PALO VERDE
NUCLEAR GENERATING STATION

Electrical Maintenance Training Program

Classroom Lesson

Electrical Maintenance Training Program	**Date: 2/16/2011 14:06:05 PM**
LP Number: NEA39C000100	**Rev Author: MARK LACOMBE**
Title: Turbine Building Crane	**Technical Review:** Connally, Erich F(Z03163) Digitally signed by Connally, Erich F(Z03163) DN: cn=Connally, Erich F(Z03163) Date: 2011.03.09 09:43:27 -07'00'
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INITIATING DOCUMENTS

CRAI 3468885 Training Electrical will develop training on PLC's and VFD to support maintenance on the Turbine Building overhead cranes.

REQUIRED TOPICS

None

CONTENT REFERENCES

PALO VERDE STANDARDS AND EXPECTATIONS HANDBOOK

01DP-0IS13 ELEC. SAFE WORK PRACTICES

13-M060-000131-000210 series vendor prints for upgraded turbine crane controls

Rockwell Automation SLC 500 and RSLogix 500 Maintenance and Troubleshooting

Magnetek IMPULSE VG+ Series 3 Instruction Manual

Magnetek Technical Training Manual 2010

02-E-NGA-015 Single Line Diagram 2E-NGN-L15

02-E-ZTB-001 Elementary Turbine Building Bridge Crane

CRDR 2831619 U1 TB Crane Drive Faults

CRDR 2583694 Cask Loading Crane Controls Locked Up

CRDR 2582753 Fuel Building Cask Handling Crane Uncommanded Move Faults

CRAI 3585626 Turbine crane controls - develop a design modification to upgrade the crane motor controls

LESSON PLAN REVISION DATA

Feb 16, 2011 Mark Lacombe Record created

Tasks and Topics Covered

The following tasks are covered in Turbine Building Crane:

Task or Topic Number*	Task Statement

Lesson: Turbine Building Crane

Total task or topics: 1

OCH01	Turbine Cranes

TERMINAL OBJECTIVE:

1.0 Given references provided by an instructor, (Turbine Crane) The Plant Electrician will maintain Turbine Building Cranes as demonstrated by achieving a minimum of 80% on a written examination.

1.1 Discuss the Function of the Turbine Building Crane

1.2 Discuss the Design of the Turbine Building Crane

1.3 Discuss the Design of the Magnetek Impulse VG+ series 3 Variable Frequency Drives

1.4 Describe the Programming of the Magnetek Impulse VG+ series 3 Variable Frequency Drive Controller

1.5 Discuss the Design of the Allen Bradley SLC 5/04 Programmable Logic Controller.

1.6 Describe the Programming of the Allen Bradley SLC 5/04 PLC

1.7 Discuss the Operation of the Turbine Building Crane.

1.8 Describe the Corrective and Preventive maintenance performed on the Turbine Crane

1.9 Discuss the Troubleshooting Techniques performed on the Turbine building crane including fault code identification.

1.10 Describe the safety and human performance factors associated with the Turbine Building Crane.

Lesson Introduction: Turbine Crane

The following items are things to consider in your Lesson Introduction. They are not mandatory.

CONTENT	METHODS AND ACTIVITIES
I. Pre-Job Brief	
A. Pre-job briefing on the day's activities modeling the use of the Palo Verde Standards & Expectations, Preventing Events	
B. Focus On Five (Task Preview) Familiarize worker with the scope of work, task sequence, and critical steps.	
1. Critical Steps (Terminal Objectives)	PVNGS Standards & Expectation book (Focus on five) Highlight the critical steps (Terminal Objectives) on the power point presentation.
2. Identify error likely situations (error traps) a. Discuss at least one specific error likely situation.	Look at Error Precursors in S&E book
3. Identify the Worst thing that can happen.	Apply to the setting you're in. (Lab versus Classroom)
4. Identify specific error prevention defenses to be used.	What defenses can we employ to prevent the "Worst thing that could happen"
5. Identify actions to assure proper configuration control.	This may not be applicable in every training setting
6. Break policy a. Two Minute Drill – After lunch at a minimum	At Instructor's discretion, not to interrupt class flow.
b. Evaluation	Per course exam

Lesson Introduction: Turbine Crane (cont)

C. Schedule	Lay out the schedule and expectations for schedule adherence
1. Length of class	60hrs
2. Break policy	
a. Two Minute Drill – After lunch at a minimum	At Instructor's discretion, not to interrupt class flow.
3. Evaluation	
4. Post training critique	Feedback (i.e. Class Climate)
D. Qualification	
1. Identify what they will be qualified to do upon completion of the course	
II. Lesson Introduction	
A. Lesson Terminal Objective	Read and/or discuss the lesson objectives
B. Lesson Enabling Objectives	Read and/or discuss the lesson objectives

Operating Experience:

Operating Experience should be inserted in a way that will **tie relevance of the Operating Experience to the lesson content.**

Ensure to identify that you will **Discuss Prevent Event Tools** that could be used to prevent reoccurrence.

TO: 1.0 **Given references provided by an instructor, (Turbine Crane) The Plant Electrician will maintain Turbine Building Cranes as demonstrated by achieving a minimum of 80% on a written examination.**

EO: 1.1 **Discuss the Function of the Turbine Building Crane**

LESSON PLAN	METHODS AND ACTIVITIES
EO 1.1 Describe the function of the Turbine Building Crane	
Design Basis Statement: • "Overhead crane equipment located in the Turbine Building used for handling various loads including radioactive material. Failures may lead to regulatory consequences and unacceptable increased risk in personnel and radiological safety hazards. Some failures are considered hidden since equipment is normally parked and not operating"	See power point to show functions

Typical Function • To perform various lifts and moves in support of maintenance of turbine, generator equipment and ancillary equipment in the turbine building **Loads** • Based on the overall rating of the Turbine Building Crane.	Show power point loads from load cell measurements

EQID • XMZTNG01*MECFUN	Show all associated EQID's

EO: 1.2 Describe the Design of the Turbine Building Crane

LESSON PLAN	METHODS AND ACTIVITIES
EO 1.2 Describe the Design of the Turbine Building Crane	
Design • Palo Verde Turbine Building Cranes are 8 motor 280/50 ton double girder Bridge Cranes with the following features and characteristics: **Features:** ○ Magnetek Impulse VG+ Series 3 Variable Frequency Drive Controllers ○ Allen Bradley SLC 5/04 PLC control ○ Complete over current protection for long life/safety ○ Phase loss protection/detection ○ Adjustable acceleration/deceleration ○ Joystick Control	See power point to show trolley and pictures

