High</td>
</tr>
<tr>
<td>Completion of scheduled electrical maintenance on electrical plant and equipment.</td>
<td>Technician</td>
<td>Frequent</td>
<td>Low</td>
</tr>
<tr>
<td>Service and maintain High Voltage reticulation, motors and switching equipment.</td>
<td>Technician</td>
<td>Common</td>
<td>Medium</td>
</tr>
<tr>
<td>Troubleshoot and maintain control system equipment including PLC, SCADA and electronic relays.</td>
<td>Engineer / Technician</td>
<td>Common</td>
<td>High</td>
</tr>
<tr>
<td>Troubleshoot and maintain plant instrumentation including weightometers, encoders, pressure transmitters, ultrasonic detectors, metal detectors, vibration monitoring equipment, etc.</td>
<td>Technician</td>
<td>Common</td>
<td>Medium</td>
</tr>
<tr>
<td>Troubleshoot and maintain VVVF drives and soft starter equipment.</td>
<td>Engineer / Technician</td>
<td>Occasional</td>
<td>Medium</td>
</tr>
<tr>
<td>Design and implement PLC and SCADA (Citect) modifications.</td>
<td>Engineer</td>
<td>Occasional</td>
<td>High</td>
</tr>
</tbody>
</table>
5.2.4 Content Analysis

A number of essential features for the proposed electrical training system have been identified and are outlined below:

- Materials and training must adhere to the guidelines provided in the HWE Mining Learning and Skills Development Policies and Procedures Manual.

- Training material and content shall be expandable as required.

- Training must be relevant to the plant and systems at Mining Area C.

- The system must provide structured training for employees.

- Training shall have minimal impact on plant production and availability.

- Competence shall be assessed and training records maintained.

- Training materials and development templates shall be quality assured and available on the HWE Mining Intranet.

- Training and reference materials shall be easily accessible to employees for troubleshooting, reference and design purposes.

- Training shall be flexible to accommodate operational requirements and allow for review and expansion of training content.

- Training shall have minimal impact on plant production and availability.

- Competence shall be assessed and training records maintained.

5.3 System Components

The following training elements and tools were selected for inclusion in the electrical training system. The system has been designed to address the issues identified in the training needs analysis and an overview of each is provided below.
5.3 System Components

5.3.1 Reference Folders

A range of reference folders will be created to provide a centralised source of relevant plant and system information for electrical engineers and technicians. The information available will include plant descriptions, procedures, troubleshooting guides, drawings, area specific training material and other relevant material.

5.3.2 Troubleshooting Guides

A range of electrical troubleshooting guides for major areas of the plant will be developed as a troubleshooting aid for technicians in breakdown situations. The utilisation of these guides will reduce the overall level of downtime associated with inexperienced personnel attempting to investigate and rectify electrical faults.

This also provides an opportunity to capture the experience and knowledge of senior technicians and engineers currently on site. This should enable a portion of the knowledge held by these valuable individuals to be retained when they leave the organisation.

5.3.3 Training Modules

Training modules will be created to introduce employees to the plant and electrical systems at Mining Area C. The modules will have a theoretical classroom component in the form of a presentation and assessment. This will serve as a precursor to a practical familiarisation and competency assessment.

5.3.4 Control System Simulation

A control system hardware simulator will be designed and built to enable trainees to develop practical skills and familiarisation with site equipment. This will enable a rapid transition from inexperienced to competent technician while having minimal impact on the operation and availability of the plant. Structured practical exercises will be developed based upon the equipment installed on the training rack. Availability of
templates will allow for the expansion of the simulator and exercises as plant technology changes or expands.

5.3.5 Training Matrix

All employees within HWE Mining are represented on site-based training matrices that the training department use to record and identify training requirements. Electrical engineers and technicians will have their training matrices extended to include the electrical training modules and simulator practical exercises developed for Mining Area C.

An electrical training plan template will also be created to provide guidance and structure to the individual development of electrical employees at Mining Area C.
Chapter 6

System Design

6.1 Overview

The Mining Area C Electrical Training System has been designed to provide a structured training pathway for engineers and technicians at Mining Area C. This chapter outlines the design of the electrical training system and provides a detailed rationale and description of each system component. The training system has been designed in line with the HWE Mining Learning and Skills Development Policies and Procedures Manual (PC-TR-6000) and provides a range of internal development training with the flexibility for expansion as required.

The development of electrical employees to a competent level as quickly as possible, is an important factor in maximising plant availability and utilisation at HWE Mining operations. This training system provides a guide for the development of individuals within the organisation, with the aim of obtaining a high level of plant familiarisation and technical skill in regards to electrical plant, systems and troubleshooting at Mining Area C.

The electrotechnology industry within Australia is integrated with the Australian Qualifications Framework (AQF). Engineers and licensed electricians are already awarded with qualifications within this framework and achievement of a higher qualification...
6.2 Electrical Reference Folders

is based upon the attainment of technical and generic competencies that are not site specific to Mining Area C. The need for HWE Mining to provide specific training on site equipment and systems does not align itself directly to the attainment available qualifications within the AQF. Such qualifications are in fact a prerequisite for the participation in the HWE Mining electrical training system at Mining Area C.

The electrical training system consists of the following components:

- Electrical Training System Overview and Implementation Overview.
- Electrical Simulation Overview.
- Electrical troubleshooting guides.
- Electrical training modules.
- Electrical reference folders.
- Templates for development of further materials.

The Mining Area C Electrical Training System Overview and Implementation Guide (Appendix D) is a controlled document available on the HWE Mining intranet and provides an overview of the system scope and components. This document is intended as a guide for supervisors and management to utilise and implement the electrical training system effectively.

6.2 Electrical Reference Folders

6.2.1 Overview

The electrical reference folders are designed to provide electrical engineers and technicians with a convenient source of relevant plant and system information. This information may be utilised to assist troubleshooting as well as aiding design and maintenance tasks on the mine site.
6.2 Electrical Reference Folders

6.2.2 Selection

The selection of areas to be covered by the electrical reference folders took into consideration the complexity of the plant and the intention that the folders would be used to provide quick and easy access to plant and electrical information. Table 6.1 provides an index of the electrical reference folders developed:

Table 6.1: Reference Folders

<table>
<thead>
<tr>
<th>Electrical Reference Folder</th>
<th>Doc. Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Reference Volume 1: Power Distribution System</td>
<td>Folder</td>
</tr>
<tr>
<td>Electrical Reference Volume 2: Control System</td>
<td>Folder</td>
</tr>
<tr>
<td>Electrical Reference Volume 3: Crushing and Screening</td>
<td>Folder</td>
</tr>
<tr>
<td>Electrical Reference Volume 4: Stackers</td>
<td>Folder</td>
</tr>
<tr>
<td>Electrical Reference Volume 5: Reclaimer</td>
<td>Folder</td>
</tr>
<tr>
<td>Electrical Reference Volume 6: Train Load Out</td>
<td>Folder</td>
</tr>
<tr>
<td>Electrical Reference Volume 7: Sampling</td>
<td>Folder</td>
</tr>
<tr>
<td>Electrical Reference Volume 8: Electrical Standards and Regs</td>
<td>Folder</td>
</tr>
<tr>
<td>Electrical Reference Volume 9: Instrumentation</td>
<td>Folder</td>
</tr>
<tr>
<td>Electrical Reference Volume 10: Infrastructure</td>
<td>Folder</td>
</tr>
<tr>
<td>Electrical Reference Volume 11: Water Systems</td>
<td>Folder</td>
</tr>
</tbody>
</table>

6.2.3 Layout

Red lever arch folders were selected for use with an appropriate identification label attached. The content was presented in sections with an index to support efficient navigation to the required information. A DVD was also included within the folders to enable the storage of relevant information that was too voluminous to be included in a hard copy format. This electronic reference allows the storage of large amounts of information that can be accessed as required such as equipment manuals and engineering drawings.
6.2.4 Content

The information included in each of the reference folders varied based upon the subject matter of the individual folder. In general, the following items were included where applicable:

- Troubleshooting guides.
- Functional descriptions of plant.
- Electrical training manuals.
- Relevant drawings.
- Vendor manuals.
- Datasheets.

Figure 6.1: Electrical Reference Folders
6.3 Troubleshooting Guides

6.3.1 Overview

The electrical troubleshooting guides are an important component of the overall electrical training system and serve as a valuable tool to reduce electrical downtime in the event of equipment faults. A template has been created to enable the expansion and creation of electrical troubleshooting guides with a consistent format. One of the electrical troubleshooting guides has been included in Appendix E to demonstrate the structure, content and style of the guides. These documents are available on the HWE Mining intranet and may be utilised by other HWE Mining operations to create their own specific guides. Table 6.2 outlines the troubleshooting guides that have been developed as part of the Mining Area C electrical training system.

Table 6.2: Electrical Troubleshooting Guides

<table>
<thead>
<tr>
<th>Troubleshooting Guide</th>
<th>Doc. Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Troubleshooting Guide Template</td>
<td>TS1270-01</td>
</tr>
<tr>
<td>Crushing Electrical Troubleshooting Guide</td>
<td>TS1270-02</td>
</tr>
<tr>
<td>Stackers Electrical Troubleshooting Guide</td>
<td>TS1270-03</td>
</tr>
<tr>
<td>Reclaimer Electrical Troubleshooting Guide</td>
<td>TS1270-04</td>
</tr>
<tr>
<td>Power Systems Electrical Troubleshooting Guide</td>
<td>TS1270-05</td>
</tr>
<tr>
<td>Control Systems Electrical Troubleshooting Guide</td>
<td>TS1270-06</td>
</tr>
<tr>
<td>Sampling Electrical Troubleshooting Guide</td>
<td>TS1270-07</td>
</tr>
<tr>
<td>TLO Electrical Troubleshooting Guide</td>
<td>TS1270-08</td>
</tr>
</tbody>
</table>

6.3.2 Design

These troubleshooting guides have been designed to provide quick reference in a breakdown situation and have been developed with a quick reference contents that identifies problems by equipment and specific fault. Each electrical fault included within the
6.3 Troubleshooting Guides

guide consists of the following sections:

**Description** provides an overview of the fault and the conditions under which such a fault may occur.

**Action** provides specific guidance to help rectify the problem through the use of descriptions or process flowcharts.

**Forcing** outlines the conditions under which this fault or alarm may be bypassed and the necessary steps to achieve such a state.

### 6.3.3 Content

The content of the troubleshooting guides was selected based upon the fault history of the plant and the experience of technicians on the mine site. Specific information relating to each fault was derived through interrogation of plant schematics, the PLC system and the Supervisory Control and Data Acquisition (SCADA) system. This information was reviewed and supplemented through consultation with technicians and engineers at Mining Area C.

![Figure 6.2: Electrical Troubleshooting Guides](image)
6.4 Training Modules

6.4.1 Overview

The core training material for this system has been presented as a series of electrical training modules to introduce electrical employees to the plant and electrical systems at Mining Area C. Training modules include a theoretical classroom component supported by a presentation and theory assessment. This will serve as a precursor to a practical familiarisation and competency assessment.

6.4.2 Design

The HWE Mining training department has theory and practical assessment templates available that have been utilised to develop the assessment material for the electrical training system. This has enabled the material to be consistent with existing HWE Mining training material. The full listing of the training module material developed for the electrical training system is outlined in Table 6.3.

The material listed in Table 6.4 has been completed by the author of this thesis as part of this project and has been included in the appendix as stated. The material presented in each of these training modules has been produced from a range of sources including:

- Vendor manuals.
- Electrical technicians.
- Production and maintenance personnel.
- Plant functional descriptions.
- Electrical and process drawings.
- Interrogation of the PLC and SCADA systems.
Table 6.3: Electrical Training Module Materials

<table>
<thead>
<tr>
<th>Document Description</th>
<th>Doc. Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Module 1: Power Systems</td>
<td>TR1270-201</td>
</tr>
<tr>
<td>Electrical Module 1: Power Systems Theory Assessment</td>
<td>TR1270-202</td>
</tr>
<tr>
<td>Electrical Module 1: Power Systems Practical Assessment</td>
<td>TR1270-203</td>
</tr>
<tr>
<td>Electrical Module 1: Power Systems Master Answers</td>
<td>TR1270-204</td>
</tr>
<tr>
<td>Electrical Module 2: Control System</td>
<td>TR1270-205</td>
</tr>
<tr>
<td>Electrical Module 2: Control System Theory Assessment</td>
<td>TR1270-206</td>
</tr>
<tr>
<td>Electrical Module 2: Control System Practical Assessment</td>
<td>TR1270-207</td>
</tr>
<tr>
<td>Electrical Module 2: Control System Master Answers</td>
<td>TR1270-208</td>
</tr>
<tr>
<td>Electrical Module 3: Crushing and Screening</td>
<td>TR1270-209</td>
</tr>
<tr>
<td>Electrical Module 3: Crushing Theory Assessment</td>
<td>TR1270-210</td>
</tr>
<tr>
<td>Electrical Module 3: Crushing Practical Assessment</td>
<td>TR1270-211</td>
</tr>
<tr>
<td>Electrical Module 3: Crushing Master Answers</td>
<td>TR1270-212</td>
</tr>
<tr>
<td>Electrical Module 4: Reclaimer and Stackers</td>
<td>TR1270-213</td>
</tr>
<tr>
<td>Electrical Module 4: Reclaimer and Stackers Theory Assessment</td>
<td>TR1270-214</td>
</tr>
<tr>
<td>Electrical Module 4: Reclaimer and Stackers Practical Assessment</td>
<td>TR1270-215</td>
</tr>
<tr>
<td>Electrical Module 4: Reclaimer and Stackers Master Answers</td>
<td>TR1270-216</td>
</tr>
<tr>
<td>Electrical Module 5: TLO</td>
<td>TR1270-217</td>
</tr>
<tr>
<td>Electrical Module 5: TLO Theory Assessment</td>
<td>TR1270-218</td>
</tr>
<tr>
<td>Electrical Module 5: TLO Practical Assessment</td>
<td>TR1270-219</td>
</tr>
<tr>
<td>Electrical Module 5: TLO Master Answers</td>
<td>TR1270-220</td>
</tr>
<tr>
<td>Electrical Module 6: Sampling</td>
<td>TR1270-221</td>
</tr>
<tr>
<td>Electrical Module 6: Sampling Theory Assessment</td>
<td>TR1270-222</td>
</tr>
<tr>
<td>Electrical Module 6: Sampling Practical Assessment</td>
<td>TR1270-223</td>
</tr>
<tr>
<td>Electrical Module 6: Sampling Master Answers</td>
<td>TR1270-224</td>
</tr>
<tr>
<td>Electrical Module 7: Infrastructure</td>
<td>TR1270-225</td>
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<tr>
<td>Electrical Module 7: Infrastructure Theory Assessment</td>
<td>TR1270-226</td>
</tr>
<tr>
<td>Electrical Module 7: Infrastructure Practical Assessment</td>
<td>TR1270-227</td>
</tr>
<tr>
<td>Electrical Module 7: Infrastructure Master Answers</td>
<td>TR1270-228</td>
</tr>
</tbody>
</table>
6.5 Simulation Equipment

6.5.1 Overview

The Area C Control and Plant System Simulation System has been designed to aid in providing training and familiarisation with the control system and electronic plant equipment at Mining Area C. It is envisioned that technicians and engineers can utilise the equipment through a range of tasks that may be directed, self-paced and/or experimental. The system may also be utilised for testing of faulty or suspect equipment.

The control system hardware simulator was designed, built and tested by the author of this thesis and enables a rapid transition from inexperienced to competent technician while having minimal impact on the operation and availability of the plant. Structured practical exercises have been developed based upon the equipment installed on the training rack. Availability of templates will allow for the expansion of the simulator and exercises as plant technology changes or expands.

The system is designed to provide interaction with the following plant equipment:

- Schneider Momentum PLC.
- Schneider Quantum PLC.
- Simicode electronic motor protection and control relays.
- Profibus cabling, active terminators and connections.
- Ethernet communications.

<table>
<thead>
<tr>
<th>Table 6.4: Completed Electrical Training Module Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Module 2: Control System</td>
</tr>
<tr>
<td>Electrical Module 2: Control System Theory Assessment</td>
</tr>
<tr>
<td>Electrical Module 2: Control System Practical Assessment</td>
</tr>
<tr>
<td>Electrical Module 2: Control System Master Answers</td>
</tr>
</tbody>
</table>
6.5 Simulation Equipment

- ABB Variable Speed Drive interface and software.

The Mining Area C Electrical Control and Plant Simulation Equipment Overview document provided in Appendix J was written to provide an overview of the training hardware and training material that has been designed, built and tested. This document is intended for use by supervisors and engineers to utilise and implement the training effectively.

6.5.2 Hardware Design

Components

The selection of components for the training simulator was based upon the equipment existing within the plant and allows trainees to become familiar with the hardware and configuration of components as they exist in the field. Interaction with these devices in the field needs to be minimal to avoid negative impact on plant availability and production. Table 6.5 outlines the control system hardware included in the design of the training rack.

This equipment is not the entire range of hardware that is installed in the plant but provides trainees with significant exposure to the majority of equipment and underlying fundamentals. While the current simulator configuration includes these components, additional equipment may be installed in the future and training exercises developed as required.

Industrial control systems monitor digital and analogue inputs and produce similar output signals to control equipment and processes. Input and output devices were simulated through the use of push buttons, toggle switches, indicator lamps, a LED display and a buzzer. These devices were mounted on a user control panel for the simulator and the panel was designed to allow for future expansion. Table 6.6 provides details of these components.
6.5 Simulation Equipment

Table 6.5: Training Simulator Components

<table>
<thead>
<tr>
<th>Description</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schneider Quantum PLC Processor</td>
<td>170 CPU 534 14A</td>
</tr>
<tr>
<td>Schneider Quantum PLC Ethernet Adapter</td>
<td>170 NOE 771 01</td>
</tr>
<tr>
<td>Schneider Quantum PLC Backplane Expander</td>
<td>170 CRA 211 10</td>
</tr>
<tr>
<td>Schneider Quantum PLC Profibus Adapter</td>
<td>170 CRP 811 00</td>
</tr>
<tr>
<td>Schneider Quantum PLC Analogue Out</td>
<td>170 ACO 020 00</td>
</tr>
<tr>
<td>Schneider Quantum PLC Digital Relay Out</td>
<td>170 DRA 840 00</td>
</tr>
<tr>
<td>Schneider Quantum PLC Digital In</td>
<td>170 DDI 353 00</td>
</tr>
<tr>
<td>Schneider Quantum PLC Power Supply</td>
<td>534 CPS 114 20</td>
</tr>
<tr>
<td>Schneider Momentum PLC Process Adapter</td>
<td>171 CCC 960 30</td>
</tr>
<tr>
<td>Schneider Momentum PLC Discrete I/O Base</td>
<td>170 ADM 390 30</td>
</tr>
<tr>
<td>Schneider Momentum PLC Discrete I/O Base</td>
<td>170 ADI 340 00</td>
</tr>
<tr>
<td>Schneider Momentum PLC Profibus Comms Adapter</td>
<td>170 DNT 110 00</td>
</tr>
<tr>
<td>Schneider Modicon TSX Profibus + tap Converter</td>
<td>490 NAE 911 00</td>
</tr>
<tr>
<td>Moeller Simocode-DP Motor Protection and Control Device</td>
<td>ZWK-6,3-EM</td>
</tr>
<tr>
<td>Moeller Profibus Bus Terminating Device</td>
<td>BAT-ZWK-DP</td>
</tr>
<tr>
<td>ABB VVVF Interface Control Card</td>
<td>RDCU-02C</td>
</tr>
<tr>
<td>ABB VVVF Profibus Adapter</td>
<td>RPBA-01</td>
</tr>
</tbody>
</table>

Layout

The layout of the equipment was designed to simulate existing plant installations and configurations. The majority of modern industrial electronic equipment utilises standard DIN and panel mount characteristics that result in practical convenience and is aesthetically pleasing. Industrial panel ducting, wiring and labeling was used to ensure a high quality installation. Figure 6.3 shows the general layout of the control hardware. A detailed description of each device is not provided here although the Electrical Module 2: Control Systems provide in Appendix F provides information relating to the hardware and software of each device.
The installation of input and output devices on the user control panel was also undertaken in a manner that allows for the future expansion of the panel components and Figure 6.4 illustrates the completed control panel. Figure 6.5 shows the completed training rack.