Characteristics: ○ A 2-Drum Bidirectional **Trolley** with a Main (280T) and Aux Hoist (50T) with Festoon cable. ▪ **Main Hoist Motor** is a 125HP 3 Phase 480V Induction Motor with Insulation Class H (Inverter Duty) • Speed is controlled by a Magnetek Impulse VG+ series 3 variable frequency drive controller (180 Amp) • Braking is per the Main Hoist Controls and is typically performed via motor torque and dynamic breaking unit and resistors until timeout occurs. After timeout, a dual unit 16” Cutler Hammer Bull DC solenoid shoe brake is utilized. • Fitted with an incremental shaft encoder that supplies 1024 pulses per revolution with a Quadrature (A+B) output and a main drum encoder.	Show power point loads from load cell measurements M060-00144 Describe Quadrature

▪ **Aux Hoist Motor** is a 100HP 3 Phase 480V Induction Motor with Insulation Class H (Inverter Duty) • Speed is controlled by a Magnetek Impulse VG+ series 3 variable frequency drive controller (150 Amp) • Braking is per the Aux Hoist Controls and is typically performed via motor torque and dynamic breaking unit and resistors until timeout occurs. After timeout, a dual unit 16" Cutler Hammer Bull DC solenoid shoe brake is utilized. • Fitted with an incremental shaft encoder that supplies 1024 pulses per revolution with a Quadrature (A+B) output and a aux drum encoder.	PP M060-00145

• **Trolley Drive Motor** is a 25HP 3 Phase 480V Induction Motor with Insulation Class H (Inverter Duty) • Speed is controlled by a Magnetek Impulse VG+ series 3 variable frequency drive controller (39 Amp) • Braking is per the Main Trolley Controls and is typically performed via motor torque and dynamic breaking resistor with no dynamic breaking unit. ○ Equipped with a Sterns brake that can be manually engaged. ○ This holding brake is denergized when trolled motion is suspended and will result in a brake set. • Fitted with an incremental shaft encoder that supplies 1024 pulses per revolution with a Quadrature (A+B) output	PP M060-00145

○ A 2 motor Bidirectional double girder **Bridge** ▪ **Bridge motors** are 40 HP 3 480V Induction Motor with Insulation Class H (Inverter Duty) • Speed is controlled by a Magnetek Impulse VG+ series 3 variable frequency drive controllers (60 Amp) • Braking is per the Bridge Controls and is typically performed via motor torque and dynamic breaking unit and resistors until timeout occurs. ○ Equipped with a Sterns brake that can be manually engaged. • Fitted with an incremental shaft encoder that supplies 1024 pulses per revolution with a Quadrature (A+B) output	Power Point M060-00146

○ **Service Trolley and Hoist** ▪ The Service Trolley utilizes twin 0.5HP 3 phase 480Vac 3 phase motors. • Speed is controlled by a Magnetek Impulse VG+ series 3 variable frequency drive controller (3.7 Amp) • Braking is per the Trolley Controls and is typically performed via motor torque and dynamic breaking resistor with no dynamic breaking unit. • Fitted with an incremental shaft encoder that supplies 1024 pulses per revolution with a Quadrature (A+B) output ▪ The Service Hoist utilizes a 20HP 3 phase 480Vac 3 phase AC motor. • Speed is controlled by a Magnetek Impulse VG+ series 3 variable frequency drive controller. (31 Amp) • Braking is per the Trolley Controls and is typically performed via motor torque and dynamic breaking resistor with no dynamic breaking unit. • Fitted with an incremental shaft encoder that supplies 1024 pulses per revolution with a Quadrature (A+B) output	Power Point M060 00147

○ **Operators Cab**: ▪ Contains the Operators Chair and various crane controls: • The Operators chair contains: ○ Momentary Start/Stop Pushbutton ○ Trolley Brake Release Pushbutton ○ Bridge Brake Release Pushbutton ○ Bridge Light On/Off Switch ○ Trolley/Bridge Dual Axis Joystick with a top button for the horn ○ Main/Aux Hoist Dual Handle and Single Axis Joystick ○ Service Hoist Single Axis Joystick ○ Service Trolley Single Axis Joystick ○ Cab Radio Selector Switch • The Cab Control Enclosure contains: ○ Flex I/O Modules ▪ DC Supply Module ▪ Remote I/O Adapter Module ▪ (2) Input Modules ▪ Analog Input Module ○ 12V Power Supply	Power Point M060-00192 M060-00192 (410-0001) M060-00188

Bridge and Walkway: • Footwalk and Railing • Under Floor lighting w/ access hatch's • Electrical Control Cabinets and equipment: o Mainline Disconnect o Lighting Contactor & Circuit breaker o Lighting Transformer Circuit breaker o Cab AC Circuit breaker o Lighting Transformer o Cab AC control enclosure o Circuit Breaker Distribution Panel o Enclosure AC control enclosure o Cab AC compressor o Enclosure AC compressor o Motor Control Cabinets o Main Hoist Dynamic Braking Resisters o Aux Hoist Dynamic Braking Resisters o S. Bridge Dynamic Braking Resisters o N. Bridge Dynamic Braking Resisters o N. Trolley Dynamic Braking Resisters o Main Hoist Dynamic Braking Resisters o Serv. Hoist Dynamic Braking Resisters o Bridge Motors o Trolley Travel Limit Switches	Power Point M060-00131-2 M060-00180-182

○ **Electronic Control System** ▪ Allen Bradley SLC500 series PLC Controller with the following features: **2^{nd} From Left Side Panel - Walkway** • 2-13 Slot SLC 5/04 chassis' • SLC 5/04 Processor • 7 AC input modules • 6 Relay output modules • 10 Amp power supply • 2 Analog Current Outputs • 4 Multichannel Hi Speed Counter Modules • Scanner Module **Cab Enclosure Panel** • Remote I/O Adapter Module • DC Power Supply Module • 2 Flex I/O Input Modules • Flex I/O Analog Input Module • 12V 3.4A power supply	Power Point M060-177 & 177 (BOM) M060-180 M060-186 M060-188

EO: 1.3 Discuss the Design of the Magnetek Impulse VG+ series 3 Variable Frequency Drives

LESSON PLAN	METHODS AND ACTIVITIES
EO 1.3 Describe the Design of the Magnetek Impulse VG+ series 3 Variable Frequency Drive Controller.	Power Point and Print review
IMPULSE VG+ series 3 Drives **Design Advantages and Features:** • Infinitely variable speed control can be accomplished using a standard, low-cost, single-speed AC squirrel cage induction motor in place of more expensive multi-speed or wound rotor. • IMPULSE crane controls minimize the typically high starting in-rush current and drastically decreases the shock effect on both the load and the equipment. This ensures a smooth movement of the load and extends equipment life. • Independently adjustable acceleration and deceleration rates and a unique torque limit function provide a cushioned, soft-start and stop. This guarantees controlled, accurate load movements and eliminates the need to jog or reverse plug the motor. • Delicate loads can be positioned with precision creep speeds without the need for costly micro-speed motors or plugging motor controls. • With IMPULSE crane controls, AC motors can produce up to 150% full load torque at all motor speeds. • Inverter output frequencies greater than 60 Hertz are possible when over-speeding of the motor is applicable. • IMPULSE controls can be retrofitted to existing AC equipment. Single-speed, two-speed or wound rotor motors can easily be converted into high performance, variable speed motors.	Describe basic ac motor theory See power point Briefly mention Flux Vector Controls B5-01 through B5-04 Discuss over-speeding

IMPULSE VG+ series 3 Drives	
Software Features • Brake Set Delay Timers • Torque Proving at Start • Ultra Lift™ • Slip Compensation • Stall Prevention • Alternate Acceleration/Deceleration • Micro-Positioning Control™ • Built-In Auto-Tuning	Show power point

IMPULSE VG+ series 3 Drives	
Software Features (continued) • Motor Torque Proving at Start • Roll Back Detection at Start • Seized Brake Detection at Start • Brake Proving at Stop • Torque Limited Load Check™ • Torque Limited Accel and Decel • Quick Stop™ • Reverse Plug Simulation™ • Multi-Level Password • Motor Thermal Overload Protection • Motor Phase Loss Detection • Ground Fault Protection • Slack Cable Protection • Overload/Load Check Counter • Number of Operations • Short Circuit Protection • Built-In Serial Communication • Fault History and Tracing via Flash ROM • Elapsed Run Timer	Show power point

Theory of OPERATION: ✓ The VG+ series 3 controller is basically a 3 phase AC voltage to DC voltage to 3 phase AC voltage converter. ✓ It starts by receiving 480Vac power and utilizes a 3 phase rectifier to supply a DC bus. ✓ The DC bus is then applied to an Output Transistor assembly to produce square wave pulses. These pulses are modulated and become additive to produce an output voltage at the desired frequency and amplitude. A basic bidirectional Inverter… o Load Reactors (Coils) are utilized to protect the drive unit from collapsing motor fields or short circuits and they improve the efficiency by creating a more perfect sine wave.	Draw a simplified schematic to show students.

Theory of OPERATION: (cont.) The Rectifier section of the Drive is energized and remains so. When a drive signal is called upon to start and run a motor, a 3 phase output is developed and delivered to the motor. When starting and operating a motor with this drive, Flux Vector Control is utilized. This minimizes the associated motor current and limits the temperature rise of the motor. <u>Flux Vector Control</u> • By limiting the starting voltage, frequency and associated rotor flux, we can limit the voltage induced into the rotor. This in turn, limits rotor current and rotor flux and provides a “Soft Start” of the motor. This is easier on the motor and limits starting current to a level closer to running current. “A Vector Drive uses feedback of various real world information (encoder and CT’s) to further modify the PWM pattern to maintain more precise control of the desired operating parameter, be it current, speed or torque. Using a more powerful and faster microprocessor, it uses the feedback information to calculate the exact vector of voltage and frequency to attain the goal. In a true closed loop fashion, it goes on to constantly update that vector to maintain it. It tells the motor what to do, then checks to see if it did it, then changes its command to correct for any error.”	Describe Magnetizing current and Torque producing current Show Flux vector control power point. Show V/F curve.

“A true closed Loop Vector Drive can also make an AC motor develop continuous full torque at zero speed. This makes them suitable for crane and hoist applications where the motor must produce full torque before the brake is released or else the load begins dropping and it can't be stopped. Closed Loop is also so close to being a servo drive that some people use them as such. The shaft encoder can be used to provide precise travel feedback by counting pulses” Magnetizing Current is current in the rotor which is not enough to turn the rotor. The total current necessary to drive the motor is the phase vector beyond magnetizing current.	Show Power Point Show Heavy Load vs. Light Load vector diagrams.

Dynamic Braking • When slowing down or stopping a motor, Dynamic Braking is utilized. Dynamic Braking occurs when the applied frequency/voltage delivered to the stator is lowered. Due to inertia, the rotor speed is now faster than the delivered stator speed which results in the motor becoming a generator. Since Generated Voltage is proportional to Speed (differential or slip) times the Magnetic Flux a voltage is now delivered back through the inverter section to the DC bus. • A Dynamic Braking Unit is connected across the +/- DC bus and this acts to dissipate the energy and limit the rise of DC voltage. o Without the Dynamic Braking resistor, damage would occur to the drive unit. DC Injection • DC potential is injected into the Stator Field (no rotating Flux) which acts to stop a rotor with limited heating.	Show Power Points Show Schematic Drawing

Encoder • Heavy Duty Industrial Type • Output Resolution – 1,024 Pulses per Revolution • 12V DC Differential Line Driver Output • Connected to Motor Shaft to Provide Zero Backlash • Shielded Cable	Show Power Point

EO: 1.4 Describe the Programming of the Magnetek Impulse VG+ series 3 Variable Frequency Drive Controller

LESSON PLAN	METHODS AND ACTIVITIES
EO 1.4 Describe the Programming of the Magnetek Impulse VG+ series 3 Variable Frequency Drive.	
Instruction Manuals **Keypad Functions & LED's** • The Keypad is a removable device that allows a user to operate the drive locally, view parameters and codes (inc. fault codes), and program the drive for custom operation. The drive keypad contains: o LED's for Fwd, Rev, Alarm and Input indication. **Verification of Software.** • **Instruction Manual revision**. The revision of the Instruction Manual is based on the software revision of the drive that you are working on. To determine the software revision of the drive, you need to look at parameter U1-14. This number should show the same number that is located on the bottom right of the front cover of the manual. ▪ Example - # 8001.6	See power point See page 4-5 in the operators manual Show the keypad. Have students look at the manual and find the software revision on the drive.