![Figure 6.3: Hardware Component Layout](image)

**Electrical Schematic**

Electrical installations are represented by electrical schematics and the electrical design of the simulator needed to consider the power supply requirements and the inputs/outputs of each component. The configuration of the simulator is represented by an electrical schematic that is included in Appendix K. The schematic was created using Microstation Version 8 and site drawing standards and conventions were maintained in the design. The schematic has been made available on the HWE Mining intranet for reference. Alterations and future additions will need to be represented on an updated version of the schematic and hence the schematic has been made available as both the Microstation .dng format and the portable Adobe .pdf format.
6.5 Simulation Equipment

![Figure 6.4: Control Panel Layout](image)

### Table 6.6: Simulator Input/Output Components

<table>
<thead>
<tr>
<th>Description</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raised pushbutton - black</td>
<td>433-3203</td>
</tr>
<tr>
<td>DPDT Std Toggle Switch</td>
<td>518-5336</td>
</tr>
<tr>
<td>Panel indicator lamp, 16mm, 28V ac/dc, red</td>
<td>339-3614</td>
</tr>
<tr>
<td>Panel indicator lamp, 16mm, 28V ac/dc, amber</td>
<td>339-3636</td>
</tr>
<tr>
<td>Panel indicator lamp, 16mm, 28V ac/dc, green</td>
<td>339-3620</td>
</tr>
<tr>
<td>P16 1 turn cermet track pot, 22K, 16mm</td>
<td>168-279</td>
</tr>
<tr>
<td>Pulsed tone buzzer, 24V ac/dc</td>
<td>311-9113</td>
</tr>
<tr>
<td>7.5-32V wide input LED digital ammeter</td>
<td>254-9175</td>
</tr>
</tbody>
</table>

6.5.3 Practical Design

The development of practical simulator exercises took into consideration the skill requirements identified by consultation with the electrical engineers and electrical supervisors at Mining Area C. A Mining Area C Electrical Practice Simulation Template was developed to enable the creation of current and future practical exercises in a consistent
format. This template has been included in Appendix L for reference.

Based upon the initial component selection and technical skill requirements, the training material outlined in Table 6.7 was selected for development and inclusion in the training system.

The practical exercises were designed to familiarise the trainee with specific hardware and develop practical skills in the operation, maintenance and utilisation of the equipment and associated software. Each exercise was developed using the template provided and includes the following sections:

**Overview** provides a description of the electrical practice session and describes the relevance of these skills to electrical plant and systems at Mining Area C.
Table 6.7: Electrical Simulator Material

<table>
<thead>
<tr>
<th>Description</th>
<th>Doc. Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Control and Plant Simulation Equipment</td>
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</tr>
<tr>
<td>Electrical Practice Simulation Template</td>
<td>TR1270-230</td>
</tr>
<tr>
<td>Electrical Practice 1: Control System and Equipment Overview</td>
<td>TR1270-231</td>
</tr>
<tr>
<td>Electrical Practice 2: Quantum PLC Overview</td>
<td>TR1270-232</td>
</tr>
<tr>
<td>Electrical Practice 3: Momentum PLC Overview</td>
<td>TR1270-233</td>
</tr>
<tr>
<td>Electrical Practice 4: Simicode Overview</td>
<td>TR1270-234</td>
</tr>
<tr>
<td>Electrical Practice 5: ABB VSD Overview</td>
<td>TR1270-235</td>
</tr>
<tr>
<td>Electrical Practice 6: Siprotec Relay Overview</td>
<td>TR1270-236</td>
</tr>
<tr>
<td>Electrical Practice 7: Concept PLC Advanced</td>
<td>TR1270-237</td>
</tr>
<tr>
<td>Electrical Practice 8: Citect SCADA Advanced</td>
<td>TR1270-238</td>
</tr>
</tbody>
</table>

**Prerequisites** lists any licencing, induction, training or miscellaneous requirements that should be met before undertaking the electrical practice session.

**Resources** lists materials, equipment or other resources that will be required to undertake the practice session. This may include supervision requirements or other reference material that may not be directly required to complete the tasks.

**Duration** provides an estimated time required to complete the electrical practice session.

**Objectives** lists the objectives and competencies that will be addressed by the electrical practice session.

**Task Outline** lists each task that forms part of the electrical practice session.

In addition to the above general sections, each individual task consists of the following information:

**Overview** provides a brief overview of what objectives this task addresses and a general outline of what is involved.
Background provides the relevant background to the equipment and task that is to be carried out. This may include an equipment description, diagrams, references, where the skills may be used and any other relevant material.

Exercise describes each step of the task in detail and includes a combination of written instructions, photographs and screenshots of relevant software to assist the trainee.

The material outlined in Table 6.8 has been completed by the author of this thesis as part of this project and has been included in the appendix as listed.

<table>
<thead>
<tr>
<th>Description</th>
<th>Doc. Number</th>
</tr>
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<tbody>
<tr>
<td>Electrical Control and Plant Simulation Equipment Overview</td>
<td>Appendix J</td>
</tr>
<tr>
<td>Simulator Electrical Schematic</td>
<td>Appendix K</td>
</tr>
<tr>
<td>Electrical Practice Template</td>
<td>Appendix L</td>
</tr>
<tr>
<td>Electrical Practice 2: Quantum PLC Overview</td>
<td>Appendix M</td>
</tr>
</tbody>
</table>

6.6 Training Matrix

6.6.1 Overview

All training undertaken by employees within HWE Mining is recorded and captured by the training department. This is initially captured on a site specific training matrix that is administered by the training coordinators and subsequently recorded on the HWE Mining SiteSafe Safety and Training Database. Theoretical and practical assessment paperwork is archived in the employee’s training file as evidence.

6.6.2 Design

The existing training matrix for HWE Mining employees at Mining Area C was utilised to ensure compatibility and compliance with HWE Mining systems and training stan-
6.6 Training Matrix

The matrix was altered to include the electrical training components developed as part of this package. The training matrix serves as a tool for tracking the training and skills of employees on the site and can be used to identify skill gaps and training requirements. The amended training matrix has been included in Appendix N.

The following items were added to the existing training matrix:

- Electrical Module 1: Power Systems.
- Electrical Module 2: Control Systems.
- Electrical Module 3: Crushing and Screening.
- Electrical Module 4: Reclaimer and Stackers.
- Electrical Module 5: Train Load Out.
- Electrical Module 6: Sampling.
- Electrical Module 7: Infrastructure.
- Electrical Practice 1: Control System and Equipment.
- Electrical Practice 2: Quantum PLC Overview.
- Electrical Practice 3: Momentum PLC Overview.
- Electrical Practice 4: Simicode Overview.
- Electrical Practice 5: ABB Variable Speed Drive Overview.
- Electrical Practice 6: Siprotec Relay Overview.
- Electrical Practice 7: Concept PLC Advanced.
- Electrical Practice 8: Citect SCADA Advanced.

6.6.3 Training Plan

HWE Mining has developed an employee training plan template for use in conjunction with their performance appraisal system to identify and develop a training plan for
each employee in the organisation. This document would normally be prepared by
the supervisor in consultation with the employee soon after the commencement of
employment.

This process has not previously been utilised by HWE Mining staff at Mining Area C
and consequently a general electrical technician training plan has been designed using
the generic template. This tool provides a documented training plan for employees and
supervisors to guide the development and training of technicians. This will simplify
the development and training planning process for the supervisor and help ensure that
a training plan is implemented for each employee. The technician will also be provided
with a sense of direction and made aware of the training opportunities within the
organisation.

Statutory training and the structured electrical training developed as part of this
project form the core of the training plan. A variety of additional training has been
identified as providing valuable development of electrical technicians within HWE Min-
ing. The following has been included as optional training modules on the training plan:

- Working at Heights Training.
- Elevated Work Platform Accreditation.
- Concept PLC Basic Course.
- Concept PLC Intermediate Course.
- Concept PLC Advanced Course.
- Citect SCADA Basic Course.
- Citect SCADA Advanced Course.
- ABB VSD ACS800 Course.
- ABB VSD ACS1000 Course.
- Confined Space and Gas Testing Accreditation.
- Australian Communications Authority (ACA) Open Cabling Registration.
6.7 Summary

- Australian Communications Authority (ACA) Fibre Cabling Endorsement.
- Australian Communications Authority (ACA) Data Cabling Endorsement.

The full training plan developed as part of this project has been included in Appendix O.

6.7 Summary

This chapter has outlined the design of each component of the electrical training system at Mining Area C. The overall training system consists of a large amount of material that has been developed which has not been included as part of this thesis. Portions of this material have been provided as appendices where stated. All material relating to this training system has been submitted as controlled documents and is available on the HWE Mining intranet. The templates that have been designed allow for the expansion of the training system as required and the possible utilisation of this system by other HWE Mining operations.
Chapter 7

System Evaluation

7.1 Overview

This chapter outlines how the training system has been implemented and evaluated within the workplace at Mining Area C. This includes a discussion on each major system component as well as identifying the ongoing evaluation that will need to be undertaken as further training materials are developed.

7.2 System Delivery

Upon completion of all core system components the training package was presented to the relevant stakeholders at Mining Area C including engineers, supervisors and management. This presentation marked the commencement of the implementation and evaluation stage of the project.

The objectives of the training system presentation were to:

- Justify and promote awareness of the training system development.
- Update stakeholders on the progress of the project.
- Present all core material for review and comment.
• Outline the roles and responsibilities of stakeholders in implementing and developing the system.

• Outline the additional development that must be undertaken.

Interest in the project was high and initial feedback was very positive. Stakeholders that were not initially involved in the project such as operational and mechanical personnel were impressed with the potential benefits and format of the training system. The successful development and implementation of this electrical training system may result in a similar project to incorporate mechanical and operational training based upon company requirements.

Commitment by management to assign resources to the completion and implementation of the training system was illustrative of their support and acceptance of the benefits the system will have for the company.

7.3 Troubleshooting Guides

7.3.1 Implementation

The troubleshooting guides were the first system components to be developed as they were identified as providing the most immediate and direct benefit. These documents were created and implemented for use before the design and development of all other components.

The implementation process involved making hard copies available in all plant substations and the supervisors office to assist in fault finding and for reference purposes. All electrical and operational personnel were made aware of the availability and intended purpose of these resources. Electronic copies have also been made available on the company intranet as a controlled document.
7.3.2 Evaluation

Initial feedback from electrical and operations personnel was very positive in relation to the troubleshooting guides. The review process identified a number of issues relating to additional information that should be included. As a result, a troubleshooting guide change request register has been set up to capture comments, ideas and requests for information to be added, altered or removed. These changes will be made on a periodic basis to support a culture of continuous improvement.

7.4 Reference Guides

7.4.1 Implementation

The electrical reference guides were developed immediately following the troubleshooting guides due to the benefit of having relevant information readily available. These folders have been placed in the electrical supervisor’s office and relevant stakeholders were encouraged to familiarise themselves with the location and content of the material.

7.4.2 Evaluation

The folders have been designed as supporting reference material and as such their was no ‘training’ to be evaluated. Electricians and engineers have acknowledged the benefit of having this information readily available however. These folders are considered flexible and under constant development in the sense that information can be continuously added as it becomes available or is deemed important.
7.5 Electrical Modules

7.5.1 Implementation

The Electrical Module 2: Control Systems (Appendix E) was selected as the initial module to be developed. This selection was based upon the need to provide control system training for employees as quickly as possible.

The training material was presented to a group of electricians, engineers and supervisors. The powerpoint presentation was hosted by myself with additional explanation and examples provided in an instructor-led training delivery style. Upon completion of the presentation, trainees were provided with the theory assessment for the control system module (Appendix F). The master answer sheet (Appendix G) was used to discuss the theory answers with trainees as a group. This provided immediate clarification and feedback to trainees on the course content.

7.5.2 Evaluation

The aim of the initial training presentation was to gain feedback from trainees on a range of factors including:

- Benefit to the employee.
- Presentation style and format.
- Effectiveness of the presentation.
- Relevance of the presentation and assessment content.
- Suggested improvements.

In general, the response was very positive. A number of improvements and consideration were highlighted including:

- Ensuring adequate time to undertake the presentation and assessment.
• Importance of the presenter’s knowledge, style and enthusiasm.

• Potential for including excess information on some topics.

• Need for regular breaks during lengthy presentations to encourage concentration and enthusiasm.

• Provision of a hard copy of the presentation as a reference for the assessment and to allow trainees to reinforce the material outside of the training session.

7.6 Control System Simulation

7.6.1 Implementation

The control system training rack was made available as soon as it had been built although it took additional time to complete the first of the electrical practice exercises. Upon completion of the Electrical Practice 2: Quantum PLC Overview (Appendix L) a number of technicians were utilised to evaluate the practical exercise.

7.6.2 Evaluation

The ability to gain exposure to the control system hardware and software without the risk of jeopardising plant production was well received by all stakeholders. The format and content of the Quantum PLC Overview was found to be user friendly and effective. The following feedback was received from trainees:

• Screenshots of relevant tasks and equipment aided in understanding and following the exercise.

• Task steps were clear and concise.

• Additional photos of selected equipment were requested to aid understanding in some areas. These have been added to the final document.


7.7 Future Evaluation

The system material currently developed has received positive feedback from all stakeholders. As further training material is developed the evaluation process will continue. This will become important as additional people begin to create training material and factors to consider will include:

- Consistency of style and formatting.
- Appropriate use of package templates.
- Accuracy of the information.
- Relevance of the information.

As the training material development is completed and the full system is implemented, ongoing monitoring of the benefits derived should be undertaken. Factors to consider may include:

- Feedback from trainees on the effectiveness of the training.
- Levels of morale as employees become highly skilled.
- Increasing skill level of employees.
- Decreasing electrical downtime of the plant.
- Perception of the training culture on site.
Chapter 8

Conclusions and Further Work

8.1 Achievement of Project Objectives

The following objectives have been addressed:

**Research training in the Australian mining industry**: Chapter 2 presented a literature review of training systems and trends within the Australian mining industry. Factors affecting training were addressed and a range of recommendations relating to the future direction of training in the industry were discussed.

**Investigate current HWE Mining training systems**: Chapter 4 presents a case study of HWE training systems and policies. A number of training initiatives currently being undertaken by HWE Mining were discussed and a comparisons were drawn between HWE Mining’s systems and the research recommendations outlined in Chapter 2.

**Identify user requirements**: Chapter 5 outlines the consultation with stakeholders and the training needs analysis undertaken to identify the requirements and essential features of the training system.

**Identify and develop an electrical training system**: Chapter 5 identifies and explains the system components that were selected for inclusion in the training package. Troubleshooting guides, reference folders, training modules and the control
Design and develop training materials: Chapter 6 provides an overview of the design and development of each individual system component. The core training system material such as the overview documentation, training simulator, troubleshooting guides, reference folders, training plan and training matrix has been completed. The initial control systems training module and PLC training exercise has also been completed and the remaining training material is under development.

Implement the training system: Chapter 7 discusses the presentation of the overall training system to relevant stakeholders and outlines the implementation of each system component in the workplace.

Evaluate and review the electrical training package: Chapter 7 continues on from the implementation process and outlines the evaluation of each system component. A number of suggestions were incorporated into the material and general feedback was very positive. The importance of ongoing review and evaluation of the training system as additional material is developed was also highlighted.

In general, the training system has been well designed and well received by all stakeholders. The perceived benefit of this training system amongst all stakeholders has been established and resources have been assigned to develop the remaining training material. The potential for expanding the system to include other disciplines and applications has also been identified. The objectives of this project have been clearly achieved beyond my initial expectations and with ongoing commitment and evaluation, the implementation of the complete training system should provide significant benefit to HWE Mining and its employees.

8.2 Further Work

The remaining electrical practice exercises and electrical training modules are under development and will be completed in the near future. As material is completed it
will need to undergo an implementation and evaluation stage similar to the existing material. This will identify any alterations and additions that need to be made to the material.

Full implementation into the workplace will require the commitment of the electrical and engineering managers to utilising the resources. Indications are strong that this system will be enthusiastically adopted. The following actions are critical to the effective implementation of the system:

- Support and understanding of the training system and material by electrical supervisors and engineers.
- Allocation of resources to develop the remaining material.
- Utilisation of the training plan in the performance appraisal process.
- Utilisation and updating of the training needs analysis matrix to track completed training.
- Improvement and updating of material to reflect changes within the workplace.
- Ongoing evaluation of the training system by relevant stakeholders.
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Australian Institute of Mining and Metallurgy (2001), *Rising to the challenge: Building professional staff capability in the Australian minerals industry for the new century*, Department of Education, Training and Youth Affairs, Australia.


HWE Mining (n.d.).

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Appendix A

Project Specification
ENG4111/4112 Research Project
PROJECT SPECIFICATION

FOR: Michael Wayne MCKAY

TOPIC: ELECTRICAL TRAINING PACKAGE FOR MINING AREA C

SUPERVISORS: Mrs Lyn Brodie
Gary Waldron, HWE Mining Area C

SPONSORSHIP: HWE Mining

ENROLMENT: ENG4111 – S1, 2007;
ENG4112 – S2, 2007

PROJECT AIM: This project aims to investigate and develop a training system that relevant to electrical plant and systems at Mining Area C. This package will provide structured in-house electrical training and may be used as a reference tool for fault-finding, engineering design and equipment information.

PROGRAMME: Issue A, 13 March 2007

1. Research current training systems and trends in the Australian mining industry.
2. Investigate current HWE Mining training systems.
3. Liaise with relevant stakeholders and identify the user requirements for an electrical training system at Mining Area C.
4. Identify, evaluate and develop an electrical training system that meets the requirements identified.
5. Design and create a number of electrical training modules.
6. Present completed modules to stakeholders and gain feedback on the design and implementation of the system.
7. Critically evaluate and review the electrical training package.

As time permits:

8. Alter the package based upon the critical evaluation and stakeholder review.
9. Produce additional training modules.

AGREED: __________________ (Student)   __________________ (Supervisor)

              ____ / ____ / ____               ____ / ____ / ____
Appendix B

Interview Guide
HWE Mining Training System Investigation
Research Interview Guide

Purpose: This interview guide is a support tool to help facilitate a successful research interview with relevant stakeholders within the HWE Mining training department.

Interview Preparation

<table>
<thead>
<tr>
<th>Task</th>
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<tbody>
<tr>
<td>Project background and objectives explained</td>
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</tr>
<tr>
<td>Outline purpose of interview</td>
<td>☐</td>
</tr>
<tr>
<td>Provide overview of interview content and expected time</td>
<td>☐</td>
</tr>
<tr>
<td>Scheduled appropriate interview time and location</td>
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<tr>
<td>Confidentiality issues discussed</td>
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Conduct Interview

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<td>Ensure punctuality</td>
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</tr>
<tr>
<td>Express thanks and appreciation to interviewee</td>
<td>☐</td>
</tr>
<tr>
<td>Outline project background and interview purpose</td>
<td>☐</td>
</tr>
<tr>
<td>Reiterate confidentiality issues</td>
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</table>

Interview Completion

<table>
<thead>
<tr>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Express thanks and appreciation to interviewee</td>
<td>☐</td>
</tr>
<tr>
<td>Offer to provide a copy of completed research</td>
<td>☐</td>
</tr>
<tr>
<td>Review interview notes and consolidate material</td>
<td>☐</td>
</tr>
</tbody>
</table>

Interviewee Details:

Name: _______________________
Position: ____________________
Interviewed By: ____________________
Date: _______________________

1
HWE Training Systems Investigation

General

What is the role and responsibilities of the head office training department?

Prompts: strategic development, site support, administration, training development

What is the role and responsibilities of the site-based training department?

Prompts: developing training manuals, providing training, organising external training, maintaining records

Outline the scope of training required across HWE Mining:

Prompts: mining/operators, OHS, statutory, technical, professional development, green employees, trainees

What areas of training have traditionally been allocated greater resources or have higher priority? Describe any changing trends?

Prompts: mining/operators, OHS, statutory, technical, professional development

Are there specific training policies and/or procedures in place at HWE Mining and how effective have they been at meeting the company’s training requirements?

Prompts: regularly reviewed, token statements, adequate

Are there specific training policies regarding green/new employees?

Prompts: increased training, additional monitoring, greater focus, recruit required skills

How is the company attempting to manage high employee turnover and lower skill levels?

Prompts: increased training budget, increased training, employee development/promotion

What tools and/or strategies are employees provided with to identify and track internal and external training requirements?

Prompts: performance reviews, mentoring, training matrix
In-house Training

How are training requirements identified and candidates for training selected?

Prompts: training matrix, performance reviews, employee files, statutory requirements

What types of training are provided on an in-house basis through-out HWE Mining?

Prompts: OHS, statutory, technical, management, HR

How is in-house training delivered within the company?

Prompts: generic presentations, supervision or training co-ordinators, inductions,

Does internal training align itself with certified courses and/or recognised accreditations?

Prompts: Australian Qualifications Framework, RTO, Accredited training packages

Professional Development

What professional training is currently being implemented by the company?

Prompts: human resources, management, safety, leadership

What professional training is currently being developed or planned?

Prompts: human resources, management, safety, leadership

How is professional development and training identified, recorded and analysed?

Prompts: training matrix, performance reviews, employee files

Outline the training delivery methods utilised for professional training:

Prompts: workshops, online, on-site, off-site

Technical Training

How are technical training needs identified and approved?

Prompts: training matrix, performance reviews, employee files, manager site
How is the development and delivery of technical training achieved?

Prompts: external providers, vendors, on-site, accredited institutions, on-line, self education

What is the current level of technical training being undertaken by the company?

Prompts: self education, as required, extensive investment, different sites

What direction is the company taking in terms of future technical training?

Prompts: forecasted increase, as required, reduction

Course Structure

What is the structure of current training courses/packages existing within HWE?

Prompts: module style, presentations, practical components, interactive, simulation, assessment

Are there templates or specific requirements that training within HWE Mining must be modelled upon?

Prompts: assessment templates, answer sheets, QA requirements

How is the development of training packages and courses organised and delivered?

Prompts: external, internal, site, head office, non-training department personnel

How is the HWE intranet and internet utilised for training purposes?