Basic Modes • **Auto-Tuning** Auto-Tuning is used to adapt a Variable Frequency Drive to many AC motors that are out there…including our wound rotor motors. Auto-Tuning is accomplished by typing in minimal motor information and then executing a tuning operation. It is typically done with the motor uncoupled but can be done coupled (Non Rotating) **Tuning Parameters viewed by the drive:** ▪ Rated Horsepower ▪ Rated Voltage ▪ Rated Current ▪ Rated Frequency ▪ Number of Poles ▪ Rated Speed ▪ Encoder Parameters.	See power point Reference Pg 4-14 of Instruction Manual ****Have the students run an Auto-Tune exercise****

Basic Modes • **Parameter Modes, Groups and Functions** All parameter modes can be accessed after the drive has been energized utilizing the MENU key on the keypad. The Modes are as follows: **<u>Operation Mode</u>** – This mode must be selected to enable operation of the drive. Monitor Parameters: ▪ U1- Monitor ▪ U2 – Fault Tracing ▪ U3 – Fault History	See power point Reference Pg 4-8 of Instruction Manual Introduce the students to the parameters on their drives. Have them scroll through and look at 5-103 to see the Monitor parameters that are available. ****Have the students run a fault exercise****

	<u>**Programming Mode**</u> – This mode selects the access level of programming and is where passwords are selected and entered. Control methods, motion and speed control is also selected here via the following set/read: **Initialize Parameters**: **“A”** ▪ A1 – Initialization Parameters including Language Selection, Parameter Access Levels, Control Method (Flux Vector) and Select Motion Parameters ▪ A2 – User-Defined Parameters. These are parameters that are specifically assigned to the user program.	See power point Introduce the students to the Initialize parameters on their drives and have them look at the A1 & A2 parameters on Pg 4-9 thru 4-13

	Application Parameters: “B” ▪ B1 – Preset references. This is used to set the reference frequencies/speeds for the setup used (i.e. 2speed multistep) ▪ B2 – Reference Limits. Used in conjunction with B1 to set lower and upper limits as a percentage of total speed. ▪ B3 – Sequence/Reference .Stop Methods. This is used to control how the motor stops. (i.e. Decel time, Coast time etc.) – Motor Rotation Change. This allows you to reverse motor direction without having to swap leads. ▪ B4 – Trim Control Level ▪ B5– Acceleration/Deceleration ▪ B6 – Speed Search ▪ B8 – Jump Frequencies	See power point Introduce the students to the parameters on their drives. Ref IMPULSE VG+ Instruction Manual: Pg 5-3 to Pg 5-5 Pg 5-6 to Pg 5-10 pg 5-10 to Pg 5-11 Pg 5-12 to Pg 5-13 Pg 5-14 Pg 5-15

Special Function Parameters: "C"	See power point Ref IMPULSE VG+ Instruction Manual:
▪ C1 - Quick Stop/Reverse Plug Simulation	Show table on Pg 5-16
	Pg 5-17 to Pg 5-18
▪ C2 - Micro Speed	Pg 5-19
▪ C3 - Travel Limits	Pg 5-20 to Pg 5-21
▪ C4 - Load Float	Pg 5-25
	Pg 5-26
▪ C5 – Load Check	Pg 5-27 to Pg 5-28
▪ C6 – Ultra Lift	Pg 5-29 to Pg 5-30
	Pg 5-30 to Pg 5-33
▪ C7 – Torque Limit	Pg 5-34 to Pg 5-37
▪ C8 – No Load Brake Hoist	Pg 5-38 to Pg 5-40
▪ C9 – G5IN4 Setup	
▪ C10 – Weight Measurement	Pg 5-41 to Pg 5-43
▪ C11 – Slack Cable Detection	Pg 5-44 to Pg 5-45
▪ C12 – Delay Timers	
▪ C13 – Inching Timers	Pg 5-46 to Pg 5-48

Tuning: "D"	See power point Ref IMPULSE VG+ Instruction Manual:
▪ D1 – DC Injection	Pg 5-49
	Pg 5-49
▪ D2 – Automatic Slip Compensation	Pg 5-50 to Pg 5-51
	Pg 5-51 to Pg 5-52
▪ D4 – Automatic Speed Regulator	Pg 5-54
▪ D5 – Torque Control	Pg 5-55
▪ D6 – Droop Control	Pg 5-56
▪ D8 – Dwell Function	
▪ D9 – S Curve Accel/Decel	

Motor Parameters: "E" ▪ E1 – V/F Pattern 1 ▪ E2 – Motor Set-up ▪ E3 – Motor 2 Method / V/F Pattern ▪ E4 – Motor 2 Setup	See power point Ref IMPULSE VG+ Instruction Manual: Pg 5-57 to Pg 5-58 Pg 5-59 Pg 5-60 Pg 5-61

Options Parameters: "F" ▪ F1 – Pulse Generator Option Set-up ▪ F2 – Motor Set-up ▪ F3 – Digital Input Option Setup ▪ F4 - Analog Output Option Set-up ▪ F5 – Digital Output 2/8 Setup ▪ F6 – Communications Options Setup	See power point Ref IMPULSE VG+ Instruction Manual: Pg 5-62 to Pg 5-63 Pg 5-64 Pg 5-64 Pg 5-65 to Pg 5-66 Pg 5-56 to Pg 5-67 Pg 5-68

Terminal Parameters: "H" ▪ H1 – Digital Inputs ▪ H2 – Digital Outputs ▪ H3 – Analog Inputs ▪ H4 - Analog Output ▪ H5 – Serial Communications Setup ▪ H6 – Pulse I/O Setup	See power point Ref IMPULSE VG+ Instruction Manual: Pg 5-69 to Pg 5-73 Pg 5-74 to Pg 5-79 Pg 5-80 to Pg 5-81 Pg 5-82 to Pg 5-83 Pg 5-84 Pg 5-85

Protection Parameters: "L" ▪ L1 – Motor Overload ▪ L2 – Under Voltage Level (Power Loss Ride Through) ▪ L4 – Ref Detection ▪ L6 - Torque Detection ▪ L8 – Hardware Protection ▪ L9 – Automatic Reset	See power point Ref IMPULSE VG+ Instruction Manual: Pg 5-86 to Pg 5-87 Pg 5-87 Pg 5-87 to Pg 5-88 Pg 5-90 to Pg 5-92 Pg 5-93 Pg 5-94 to Pg 5-95

Operator Parameters: "O" ▪ O1 – Monitor Selection ▪ O2 – Keypad Key Selection ▪ O3 – Clear History ▪ O4 - Copy Parameters (This allows the user to copy the program parameters to or from the keypad.	See power point Ref IMPULSE VG+ Instruction Manual: Pg 5-96 to Pg 5-97 Pg 5-98 to Pg 5-99 Pg 5-100 Pg 5-100 to Pg 5-102

Copying data **Operator Parameters: "O"** ▪ O4 - Copy Function - (This allows the Drive and the Operators keypad to share information with each other. This also allows the Drive instructions to be overwritten with another keypad as long as the drive specifications and software are identical to each other.	See power point Ref IMPULSE VG+ Instruction Manual: Pg 5-100 Pg 5-100 to Pg 5-102

EO: 1.5 Discuss the Design of the Allen Bradley SLC 5/04 Programmable Logic Controller.

LESSON PLAN	METHODS AND ACTIVITIES
EO 1.5 Discuss the Design of the Allen Bradley SLC 5/04 Programmable Logic Controller.	Power Point and Print review
Basis: The Turbine Cranes at PVNGS have been upgraded to a newer technology utilizing programmable electronic devices to control and operate the various equipment associated with overhead cranes. PLC's (or Programmable Logic Controllers) are basically the centralized brain and nervous system of the crane. They are used to receive commands from an operator (and/or components) and quickly provide intelligent signals to various control and operating equipment (VFD's etc…) on the crane. • Utilize an SLC 500 operating platform with the SLC 5/04 version installed. • Utilize RSLogix 500 operating software	See power point RA 1-3

Benefits: • PLC's offer a compact design • Modular and flexible system configuration • Communication speed • Precise and Smooth operation	See power point RA 1-3

Component Hardware: The SLC 5/04 utilizes a modular style which includes: • Power Supply • Processor • Chassis • I/O modules & Flex I/O	See Print M060-00183

Hardware:
 	
Power Supply:
• Provides system power requirements for the processor and the I/O modules.
    o Many models are available and are typically sized to the voltage and current requirements of the end user.
    o LED is lit when proper voltage is supplied
    o Not considered a chassis slot.
	See Print M060-00183

Hardware:
 	
Processor:
• Considered the Brain of the entire system which performs the following functions:
    o Receives information from the Input devices via and I/O module.
    o Makes decisions based on input received and program installed
    o Sends information the output devices via an I/O module.
	See Print M060-00183

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Hardware:

Chassis:

- The Chassis is the hardware assembly which physically houses the Processor and I/O modules associated with the PLC. It also performs the following functions:
  - Provides power distribution from the power supply
  - Provides the communication path from the processor to/from the modules.
    - Assigns a Software address used by the processor
    - Assigns a hardware address based on the slot number, module type etc.
      - Processor is always slot 0
      - Input and Output (& I/O) modules will be in slot 1-?
  - Houses components in the following sizes:
    - 4-slot
    - 7-slot
    - 10-slot
    - 13-slot

</td><td>See Print M060-00183</td></tr>
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Hardware:

Chassis:

- The Chassis' can be ganged together using an interconnecting cable with a maximum of 3 total used.
- Remote I/O (Flex I/O) can also be utilized and is used on the Turbine Crane.
  - Separate I/O units are in the operators cab.

</td><td>See Print M060-00183

See Print M060-00188

RA 1-12</td></tr>
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Hardware:
 	
I/O Modules:
• I/O modules are electronic units which are designed to provide the interface between the cranes input and output devices (Processor, Joysticks, Drives, Encoders etc…). These modules can be Input, Output or I/O (Combination).
  o Designed to plug into the Chassis
  o Come in various forms that provide various functions. The most common are:
    ▪ **Analog** – sends or receives infinitely variable signals.
      • Input signal examples include Potentiometers, Joysticks
      • Output signal examples include VFD's, recorders, actuators, valves and meters.
    ▪ **Digital (Discreet)** – sends or receives on/off (1 or 0) signals
      • Input signal examples include circuit breakers, limit switchs, contactors and pushbuttons.
      • Output signal examples include alarms, lights solenoids.
    ▪ **Process Control** – used for varying control of signals
	See Print M060-00183
	
	RA 1-7
	
	TG Page 95

Basic Signal Operation:
 	
Data/Operational Flowpath:
• A signal would be derived from an input device such as a pushbutton, joystick, encoder etc… and it would then be sensed/delivered to the input module.
• The **input module** will take the signal and convert it to the necessary language (Data File type) supported by the processor and deliver the signal with an address to the processor.
  o Data file types include:
    ▪ Output
    ▪ Input
    ▪ Status
    ▪ Binary
    ▪ Timer
    ▪ Counter
    ▪ Control
    ▪ Integer
    ▪ Floating Point
    ▪ ASCII
    ▪ String
  o Addresses –Software and Hardware.
	See Power Point
	
	RA
	
	Discussed later

Basic Signal Operation: • The **Processor** will read what the input module sent, interpret the data and compare it with the program files (ladder logic). It will then make the necessary decisions and provide an output in the correct format to the output module • The **Output Module** will interpret the information sent from processor and provide an output signal to the prescribed output device (Drive, relay, lamp, etc…)	See Power Point RA Dscussed later Have students identify the components on their PLC's. Have them use the book and prints and describe the hardware types.

Data/Operational Flowpath: **Communications Equipment:** • **Network** - A series of stations (or nodes) which are physically connected together. • **Node** – A device on a network which is capable of sending or receiving information. • **Link** – The physical means of sharing or transmitting data between 2 or more locations. • **Baud** – Measurement of signal speed typically across a communications link (usually in bits per second)	See Power Point and show cables as necessary.