Prompts: feedback, course material, assessment

What support materials are utilised or preferred?

Prompts: presentations, online resources, manuals, interactive, simulation

How are these support materials stored and/or accessed?

Prompts: site specific, intranet, hard copy, training department access

How are these support materials developed and by whom?

Prompts: non-training department staff, training department, external
How is competence assessed and recorded?

Prompts: practical, theory, training files

How is course evaluation achieved?

How is the course feedback utilised?

Training and Development for Engineers

How is the development and training of engineers in the company managed and are there dedicated training pathways and plans?

Prompts: graduate development program, self managed, site specific, discipline specific, mentoring

How effective has the professional development of engineers been executed throughout the company?

Prompts: improving, excellent, site specific, discipline specific

Are there areas that have been identified as requiring improvement in the area of graduate development?

Prompts: graduate development plans, mentoring, rotations

How does engineer development vary across disciplines? Do they follow differing development plans?

Prompts: preferential disciplines, generic plans, site specific

Does HWE Mining encourage and support development towards Engineers Australia Chartered status?

Is the company affiliated with Engineers Australia?

How does HWE Mining support undergraduate professionals?

Prompts: sponsorship, vocational experience
Self Education

How does the company support self-education of employees?

Prompts: self education policies, encouragement

Has the self-education provisions been utilised by employees?

Prompts: minimal, approval difficulty, actively encouraged

Facts and Figures

What is the percentage of payroll is spent on training within the company and does this vary significantly between operations?

What factors (if any) affect the variation in training expenditure between sites?

How many workers does HWE Mining employ and what percentage of these are full-time permanent employees? What percentage are contractors?

Outline variations that may exist between the type and quantity of training supplied to contractors and training supplied to full-time employees?

What are the current and historical levels of employee turnover experienced by HWE Mining? Does this vary between operations?

What are the approximate costs of employee turn over to the company?

Prompts: re-training costs, recruitment costs, excessive/manageable

Conclusion

What are the current major focus areas for the HWE Mining training department?

Prompts: statutory, technical, management, professional, safety, systems

What is the future direction and objectives of the HWE training department?
Appendix C

Training Evaluation Form
Your feedback is extremely important to HWE Mining to improve the effectiveness, quality and value of our training system. Please complete this evaluation feedback form and return it to your trainer during the time provided at the conclusion of your training and prior to assessment.

A. Trainee Details

<table>
<thead>
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Training Details - Please Complete

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<th>Trainer’s Name:</th>
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B. Evaluation

Please respond to each of the statements below by rating them using the following descriptors:

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<th>1 Strongly Disagree</th>
<th>2 Disagree</th>
<th>3 Neutral Undecided</th>
<th>4 Agree</th>
<th>5 Strongly Agree</th>
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Please circle your response.

1. I was provided with adequate notice of the training.

2. I clearly understood why I was undertaking the training.

3. The competency or competencies to be attained were clearly explained prior to the training commencing.

4. The trainer checked what knowledge and skills I already possessed prior to commencing training.

5. The trainer fully explained how the training would be conducted.

6. The trainer was well prepared and organised:
   a. Venue.
   b. Training materials.
   c. Equipment and resources.

7. The training method/s used were appropriate to the context, the task and my preferred learning style.
8. The training tasks reflected those typically performed in the workplace.

9. The trainer was very helpful:
   a. Presented and/or explained information in a clear, easily understood way.
   b. Provided me with feedback and as much practice as I needed to get it right.

10. The trainer reinforced safety and environmental issues throughout the training.

11. I was given enough time and training to feel confident that I was competent. I did not feel rushed.

12. I was given the opportunity to complete the Self-Assessment Checklist and seek further training if I thought I needed it.

13. The trainer clearly “knew his/her stuff”.

14. The trainer treated me fairly, equitably and without harassment.

15. The training materials were of a high standard (eg, OHTs, videos, reference materials, etc)

16. What weaknesses did you identify in the training process?

17. What improvements would you recommend to the training process?

THANKYOU FOR YOUR ASSISTANCE
PLEASE RETURN THIS FORM TO YOUR TRAINER

Notes:

1. When completed, this form is to be returned to the Training Co-ordinator for review.

2. The Training Co-ordinator must maintain a file of all completed assessment evaluation feedback forms. Completed forms will be reviewed during audits and must be completed to meet the requirements of the Australian Training Qualifications Framework and ISO 9001.
Appendix D

Training System Overview and Implementation Guide
Overview

The Mining Area C Electrical Training System has been designed to provide a structured training pathway for engineers and technicians at Mining Area C. This document outlines the scope of the training system and has been designed in line with the HWE Mining Learning and Skills Development Policies and Procedures Manual (PC-TR-6000). The system is designed to provide a range of internal development training and provides flexibility for expansion as required.

Scope

The development of electrical employees to a competent level as quickly as possible is an important factor in maximising plant availability and utilisation at HWE Mining operations. This training system provides a guide for the development of individuals within the organisation, with the aim of obtaining a high level of plant familiarisation and technical skill in regards to electrical plant, systems and troubleshooting at Mining Area C.

System Components

The electrical training system consists of the following components:

- Electrical training system overview and implementation guide
- Electrical employee training plan template
- Electrical reference folders
- Electrical training modules
- Electrical control and plant simulation equipment
- Electrical troubleshooting guides
- Templates for development of further materials

The main components are outlined in the following sections.

Electrical Reference Folders

A number of reference folders have been created to provide a centralized source of relevant plant and system information for electrical engineers and technicians. The information available includes plant descriptions, procedures, troubleshooting guides, drawings, functional descriptions, area specific training material and other relevant material. These are located in the electrical supervisors office and are intended to be a flexible and expandable tool for engineers and technicians.
Electrical Troubleshooting Guides

A number of electrical troubleshooting guides for major areas of the plant have been developed as a troubleshooting aid for technicians in breakdown situations. The utilization of these guides will reduce the overall level of downtime associated with inexperienced personnel attempting to investigate and rectify electrical faults. This also provides an opportunity to capture the experience and knowledge of senior technicians and engineers currently on site. This should enable a portion of the knowledge held by these valuable individuals to be retained when they leave the organization. These documents should be regularly reviewed and updated with relevant information as required. A troubleshooting guide template has also been created to allow for plant expansion and for use within other HWE Mining operations.

Training Modules

Training modules have been created to introduce employees to the plant and electrical systems at Mining Area C. The modules will have a theoretical classroom component in the form of a presentation and theory assessment. This will serve as a precursor to a practical familiarization and competency assessment.

Control System Simulation

A control system hardware simulator has been designed and built to enable trainees to develop practical skills and gain familiarity with site equipment. This will enable a rapid transition from inexperienced to competent technician while having minimal impact on the operation and availability of the plant. Structured practical exercises have been developed based upon the equipment installed on the training rack. Availability of templates will allow for the expansion of the simulator and exercises as plant technology changes or expands.

Implementation

An electrical technician training plan template has been created to outline the recommended training path for technicians at Mining Area C. Please refer to the Mining Area C Electrical Employee Training Plan Template.

Internal training modules and practical simulations will be presented by senior technicians, leading hands, supervisors or engineers within the electrical department. This will be determined by operational requirements and available resources. External training will be identified and organised by the electrical supervisor based upon organisational requirements and the employee performance review and development process.
Training Matrix

All training undertaken by employees within HWE Mining must be recorded and captured by the training department. The internal modules and the simulation practical sessions are included on the training matrix for electrical employees within the Mining Area C OHP. Theoretical and practical assessment paperwork shall be archived in the employee’s training file and completed training recorded on the relevant training matrix.

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Prepared By: Michael McKay
Approved By: Electrical Engineer
Date: 23/08/2007
Date: 12/09/2007
Document Number: TR1270-199
Date Implemented:
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1.0 Introduction

This electrical troubleshooting guide is designed as a fault-finding and reference tool for electrical technicians and engineers. The document provides information and guidance on a wide range of common faults and problems relating to the Stackers.

Many of these faults have been identified as ambiguous and problematic for new technicians to rectify quickly. Consequently, this guide also serves to accelerate and increase the plant knowledge of new and inexperienced technicians at Mining Area C.
2.0 Long Travel

2.1 Brake Not Lifted Alarm

Description

The long travel brake not lifted alarm operates when the micro-switch on a long travel brake fails to actuate after the PLC has output a brake release command. Each individual long travel drive is separately monitored to allow for identification of the faulted equipment. This alarm will fault the long travel system and restrict travel until the fault is cleared. Brake power is supplied by brake lift relays located in the MCC relay panel.

Action

1. Visually inspect faulted motor and brake.
   - Yes: Repair as required
   - No: Check brake supply

2. Is brake lifting?
   - Yes: Switch operating?
     - Yes: Check supply to switch
     - No: Clean and blow out brake unit
   - No: Check input switching to PLC

3. Adjust micro-switch
Forcing

The alarm may require forcing into a healthy state under the following circumstances:

- Parts unavailable for repair of faulty brake.
- Major repair required and plant operation is of high priority.
- Authorisation to force equipment/alarm has been received.

The micro-switch input to the PLC is monitored in both the brake engaged and brake lifted states. In addition, the long travel speed of the machine is restricted until all brake lifted inputs have been received. Consequently, the following steps should be taken to force this alarm:

- Manually lift the brake using the brake handle and lock in the raised position using the swing arm on the brake cover.
- Force the brake lifted input (eg. LT01_ZS01).
- Force the brake not lifted alarm on the PLC (eg. LT01_ZS01LA).
- Force the brake failed to engage alarm on the PLC (eg. LT01_ZS01SA).
- A hardwired bridge may be used instead of forcing the PLC variables by paralleling the brake lift switch in the field terminal box with a switch from another drive.

2.2 Brake Not Engaging Alarm

Description

This alarm operates when a brake does not engage after it has been de-energised. It will inhibit the travel of the stacker.

Action

This alarm is similar to the brake not lifted alarm above and a similar inspection of the equipment should be undertaken. The occurrence of this alarm indicates that the brake has previously been engaged. Hence it is likely that the problem lies with the micro-switch or brake itself as opposed to a supply problem.

Forcing

A similar procedure to the brake not lifted alarm above should be undertaken if the brake operation is to be forced.

2.3 Microwave Anti-collision Faults

Description

The microwave detection alarm activates when the microwave beam between the sender and receiver unit is interrupted. The LHS and RHS microwaves protect the boom from collision with a stockpile or another machine. The microwave transmitter has a single N/O contact that switches on when a signal is detected (Healthy State).
Action

Visually inspect microwave transmitter, sender and receiver

Obvious fault?

Yes

Repair as required

No

Is green TX power light on?

Yes

Check that N/O contact is switching correctly

No

Test for 24V supply

Check 24V DC supply for Microwave is OK in the MCC pop-up on Citect

Is red TX signal light on?

Yes

Check coil delay settings and sensitivity

No

Check wiring to sender and receiver

Temporarily connect new sender to test receiver

Temporarily connect new receiver to test sender

Replace sender or receiver as appropriate

MCC pop-up on receiver as appropriate

Test for 24V supply

No

Microwave transmitter, light on?

Yes

Replace unit if faulty
Forcing

Note: The anti-collision microwaves should not be left in a disabled state without continuous monitoring where there is a risk of collision.

The alarm may require forcing into a healthy state under the following circumstances:

- Parts unavailable for repair of microwaves.
- To continue plant operation while repairs are carried out.
- Intermittent and/or frequent tripping due to excessive dust.
- Authorisation to force equipment/alarm has been received.

The signal from the microwave transmitter provides power to a number of hardwired relays that are interlocked to various machine relays. Consequently a simple PLC force will not allow the microwaves to be bypassed. The microwave can be effectively bypassed by bridging the N/O contact of the transmitter in the field. If this is not an option due to a faulty transmitter or cable fault on the supply side of the circuit, the hardwired relays will need to be bridged. Refer to relevant drawing for details.

2.4 Encoder Error Alarm

Description

The encoder error alarm occurs when the long travel encoder position error is greater than the deadband value specified in the PLC. The dead-band default set point is 500mm. The Telsor page is accessible from the Stacker Overview page and shows the Telsor number, position and error values from the last telsor update at each location. The error shows the difference between the encoder reading and what the actual position should be at each point. This alarm will fault the long travel and restrict movement of the machine.
### Action

- Check the dead band error on the telsor page on Citect
- Check the encoder page to identify encoder differences/slipping
- Stacker will need to be travelled over a telsor tag in Maintenance mode to reset alarm
- Monitor and identify encoder slippage or fault

Increase dead-band if required and monitor operation to identify fault

- **Is Encoder slipping?**
  - **No**
  - **Yes**

Repair/replace coupling or encoder as required

### Forcing

The encoder dead-band may need to be increased under the following circumstances:

- Dead-band error is only just over the dead-band set point (500mm). This may indicate a deteriorating encoder or slight slippage that can be repaired at a later opportunity.
- For monitoring purposes to inspect how the encoders are responding in normal operation without continually faulting the stacker.
- No spare encoder or coupling to replace faulty equipment.

The dead-band value is declared as a constant within the TISR section of the stacker PLC program. The constant is defined in metres (e.g. 0.5 = 500mm). The dead-band can be changed by locating the constant declaration within this section for `const_enc_err_deadband`. The default value is 0.5 (500mm) and it is important that any changes made to the PLC need to be recorded in compliance with current procedures. Any changes made for fault identification purposes shall be reverted to original values once equipment is repaired.
2.5 Encoder Comparison Fault

Description

The encoder comparison fault occurs when the difference between the two encoder position readings exceeds the preset maximum. This alarm will inhibit the long travel of the machine. The encoder detail page is accessible from the Stacker Overview page.

Action

![Diagram of the encoder comparison fault action flowchart]

**Forcing**

The encoder comparison fault may need to be forced into a healthy state under the following circumstances:

- No spare encoder to replace faulty device.
- To continue plant operation while repairs are scheduled for shutdown.
- Authorisation to force equipment/alarm has been received.

If the faulty encoder is the No.2 encoder than the alarm can be forced directly in the PLC. Force the alarm (eg. LT02_ENC_COMPA) into the low (OFF) state. If the faulty encoder is No.1 than No.1 should be replaced or swapped for No.2 and the force applied as above.

In the event that this is not possible there is additional changes required to enable plant operation to continue. This is because the PLC uses the value derived from encoder No.1 to operate (Encoder No.2 is only used as a comparison to No.1). To use Encoder No.2 as the primary encoder follow the steps...
below. LT02 in the steps below relates to Stacker 2. For Stacker 1 these variables will be begin with LT01:

- Open LT_Encoder section of the PLC.
- Delete link from LT02_ENC1_RAW block to the ENC_RAW input of the first ENCODER DFB.
- Insert link from LT02_ENC2_RAW block to the ENC_RAW input of the first ENCODER DFB. This will ensure the PLC uses the raw input from Encoder No.2 to operate the machine.
- Invert the REV_DIR input of the first ENCODER DFB. This is because Encoder No.2 rotates in the opposite direction to Encoder No.1.
- Replace the LT02_ENC1_DIAG01 input to the Encoder Healthy Status block with LT02_ENC2_DIAG01. This will ensure the PLC believes that Encoder No.1 is healthy.

Ensure all current PLC change policies and procedures are followed.

2.6 Two Telsor Tags Missed Alarm

Description

This alarm is generated when the stacker fails to read two telsor tags consecutively. The stackers This alarm will inhibit the long travel of the machine.

Action

Travelling the machine across a telsor tag in Maintenance mode and obtaining a valid position reading will clear this alarm. Although the alarm will clear it may reoccur once operation recommences if there is an ongoing fault with the telsor reading system. The long travel and telsor system should be monitored to establish the existence of a fault.

Interesting points to note:

- Faulty telsor tags are extremely uncommon as they are solid state devices. Travelling over the tag multiple times in Maintenance mode can check the integrity of a tag.
- Adjustment of tags will not normally be required due to the range of the antenna unless the bracket or antenna has been damaged or come loose.

The antenna is susceptible to electrical faults and has been damaged in the past. Visual inspection or antenna replacement may be required.

The tag reading system is sensitive to low voltages. The long travel strobe lights are supplied from the same 24V C/B and have been known to drag down the voltage of the circuit when a flashing light faults or begins to deteriorate. The 24V system will not operate correctly if the voltage drops below ~20 V and this may result in the system failing to read tags intermittently. Removing the flashing light relays and monitoring the operation of the telsor system may identify a fault on the light circuit and allow the telsor tag system to operate correctly.
Forcing

This alarm should not be forced as the machine requires accurate monitoring of its position due to the nature of stacking and the interaction with other machines controlled by the stockyard anti-collision system.

2.7 North/South Software Limit Alarm

Description

The north and south software limit alarm will be raised if the machine attempts to travel past the relevant long travel limit as defined for the machine. These limits are summarised on the Limits Overview page. A south software limit alarm will inhibit further southern long travel. Similarly, a northern alarm inhibits northern travel.

Action

Since this alarm is based simply upon the long travel position and a software limit within the control system there is minimal chance of equipment failure. The following may be a useful guide to deal with this alarm:

- Determine why the stacker is attempting to travel beyond the designated software limits.
- Investigate if the software limit has been changed recently and is impacting on normal stacking operation.
- Check that encoders are reading correctly (although the telsor tag system and encoder alarms should capture any existing faults).

Forcing

The software limits should not require changing in the course of normal operations. Extreme care should be taken before any design limits are altered and the appropriate authorisation and change procedures shall be adhered to. If the limit requires changing then it can be altered by logging onto Citect as manager and accessing the value from the Parameters page. Care should be taken to record the original value before changes are made to ensure a record is maintained.

2.8 North/South Overrun Limit Alarm

Description

The north and south overrun limits are designed to inhibit further long travel when activated and should be physically mounted past the long travel software limits. A visual indication of the long travel software, overrun and emergency limits can be seen on the Limits Overview page on Citect.
Action

Visually check the location of the stacker in relation to the overrun switch

Travel the machine in Maintenance mode away from the overrun switch and reset the machine

Yes  Has stacker hit switch?  No

Check the software limits of the machine and investigate why the overrun tripped first

Inspect overrun switch for damage or failure

Check voltage supply to switch

Check overrun switch relay in MCC relay panel for failure / operation

Repair/replace equipment as required

Forcing

The overrun limits should not be forced or bypassed in normal operation. These devices provide hard-wired protection to prevent excessive long travel. The machine should not exceed the software limit in normal operation and consequently these switches should never activate. In the event that a switch is faulty and requires bypassing to repair, the hard-wired relay will need to be bridged. Refer to the long travel drawing for the relevant stacker.

2.9 North/South Emergency Limit Alarm

Description

The north and south emergency limit alarm performs a similar function the overrun limits described above. The emergency limit is the second hard-wired limit and acts as a final over travel protection device. The switch is physically mounted past the overrun switch and a visual indication of the long travel software, overrun and emergency limits can be seen on the Limits Overview page on Citect. The main difference to the overrun limit however, is that the long travel must be physically switched into bypass mode before travel in maintenance mode occur.
Action

Visually check the location of the stacker in relation to the emergency switch

Toggle the switch on the long travel MCC cubicle to bypass mode

Has stacker hit switch? Yes

Travel the machine in Maintenance mode away from the emergency switch

No

Inspect emergency switch for damage or failure

Check voltage supply to switch

Check overrun switch relay in MCC relay panel for failure/operation

Repair/replace equipment as required

Check the overrun limit of the machine and investigate why it did not trip the machine

Check the software limits of the machine and investigate why the overrun tripped first

Forcing

The emergency limits should never be forced. These devices provide final hard-wired protection to prevent excessive long travel. Further travel of the machine past the emergency limits will result in collision with the structural hard stops.

The machine should not exceed the software limit in normal operation and consequently these switches should never activate. In the event that a switch is faulty and requires bypassing to repair, the hard-wired relay will need to be bridged. Refer to the long travel drawing for the relevant stacker. In this case the operation of the overrun switches should be tested to ensure that some form of protection is still in place.
3.0 Luff

3.1 Zero Proxy Fault

Description

This alarm is triggered when the above zero proxy switch is detected when it is not required to be seen. If the proxy is detected when the luff is outside the range of 0.1 +/-0.5 degrees then the alarm will actuate.

Action

1. Visually check the zero proxy and compare the luff position of the boom to the encoder reading.
2. Inspect the proxy switch for damage, failure or loose movement.
   - Yes: Check zero calibration of luff and calibrate if required.
      - No: Inspect the proxy switch for damage, failure.
3. Repair/replace as required.
4. Luff up and down over proxy switch in Maintenance mode to clear fault once problem rectified.

Forcing

There should be no need to force this alarm as it provides an accuracy check of the luff encoder. Any fault with the encoder or proxy should be rectified before operation recommences.
3.2 Encoder Comparison Fault

Description

The encoder comparison fault occurs when the difference between the two encoder position readings exceeds the preset maximum. This alarm will inhibit the luffing of the machine. The encoder detail page is accessible from the Stacker Overview page.