Data/Operational Flowpath:
 	
Connections & Networks: (used at PVNGS)
• **Data Highway plus** (**DH+) –** Local area network that is designed to support remote programming.
  o Fairly high speed
    ▪ Up to 230 kbits/sec based on distance of cable.
  o Can have up to 64 nodes
  o Cable lengths to 10,000 ft.
  o Computer connection requires a PCMK link and RSLinx software.
 	
• **RS-232 Connection (Serial)**
  o Medium speed
    ▪ Up to 19kbits/sec
  o Requires a 1747-CP3 cable and RSLinx software
	See Power Point and show cables as necessary.

Data/Operational Flowpath:
 	
Connections & Networks: (used at PVNGS)
• **Universal Remote I/O Netowrk –** Used to connect SLC 500 processors to remote I/O chassis and other intelligent devices.
    o Fairly high speed
        ▪ Up to 230 kbits/sec
    o Can have up to 16 nodes
    o Uses a 1747-SN (Scanner Module) and an Adapter Module - ASB
	See Power Point

EO: 1.6 Describe the Programming of the Allen Bradley SLC 5/04 PLC

LESSON PLAN	METHODS AND ACTIVITIES
EO 1.6 Discuss the Operation / Programming of the Allen Bradley SLC 5/04 Programmable Logic Controller.	
Software **RSLogix 500:** • RSLogix software is a Windows ladder logic programming tool for SLC500 processors. This software allows the user to: ○ Establish Communications with SLC 500 processors. ○ Display and monitor process data including FAULT Codes ○ Create and Modify new ladder logic ○ Configure your I/O modules	See power point RA 1-21

Off-line Computer operation: (Projects that reside on the hard disc of a computer) **Viewing Projects:** ▪ Projects are files that store all of the program logic and data for a single processor. ▪ Example: Turbinecrane.rss **Project Files:** ○ Database Files: ▪ Files that contain information which is not used by the processor and is typically stored in the computer memory only. ▪ Examples: Custom Data Monitors, Trends etc… **Processor Files:** ▪ Files that can be modified or monitored from the computer while they are being used by the PLC processor ▪ Examples: Data Files, Program Files, Force Files. **Viewing Ladder Logic:** ○ To view ladder logic, you must first open the project you are interested in. ○ Next, you are to open the ladder file you are interested in (i.e. LAD02)	Power Point RA 2-1 Have students find examples on the computer Show Examples RA 2-2

Connecting a Computer and Going On-line: **Online:** • The computer must be in continuous communication with the processor to allow the following actions can be performed: ○ Monitor or modify a project loaded in a processor ○ Monitor data while it is being collected ○ Modify data stored in a processor	Power Point

Connecting a Computer and Going On-line: **Download:** ○ Transfers a copy of a project from a computer to a processor ▪ **CAUTION –** This will **OVERWRITE** the program that is currently installed on the PLC	Power Point

Connecting a Computer and Going On-line: **Upload:** ○ Transfers a copy of a project from a PLC Processor to the memory of a Computer.	Power Point

Connecting a Computer and Going On-line: • RSLinx software must be loaded and enabled to allow communication between the computer and the processor. ○ A Communications Driver must be established to allow the software to communicate with the processor. ▪ We will use Data Highway + (DH+) or RS-232 connection typically ○ A cable will run from the computer to the Processor to establish the link. ▪ Typically this will either be a RS-232 link or a PCMK (DH+) connection ▪ A USB to DH+ is also currently available. ▪ program that is currently installed on the PLC	Power Point

Modes of Processor Operation
 	
▪ There are 3 modes of control for the SLC500 processor and they allow different functions to occur. They are selected from a keyswitch on the front of the processor and allow functions to occur as follows:
  o **RUN** – This is the mode you should find the PLC processor in. It allows the processor to perform its intended function and control the crane.
    ▪ No programming can be performed in this mode.
  o **PROGRAM** – (PROG) When this mode is selected, the operation of the crane will cease. Downloading /uploading and modification of processor projects can occur.
  o **REMOTE** – (REM) This mode is used to control a processor's operating mode from the laptop connected to the processor. There are 3 separate modes of remote operation and they must be selected by the computer you have connected.
    ▪ **Remote RUN** – This will allow for crane operation while the computer is connected.
    ▪ **Remote PROGRAM** – This is the same as the regular program mode.
    ▪ **Remote TEST** – This mode will allow you to run a program from a computer but it will disable the outputs of the PLC.
.
	Power Point
	
	Have the class make the connection and perform the operations if necessary.
	
	Show the rotating ladder when online
	
	Show Power Point examples
	
	Have students perform and swap modes
	
	RA 6-3

Data View or Transfer
 	
• After the connection is made, your computer can be used to view or work with a project that is loaded in the SLC500 Processor.
    ○ To do this, you must **upload** the project from the processor to the computer
        ▪ This will be the means you have as a technician to view problems or troubleshoot a component.
    ○ If you want to install a file (project) onto the processor, you would select the **download** option.
        ▪ It is important to understand that downloading a project WILL overwrite the current project on the processor.
	Power Point
	
	RA 2-1
	
	Have students find examples on the computer
	
	Show Examples RA 2-2

Memory Layout and System Addresses
 	
SLC 500 Software Address Characteristics:
    ○ Example Address'
B 15 : 3 / 2
        ▪ **B –** indicates the File Type (B- Binary Bit)
        ▪ **15 –** indicates the File Number
        ▪ **3 –** indicates the Element number
        ▪ **2 –** indicates the Bit number
 	
T 14 : 2. PRE
        ▪ **T –** indicates the File Type (T – Timer)
        ▪ **14 –** indicates the File Number
        ▪ **2 –** indicates the Element Number
        ▪ **PRE –** would indicate a word address
 	
    ○ **Other File types**:
        ▪ **O** – Output file
        ▪ **I** – Input file
        ▪ **S** – Status file
        ▪ **C** – Counter
        ▪ **R** – Control
        ▪ **N** – Integer
        ▪ **F** – Floating Point
        ▪ **A** – ASCII
        ▪ **ST** – String
	Power Point
	
	RA 4-4
	
	Have students find examples on the computer

Memory Layout and System Addresses **SLC 500 Hardware Address Characteristics**: ○ Example Discrete Address': **I : 3 / 10** ▪ **I –** indicates the Module Type (**I**- Input) ▪ **3 –** indicates the Slot Number ▪ **10–** indicates the Terminal Number **O : 5 / 3** ▪ **O –** indicates the Module Type (**O** – Output) ▪ **5 –** indicates the Slot Number ▪ **3 –** indicates the Terminal Number ▪ **.** ○ Example Analog Address: **O : 4 . 2** ▪ **O –** Analog Module Type (**O** – Output) ▪ **4 –** indicates the slot number ▪ **. –** indicates the Word Delimiter ▪ **2 –** indicates the analog channel number	Power Point RA 4-4 Have students find examples on the computer Perform exercises if applicable

Hardware to Data Table Relationships **SLC 500 Hardware Address Characteristics**: **Analog modules** ○ Will be represented by a Decimal equivalent. ▪ Radix must be changed to Decimal to view the number	Power Point RA 4-4

Ladder Logic Basics	Power Point
• PLC Ladder Logic is used in software programming and is similar but very different than conventional Ladder Logic. – PLC Ladder Logic is broken up into 2 parts as follows: • Conditional instructions: – Used to examine, check or compare specific conditions – Typically on the left side of the ladder. • Output Instructions: – Will cause an action to occur – Typically on the right side of the ladder	

PLC Scan Cycle	Power Point
• During a processor operating cycle (which occurs very fast), several events occur such as: – Input modules are read and looked at for change. – The program file instructions are executed based on what is seen. – Output data is sent to output modules. – Status file updates and indication occurs. • Scans will be determined by keyswitch position	

Input Bit Instructions	Power Point
• Bit Instructions are ladder logic instructions that examine or change a single bit of data in the data files. There are typically 3 types of bit instructions: – Conditional Bit instructions – Non-Retentive output instructions – Retentive bit output instructions	

EO: 1.7 Discuss the Operation of the Turbine Building Crane.

<table>
<tr><th>LESSON PLAN</th><th>METHODS AND ACTIVITIES</th></tr>
<tr><td>EO 1.7 Describe the Operation of the Turbine Building Crane.</td><td>Power Point and Print review</td></tr>
<tr><td>Basic Startup and Operation:
• Verify power is available from E-NGN-L15D4 through a disconnect switch XEE-NGL-NGN-W01 located in the Turbine Building 176’, plant north near the Generator End.
• The Crane Operator would operate the Walkway Mainline Disconnect Switch and then CB104 (250A Breaker – Right Side Panel), the 40A Lighting Transformer Circuit Breaker and the Lighting Contactor Circuit Breaker.
• For Chair Operational Control:
o CB113, CB604 and CB627 must be closed to energize the master control relay CR604 and the mainline relay CNT627 after the reset pushbutton is depressed.
▪ All Variable Frequency Drives will now be energized and await commands from their Energized PLC’s.
▪ With the remaining control breakers in the closed position, the operators chair should now be fully functional.</td><td>See power point to show functions

M060-143

M060-191

M060-148 (310-006)
M060-168</td></tr>
</table>

Operational / Design Example **MAIN HOIST Control:** • When the operator selects and operates the Main Hoist **Lower** Joystick the following logic occurs: o 115Vac Power is supplied to the MHL Joystick contacts (JS3016) via the Main Crane Enclosure Power. ▪ The joystick output (Discreet) signal is applied to the Flex I/O input module PLC2904 ▪ This signal is now assigned an address (I:1.1/00) and it is delivered to the Remote I/O Adapter module ▪ The Remote I/O Adapter module communicates with the Scanner module and the signal is supplied directly to the CPU. ▪ The CPU reads the signal and makes the decision and sends a corresponding signal to a Relay Output Module (PLC 2445). ▪ This signal is now sent to the Magnetek VFD (AFD 228 Term S2)	Show power point M060-192 (410-0001) M060-00170 (310-0028) M060-00171 (310-0029) M060-00172 (310-0030) Have students start the trace with the Electrical Logic and then trace the PLC Ladder Logic and then go back to the Electrical Logic to determine the output.
Operational / Design Example **MAIN HOIST Control:** o 12Vdc Power in supplied to the MHL Joystick Potentiometer (JS3016) via 12Vdc PWR3005 ▪ The joystick output (Analog) signal is applied to the Flex I/O Analog Input module PLC 2944 ▪ This signal is now assigned an address (I:1.2/00) and it is delivered to the Remote I/O Adapter module ▪ The Remote I/O Adapter module communicates with the Scanner module and the signal is supplied directly to the CPU. ▪ The CPU reads the signal and makes the decision and sends a corresponding signal to an Output Current Output Module (PLC 1905) ▪ This 4-20mA signal is now sent to the Magnetek VFD (AFD 228 Term A2) and a corresponding signal is delivered to the motor with flux vector control.	Show power point M060-192 (410-0001) M060-00170 (310-0028) M060-00171 (310-0029) M060-00172 (310-0030) Have students start the trace with the Electrical Logic and then trace the PLC Ladder Logic and then go back to the Electrical Logic to determine the output.

Operational / Design Example
 	
MAIN HOIST Brake and Auxiliaries Control:
• When the operator selects and operates the Main Hoist **Lower** Joystick the following logic occurs (continued):
  ○ 115Vac Power is supplied to the MHL Lower Limit Switch (LS2154) via CB702
    ▪ The switch position will determine the ability of the crane to further lower.
    ▪ This signal is sent to PLC 2146 is now assigned an address (I:1504) and it is routed to the CPU
    ▪ The CPU reads the signal, makes the decision and sends a corresponding signal to enable hoist motion or not.
    ▪ This signal is now sent to the Magnetek VFD (AFD 228)
    ▪ The VFD (AFD 228) actuate Relays CNT1003 and CNT1005
    ▪ The Brakes will now release and the hoist may be operated.
	M060-00149 (310-0007)
	
	M060-00163 (310-0021)

Operational / Design Example
 	
MAIN HOIST Brake and Auxiliaries Control:
• When the operator selects and operates the Main Hoist **Lower** Joystick the following logic occurs (continued):
  ○ 115Vac Power is supplied to the VFD (AFD 228)
    ▪ When the joystick is selected for lower, the AFD discreet input S2 receives a signal as described above.
    ▪ This signal is now operates a set of contacts (M0-M1 & M2-M3) which in turn actuate Relays CNT1003 and CNT1005
    ▪ The Brakes will now release and the hoist may be operated.
	M060-00152 (310-0010)