Action

```
Check the encoder differences on the Stacker encoder page on Citect

Change PLC logic to use encoder 2 as the primary encoder if other options are exhausted

Perform luff calibration when at zero degrees (use spirit level or markers)

Alarm may be forced to allow repairs at a later date while operation proceeds

Repair/replace as required (Swap with encoder 2 if no spares)

Luff the machine to determine which encoder is slipping

Repair/replace as required

Inspect encoder and linkage arm

Which encoder faulty?

1

2

Inspect encoder and linkage arm
```

Forcing

The encoder comparison fault may need to be forced into a healthy state under the following circumstances:

- No spare encoder to replace faulty device.
- To continue plant operation while repairs are scheduled for shutdown.
- Authorisation to force equipment/alarm has been received.

If the faulty encoder is the No.2 encoder than the alarm can be forced directly in the PLC. Force the alarm (eg. LT02_ENC_COMPA) into the low (OFF) state. If the faulty encoder is No.1 than No.1 should be replaced or swapped for No.2 and the force applied as above.

In the event that this is not possible there is additional changes required to enable plant operation to continue. This is because the PLC uses the value derived from encoder No.1 to operate (Encoder No.2 is only used as a comparison to No.1). To use Encoder No.2 as the primary encoder follow the steps below. HP12 in the steps below relates to Stacker 2. For Stacker 1 these variables will be begin with HP11:
- Open Luff Encoder section of the PLC.
- Delete link from HP12_ENC1_RAW block to the ENC_RAW input of the first ENCODER DFB.
- Insert link from HP12_ENC2_RAW block to the ENC_RAW input of the first ENCODER DFB. This will ensure the PLC uses the raw input from Encoder No.2 to operate the machine.
- Invert the REV_DIR input of the first ENCODER DFB. This is because Encoder No.2 rotates in the opposite direction to Encoder No.1.
- Replace the HP12_ENC1_DIAG01 input to the Encoder Healthy Status block with HP12_ENC2_DIAG01. This will ensure the PLC believes that Encoder No.1 is healthy.

Ensure all current PLC change policies and procedures are followed.

3.3 Encoder Calibration Fault

Description

The luff encoder is checked for accuracy by the above zero degrees proxy. On each transition of the state of the proxy the PLC records the luff position. This position is checked to ensure it is within an acceptable range. The range is currently +/- 1.0 degrees. If the luff value is outside this range upon switching of the proxy an alarm is generated. This alarm will inhibit the luffing of the machine.
Action

1. Inspect the proxy switch for damage, failure or loose mounting
2. Check the encoder values to determine degree of inaccuracy
3. Change PLC logic to use encoder 2 as the primary encoder if other options are exhausted
4. Luff up and down past proxy in Maintenance mode to reset
5. Repair/replace as required (Swap with encoder 2 if no spares)
6. Perform luff calibration and adjust proxy switches if required
7. Repair/replace as required
8. Inspect encoder/coupling
9. Is encoder faulty?
10. No
11. Increase acceptable accuracy range if required

Forcing

There should be no need to force this alarm as it provides accuracy checking for the encoders and confirms the integrity of the luff positioning system. A luff calibration should be performed if required and any faults with the proxy or encoder should be rectified before operation continues.

If plant operation is to continue while the luff encoder is monitored for a fault, alarm may be forced or the accuracy range may be increased slightly. This should be a last resort for fault finding and the current PLC change procedures shall be followed. Refer to the Constants section of the PLC to access the accuracy check constants const_luf_up0_lmt and const_luf_dn0_lmt. The default value is 1.0 and –1.0 degrees respectively.
3.4 Lower Software Limit Fault

Description

The machine luff software limits are determined by the position of the machine. The default lower luff limits are outlined below:

- Embankment or conveyor zone: 0 degrees
- Quadrant 2: -8.5 degrees
- Quadrant 3: -14.5 degrees

These values can be viewed on the Parameters and Limits pages for the machine.

Action

Generally, the lower software limit fault will not be a problem in normal operation, as they have been designed as required. If operations believe the software limit should not be restricting the machine in its current position, investigate if the software limits have been altered recently and for what reason.

Forcing

The luff may be required to be lowered past the software limit for maintenance purposes. In this case the software limits may be accessed from the Parameters page. Note that Citect must be logged in under manager mode to enable the alteration of controlled set points such as software limits. It is important to note that altering the design set points of the machine may result in equipment damage or incorrect operation.
4.0 Slew

4.1 Brake Not Lifted Alarm

Description

The slew drive brake not lifted alarm operates when the micro-switch on a slew drive brake fails to actuate after the PLC has output a brake release command. Each of the two slew drives are separately monitored to allow for identification of the faulted equipment. This alarm will fault the slew system and restrict slewing until the fault is cleared. Brake power is supplied by a circuit breaker and brake contactor that is mounted within the slew drive MCC cubicle.

Action

![Flowchart of brake not lifted alarm action](image-url)

Forcing

The alarm may require forcing into a healthy state under the following circumstances:

- Parts unavailable for repair of faulty brake.
- Major repair required and plant operation is of high priority.
- Authorisation to force equipment/alarm has been received.

The micro-switch input to the PLC is monitored in both the brake engaged and brake lifted states. In addition, the slew speed of the machine is restricted until all brake lifted inputs have been received. Consequently, the following steps should be taken to force this alarm:

- Manually lift the brake using the brake handle and lock in the raised position using the swing arm on the brake cover.
- Force the brake lifted input (eg. SD01_ZS01).
- Force the brake not lifted alarm on the PLC (eg. SD01_ZS01LA).
- Force the brake failed to engage alarm on the PLC (eg. SD01_ZS01SA).

4.2 CW/CCW Overrun Limit Alarm

Description

The slew overrun limit alarms are similar to the long travel overrun limits and this alarm occurs when the overrun limit switches are actuated. The CW and CCW overrun limits are designed to inhibit further slewing when activated and should be physically mounted past the slew software limits. A visual indication of the slew software, overrun and emergency limits can be seen on the Limits Overview page on Citect.

Action

```
Visually check the location of the boom in relation to the overrun switch

Slew the machine in Maintenance mode away from the overrun switch and reset the machine

Check the software limits of the machine and investigate why the overrun tripped first

Yes → Has boom hit switch?

No → Inspect overrun switch for damage or failure

Check voltage supply to switch

Check overrun switch relay in MCC relay panel for failure/operation

Repair/replace equipment as required
```
Forcing

The overrun limits should not be forced or bypassed in normal operation. These devices provide hard-wired protection to prevent excessive slewing. The machine should not exceed the software limit in normal operation and consequently these switches should never activate. In the event that a switch is faulty and requires bypassing to repair, the hard-wired relay will need to be bridged. Refer to the slew drive drawing for the relevant stacker.

4.3 CW/CCW Emergency Limit Alarm

Description

The CW and CCW emergency limit alarm performs a similar function the overrun limits described above. The emergency limit is the second hard-wired limit and acts as a final over travel protection device. The switch is physically mounted past the overrun switch and a visual indication of the slew software, overrun and emergency limits can be seen on the Limits Overview page on Citect. The main difference to the overrun limit however, is that the long travel must be physically switched into bypass mode before travel in maintenance mode occur.

Action
Forcing

The emergency limits should never be forced. These devices provide final hard-wired protection to prevent excessive slewing. Further travel of the machine past the emergency limits will result in collision with the structural hard stops. The machine should not exceed the software limit in normal operation and consequently these switches should never activate. In the event that a switch is faulty and requires bypassing to repair, the hard-wired relay will need to be bridged. Refer to the slew drawing for the relevant stacker. In this case the operation of the overrun switches should be tested to ensure that some form of protection is still in place.

4.4 Quadrant SW Faults

Description

The quadrant switches provide a check on the slew encoder accuracy by comparing the encoder position to a known accurate value each time a quadrant switch is activated. The stacker Limits pages provides an overview of the slew quadrants and relevant limits.

Action

To clear this alarm the stacker must be slewed over the faulted quadrant proxy switch while in Maintenance mode.

Forcing

The alarm may require forcing into a healthy state under the following circumstances:

- Alarm does not reset due to a faulty proximity switch.
- Repair required and plant operation is of high priority.
- Authorisation to force equipment/alarms has been received.

4.5 Encoder Calibration Fault

Description

The slew encoder is checked for accuracy by the quadrant 2 and quadrant 3 proxy switches. On each transition of the state of the proxy the PLC records the slew position. This position is checked to ensure it is within an acceptable range. The range is currently +/- 0.5 degrees. If the slew value is outside this range upon switching of the proxy an alarm is generated. This alarm will inhibit the slewing of the machine.
Action

Inspect the proxy switch for damage, failure or loose mounting (may not have access if operating)

Check the encoder values to determine degree of inaccuracy

Change PLC logic to use encoder 2 as the primary encoder if other options are exhausted

Slew back and forward past proxy in Maintenance mode to reset

Repair/replace as required (Swap with encoder 2 if no spares)

Perform slew calibration and adjust proxy switches if required

Repair/replace as required

Inspection encoder/coupling

Is encoder faulty?

1

No

Increase acceptable accuracy range if required

2

Inspect encoder/coupling

Forcing

There should be no need to force this alarm as it provides accuracy checking for the encoders and confirms the integrity of the slew positioning system. A slew calibration should be performed if required and any faults with the proxy or encoder should be rectified before operation continues.

If plant operation is to continue while the luff encoder is monitored for a fault, alarm may be forced or the accuracy range may be increased slightly. The PLC variable SD02_ENCCHECKA should be forced. If there is an error with encoder 1 that can not be repaired immediately the PLC logic can be altered to allow encoder 2 to drive the machine. Please see the Encoder Comparison Fault section below for a detailed description of the method.

4.6 Encoder Comparison Fault

Description
The encoder comparison fault occurs when the difference between the two encoder position readings exceeds the preset maximum. This alarm will inhibit the slewing of the machine. The encoder detail page is accessible from the Stacker Overview page.

**Action**

1. **Check the encoder differences on the Stacker encoder page on Citect**
2. **Slew the machine to determine which encoder is slipping**
3. **Which encoder faulty?**
4. **Perform slew calibration as required**
5. **Alarm may be forced to allow repairs at a later date while operation proceeds**
6. **Repair/replace as required**
7. **Repair/replace as required (Swap with encoder 2 if no spares)**
8. **Inspect encoder and coupling**

**Forcing**

The encoder comparison fault may need to be forced into a healthy state under the following circumstances:

- No spare encoder to replace faulty device.
- To continue plant operation while repairs are scheduled for shutdown.
- Authorisation to force equipment/alarm has been received.

If the faulty encoder is the No.2 encoder than the alarm can be forced directly in the PLC. Force the alarm (eg. SD02_ENC_COMPA) into the low (OFF) state. If the faulty encoder is No.1 than No.1 should be replaced or swapped for No.2 and the force applied as above.

In the event that this is not possible there is additional changes required to enable plant operation to continue. This is because the PLC uses the value derived from encoder No.1 to operate (Encoder No.2 is only used as a comparison to No.1). To use Encoder No.2 as the primary encoder follow the steps below. SD02 in the steps below relates to Stacker 2. For Stacker 1 these variables will be begin with SD01:

- Open Slew_Encoder section of the PLC.
- Delete link from SD02_ENC1_RAW block to the ENC_RAW input of the first ENCODER DFB.
- Insert link from SD02_ENC2_RAW block to the ENC_RAW input of the first ENCODER DFB. This will ensure the PLC uses the raw input from Encoder No.2 to operate the machine.
- Replace the SD02_ENC1_DIAG01 input to the Encoder Healthy Status block with SD02_ENC2_DIAG01. This will ensure the PLC believes that Encoder No.1 is healthy.

Ensure all current PLC change policies and procedures are followed.

4.7 Microwave Anti-collision Faults

Description

The microwave detection alarm activates when the microwave beam between the sender and receiver unit is interrupted. The LHS and RHS microwaves protect the boom from collision with a stockpile or another machine. The microwave transmitter has a single N/O contact that switches on when a signal is detected (Healthy State).

Action

- Visually inspect microwave transmitter, sender and receiver
- Obvious fault?
- Yes
- No
- Is green TX power light on?
- Yes
- Check that N/O contact is switching correctly
- No
- Is red TX signal light on??
- Yes
- Is yellow coil light on??
- Yes
- Temporarily connect new sender to test receiver
- Temporarily connect new receiver to test sender
- Replace sender or receiver as appropriate
- No
- Replace unit if faulty
- Check wiring to sender and receiver
- Check 24V D.C. supply for Microwave is OK in the MGC pop-up on CIect
- Test for 24V supply
- Check 24V D.C. supply for Microwa...
Forcing

Note: The anti-collision microwaves should not be left in a disabled state without continuous monitoring where there is a risk of collision.

The alarm may require forcing into a healthy state under the following circumstances:

- Parts unavailable for repair of microwaves.
- To continue plant operation while repairs are carried out.
- Intermittent and/or frequent tripping due to excessive dust.
- Authorisation to force equipment/alarm has been received.

The signal from the microwave transmitter provides power to a number of hardwired relays that are interlocked to various machine relays. Consequently a simple PLC force will not allow the microwaves to be bypassed. The microwave can be effectively bypassed by bridging the N/O contact of the transmitter in the field. If this is not an option due to a faulty transmitter or cable fault on the supply side of the circuit, the hardwired relays will need to be bridged. Refer to the relevant stacker drawing for details.
5.0 Boom Conveyor MC09 and MC12

5.1 Belt Tension Alarm

Description

The stacker boom conveyors have belt tension sensors located on the head end pulley and provide feedback to Citect on the current tensions on each side of the conveyor. The belt tension alarm for each side actuates when the belt tension falls outside a specified operating range. These minimum and maximum set points can be found on Parameter Page 3 for the relevant stacker. At the time the guide was created these values were 2.0t and 11.0t respectively.

Action

Forcing

The belt tension alarm may be forced if there appears to be a failure of the sensor itself and operation is to continue. Load cells can not be easily replaced and must be performed on a shutdown. Locate and force the relevant belt tension alarm for the stacker (ie. MC12_XY01A or MC12_XY02AB).

5.2 Brake Not Lifted Alarm

Description

The boom conveyor drives have a hydraulic brake unit to assist in keeping the drive stationary and to decrease stopping time when the conveyor is de-energised. The brake calliper includes a pressure switch that operates when the pressure in the calliper is great enough to ensure the brake has lifted.
The brake not lifted alarm when the pressure switch on the brake calliper fails to operate within 20 seconds of attempting to start the conveyor.

**Action**

- Visually inspect brake callipers
- Put brake into test mode to check operation
  - Is brake lifting?
    - Yes: Check pressure switch
    - No: Is motor operating correctly?
      - Yes: Repair switch as required
      - No: Repair motor as required
        - Remove brake calliper and force alarm if unable to repair
        - Check oil level in reservoir
          - Remove brake calliper and force alarm if unable to repair
          - Contact fitters

**Forcing**

If the brake is still releasing and the alarm is forced due to a faulty pressure switch, there will be no indication of a brake failure other than a possible underspeed or visual burning of the brake pads. Consequently, the brake not lifted alarm is not to be forced in normal operation unless the brake callipers have been removed or backed off to ensure that the boom conveyor is free to operate as required. To force the pressure switch input into the operational state the MC12BK01_PS1 (or MC09BK01_PS1) variable will need to be forced into the high state (ON).
5.3 Brake Mode Switch Alarm

Description

The brake mode toggle switch is located next to the local stop/start station for the boom conveyor brake. The toggle switch has a normal position and a test position. The brake mode switch alarm actuates when the toggle switch has been left in the test position.

Action

The brake mode switch should be inspected and placed into the normal operating position. If the fault still exists an internal inspection of the switch should be undertaken to identify any contact block or mechanism failure in the switch. There is also the possibility that the supply to the switch has failed.

Forcing

There should be no need to force this alarm in normal operation. Repairs on the switch should be made as required.

5.4 Underspeed Alarm

Description

The underspeed proximity switch for the boom conveyor is located on the head pulley. The PLC logic counts the pulses detected by the switch and will fault the conveyor if the speed drops below 90% of normal. The current setting is to count 6 pulses in 1.4 seconds. The underspeed alarm forms part of the boom conveyor safety devices.

Action

Yes

Mechanical problem?

No

Repair mechanical issues and test operation of conveyor and underspeed again

Visually inspect the conveyor for mechanical or operational failure that may be causing the underspeed

Repair/replace equipment as required

Inspect underspeed proximity for damage or failure

Check voltage supply to switch
Forcing

There should be no forcing of the underspeed alarm under normal operating conditions. The underspeed provides indication of mechanical failure or bogging down of the conveyor and consequently is a critical safety device. Repairs should be made before operation recommences.

5.5 Fluid Coupling Over-temp Alarm

Description

The boom conveyors use a fluid coupling arrangement to transfer the rotation of the electrical drive motor to the gearbox as a form of motor starting and equipment protection. The fluid coupling over-temp alarm is actually an underspeed device similar to the proxy used on the head drum of the conveyor. A small high frequency proximity switch counts the rotations of the fluid coupling and feed this signal back to a pulse controller in the MCC relay panel. This IFM effector controller is customizable and provides a single healthy output to the PLC when the fluid coupling is rotating above the minimum set point. There is also a small time delay to allow for start up of the drive. This fault will restrict the operation of the conveyor.

Action

Forcing

The fluid coupling proximity alarm may be forced under the following conditions:

- Parts unavailable for repair of faulty switch or controller.
- Major repair required and plant operation is of high priority.
- Authorisation to force equipment/alarm has been received.

This alarm is effectively an underspeed protection on the machine similar to the normal underspeed located on the head pulley of the conveyor. Consequently, the normal underspeed will provide a
secondary redundancy protection for the fluid coupling. Ideally, equipment should be repaired where possible and left in a disabled state for the shortest possible time period.

The alarm can be bypassed by forcing the MC12_SY01A (or MC09_SY01A) variable into the low (OFF) state.
6.0 Stockyard Conveyors MC08 and MC11

6.1 Tripper Pullwires

Description

The conveyor pullwires consist two separate circuits including a PLC/Citect indication circuit and a hard-wired emergency stop circuit wired directly into the conveyor control circuit. The east and west tripper pullwires on each stacker will also trip the 6.6kV high voltage supply to the stacker causing immediate de-energisation of all equipment on the stacker.

Action

Check that there is no one in danger at the stacker tripper location. The tripper pullwire will need to be reset before power can be restored to the stacker from the main substation. If it was an intermittent or false trip the pullwire may need to be adjusted before restoring power to ensure it does not trip unintentionally again.

Forcing

Emergency safety devices such as pullwires and shall never be forced or bypassed in order to resume operation. Repairs should be carried out before equipment is put back into service.

6.2 Take Up Alarm

Description

The take up proximity switch is located at the counterweight tower at the tail end of the stockyard conveyors. The take up proximity switch provides indication when the counterweight rises up above the safe operating height and may indicate a belt or counterweight problem.

Action

Inspect the counterweight and take up proximity switch. If no mechanical problem with the belt and counterweight then inspect the switch for failure and repair/replace as required.

Forcing

If the proximity switch has failed or been damaged and operation is to continue then the alarm may be forced to enable running of the conveyor. Repairs can then be scheduled for the next available opportunity. Ensure that authority has been given before implementing any force. The variable to be forced is the take up alarm MC11_ZS1A (or MC08_ZS1A).
7.0  Master Control

7.1  VVVF Temp High Alarm

Description

The VVVF cubicle on each stacker has an individual thermostat located in the top corner. This thermostat is adjustable and provides over temperature protection for the VVVF drives.

Action

Inspect the VVVF cubicle, ensure air conditioners are operational on the stacker and inspect VVVF cubicle dust filters. Also ensure VVVF cubicle fans are operational. If temperature appears good then inspect thermostat for failure and repair/adjust as required.

Forcing

The temperature protection should not be forced under normal circumstances due to the VVVF drives being susceptible to high temperatures. If the thermostat has failed than the input may need to be forced to the PLC in order to repair or while waiting on parts.

7.2  Motion Fault

Description

The stacker motion fault is actuated when movement is detected on any stacker drives when no movement has been requested. This includes long travel, slew and luff drives. There is a time delay to allow the machine movement to stop when targets have been reached but if motion persists then the motion alarm will fault. This alarm will trip the 6.6kV high voltage supply from the main substation to the stacker.

Action

Inspect all of the stacker drives for movement and ensure there has been no damage to the machine.

Forcing

This alarm should never require forcing in normal operation.

7.3  Earth Continuity Trip

Description

The stacker earth continuity fault will trip the 6.6kV high voltage supply to the stacker. There are two earth continuity relays for each stacker that utilise the two pilot cores that run through the stacker trailing cables. One circuit consists entirely of the tripper lanyards and the second circuit consists of other safety devices in series. These include:
- 6.6kV Incomer emergency stop
- Machine emergency stops
- HV slip ring cover limit switch
- Fire panel trip relay
- MCC earth fault relay

Refer to the stacker 6.6kV feeder and trailing cable drawings for specific details.

**Action**

Earth continuity trips may be caused by any of the devices listed above as they are all connected in series. Citect indication should accompany any earth leakage trip to help identify the cause of the fault. The cause should be identified and repaired as required to allow the relay to be reset. Refer to the relevant drawing to help tracing out of the circuit. Past earth continuity faults have included:

- Faulty HV slip ring cover limit switch
- Faulty hardwire contact on tripper pullwires (without Citect indication)
- Fire panel trip
- Faulty end of line resistor (located in relay panel)
- Damaged brush gear/slip rings within the trailing cable slip ring cubicle

**Forcing**

The earth continuity protection shall never be forced off in normal circumstances as it provides critical safety protection for both people and the equipment. Faults on the circuit shall be rectified before operation recommences.

### 7.4 Fire Alarm Trip

**Description**

The fire alarm panels on the reclamer provides a fire alert and trip the 6.6kV high voltage supply to the reclamer in the event of a fire. The VESDA units monitor smoke levels and provide fire inputs to the main fire panel controller. There are three stages the VESDA goes through before tripping the panel and there is a small time delay before stepping between stages.

**Action**

Initial response to a fire alarm trip of the reclamer should be to physically inspect the machine for the existence of a fire and respond appropriately. If no fire is present and the fault is a nuisance trip of the fire system, the VESDA panel should be isolated by pressing the ISOLATE button on the VESDA panel. This will effectively replace the trip output of the main fire panel with a fault output. Once isolated the 6.6kV high voltage supply from the main sub can be switched back on. The process isolator may require switching back on if it has tripped and the reclamer can be reset to allow operation to continue.

Loss of power to the reclamer will normally also require the incomer and transformer feeder to be racked back in once the supply from the main substation is restored. This is done by following normal HV switching procedures and will involve charging the breaker before switching power back on.
Forcing

The fire alarm panels may be isolated on the VESDA unit if it has been a VESDA trip or on the main fire panel itself if the trip is due to a faulty break glass unit or other fault on the main fire panel itself.
8.0 Cable/Hose Reeler

8.1 Overtension Fault

Description

The cable and hose reeler on the stackers use a cable feeder system to assist the feeding of the cable from the cable tray up onto the appropriate drum. The VVVF drives for the cable and hose reeler monitor the torque of the motors and wind or unwind the cable/hose as appropriate. The cable feeder uses two overtension switches to protect against excess stress being placed upon the cables while the stacker is long travelling. These switches are located on each end of the cable feeder and will actuate when excess pressure forces the guide rollers to come in contact with the switches. The switch will fault the cable/hose reeler drive and restrict further long travel of the machine.

Action

Visual indication of the hose/cable reeler and the feeder should identify any obvious problems. The fault may have reset once long travel movement has stopped. The hose/cable reeler may need to be placed into maintenance mode and operated at the local stop/start station to clear the fault. Once the fault is cleared, monitor the reclaimer as it continues to long travel. The following lists a number of possible causes/faults:

- Dirt build up on the guide rollers that results in premature contact with the overtension switch
- Motor or VVVF drive failing to operate correctly
- Failure of the overtension switch
- Mechanical clutch problems (contact mechanical maintenance)

Forcing

The overtension faults should not be forced in normal operation. The switches provide protection from excess stresses and damage that may occur from an over travelling reclaimer or faulty reeler equipment. The consequences of a major cable/hose failure are severe and all effort needs to be made to maintain the integrity of the system.

8.2 Undertension Fault

Description

The cable and hose reeler on the stackers use a cable feeder system to assist the feeding of the cable from the cable tray up onto the appropriate drum. The VVVF drives for the cable and hose reeler monitor the torque of the motors and wind or unwind the cable/hose as appropriate. The cable feeder an undertension switch to protect against cable/hose piling up and catching beneath the stacker while it is long travelling. This switch is located on the centre point of the cable feeder and will actuate when the cable/hose becomes slack enough to fall past the mid point of the feeder. The switch will fault the cable/hose reeler drive and restrict further long travel of the machine.

Action
Visual indication of the hose/cable reeler and the feeder should identify any obvious problems. The fault may have reset once long travel movement has stopped. The hose/cable reeler may need to be placed into maintenance mode and operated at the local stop/start station to clear the fault. Once the fault is cleared, monitor the reclamer as it continues to long travel. The following lists a number of possible causes/faults:

- Dirt build up on the feeder that results in false tripping of the switch
- Motor or VVVF drive failing to operate correctly
- Failure of the undertension switch
- Mechanical clutch problems (contact mechanical maintenance)
- Excess cable/hose being reeled off due to previous uneven laying of the cable/hose onto the reeler. In this case there is little that can be done except allow the excess to continue to roll off and standby to keep resetting the cable/hose reeler

Forcing

The undertension fault should not be forced in normal operation. The switches provide protection from excess stresses and damage that may occur from an over travelling stacker or faulty reeler equipment. The consequences of a major cable/hose failure are severe and all effort needs to be made to maintain the integrity of the system.

8.3 Reel Empty Fault

Description

The reel empty switch provides end of line protection for the trailing cable and hose on the stackers. The switches have been set up to provide a trip protection to the reellers (and consequently the long travel) to ensure that the final layers of the reeler are not unreeled. The potential damage to the cable/hose is extreme in this circumstance. This fault will restrict the operation of the cable/hose reeler and consequently the long travel of the machine.

Action

The reel empty switch is located in the low voltage section of the slip ring cubicle for the cable reeler and in the water valve enclosure for the hose reeler. The switch is a cam style belt driven unit with a number of customisable cam limits. This switch should not operate in normal circumstances as the length of cable and hose on the drum is sufficient to allow the software, overrun and emergency limits to operate first. In the case of a trip in normal operation it is likely that the cam switch has failed and requires replacement or readjustment. Refer to the vendor manual for the adjustment and setup procedures. The cam can be quite confusing and complicated to adjust and care should be taken to ensure equipment is left in an effective operating state.

Forcing

This switch may need to be forced to allow normal operation to continue while repairs or adjustment are scheduled for a shutdown. Due to the redundant protection devices and long travel limits the forcing of this switch may be undertaken as long as there is no obvious problems with the effective operation of the reeler or length of the cable/hose. The best practical method of bypassing this switch is to bridge the contact at the switch itself.
8.4 Pendulum Fault

Description

The cable and hose reeler feeders have a north and south limit switch mounted to provide indication as to which position the feeder is currently in. The pendulum alarm activates if both of these switches operate at the same time as this should not normally be possible. The pendulum alarm is also triggered if the north switch is turned on while the reclaimer is on the south side of the centre point (dead end box) and vice versa.

Action

A visual of the reelers and switches should be undertaken to identify any obvious faults. Placing the cable/hose reeler into out to maintenance and jogging the drive should clear the fault by returning the reel to the correct position. It is possible the switch has failed and may require repair or replacement. Once the fault is reset the operation of the reeler should be monitored while the machine is travelling.

Forcing

There are two switches that are used for the pendulum alarm and they can not be forced one way or the other as the PLC monitors the state of these switches at all times. Consequently, if there is a fault that can not be repaired immediately, the pendulum alarm itself may need to be forced to allow operation to continue. The variable to be forced is HL02_PENDA (or CB02_PENDA).

8.5 Water Pressure Fault

Description

The reclaimers water pressure fault occurs when the water pressure supplied to the machine drops below a specific set point. The pressure switch is located in the hose reeler valve enclosure on the reeler deck. This pressure switch can be adjusted locally. This alarm will restrict reclaiming operations including long travel. The purpose of the alarm is to ensure the hose reeler has adequate pressure to travel and reel effectively and also to identify the possibility of a burst hose along the stockyard.

Action

The water supply to the stackers should be checked on Citect upon the tripping of this alarm. The stockyard water supply pumps should be investigated or started if there has been a fault with the pumps. If the water pressure to the stacker is sufficient then the hose should be checked for damage and a visual inspection of the reeler should be undertaken. There is a possibility of the pressure switch failing and this should be repaired or replaced as required.

Forcing

There should be little reason to bypass this alarm in normal operation. If the pressure switch has been set too high then it may require adjustment but this should not normally be the case.
Appendix F

Electrical Module 2: Control Systems
Control System Overview

Hardware - Field:
- Central PLC hardware is the Modicon Quantum rack mounted PLC. These are used for the main PLC programs and are located in substations and on stockyard machines.
- Remote PLC hardware is the Modicon Momentum PLC. These are used for smaller PLC programs located in HV rotor cubicles and borefield MCC cubicles.
- Field I/O modules used in terminal boxes and remote panels are Modicon Momentum modules.
- HV motor protection relays are Siemens Siprotec relays.
- LV motor protection relays are Moeller ZWK Simicode relays.

Hardware - Servers:
- Rack mounted plant servers with hot swappable hard drives.
- C-Deposit OHP Office Communications Room Rack:
  - Citrix Server (3210OIS04)
  - Domain Controller, File and RIS Server (3210OIS05)
  - Primary Citect Report, Alarm, Trend and I/O Server (3210OIS01)
  - CitectSCADA Reports Server (3210OIS06)
- E-deposit Crushing Substation Rack:
  - Domain Controller, File and RIS Server (3230OIS07)
  - Backup Citect Report, Alarm, Trend and I/O Server (3230OIS02)
  - Backup CitectSCADA Reports Server (3230OIS03)
Hardware - Servers:
- **Citrix Server:** Used for centralizing controls software applications and controlling user access to them. Also used for remote access to plant controls system.
- **Domain Controller, File and RIS Server:** Manages the controls network domain and remote installation services. Also acts as a central data storage area, with the following drive mappings –
  - 'J' drive – links to the master Citect development databases
  - 'P' drive – links to the Concept DFB and master PLCs
  - 'S' drive – links to other software which may be used
  The mappings are set up as a distributed file system (DFS) so that each drive maps simultaneously to both the primary and backup file server data storage area.

- **Citect Report, Alarm, Trend and I/O Server:** Communicates with the PLC and other control devices (Multilins) on site. Logs alarms, archive trends and generates reports and events.
- **CitectSCADA Reports Server:** Historizes events such as alarms, plant status and operator actions. Used for event re-construction.

Hardware – Computer Terminals:
- There are two types of terminals that have been configured around the plant to enable users access to the control network. These include:
  - Operator Interface Terminals (OIT).
  - Engineering Interface Terminals (EIT).
- Various users are provided with different levels of access based upon the need to have access to specific software and tools. The differences between different terminals and users are covered in the following sections.

Hardware – Operator Interface Terminals:
- **Function:** Control room terminals to provide plant control interface.
- **Citrix login – operator level:** Username and password are the PC ID (e.g: 3210OIT01). This allows access to Excel, Word, MAC Webpage and view only Citect runtime.
- **Citrix login – maintenance level:** Log on details will be supplied on an individual basis. Allows access to Excel, Word, MAC Webpage, full control Citect and Concept.

Hardware – Engineering Interface Terminals:
- **Function of EIT is to allow access for properly trained personnel to all the necessary tools needed to modify any of the control systems devices.**
- **Software available on EIT includes:**
  - Citect
  - Concept
  - Sycon Configurator (Used to configure Profibus networks)
  - GE Multilin
  - Multinet
  - WIN-Simicode
Control System Overview

Physical Communication Media:

- Within PLC cubicles and control room (Ethernet)
- PLC to Control Room (Single Mode Fibre Optic)
- Rotor cubicles to substation (Single Mode Fibre Optic)
- Field terminal boxes to substation PLC’s (Profibus DP)
- Field devices to field terminal boxes (Cable)
- Field instruments (Profibus DP)
- TLO control room to bore fields (Radio Frequency Link)

Control System Overview

Software:

- Concept V2.6 for use with Momentum and Quantum PLC modules.
- Citect V6.1 SCADA software for providing a plant control interface to the PLC.
- ABB DriveWindow for connecting directly to an ABB VVVF drive.
- WIN-Simicode for connecting directly to LV Simicode relays.
- DIGSI 4.3 for connecting directly to HV Siprotec relays.
- Other vendor software for advanced applications.

Control System Overview

PLC Functions:

- Collection of inputs.
- Control of outputs.
- Solving logic including interlocks, sequences, etc.
- Solving control loops.
- Receiving commands from the HMI (Citect SCADA system).
- Allows data to be collected by the HMI (Human Machine Interface).
- Control of inter-PLC communications.
- Control of remote I/O module communications.

Control System Overview

Citect Functions:

- Graphical status displays of all plant areas.
- Plant control interface.
- Alarm displays and logs.
- Control loop displays.
- Trend displays and archiving by the Citect reports server.
- Displays the status and alarming of the control system including the Profibus network, PLC-to-PLC communications and other communication links.

Control System Overview

Control Network:

- Overview of the control networks are available on Citect.
- Citect network pages show the following information:
  - Profibus DP substation bus and field networks.
  - PLC-to-PLC communications summary.
  - LAN communications overview.
- The alarm page also displays hardware and communications faults that have occurred.
Control System Overview

Profibus Substation Network Overview

Part 2: Hardware Overview

Control System Hardware

Quantum PLC:
- Used for main plant PLC control.
- PLC has a power supply module requiring 240V AC. This is supplied by a 240V circuit breaker.
- All modules except the CPU and power supply are hot swappable while PLC is running.
- Range of different modules used including Ethernet, Profibus DP, analogue and digital I/O.

Momentum PLC and I/O:
- Primarily for field mounted I/O functionality. PLC modules used for rotor cubicles and bore fields.
- Modules have a 24V fused terminal for protection.
- Terminals strips are removable to assist in changing backplanes.
- Profibus cables are looped and each module has an allocated node number set by rotary switch.
- LED indication of inputs, outputs, run, ready and fault.

Control System Hardware

Substation PLC Cubicles:
- Computer terminal.
- Quantum PLC rack.
- PLC supply C/B's.
- Fibre FOBOT panels.
- Ethernet/Fibre converter modules.

Plant Control Terminals:
- LIVE control terminals located at: Stockyard machines, TLO control room, Main plant control room, E-deposit control room, OHP1 Main Substation, OHP1 Offices.
- Flat screen monitors.
- Terminals also located in each substation.
- Each terminal has a computer ID name that should be attached to the machine.
Simicode LV Relays:
• Electronic control and protection of LV equipment.
• Individually configured for specific equipment.
• Range of different current ratings but all use same software and functionality.
• Profibus cable connects relay to the control network.
• Hardwire control circuits connect directly to relay from the field.

Siprotec HV Relays:
• Electronic control and protection of HV equipment.
• Individually configured for specific equipment.
• Current transformers and RTD’s are connected directly to the unit for monitoring.
• Profibus cable connects relay to the control network.
• Circuit breakers inside panel feed the control circuits.

ABB VSD Drives:
• Also known as VVVF drives (Variable Voltage Variable Frequency).
• ACS 800 model in use with a range of sizes and ratings. ACS 1000 used for overland conveyor.
• Spares of each are available in the store.
• Do not perform an insulation test (megger) on cables while connected to the unit!

Field Terminal Boxes:
• Relevant drawings located inside panels.
• Circuit breakers and fuses for field circuits mounted in panels.
• Field mounted momentum PLC modules.
• Profibus cable and surge arrestors.
• Spare fuses should be located in all panels.

Ethernet/Fibre Converters:
• Two types of media converters are used on site for converting between Ethernet Cat 5 UTP and Ethernet Fibre Optic:
  • Sixnet Switches – Used for connecting Ethernet devices, mainly Momentum PLC modules, mounted in remote locations (eg: rotor cubicles, bore pump MCC).
  • IMC Media Converters – Used for converting the backbone Ethernet connections between buildings (ie: substations, equipment rooms and control rooms).
Cisco Switches:
- Integral part of the plant Ethernet control network.
- Virtual LAN’s (VLAN) are configured on each switch to allow switching of multiple networks.

Citect Runtime:
- Citect Runtime is the Supervisory Control and Data Acquisition (SCADA) application that enables the plant to be controlled through a human machine interface (HMI) terminal.
- Citect at Mining Area C has been developed to provide operators with detailed plant pages and pop ups to effectively control the plant.
- Familiarization with the Citect pages and navigation to all relevant plant areas is an essential skill for all site electricians. The following is of highest importance:
  - Searching and identifying alarms
  - Resetting equipment
  - Bringing up trends and manipulating trends
  - Bringing up PLC tag information from on-screen information

Citect Explorer:
- Citect Explorer is the development platform for the Citect SCADA system.
- Access can be gained to the site master Citect development databases.
- Citect functionality and design is developed using Explorer such as:
  - Variable tags
  - Trends
  - Pop-ups
  - Events
  - Pages
Software Overview

Concept PLC Software:
• Concept is a PLC programming program that is compatible with both Momentum and Quantum PLC modules.
• The software can utilize any of the 7 IEC standard PLC programming languages. Mining Area C PLC programs use the following PLC language styles:
  - Primarily Function Block Diagram (FBD) logic.
  - Sequence Flow Chart (SFC) to program plant sequences.
  - Structured Text (minimal use for specialized code).
• PLC programs can be viewed and users can connect directly to the PLC for online monitoring and interaction.
• Concept can be used for fault finding and to apply forces to PLC variables as required.

Software Overview

Citrix:
• The Citrix server provides centralized control system software applications and controls access to these applications.
• May be accessed from any plant terminal through the windows Start menu:
  - Start → Programs → Citrix → Citrix Neighbourhood
• Three levels of Citrix access:
  - Operator
  - Maintenance
  - Engineer
• Programs used through the Citrix login are running on the Citrix server (not on the local machine).

Software Overview

MAC Webpage:
• The MAC Webpage is accessible to all users via Citrix.
• The webpage provides access to the following:
  - Plant Control Philosophy document (FUSP-860-00002).
  - Plant Control Maintenance Procedure (MAPR-860-E-00001).
  - Latest Quantum and Momentum PLC address maps.
  - List of IP addresses used on the MAC control network.
  - List of the inter-PLC addresses and data being transferred.
  - Access to the Citect Reports Server.
Software Overview

UltraVNC:
- UltraVNC is a powerful network connection application that can provide a remote connection to another terminal on a network.
- The VNC connection provides a 'window' into the remote terminal and allows the user to operate the terminal as if they were at the machine. Consequently, the potential for accidental misuse or damage is high.
- This functionality should not be required in normal operation and access to this software is provided to engineer level users including supervisors and leading hands only.
- This program is accessed via a Citrix connection.

WIN-Simicode:
- Vendor application software that allows direct connection to Simicode motor protection relays via a serial connection.
- Data within the relay can be uploaded, viewed and downloaded as required. Device settings should not need to be changed from commissioned settings, although the correct settings will need to be downloaded if a new Simicode relay is installed.
- Parameters may not be changed while the Profibus DP cable is still connected to the Simicode. This feature provides peace of mind that the unit configuration should not be accidentally changed.
- This program is installed on both Mining Area C electrical laptops.

Digsi 4.3:
- Vendor application software that allows direct connection to Siprotec HV motor protection relays via a serial connection.
- Similar to the LV Simicode relays, the configuration should not need to be altered from the original settings for each machine. In the event of replacing a relay, the parameters will need to be downloaded.
- The software allows online monitoring of the drive parameters including power, current and voltage. Trend and graphing functionality can aid in interrogating the machine operation. The relay also stores an archive of past faults and relay events.
- This program is installed on both Mining Area C electrical laptops.
Software Overview

DriveWindow:

• Vendor application software from ABB that allows direct connection to ABB VVVF drives via a fibre optic connection.
• Connection is made using a DDCS/PC CARB adapter that inserts into a laptop. A dedicated fibre optic cable then connects to the fibre connection module on the VVVF drive.
• The software allows online monitoring of the many VVVF drive parameters. Trend and graphing functionality can aid in interrogating the machine operation. Parameters may be changed online while the drive is running.
• This program is installed on both Mining Area C electrical laptops.

Communications Protocols

Profibus - Overview:

• Profibus cable on site is a purple cable that is easy to identify.
• The cable has a green core and red core surrounded by a shield.
• Profibus connectors have both an input and output set of terminals marked 1A/1B and 2A/2B respectively. A connections correspond to the green cable and B connections correspond to the red cable.
• There is a range of different Profibus connectors used but each has a switch of some description that allows a passive terminating resistor to be switched ON or OFF. Only devices at the end of the network should be switched ON.
Communications Protocols

Profibus - Addressing:
• Profibus is a master/slave protocol.
• Individual nodes on the same Profibus network must have a unique address.
• Address maximum of 126 nodes on the one network, 32 nodes without use of a repeater. Note: some devices don't provide provisions to have an address higher than 99.
• Data speeds can vary between 4600bps and 1.5Mbps.
• Many slaves detect the speed via the master configuration.

Profibus - Addressing:
• There are a number of devices that do not have Profibus addresses but exist on the network, and are essential parts in ensuring stable operation. These include:
  - Active/passive terminators.
  - Repeaters.
  - Surge Suppressors.

Communications Protocols

Profibus - Terminators:
• A RS485 based network such as a Profibus network requires the use of an impedance on the end of each line (a termination, if you will).
• Basically, it is an introduction of a 220 ohm impedance between the two wires that allows for proper reflection of the signal off the end-of-line (plus a pull up and pull down resistance to give a voltage bias between the lines). Do not use meter when device is powered due to high frequency and impedances.

Profibus - Terminators:
• Rarely a cause for concern. If suspected fault, check with a multimeter that there is 24V to the circuit.
• Also the impedance across the red and green connections should be 220 ohms. Impedance matching means there is no signal reflection.
• Basically, it is an introduction of a 220 ohm resistance between the two wires that allows for proper reflection of the signal off the end-of-line (plus a pull up and pull down resistance to give a voltage bias between the lines).

Communications Protocols

Profibus - Repeaters:
• Repeaters are placed at points in the network where there is a particularly long Profibus cable run or there are 32 nodes in a row. The repeater is there to retransmit the signal in both directions with what is essentially a full signal strength.
• They are powered by a 24V DC power source. The terminals for this are on the top of the unit. Next to this are terminals for the "incoming" Profibus cables which are Port A (Green core), Port B (Red core) and GND (ground/shield). The "outgoing" cable may be on one of two output rows (providing for two repeated outputs at one time). The colour coding is the same as for the "incoming" terminals.
• If the cover is slid off the repeater, it reveals two switches and four DIP switches on the circuit board. The two switches are for the terminating resistors on port A and port B.

Profibus - Repeaters:
• The four DIP switches are used to determine the speed at which to operate.

<table>
<thead>
<tr>
<th>Speed (kbps)</th>
<th>Switch 1</th>
<th>Switch 2</th>
<th>Switch 3</th>
<th>Switch 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>500</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
</tr>
<tr>
<td>375</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>187.5</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
<td>ON</td>
</tr>
<tr>
<td>136</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>115.2</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
</tr>
<tr>
<td>93.75</td>
<td>ON</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>75</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>57.6</td>
<td>ON</td>
<td>ON</td>
<td>OFF</td>
<td>ON</td>
</tr>
<tr>
<td>38.4</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
<td>OFF</td>
</tr>
</tbody>
</table>

In the substations, a speed of 1.5Mbps is being used, while for the field I/O, the speed is 187.5kbps.
Communications Protocols

Profibus – Repeaters:
• The following describes the LED indications on the repeaters:
  Td = transmit
  Rd = receive
  Vcc = power

Profibus – Surge Suppressors:
• Surge suppressors are used to protect the devices and Profibus network from external noise and surges.

Profibus – Master/Slave Configuration:
• The Quantum Profibus DP module is the master device on the Profibus network.
  • As shown by most of the PLC’s, it is not restricted to one Profibus master module per PLC. However, it is important as to which slot the Profibus module sits in. It is acceptable to have nodes with the same Profibus node numbers connected to different Profibus masters, simply because it is treated as a separate network.
  • On the drawings and on the diagnostic pages, the addresses are shown as 2-5-57
    where the first number is the PLC number, the second is the slot that the master module is in, and the third is the slave node number.

Profibus – Momentum I/O Modules:
• Adapter module providing Profibus communications is a 170 DNT 110.00.
  • Two dials to allow for addresses between 0 and 99 (ships with 0).
  • A bus fault red LED operates when not communicating on the bus.
  • The adapter itself doesn’t determine the nature of the inputs - the I/O base does.
  • 170 ADI 340.00 - digital input 24VDC
  • 170 AAI 030.00 - analog input set to read 4-20mA
  • 170 ADM 390.30 - 10 digital inputs, 8 digital outputs, 24VDC

Profibus – Momentum Bus Faults:
• The following figures show how both individual and multiple communications faults are indicated on Momentum modules.
Communications Protocols

Profibus – Level Transmitters:
• The Endress and Hauser ultrasonic level transmitters ship with address 0, and the address is set via 8 dip switches behind the display, although the 8\textsuperscript{th} dip switch (the one on the left) is not used. The address is in binary, from MSB to LSB.

![Dip Switches 0 - 2 - 10](dip_switches.png)

• On the main terminal strip of the unit, there are also 4 dip switches that can provide a termination of the network if required. They should all be set to off if there is no termination, or the middle two can be turned on to terminate the network.

Communications Protocols

Profibus – Weightometers:
• The weightometers on-site are supplied by Thermo Ramsey, and have the model numbers 2001 and 2101.

• They ship with address 1, and since that is the address of the master module, it is important to change it before connecting it to the network.

• The Profibus card in the weightometer doesn't come standard, so it must be specified, and it usually exists in slot 2.

• Note: the weightometer on the machines do not talk Profibus - instead, they use a 4-20mA output from the analog card and a tonnes pulse which is sent straight to a PLC input card.

Communications Protocols

Profibus – Simicode/Siprotec/VVVF:
• These also exist on the Profibus network, but for the relays, the addresses are set within the programs themselves, while for the VSD's the address is set via rotary switches next to where the connector plugs into the unit. For the ABB VVVF drive the node address is also set as a software parameter.

• For the electronic Siprotec and Simicode relays the profibus address is set within the programs themselves (Digsi 4.3 and WinSimicode).

• Citect provides indication of the profibus network overview for each substation and field bus. This is a good starting point for identifying communications problems. Each drive in the plant has Citect indication of communications faults.

• If communications faults can not be cleared, the Profibus DP card may need to be lifted momentarily on the Quantum PLC rack to cycle the card. This can be done on the run but obviously all devices on that Profibus network will cease to function.

• If multiple devices have communications problems the probable cause will be the first device or profibus connection on the network that shows problems. Remember that each connector has a terminating switch that effectively isolates all downstream devices from the network. This has been known to cause problems.

• ABB VVVF drives often exhibit communications faults and the majority of the time only require a power cycle to reset the device.

• The profibus adapter module on the VVVF drives have also been known to fail occasionally.

• If the power cycle and profibus adapter are not the solution and all parameters and rotary switches for the device are correct then the VVVF drive may require replacement.

• Simicode modules have a green bus LED that indicates when the network (bus) circuit is healthy.

• If all connections, terminators and parameters of the Simicode relay are correct then the Simicode relay may require replacement.

Communications Protocols

Ethernet - Overview:
• A collection of devices that communicate to each other through the use of a CSMA/CD (carrier sense multiple access collision detect) protocol via copper Ethernet, fibre Ethernet or by radio link.

• Every device with a network interface has a worldwide unique MAC address.

• Every device on the local network must have a unique software settable address, referred to as an IP address. Conflicts occur if two devices have the same IP address.

• IP address is a 4 byte address such as 10.27.120.41.
Ethernet - Overview:

- Links operate at speeds of 10, 100, or 1000Mbps.
- Can be half duplex or full duplex.
- Some devices auto-negotiate speed and duplex mode; some don’t.
- Switches provide connectivity between different devices, and manage network traffic.
- Fibre is used for Ethernet links that need to travel longer distances, as the losses are less than copper Ethernet.

Devices on the Ethernet network include:
- Quantum PLC Ethernet modules.
- Plant control servers.
- All the computers onsite.
- Cisco Switches.
- Printers.
- Ethernet Radios.
- Momentum CPU’s in the rotor cubicles and bore pump panels.
- Media converters.
- CEV Ethernet to RS232 converter.
- CCTV system.
- IP Phones.
- UPS.

Devices central to the plant Ethernet network include:
- All Cisco switches.
- Citect Servers (Server 1 and 2)
- Domain Controller Servers (Server 5 and 7)
- The Citrix server (Server 4) is also an integral part of the network that allows connection to PLC and Citect environments from various terminals.

Ethernet - VLAN:

- Virtual Local Area Network (VLAN) separates communications into separate LANs using a software configuration within the plant Cisco switches.
- This reduces the need for separate switches for each network and hence network cabling is not required to be physically separated. The multiple port connections will be grouped into different network.

Network addresses are used at Mining Area C.
- 10.27.120.XXX (HMI to HMI) – for computers/printers that talk directly to other computers/printers.
- 10.27.121.XXX (HMI to PLC) – for PLC’s that interact with PC’s.
- 10.27.122.XXX (PLC to PLC) – for inter-PLC communications.
- 10.27.123.XXX (Village) – for village communications.
- 10.27.124.XXX (IP Phone) – for IP Phone network.
- 10.27.125.XXX (CCTV) – for the CCTV servers and workstations.

Ethernet - Radios:

- The plant bore fields incorporate Ethernet radio telemetry that allows plant communications to be maintained into the rail loop.
- The frequency range of this communication is 2.4 - 2.497 GHz. The data rate is 11Mbps.
- Each bore MCC has an antenna that allows connection to an aironet switch located in the TLO control room communications rack.
Communications Protocols

Ethernet – Momentum PLC:
• Consists of two parts - processor adapter, and I/O base.
• 171 CCC 960 30 is a CPU top hat with Ethernet port and Interbus port.
• IP address assigned to module through configuration of Ethernet IO Scanner settings in PLC database.
• In rotor cubicles and bore fields, Momentum modules communicate between each other using Interbus. Interbus is another communication protocol.
• Healthy communications = green LED’s.

Ethernet – Quantum PLC:
• Each Quantum configuration is made up of a number of components including the backplane, CPU, power supply and various modules.
• There are two NOE 771 11 Ethernet modules on each Quantum PLC backplane. One is used for inter-PLC communications and the other to facilitate HMI-PLC communications. A third NOE card is used for the plant power communications on PLC02.
• The Inter-PLC Ethernet network is critical to enable plant information to be transferred between PLC modules.
• The HMI-PLC Ethernet network allows users to connect to individual PLC modules on the network for online monitoring, alterations and fault finding.

Part 5: Plant Control Principles

Citect Trends:
• Many of the analogue variables displayed on Citect are recorded as trend variables. This enables the data to be trended over a specific time frame in order to identify plant operating trends and possible problems.
• Examples of information that can be trended:
  - Drive Power/Load/Current.
  - Bearing temperatures.
  - Bin levels.
  - Flow and pressure readings.
  - Slew, jiff and long travel positions.
  - Vibromac readings.

Citect Control Loops:
• There are a number of control loops in use within the plant that are controlled by the PLC. Most loops can be placed into Manual or Automatic modes.
• Manual mode allows operations personnel to adjust the set points manually and stop and start equipment as required to respond to known plant changes.
• Automatic control attempts to control plant variables in an attempt to maintain a specific set point entered by an operator. These loops are being continuously tuned and reviewed to increase efficiency and improve production. Not all plant conditions can be optimally managed in auto at this stage.
Plant Control Principles

Citect Control Loops:

PLC Forces:
- Plant PLC control can be monitored in real-time by connecting directly to the plant PLC modules over the Ethernet network. Once connected to a PLC using the Concept PLC software, the logic can be animated to show the condition of input and output states in real-time.
- The Reference Data Editor is a Concept facility to view and disable discrete input/outputs and force the variable into a desired state.
- This is generally done to facilitate fault finding or to allow plant operation to continue while repairs are carried out on equipment.
- Many plant variables cannot be disabled due to safety reasons. Authorization needs to be given by relevant supervision before a force is applied.

PLC Forces:
- The Reference Data Editor enable templates to be created that contain a saved list of variables. This is utilized at Mining Area C as a FORCES template that contain frequently used, past and current forces.
- All new forces should be added to this template for ease of identification and removal.
- There is a PLC Forces Log excel spreadsheet located in the Electrical SHARED folder on the HWE network. This needs to be updated each time a force is applied or removed from the plant PLC system. This enables tracking of information such as the date of the force, reason for the force, who applied the force, who authorized the force and when the force was removed.

Drive Operating Modes:
- Plant drives can be operated in two different modes: Auto Mode, Out To Maintenance Mode (Local)
- The plant normally operates in Auto mode.
- Maintenance mode is often used for maintenance, function testing, fault-finding, clearing machine faults and other specialist activities.

Drive Operating Modes:

<table>
<thead>
<tr>
<th>Mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out To Maintenance</td>
<td>Plant drives stop immediately in Out to Maintenance Mode due to loss of system communications. Process Interlocks implemented by PLC software.</td>
</tr>
<tr>
<td>Auto Mode</td>
<td>Drives already running in Out To Maintenance Mode remain running when switched to Auto mode.</td>
</tr>
</tbody>
</table>

Equipment protections implemented by PLC software.
Plant Control Principles

Fault Resetting - Citect:
- Citect provides a number of fault reset buttons for different areas of the plant. These are located on the bottom left on the main Citect overview page.
- A number of drives have additional reset buttons. These may be accessed by right clicking on a drive button. This will usually bring up a detailed drive summary page applicable to that machine. Any additional Citect resets will be located here.
- Citect often provides many fault alarms to the operator simultaneously. In this case, the alarm page should be investigated to identify which alarm occurred first or which alarm is the actual problem. Care should be taken not to chase phantom faults. Although operational input is valuable it is not always the correct information!

Fault Resetting – Simicode/Siprotec/VVVF:
- Siprotec devices have a reset button labeled F1 that needs to be pressed when the HV drive experiences an overload fault. This may also be required for other faults with the relay.
- VVVF drives also have a physical reset button located on the hand programming panel mounted on the front of the unit. Often a useful way to reset VVVF drives is to cycle the mains power to the unit and allow the unit to reset and reboot afresh.
- Both Siprotec and VVVF devices provide past event and fault information. This data can be seen by scrolling through the menus and stepping through the fault history.
- Simicode devices will automatically reset from an overload condition after 5 minutes.

Fault Resetting – Rotor Cubicles/Profibus:
- The HV drive rotor cubicles occasionally enter an unhealthy state and require resetting. If a Citect reset is not effective then there is a physical rotor cubicle reset button mounted on the cubicle in the field. There should also be a field mounted indicator light to show when the cubicle is healthy. This generally occurs after a power outage or plant shutdown.
- Profibus networks can be viewed from Citect and individual equipment will show a communications fault if the profibus network is not healthy. The following may be a useful starting point:
  - Cycle power to device.
  - Lift the Profibus DP card momentarily to reset the whole network.
  - Ensure profibus connector terminator is not ON unless the device is on the end of the network line.

Fault Resetting – Stockyard Machines:
- Many long travel, slew and luff faults that occur on stockyard machines require the drives to be placed into Out To Maintenance mode and the drive operated locally to clear the fault.
- Examples of these include:
  - Slew quadrant faults.
  - Telsor tag faults.
  - Hose and cable reeler undertension faults.
  - Luff zero proxy faults.
- Encoder calibrations may be required if encoder faults indicate excessive errors. These need to be done as outlined on the encoder Citect page for each machine.

Available Resources

General:
- There are a number of resources available to electricians and engineers to assist in fault finding and learning about the plant control network. These include:
  - Citect
  - Electrical Reference Folders.
  - Electrical Troubleshooting Guides.
  - Electrical Training Module Presentations.
  - Plant Equipment Simulation and Training Rack.
  - MAC Webpage.
  - Electrical Folder on HWE SHARED drive.
  - Engineers, supervisors and leading hands.
Available Resources

Citect:
- Overview of the control networks are available on Citect.
- Citect network pages show the following information:
  - Profibus DP substation bus and field networks.
  - PLC-to-PLC communications summary.
  - LAN communications overview.
- The alarm page also displays hardware and communications faults that have occurred.

Available Resources

Electrical Reference Folders:
- These folders are located in the electrical supervisor's office.
- A range of folders have been created covering critical areas and topics including Control Systems.
- Information available includes:
  - Functional descriptions.
  - Vendor manuals.
  - Data sheets.
  - Troubleshooting Guides.
  - Relevant drawings.
  - Training documentation.

Available Resources

Electrical Troubleshooting Guides:
- Designed as an aid for fault finding and troubleshooting plant faults.
- Each topic is included in the contents and incorporates three headings:
  - Description
  - Action
  - Forcing
- Guides are located in each substation and are available on the HWE intranet.

Available Resources

Electrical Training Module Presentations:
- A number of training modules have been designed to provide electricians and engineers with introductory training to the plant and electrical systems and Mining Area C.
- These modules include:
  - Module 1: Power Systems
  - Module 2: Control Systems (This Presentation)
  - Module 3: Crushing and Screening
  - Module 4: Reclaimer and Stackers
  - Module 5: TLO
  - Module 6: Sampling
  - Module 7: Infrastructure

Available Resources

Plant Equipment and Simulation Training Rack:
- A simulation training rack has been developed to enable training on plant equipment and software without being connected to the plant network.
- The following practice sessions are being developed:
  - Control Systems Overview
  - Quantum PLC Overview
  - Momentum PLC Overview
  - Simnode Overview
  - ABB VSD Overview
  - Siprotec Overview
  - Concept Advanced
  - Citect Advanced

Available Resources

MAC Webpage:
- The MAC Webpage has links to documentation on the plant IP addresses.
- Links are also provided for the following useful documents:
  - Control Philosophy
  - Control Maintenance Procedure
  - Control Maintenance Procedure
- Link also provided to the CitectSCADA Reports server to run reports and access archived trends and alarms.
- MAC Webpage available via Citrix.
Available Resources

Electrical Folder on HWE SHARED Drive:
- The Electrical folder on the HWE Mining Area C SHARED drive is located under the OHP folder.
- A large range of information is stored under this folder relating to electrical maintenance, records and systems. Some of the useful information may include:
  - Procedures.
  - Isolation information.
  - Training documentation.
  - Troubleshooting Guides.
  - Manuals.
  - Plant drawings.
  - Relevant contact details.
  - PLC Forces Log.

Available Resources

Engineers, supervisors and leading hands:
- Engineers and senior electrical personnel should be able to provide access to documentation and other resources that may be required.
- A good source of technical information.
- Do not know everything but may be able to point you in the right direction.

The future in the making

www.hwe.com.au
Appendix G

Theory Assessment
1. What are the two types of Modicon PLC’s used on site?

____________________________________________________________________

2. What is the function of the Citrix Server (3210OIS04)?

____________________________________________________________________

3. What are the three levels of Citrix login?

____________________________________________________________________

4. What are the two types of computer terminals on site?

____________________________________________________________________

5. List the software that relates to each item below:

   PLC
____________________________________________________________________
   SCADA Interface
____________________________________________________________________
   VVVF Drives
____________________________________________________________________
   Sismcode Relays
____________________________________________________________________
   Siprotec Relays
____________________________________________________________________

6. List four locations of LIVE Citect terminals:

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

Prepared By: Michael McKay          Date: 26/06/2007          Document Number: TR1270-206
Approved By: Electrical Engineer    Date: 27/06/2007          Date Implemented:
7. Each module in a Quantum PLC rack is identical.

   TRUE   FALSE

8. Momentum PLC modules have a 24V fused supply.

   TRUE   FALSE

9. Simicode relays are used to control what type of equipment?

__________________________________________

10. What device is used to provide electronic control and protection of High Voltage (HV) equipment?

__________________________________________

11. What does VVVF stand for?

__________________________________________

12. It is okay to undertake an insulation resistance test (megger) on the motor supply cables while they are connected to a VVVF drive.

   TRUE   FALSE

13. What are the two types of Ethernet-to-Fibre converters?

__________________________________________

14. Where can information regarding plant IP addresses be easily found?

__________________________________________

15. The OHP electrical laptop can be connected to which plant equipment?

__________________________________________

__________________________________________
16. What colours relate to the following profibus characteristics?

   Outer sheath
   Core A
   Core B

17. All devices on a profibus network must have a unique node address.
   TRUE          FALSE

18. What is the impedance of a profibus terminator?

19. Field devices such as weightometers, level transmitters, Siprotec relays, VVVF drives and Simicode relays all connect to which plant communications network?

20. Momentum I/O modules have what colour LED to indicate a bus fault?

21. What four things may need to be done if a VVVF has a communications fault?

22. List 8 devices that exist on the plant Ethernet network?
22. How does a VLAN separate networks that use the same switch?

____________________________________________________________________

24. What are the three main Ethernet LANS on site and list the IP network path:

____________________________________________________________________

25. How do the bore fields communicate with the plant network?

____________________________________________________________________

26 Citect enables multiple trends to be shown on one trend page.

TRUE          FALSE

27. List 5 variables that can normally be trended in Citect:

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

28. PLC forces can only be placed after appropriate authorisation has been given.

TRUE          FALSE

29. What must be updated once a PLC force has been applied?

____________________________________________________________________

30. Simicode relays have an F1 reset button that must be used once an overload occurs.

TRUE          FALSE

31. Rotor cubicles have a field mounted reset button on the rotor cubicle.

TRUE          FALSE
32. Simicode relays will automatically reset from an overload trip after 5 minutes.

TRUE       FALSE

33. List 8 available sources of information in relation to plant control systems:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Appendix H

Theory Master Answers
1. What are the two types of Modicon PLC’s used on site?
   Quantum
   Momentum

2. What is the function of the Citrix Server (3210OIS04)?
   To centralize control system software applications
   To provide remote access to the plant controls system
   Controlling access to remote application via Citrix

3. What are the three levels of Citrix login?
   Operator
   Maintenance
   Engineering

4. What are the two types of computer terminals on site?
   Operator Interface Terminal
   Engineering Interface Terminal

5. List the software that relates to each item below:

<table>
<thead>
<tr>
<th>PLC</th>
<th>Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCADA Interface</td>
<td>Citect</td>
</tr>
<tr>
<td>VVVF Drives</td>
<td>DriveWindow</td>
</tr>
<tr>
<td>Simicore Relays</td>
<td>WIN-Simicore</td>
</tr>
<tr>
<td>Siprotec Relays</td>
<td>Digsi 4.3</td>
</tr>
</tbody>
</table>

6. List four locations of LIVE Citect terminals:
   Stockyard Machines and Main Substation
   TLO Control Room
   Main Control Room
   E-deposit Control Room
7. Each module in a Quantum PLC rack is identical.
   
   TRUE     FALSE

8. Momentum PLC modules have a 24V fused supply.
   
   TRUE     FALSE

9. Simicode relays are used to control what type of equipment?
   
   Low Voltage Drives

10. What device is used to provide electronic control and protection of High Voltage (HV) equipment?
    
    Siprotec Relays

11. What does VVVF stand for?
    
    Variable Voltage Variable Frequency

12. It is okay to undertake an insulation resistance test (megger) on the motor supply cables while they are connected to a VVVF drive.
    
    TRUE     FALSE

13. What are the two types of Ethernet-to-Fibre converters?
    
    Sixnet switches
    IMC Media Converter

14. Where can information regarding plant IP addresses be easily found?
    
    MAC Webpage

15. The OHP electrical laptop can be connected to which plant equipment?
    
    Simicode Relays
    Siprotec Relays
    VVVF Drives
    PLC
16. What colours relate to the following profibus characteristics?
   - Outer sheath: Purple
   - Core A: Green
   - Core B: Red

17. All devices on a profibus network must have a unique node address.
   TRUE          FALSE

18. What is the impedance of a profibus terminator?
   220 Ohms

19. Field devices such as weightometers, level transmitters, Siprotec relays, VVVF drives and Simicode relays
   all connect to which plant communications network?
   Profibus DP

20. Momentum I/O modules have what colour LED to indicate a bus fault?
   Red

21. What four things may need to be done if a VVVF has a communications fault?
   - Cycle power to the VVVF drive
   - Lift the Profibus DP card momentarily to reset network
   - Replace Profibus communications adapter on VVVF drive
   - Replace VVVF drive

22. List 8 devices that exist on the plant Ethernet network?
   - Quantum PLC Ethernet modules and Momentum CPU’s
   - Plant control servers and all other computers on site.
   - Cisco switches
   - Printers
   - Ethernet radios
   - Media converters
   - CCTV System
   - IP phones and UPS
22. How does a VLAN separate networks that use the same switch?
   
   Software configuration within switch
   
24. What are the three main Ethernet LANS on site and list the IP network path:
   
   HMI-HMI  10.27.120.XXX
   HMI-PLC  10.27.121.XXX
   PLC-PLC  10.27.122.XXX
   
25. How do the bore fields communicate with the plant network?
   
   Ethernet radio
   
26. Citect enables multiple trends to be shown on one trend page.
   
   TRUE    FALSE
   
27. List 5 variables that can normally be trended in Citect:
   
   Power/Load/Current
   Temperatures
   Flow and Pressure
   Vibromacs
   Slew, luff and long travel positions
   
28. PLC forces can only be placed after appropriate authorisation has been given.
   
   TRUE    FALSE
   
29. What must be updated once a PLC force has been applied?
   
   PLC Forces Log
   
30. Simicode relays have an F1 reset button that must be used once an overload occurs.
   
   TRUE    FALSE
   
31. Rotor cubicles have a field mounted reset button on the rotor cubicle.
   
   TRUE    FALSE
32. Simocode relays will automatically reset from an overload trip after 5 minutes.

   TRUE    FALSE

33. List 8 available sources of information in relation to plant control systems:

   Citect
   Electrical reference folders
   Electrical troubleshooting guides
   Plant equipment simulation and training rack
   MAC Webpage
   Electrical folder on HWE SHARED drive
   Electrical training module presentations
   Engineers, supervisors and leading hands
Appendix I

Practical Assessment
Prerequisites

- HWE Mining Induction / WAIO / OHP
- Electrical Module 2: Control Systems presentation
- Electrical Module 2: Control Systems theory assessment
- Electrical Practice 1: Control System Overview
- Electrical Practice 2: Quantum PLC Overview
- Electrical Practice 3: Momentum PLC Overview
- Electrical Practice 4: Simicode Overview
- Electrical Practice 5: ABB VVVF Overview
- Electrical Practice 6: Siprotec Relay Overview
- Minimum 2 weeks working on site under buddy system

Required Resources

- Practical Assessment Sheets
- Electrical laptop
- ABB VVVF cables and laptop card
- Access to plant equipment and the PLC training rack

Assessment Standards and Conditions

- Employee to demonstrate knowledge with little prompting and assistance from trainer.
- To be deemed competent, the employee must be able to identify equipment and perform electrical activities in a safe and effective manner.
Assessment Methods

Practical Assessments will include oral questions and observation of the person performing the tasks. Practical Assessments are to be conducted in the work environment wherever possible. Some aspects may be conducted under stimulated conditions where operational are limiting factors. Assessments have been designed to be valid, reliable, fair and flexible in accumulating sufficient evidence to demonstrate the required competence.

- Before commencing assessment, check that the trainee has completed all pre-requisites.
- Ensure the trainee has successfully completed the Theory Assessment prior to commencing the Practical Assessment.
- Explain assessment requirements and conditions to the trainee. Advise the trainee they will be asked questions to determine their knowledge of the steps undertaken in the processes being assessed.
- Instruct trainee to commence designated activities and use this Practical Assessment to ensure that all steps/activities and knowledge required in relation to this training is demonstrated. The order and opportunity to conduct some activities will be dependent on operational requirements, so some flexibility in the sequence and duration of the assessment will be required.
- Assessors MUST tick each completed item and initial and date EACH page of the practical assessment using RED pen. Where appropriate, the assessor should record comments throughout the assessment, eg, commending the trainee in areas where they have performed well or recording evidence/examples where the employee may need to improve their skills, particularly if not yet competent. The opportunity is also provided at the end of the assessment for the assessor to record comments. Recording comments as the assessment progresses will assist you provide the trainee specific feedback on completion of the assessment.
- Where the trainee does not demonstrate competence, appropriate retraining should be arranged, prior to a re-assessment. Any corrections made on this document MUST be initialed and dated by the assessor using RED pen.
- Provide feedback to the trainee on completion and advise whether the trainee was successful. Both the trainee and assessor are to sign the Practical Assessment and the Assessment Record Sheet when all relevant activities are completed and competency has/hasn’t been achieved. These materials are to be completed regardless of the assessment outcome.
Section 1: Control Systems – Practical Tasks

1. Log on to Concept via Citrix using an OIT. Connect to a selected PLC. Animate, search and apply a force to selected variables chosen by the assessor.  

2. Identify all current disabled discrete variables (forces) on each PLC and update the PLC Forces Log to accurately reflect this.  

3. Demonstrate Citect fault diagnosis tools such as alarms, pop ups and trending. Set up a number of trends that include multiple variables and specific time frames.  

4. Show how to identify plant LAN, Profibus and PLC-to-PLC faults using Citect.  

5. Demonstrate how to reset various plant faults including fire alarms, communications faults, overload faults, telsor tag faults and other faults identified by the assessor.  

6. Connect to an online Simicode relay, view current parameters and create a backup of the parameters.  

Prepared By: Michael McKay  Date: 26/06/07  Document Number: TR1270-207
Approved By: Electrical Supervisor  Date: 26/06/07  Date Implemented:  
Electronic File & Path:  

Page 3 of 7
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>7</strong></td>
<td>Change out a Simicode relay and configure the parameters via a download. This may need to be done using the training rack due to operational requirements.</td>
<td>NYC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>8</strong></td>
<td>Connect to an online Siprotec relay and view current parameters, alarm history and set up a trend of variables using the software.</td>
<td>NYC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>9</strong></td>
<td>Connect to a VVVF drive using the DriveWindow software. View, explain and change various parameters as selected by the assessor. Make a backup of the drive parameters.</td>
<td>NYC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>10</strong></td>
<td>Use the local VVVF panel control to identify faults, parameters and actual running values. Download and upload drive parameters using the local panel. Transfer parameters between drives using the local panel controller.</td>
<td>NYC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>11</strong></td>
<td>Place a VVVF drive into local control and operate the drive using the local control panel.</td>
<td>NYC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>12</strong></td>
<td>Explain the process of changing a VVVF drive. Identify how to set the Profibus node number for a drive and perform an in initial drive setup and ID Magnetisation.</td>
<td>NYC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>13</strong></td>
<td>Operate and configure the CCTV camera software in the plant control rooms.</td>
<td>NYC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Electronic File & Path:  
Page 4 of 7
14 Operate and reset the TLO speed camera software on the speed camera terminal in the TLO control room.

<table>
<thead>
<tr>
<th>NYC</th>
<th>Comp.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

15 Additional task as specified by the assessor:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section 2: Observation Checklist

1. Did the trainee perform at a level compatible with the needs of the business (operations permitting)?
   - NYC
   - Comp.

2. Did the trainee observe and operate within safe electrical and operational parameters as specified in statutory regulations, site procedures and inductions?
   - NYC
   - Comp.

3. Did the trainee have an acceptable level of understanding relating to each task and was not stumbling through blindly?
   - NYC
   - Comp.

4. Was the trainee’s communication with operational and maintenance personnel clear, professional and informative?
   - NYC
   - Comp.

5. Was the operator able to answer and explain questions asked relating to their tasks?
   - NYC
   - Comp.
PRACTICAL ASSESSMENT

The participant: ...........................................................................................................

Employee number: ........................................ is assessed as:

☐ COMPETENT ☐ NOT YET COMPETENT

Comment by the Assessor that clarifies the competency rating:
........................................................................................................................................
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Comment by the Assessee on the assessment method and rating:
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Date for re-assessment if required: ..................................................................................

Date for review observation (6 months): ........................................................................

Name of Assessor: ............................... Signature: ..............................................

Name of Assessee: ............................... Signature: ..............................................

Location: .......................................................... Date: ..............................................

This is to certify that the person who conducted this assessment is competent in the unit and is a holder of nationally recognised qualifications as a Workplace Trainer and Assessor.
Appendix J

Control and Plant Simulation Equipment
Overview

The Area C Control and Plant System Simulation System has been designed to aid in providing training and familiarisation with the control system and electronic plant equipment at Mining Area C. It is envisioned that technicians and engineers can utilise the equipment through a range of tasks that may be directed, self-paced and/or experimental. The system may also be utilised for testing of faulty or suspect equipment.

The system is designed to provide interaction with the following plant specific equipment:

- Schneider Momentum PLC
- Schneider Quantum PLC
- Simocode motor control relay
- Profibus cabling and connections
- Siprotec electronic motor control relay
- Fibre optic communications
- Ethernet communications
- ABB Variable Speed Drive interface
- Citect SCADA

Reference Material

The following material is relevant to this simulation equipment:

<table>
<thead>
<tr>
<th>Description</th>
<th>Document Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABB ACS 800 Hardware Manual (0.55kW to 110kW)</td>
<td>3AFE64382101 Rev C</td>
</tr>
<tr>
<td>ABB ACS 800 Hardware Manual (90kW to 500kW)</td>
<td>3AFE64671006 Rev A</td>
</tr>
<tr>
<td>ABB ACS 800 Firmware Manual Application Prog 7.x</td>
<td>3AFE64527592 Rev C</td>
</tr>
<tr>
<td>ABB RPBA-01 Profibus-DP Adapter Module User Manual</td>
<td>3AFE64504215 Rev B</td>
</tr>
<tr>
<td>ABB RDCO-0x DDCS Fibre Communication Module</td>
<td>3AFE64492209 Rev A</td>
</tr>
<tr>
<td>ABB Driveware 2 User Manual</td>
<td>3BFE64560981 Rev D</td>
</tr>
<tr>
<td>ABB Adaptive Program Application Guide</td>
<td>3AFE64527274 Rev A</td>
</tr>
<tr>
<td>Concept User Manual</td>
<td>540 USE 503 00 Ver2.6</td>
</tr>
<tr>
<td>TSX Momentum Profibus-DP Communication Adapter</td>
<td>870 USE 004 00</td>
</tr>
<tr>
<td>Momentum Process Adapter and Option Adapter User Guide</td>
<td>870 USE 101 10 Ver2.0</td>
</tr>
<tr>
<td>TSX Momentum I/O Base User Guide Volume 1</td>
<td>870 USE 002 00 Ver3.0</td>
</tr>
<tr>
<td>TSX Momentum I/O Base User Guide Volume 2</td>
<td>870 USE 002 00 Ver3.0</td>
</tr>
<tr>
<td>Modicon Quantum Hardware Reference Guide</td>
<td>840 USE 100 00 Ver8.0</td>
</tr>
<tr>
<td>Siemens Simocode-DP Motor Protection and Control Device</td>
<td>GWA4NEB6314286-02a</td>
</tr>
<tr>
<td>Moeller Profinbus Bus Termination Device Installation Instructions</td>
<td>12/97 AWA 2326-1636</td>
</tr>
</tbody>
</table>
Components

The training rack consists of the following components:

<table>
<thead>
<tr>
<th>Description</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schneider Quantum PLC Processor</td>
<td>140 CPU 534 14A</td>
</tr>
<tr>
<td>Schneider Quantum PLC Ethernet Adapter</td>
<td>140 NOE 771 01</td>
</tr>
<tr>
<td>Schneider Quantum PLC Backplane Expander</td>
<td>140 CRA 211 10</td>
</tr>
<tr>
<td>Schneider Quantum PLC Profibus Adapter</td>
<td>140 CRP 811 00</td>
</tr>
<tr>
<td>Schneider Quantum PLC Analogue Out</td>
<td>140 ACO 020 00</td>
</tr>
<tr>
<td>Schneider Quantum PLC Digital Relay Out</td>
<td>140 DRA 840 00</td>
</tr>
<tr>
<td>Schneider Quantum PLC Digital In</td>
<td>140 DD 353 00</td>
</tr>
<tr>
<td>Schneider Quantum PLC Power Supply</td>
<td>140 CPS 114 20</td>
</tr>
<tr>
<td>Schneider Momentum PLC Process Adapter</td>
<td>171 CCC 960 30</td>
</tr>
<tr>
<td>Schneider Momentum PLC Discrete I/O Base</td>
<td>170 ADM 390 30</td>
</tr>
<tr>
<td>Schneider Momentum PLC Discrete I/O Base</td>
<td>170 ADI 340 00</td>
</tr>
<tr>
<td>Schneider Momentum PLC Profibus Comms Adapter</td>
<td>170 DNT 110 00</td>
</tr>
<tr>
<td>Schneider Modicon TSX Profibus + tap Converter</td>
<td>490 NAE 911 00</td>
</tr>
<tr>
<td>Moeller Simocode-DP Motor Protection and Control Device</td>
<td>ZWK-6,3-EM</td>
</tr>
<tr>
<td>Moeller Profibus Bus Terminating Device</td>
<td>BAT-ZWK-DP</td>
</tr>
<tr>
<td>ABB VVVF Interface Control Card</td>
<td>RDCU-02C</td>
</tr>
<tr>
<td>ABB VVVF Profibus Adapter</td>
<td>RPBA-01</td>
</tr>
</tbody>
</table>
Physical Layout

![Image of an electrical control panel with various switches and displays.]

Prepared By: Michael McKay  Date: 22/05/2007  Document Number: TR1270-229

Approved By:  Electrical Engineer  Date: 28/05/2007  Date Implemented:  

Electronic File & Path:  

Page 3 of 5
Simulations

There are a number of practical exercises that have been developed to provide technicians and engineers with the competencies required at Mining Area C. The list below provides an overview of the material currently developed. This document shall be reviewed periodically to include any new material that is available.

<table>
<thead>
<tr>
<th>Lab No.</th>
<th>Description</th>
<th>Document No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Electrical Practice 1: Control System and Equipment Overview</td>
<td>TR1270-231</td>
</tr>
<tr>
<td>2</td>
<td>Electrical Practice 2: Quantum PLC Overview</td>
<td>TR1270-232</td>
</tr>
<tr>
<td>3</td>
<td>Electrical Practice 3: Momentum PLC Overview</td>
<td>TR1270-233</td>
</tr>
<tr>
<td>4</td>
<td>Electrical Practice 4: Simicode Overview</td>
<td>TR1270-234</td>
</tr>
<tr>
<td>5</td>
<td>Electrical Practice 5: ABB VVVF Overview</td>
<td>TR1270-235</td>
</tr>
<tr>
<td>6</td>
<td>Electrical Practice 6: Siprotec Relay Overview</td>
<td>TR1270-236</td>
</tr>
<tr>
<td>7</td>
<td>Electrical Practice 7: Concept PLC Advanced</td>
<td>TR1270-237</td>
</tr>
<tr>
<td>8</td>
<td>Electrical Practice 8: Citect SCADA Advanced</td>
<td>TR1270-238</td>
</tr>
</tbody>
</table>
Appendix K

Simulator Schematic
Appendix L

Electrical Practice Template
Overview

< Provide a description of this electrical practice session and describe the relevance of these skills to the electrical plant and systems at Mining Area C. >

Prerequisites

< List any licence, induction, training or miscellaneous requirements that should be met before undertaking this electrical practice session. This may include other electrical practice sessions that should be completed prior to this session. >

Required Resources

< List any materials, equipment or resources that will be required to undertake this electrical practice session. This may include the supervision or direction of senior technicians. This may also include reference material that may not be directly required to complete the tasks. >

Duration

< Provide an estimated time required to complete this electrical practice session. >

Objectives

< List the objectives and competencies that should be addressed by this electrical practice session. >

Task Outline

Task 1: < Insert name of task 1 >
Task 2: < Insert name of task 2 >
Task 3: < Insert name of task 3 >
< continued >
Task 1: <Insert name of task 1>

Overview

<Provide a brief overview of what objectives this task addresses and an outline of what is involved.>

Background

<Provide the relevant background to the equipment and task that is to be carried out. This may include an equipment description, where the task skills may be used, diagrams, references and/or other relevant material.>

Exercise

<Describe each step of the task in detail. Ensure the steps are logical and clear. The purpose of these task steps is to adequately address one or more of the practice session objectives.>

Task 2: <Insert name of task 2>

<As above>

Task 3: <Insert name of task 3>

<continued>

<The following pages show an example of a partially complete electrical practice session>
Overview

This electrical practice session provides an overview of the Modicon Quantum PLC system provided by Schneider. The Quantum PLC is one of the critical elements that comprise the plant control system at Mining Area C and these tasks will allow the technician to become familiar with both the hardware and software of the Quantum PLC used on site. Upon completion the technician will have gained valuable competencies relating to the PLC system at Mining Area C.

Prerequisites

- HWE Site Induction
- OHP Induction
- WA ‘A’ Class Electrical Licence or Electrical Engineering qualification
- Electrical Practice 1: Control System and Equipment Overview

Required Resources

- Control and Plant Simulation Rack
- Electrical Department Laptop
- Serial Cable
- Access to plant PLC system
- Guidance of experienced technician

Duration

The estimated duration of this electrical practice session is 6 hours.
Objectives

1. Develop a familiarity and understanding of the Quantum PLC hardware used at Mining Area C
2. Develop knowledge and skills to enable the troubleshooting and repair of Quantum PLC hardware
3. Connect to the Quantum PLC directly using the laptop
4. Connect to the Quantum PLC using the plant network
5. Viewing and interacting with the Quantum PLC online
6. Disabling and forcing PLC inputs and outputs

Task Outline

Task 1:  Power supply and PLC batteries
Task 2:  Connecting to the PLC using a laptop
Task 3:  Connecting to the PLC using the plant network
Task 4:  Searching and animating PLC variables
Task 5:  Disabling variables and applying forces
Task 6:  Identify and change PLC modules
Task 7:  Identify hardware faults
Task 1: Power supply and PLC batteries

Overview

This task identifies the power supply requirements of the Quantum PLC. Areas covered include:

- Voltage requirements, location and changing of the PLC power supply modules.
- Type, location and replacement of PLC batteries

Background

The power supply module provides power to the Quantum backplane and protects the system from noise and swings in nominal voltages. It also ensures that the Quantum system will operate in typical plant electrical environments. In the event of unforeseen electrical problems, it will ensure the system has adequate time to complete a safe and orderly shutdown. The supply is fully over-volt and over-current protected. The module develops a 5.1 VDC bus voltage and there is an internal fuse that is not accessible to the user. The module will be protected by a 2A circuit breaker on the 240V supply.

Figure 1: Power Supply Module
The CPU contains a battery that enables the processor to retain the PLC program and memory in the event of a power supply failure. Lithium Ion batteries are used for longevity and do not require frequent replacement. The batteries may be removed and replaced with no effect on the CPU while the main power supply is operational.

![CPU diagram]

**Figure 2: CPU**

**Exercise**

1. Locate and inspect the power supply module located on the Quantum backplane.
2. Identify the model number and module description.
3. Turn off 240V supply to power supply module.
4. Remove power supply module.
5. *continued…*
Appendix M

Electrical Practice 2: Quantum PLC Overview
Overview

This electrical practice session provides an overview of the Modicon Quantum PLC system provided by Schneider. The Quantum PLC is one of the critical elements that comprise the plant control system at Mining Area C and these tasks will allow the technician to become familiar with both the hardware and software of the Quantum PLC used on site. Upon completion the technician will have gained valuable competencies relating to the PLC system at Mining Area C.

Prerequisites

- HWE Site Induction
- OHP Induction
- WA ‘A’ Class Electrical Licence or Electrical Engineering qualification
- Electrical Practice 1: Control System and Equipment Overview

Required Resources

- Control and Plant Simulation Rack
- Electrical Department Laptop
- Serial Cable
- Access to plant PLC system
- Guidance of experienced technician
- Quantum Hardware Reference Guide (840 USE 100 00)

Duration

The estimated duration of this electrical practice session is 6 hours.
Objectives

1. Develop a familiarity and understanding of the Quantum PLC hardware used at Mining Area C
2. Develop knowledge and skills to enable the troubleshooting and repair of Quantum PLC hardware
3. Connect to the Quantum PLC directly using the laptop
4. Connect to the Quantum PLC using the plant network
5. Viewing and interacting with the Quantum PLC online
6. Disabling and forcing PLC inputs and outputs

Task Outline

Task 1: Power supply and PLC batteries
Task 2: Connecting to the PLC using a laptop
Task 3: Connecting to the PLC using the plant network
Task 4: Searching and animating PLC variables
Task 5: Disabling variables and applying forces
Task 6: Identify and change PLC modules
Task 7: Identify hardware faults
Task 1: Power supply and PLC batteries

Overview

This task identifies the power supply requirements of the Quantum PLC. Areas covered include:

- Voltage requirements, location and changing of the PLC power supply modules.
- Type, location and replacement of PLC batteries

Background

The power supply module provides power to the Quantum backplane and protects the system from noise and swings in nominal voltages. It also ensures that the Quantum system will operate in typical plant electrical environments. In the event of unforeseen electrical problems, it will ensure the system has adequate time to complete a safe and orderly shutdown. The supply is fully over-volt and over-current protected. The module develops a 5.1 VDC bus voltage and there is an internal fuse that is not accessible to the user. The module will be protected by a 2A circuit breaker on the 240V supply.

Figure 1: Power Supply Module
The CPU contains a battery that enables the processor to retain the PLC program and memory in the event of a power supply failure. Lithium ion batteries are used for longevity and do not require frequent replacement. The batteries may be removed and replaced with no effect of on the CPU while the main power supply is operational.

Figure 2: CPU

Exercise

1. Locate and inspect the power supply module located on the Quantum backplane.
2. Identify the model number and module description:

   **Model No:** ___________________  **Description:** ___________________

3. Inspect the power supply terminal strip and answer the following:

   What must be done to convert the power supply module to accept a 115V AC supply?

   ____________________________________________________________

   **What terminal position is associated with:**

   L ___________________ N ___________________ Earth _________________
4. Turn on circuit breaker Q1 (240V) feeding the power supply module. Note that the Pwr ok LED becomes lit.
5. Locate and inspect the CPU module on the back plane.
6. Identify the model number and module description:
   Model No: __________________________ Description: __________________________
7. Remove the battery from the CPU module. Note the Bat Low LED becomes lit. Batteries can be changed while the PLC is running but if the battery is removed or fails while mains power is OFF then the CPU will lose the program and configuration information stored in its memory. A full download will then be required using a laptop.
8. Replace the battery.

Task 2: Connecting to the PLC using a laptop

Overview

This task shows how to connect to the Quantum PLC using a laptop. This is an essential skill as this is the only way to initially configure the Quantum PLC after a CPU failure, plant network failure or Ethernet module failure.

Background

The Quantum CPU modules provide two Modbus and one Modbus Plus connectors for communication. See Figure 2 from previous task for a detailed layout of connectors. The Modbus connectors are used for connecting a PC or laptop as well as inter-rack communications where more than one backplane is used.

Modbus is a communications protocol developed by Modicon as an international standard for communicating to Modicon devices. See the Modicon Modbus Protocol Reference Guide (PI–MBUS–300) for more information. This protocol is designed to send data in one of two modes, ASCII and RTU mode. ASCII allows greater time tolerances for data transfer while RTU allows greater data throughput for the same baud rate. These modes are selected using the slide switch on the CPU. RTU is utilised for all CPU modules at Mining Area C.

Exercise

1. Boot up the Mining Area C technician laptop.
2. Open the Concept PLC software on the laptop.
3. Connect the black Modbus programming cable from the CPU Modbus Port 1 to the laptop COM 1 serial port (DB9 Male to DB9 Female). Ensure the slide switch is set to RTU mode.

4. Create a new project (File → New Project).

5. The PLC Configuration menu should open. If not then open using Project → Configurator.
6. Select Quantum 140CPU53414 under the PLC Selection menu and click OK.
7. Under the Config Extensions → Select Extensions, assign 1 x TCP/IP Ethernet and click OK.

8. Open the I/O Map and click the Edit button.

9. Assign the CPU module and Ethernet (NOE) module to the correct slots and click OK twice.
10. If the following screen is displayed then click YES.

11. Select Config Extensions → Ethernet I/O Scanner and assign 10.27.121.155 as the IP address to the Ethernet (NOE) card.
In theory the IP address for the PLC training rack can be any address you wish although you will need to ensure the laptop is on the same IP subnet when attempting to connect to the PLC over Ethernet later in this exercise. The Mining Area C plant network operates on the 10.27.121.XXX network and when configuring a new CPU on the plant network the correct IP address for that PLC should be selected from the plant network IP register available on the MAC webpage. This page is accessed via the normal Citrix plant logon.
12. Save the project as **PRAC2.prj** or a similar temporary name.

13. The IP address of the laptop needs to be checked to ensure it has been set that same subnet of the PLC configuration. Open the network connections icon in the Windows Control Panel. Right click on the local area connection and select properties. The following page should be displayed.

14. Select Internet Protocol (TCP/IP) and click Properties. Change the settings to ‘Use the following IP address’ and enter **10.27.121.156**. The Subnet mask should be **255.255.255.0**.
15. Connect to the PLC using the Modbus port (Online → Connect). The port settings should be 9600, Even, 1, RTU Address 1. The training rack may have an existing configuration and downloading may produce miscompare and not equal warnings. Ignore these at this stage.

16. Once connected, download the temporary configuration to the controller (Online → Download). You will be asked if you wish to stop and start the controller, answer YES.
17. Once the download is complete, disconnect from the controller (Online → Disconnect).

18. Power cycle the Ethernet NOE module by unscrewing the lower mounting screw and tilting the module upwards. Replace the module after 10 seconds. This allows the CPU to assign the configured IP address to the NOE card. Now that the Ethernet card has an IP address assigned you have the option of connecting via Ethernet as well as Modbus. This is shown in the following steps.

19. Under the Config Extensions → Select Extensions, assign 1 x Profibus DP and click OK.

20. Repeat steps 8 and 9 and add all other remaining modules mounted on the rack into the appropriate slots. The slot number corresponds to the position on the backplane. The training rack backplane has 10 slots. Note the address ranges that need to be entered.
The address ranges will already be configured for PLC programs that are in use in the plant. For this PLC training rack the address range will be the first available addresses the PLC has available for each data type. Quantum PLC's start at the following addresses:

- Digital Outputs 000001
- Digital Inputs 100001
- Analogue Inputs 300001
- Analogue Outputs 400001

21. Connect to the PLC using the TCP/IP Ethernet mode.

22. Once connected, download the new configuration settings (Online \rightarrow Download).

23. Disconnect from the PLC and reconnect using the Modbus protocol. Check that the configuration is equal and includes all the appropriate modules.

24. Disconnect and close the project.
Task 3: Connecting to the PLC using the plant network

Overview

This task shows how to connect to a PLC on the plant network using the operator interface terminals (OIT) or engineering interface terminals (EIT) located in the plant substations and control rooms.

This task should be undertaken with an experienced plant technician to ensure plant operation is not compromised.

Background

The operator and engineering terminals in the plant sit on the 10.27.120.XXX HWE plant network. User accounts and interfacing to other networks is managed by two Domain Control Servers for the plant (Servers 5 and 7). Server 5 is located in the Area C Control and Communications room. Server 7 is located in the E-deposit Control and Communications room.

These servers authorise the user name and password of the employee and provide access to different utilities, programs and networks based upon the access privileges of the user. For example, engineers will have access to advanced utilities and network devices that an electrician will not. All electrician log ons provide access to the essential tools such as:

- Concept PLC software
- Citect SCADA Runtime environment
- Mining Area C network web page
- Microsoft Word
- Microsoft Excel

Each of these tools are available upon connecting to the plant Citrix Server. This Citrix Server provides remote access to the programs and utilities on the server. Each of the plant PLC projects can be opened using Concept across the Citrix network. The PLC projects are numbered from PLC01 upwards. The number of the PLC for each plant area can be determined from the IP register as described in Task 2 → Step 11. For example:

- PLC01 OHP1 Primary Area
- PLC02 OHP1 Screening Area
- PLC04 TLO Area
- PLC05 Stockyard 1 Stacker 1
- PLC06 Stockyard 1 Stacker 2
- PLC07 Stockyard 1 Reclaimer 1
- PLC08 OHP1 Sample Station
Exercise

1. Using an OIT or EIT click on Start → Programs → Citrix → Program Neighbourhood. The following screen should then be displayed.

2. Double click on the Concept icon.

3. Once Concept opens, select File → Open.

4. Scroll through the folders and open the PLC05 folder. Click OK.
5. The following screen should open. If the project browser does not appear or other windows are open this is okay. If a file is closed with windows open then the windows will remain open next time someone opens the PLC project.

Note the PLC is not connected when the project is first opened.

6. Click Online → Connect.
Note that the connection method over the plant network is TCP/IP Ethernet. There are also four levels of access when connecting. There should be no need to connect at any access level greater than Change Data unless an engineer is making logic changes to the PLC. For this exercise and general fault finding in the plant, Monitor mode should be selected to avoid the potential for making unintentional changes to the PLC. Change Data can be used when a force is to be applied to a PLC variable. Monitor and Change Data modes will result in the following prompt:

7. Click OK.
8. The following screen will be displayed. Note the change in status from NOT CONNECTED to RUNNING: MONITOR EQUAL.

Note the PLC is running in MONITOR mode and is EQUAL.
The PLC should always be EQUAL when correctly connected. IF NOT EQUAL appears then the program within the PLC differs to the project file that is open within Concept. A full download will be required to ensure the project file and program inside the PLC are EQUAL. This is covered in a later section. Another problem may occur if the wrong IP address is used when attempting to connect to a PLC. This scenario is shown below.

9. Disconnect from the PLC (Online → Disconnect).
10. Click Online → Connect.

11. Change the IP address from 10.27.121.65 to 10.27.121.68.
12. Since PLC05 is open but the IP address has been changed, Concept will attempt to connect to the PLC with the address 10.27.121.68 (PLC08). The subsequent comparison between the open project (PLC05) and the connected PLC (PLC08) will generate error messages as shown below:

13. This message indicates that the configuration of the PLC is different to the project file that is opening Concept. This should NEVER be the case if the correct file is being used to connect to the correct PLC. This should be a first warning of a major problem and no work should continue until the problem is resolved. Click OK.
14. This message indicates that the PLC project file open is different to the program within the PLC. Unlike the previous message that indicates a configuration problem, this message may be generated even if the correct project file is used to connect to the PLC. Small changes to the program logic such as moving the location of a logic block or link will cause a version mismatch, even if the logic functionality has not changed. This message may come up for number of reasons including the configuration problem mentioned in step 13, an older version of the PLC project file being used to connect or due to PLC changes that have been made to the project file without being downloaded to the PLC. If the latest version of the program is open and the correct IP address is being used then the only way to revert the PLC to an EQUAL state is to undertake a full download. This will stop the controller and must be done when the plant is shutdown. This is covered in a later section. Click OK.

15. Disconnect from the PLC and reconnect using the correct IP address 10.27.121.65. This needs to be done to avoid problems next time someone attempts to connect with PLC05.
Concept remembers the last IP address it used to connect from the project file in use, even if the IP address is the incorrect one. People tend to assume the IP address is correct when attempting to go online to a PLC in the field. This is something to be wary of if you receive errors or warning like those above when connecting over the plant network.

16. Ensure that the PLC is online and EQUAL. Disconnect and close the project file (File → Close project).

17. Open a number of other PLC projects and connect to the respective PLC. Ensure that each PLC is connected using Monitor mode and that they connect EQUAL. Disconnect and close each project in turn. The aim of this step is to familiarise yourself with the folder structure, IP addresses and the different PLC numbers used in each area of the plant.

18. Once complete, ensure the project is disconnect and closed. Close Concept and then close the Citrix Program Neighbourhood screen.

Task 4: Searching and animating PLC variables

Overview

This task shows how to search for variable within a PLC program and how to animate variables so that the state of the variables can be monitored in real time. This is an essential ability for plant fault finding.

Background

The Mining Area C plant uses the Citect SCADA Human Machine Interface (HMI) to provide an interface between the operator and the PLC. Citect is configured to generate alarms and indications based upon the state of variables in the PLC. For example, conveyor lanyards, rip switches and belt drift switches will flash red on Citect when the relevant PLC variable indicates a fault. Some Citect alarms can be much more vague than these examples however and in such cases the PLC may need to be interrogated to identify the cause of the fault or simply to see how the plant is operating.

The Concept PLC program has the ability to show the plant logic operating in real time and this allows the technician or engineer to monitor and track the operation of the plant.
Exercise

1. Open PLC05 as outlined in Task 3.
2. The project browser should appear on the left hand side of the screen. If not click Project → Project Browser. The browser shows all the PLC sections that make up the PLC program. Expand the folders and familiarise yourself with the structure. Double clicking on a Function Block Diagram (FBD) section will open a window that includes the PLC logic for that section. Concept supports multiple windows being open at once. Experiment with opening, resizing and moving sections.

3. Close all logic windows and open the LT01 section. Experiment with the zoom tools in the menu pane. Note that you can zoom in and zoom out of the logic within a logic window. The next screen shot shows a fully zoomed out shot of the LT01 logic section.
4. Zoom in and select the LT01_ZS30 variable.
5. A box can be drawn around specific logic in a logic window to select everything within the box. Draw a box around the LT01 stop/start logic. All logic within the box should be selected and be highlighted in blue.

6. Concept has search functions that enable a variable to be located anywhere within the current PLC program. Click Program → Search (Shortcut is F3) and enter the variable name as shown below.
7. Note that there are a number of options for searching but generally the only choice that needs to be made is whether to search by variable name or by variable address. Click Direct Address and enter the address number shown below.

8. Click Search and the following pop up should appear.

9. This displays all the locations where the variable is used in the program. Select the first instance and click Goto. Note that a window pops up with the searched variable selected in blue.
10. Click Project ➔ Search history (Shortcut is F5). This brings up the previous search that you undertook. Select the next instance and click Goto. Another window is displayed showing where the variable is used.
11. Another useful search tool if there are multiple instances of a variable is the Search Next tool. This tool automatically jumps to the next instance in the search list. Click Project → Search next (Shortcut is F6). Note that a window automatically opens showing the next location of the variable. If F6 is pressed continuously the following pop up will display when Concept reaches the end of the search list. Click OK.

12. When Citect indicates an alarm or fault it may be necessary to find where that alarm is generated in the PLC for the purposes of fault finding. Citect offers a facility to provide the PLC address and variable tag name that can then be used in the search process shown above.

Go to the Stacker 1 Citect Overview page on Citect. This is shown below.
13. Click on the MC09 tab to bring up the MC09 drive pop up.

14. Place the mouse cursor over the first green box next to Pull Wire. Note that a small description pops up after a second or two. Now hit F11 on the keyboard and this brings up a summary page relating to that PLC variable.

This pop up provides information on the variable name (MC09_PW1), type of variable (DIGITAL), PLC number (IODev05 = PLC05) and the unique PLC address (100005).
15. Click on Next Expression at the bottom of the pop up, this will bring up the alarm variable information that relates to this variable.

16. Use the Concept search tools to search either of these variables and the following page should be displayed.
17. Note that the first variable is an input to the derived function block (DFB) and the alarm variable is an output of the DFB. The logic inside the DFB may also need to be viewed in troubleshooting situations to determine how the inputs are processed into the output. Double click on the DFB brings up the following window.

![DFB window](image1)

18. This function block summary provides information on inputs and outputs of the DFB. The logic may be viewed by clicking Refine. This brings up another window containing the logic within the DFB.

![DFB logic](image2)
19. Click on the original MC09 logic window. Connect to the PLC and check that the PLC is EQUAL.

20. Concept has the ability to animate a section of logic that enables the variables to be viewed in real time. There are two animate buttons located on the tool bar. One is a double arrow signal that will animate all selected variables. The second is an I/O button that animates all Boolean values on the page. A high Boolean value is represented by a green triangle. A red triangle indicates a low state. Click on the animate all Boolean values button. Note the healthy (high) state of the pull wire inputs and the healthy (low) state of the pull wire alarm variables.

21. Change back to the DFB logic section window and animate again. Note that the logic inside the DFB can be animated in the same way.

22. These windows can be closed while still animated without any problems. Close all active logic windows and open MC09 section again. Click Edit → Select all (Shortcut is Ctrl-A). Press animate all selected variables button and navigate through the logic section until the three main DFB blocks are displayed. The page should be similar to that overleaf.
Note the red and green lines that are animated links between function blocks. This helps the user to trace through logic. Also note the yellow highlighted variables that indicate an analogue variable. These yellow values are related by the variable name when the window is not animated.

Close the MC09 logic window but remain connected to the PLC for the next task.

**Task 5: Disabling variables and applying forces**

**Overview**

This section deals with disabling variables and applying forces on a PLC program. This may be required in a fault situation if a device or variable needs to be manipulated to enable the plant to run or to aid troubleshooting. This exercise involves placing forces onto a Live PLC.

**Background**

Applying forces to variables is a common occurrence in breakdown situations or to allow plant operation to continue until repairs can be to faulty equipment on shutdowns. Concept provides a facility to disable PLC variables and assign any value that is desired. The practice of bypassing variables should be closely controlled and monitored to ensure that employees and plant equipment is not in danger. It is against the law to bypass certain devices such as personal safety devices such as pull wires and emergency stops. The penalties are large and this practice puts the safety of yourself and others at risk.
Exercise

1. Navigate to the Stacker 1 Overview page on Citect and determine the variable details for the Stacker substation temperature over 30 degrees alarm.

2. On Concept, click Online → Reference Data Editor.
3. Do a search on the temperature alarm variables previously found. Animate the page and enter the variable address or name into the reference data editor table.

4. Contact the Control Room operator and notify them that you will be working on the Stacker 1 over temperature alarm and they should ignore any pop ups or alarms that are generated. Click the disable box for the temperature high input and change to ON.

Note the disabled variable value can be edited and a tick is displayed in the disabled column. The disabled variable also becomes highlighted in BROWN to indicate it has been disabled. The DFB subsequently changes the alarm state as expected.
5. Forcing the input above will generate the following Citect pop up and alarms.

![Temperature Alert]

The over temperature alarm is indicated by a flashing RED signal.
6. Remove the force by clicking the tick in the disable column again. The input will automatically revert to its true state. Note that the alarm still remains ON however. This is because it requires a reset from Citect to deactivate the alarm. Click the Stockyard 1 reset button or call up the Control Room to reset. Once all forces are removed and the alarms are healthy, contact the Control Room and notify them that you have finished working on the temperature system.

Task 6: Identify and rectify hardware faults

Overview

This task provides an overview of the possible hardware problems that can occur with Quantum PLC equipment. This is only a brief introduction and aims to point technicians and engineers in the right direction as opposed to providing all possible solutions.

Background

Most PLC systems are relatively reliable and most control system problems and plant faults are related to field devices and field wiring. Industrial electronic equipment is not immune from hardware failure however and the Quantum PLC equipment is no exception. The Quantum modules have a range of LED indicators at the top of the module that indicates a range of information. The associated vendor documentation provides details on what each LED is indicating and the status of any faults.

Exercise

1. Familiarise your self with the Quantum Automation Series Hardware Reference Guide (Document Number: 840 USE 100 00). This document provides an overview of all the Quantum hardware modules available. A description of each module is provided which includes the module functionality, electrical connection overview, layout of indicator LED’s and an explanation of the LED fault modes. If this document is not available with the simulator training rack then contact the electrical supervisor to obtain a copy.

2. Use the hardware reference guide to answer the following questions:

What colour is the CPU Error A LED?

What fault does the Error A LED indicate?

How do you clear a fault on a Profibus DP module?
What does the collision LED a NOE Ethernet module indicate?

______________________________________________________________________________

Under what condition does an F LED become lit on an analogue input module (140 ACI 030 00)? Inspect this module on the simulator backplane and note the RED F LED.

______________________________________________________________________________

Each Quantum I/O module has an F LED and a RED and GREEN LED for each input/output. What does each of these indicate?

F indicates _____________________________________________

RED indicates __________________________________________

GREEN indicates _________________________________________

______________________________________________________________________________

You have now completed the Electrical Practice 2: Quantum PLC Overview.
Appendix N

Training Matrix
### Electrical Inductions and Training

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Appendix O

Training Plan Template
OPTIONAL MODULES

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NOTES:

- The diagram indicates the ideal flow of training for HWE Mining Employees working in the electrical department at Mining Area C to perform the primary functions or their roles.
- Each title represents a module of training.
- Modules higher in the diagram must be completed before those modules below them.
- Modules on the same row can be completed in any order, except where indicated.
- The tables on the following pages are for the Supervisor to develop training plans for all employees in conjunction with the Training database and Shift Profile.
- Using the sequence suggested in the diagram, Supervisors are to allocate realistic start/ completion dates to ensure employees develop competence (trained & assessed) within the identified timeframes.
- The plan should take into account suggested nominal durations for each module, production schedules, equipment availability, etc.
- Employee training plans are to be reviewed regularly to ensure employees are receiving the training necessary to perform their role in a standardised manner.
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### Mining Area C Electrical Employee Training Plan Template

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Employee Signature: ___________________________  Supervisor Signature: ___________________________