Operational / Design Example
 	
MAIN HOIST Encoder:
• When the operator selects and operates the Main Hoist **Lower** Joystick the following logic occurs (continued):
  o Two Main Hoist Encoders will now begin to provide an output.
    ▪ Encoder "A" (Motor Encoder) will provide input directly to the VFD (AFD228).
    ▪ The VFD will in turn provide an output signal to PLC 1306
    ▪ The signal is now assigned a software address (**I**:0300) and it is routed to the CPU
    ▪ The Main Hoist Drum Encoder will also read hoist motion and provide this signal to PLC 1306.
    ▪ The signal is now assigned an address (**I**:0301) and it is routed to the CPU
	M060-00155 (310-0013)

Operational / Design **Remaining Equipment:** • The Aux Hoist, Trolley, Bridge, Service Hoist and Trolley will all function in a similar manner to the Main Hoist.	Have the Students completely trace the components as selected by the instructor.

EO: 1.8 Describe the Corrective and Preventive maintenance performed on the Turbine Crane

LESSON PLAN	METHODS AND ACTIVITIES
EO 1.8 Describe the Corrective and Preventative maintenance performed on the Turbine Building Crane.	

Preventative Maintenance
 	
• **Visual Crane Inspections**
  ○ Check collectors and shoes for wear.
  ○ Visually check insulators for cracks.
  ○ Inspect all lighting fixtures, on the crane to insure all are illuminated and that the lighting in the cab, and that all electrical outlets (receptacles) are functional and grounded.
  ○ Inspect all the flat festoon cables for degradation and or damage. Insure cables are being properly supported and there is proper clearance between the structure and the cables so the do not make any contact to wear or rub the jacket**.**
  ○ Inspect the control cab conduit for proper installation and are properly supported, outlet receptacles are functional, status lights and all crane rail lights to insure they illuminate are in a working condition.
  ○ Worker Verification: In **Panels 4, 3, 2, & 1,** ensure all fuses are the **correct size,** for the various components, and there are no signs of damage or degradation to the fuse blocks.
  ○ Inspect the Cranes safety Horn wiring , switches and contacts on the control panel in the cab for degradations.
	See power point
	
	Review current WSL instructions if necessary

• **PLC Battery Replacement:** o Replace the back-up battery (s) in SLC Processor (S). ▪ Catalog Number 1747-BA, Every Re-fuel cycle. • Note: Processors have a capacitor that provides at least 30 minutes of battery back-up while the battery is disconnected. Data in RAM is not lost if the battery is replaced within 30 minutes. .	See power point Verify correct parts

• **Motor Inspection and testing:** o Main Hoist Motor o Aux Hoist Motor o Main Trolley Motor o North/South Bridge Crane ▪ Inspect the motors for dust, dirt, signs of oil and grease and any other contaminates or degradation ▪ Inspect the Motor & Brake Heaters for damage or degradation ▪ Inspect all electrical conduit, flex, for proper installation and that there is no broken or degraded flex ▪ Inspect the break enclosure and verify that it is clean, free of dust, dirt and any contamination that will interfere with the safe operation of the crane o Main and Aux Hoist Geared Limit Switches ▪ Inspect the flex conduit for damage and degradation o North and South Bridge Crane ▪ Inspect the limit switches conduit and flex for damage or degradation that will interfere with the safe operation of the crane. .	See power point Review current WSL instructions if necessary

EO: 1.9 Discuss the Troubleshooting Techniques performed on the Turbine building crane including fault code identification.

LESSON PLAN	METHODS AND ACTIVITIES
EO 1.9 Discuss troubleshooting techniques performed on the Turbine Building Crane including fault code identification.	
Troubleshooting Methodology: • To effectively troubleshoot the Turbine Building Crane, you really need to observe the indications associated with the failure. The crane operator will usually be the best point of reference as to the degree and change of symptoms that are occurring or have occurred. The next level of indication will be the VFD and then PLC indications for the faults. Another level of indication is often times sensory.	See power point

<u>**VFD Codes:**</u>
 	
Alarm Codes:
• Alarm codes may or may not result in a Base Block.
• All **BE** (BE1 – BE7) (BE= Brake or Torque alarms)
    o A Base Block (**BB**) will occur with all BE alarms with the exception of BE6
    -Base Block (BB) = The signal to the bases of the Insulated Gate Bipolar Transistors (IGBT) have been blocked or removed. This will prevent the transistors from “turning on” and conducting.
 	
• No Reset function is required
• An output will occur from the drive contacts M5/M6
• Alarms BE1/BE2/BE3 are recorded in Fault History (U2-01, U2-02 and U3-01…)
    o BE6 is not recorded
	Have class discuss prior to showing Power Point
	
	See page 6-4 in Inst Manual
	
	See page 3-5
	
	Have the students look at the fault history on their drives

VFD Fault Codes: **Fault Codes**: • All Fault codes will result in a Base Block. • All codes with the exception of **BE** (BE1 – BE7) • A Reset function of some form IS required • An output will occur from the drive terminals MA/MB/MC • All Faults are recorded in Fault History (U2-01, U2-02 and U3-01…) and displayed on the keypad.	Have class discuss prior to showing Power Point See fault codes on Pg 6-5

VFD Fault Codes: **Common Faults:** **OL1** – Motor Overload Fault = 150% • 1.5 X Motor FLA / 1min. (programmable) • The higher the current, the shorter the time. **OL2** – Drive Overload Fault = 150% • 1.5 X Drive Ref. Current / 1min **95% of OL1 & OL2 faults are caused by due to mechanical Problems (i.e. brakes, load problems etc…) **OC** – Drive Over-current Fault = 250% of drive rated current • 2.5 X Drive rated current / 0min (instantaneous) **Typically a major fault (i.e. direct motor shorts) ***The OL1, OL2 & OC faults will have balanced output currents . **SC** – Short Circuit Fault (typically motor short) **GF** – Ground Fault = Sums are all phases should be 0 **LF** – Output Phase Loss = looks for an open phase. **OV** – Over-voltage = DC Bus voltage (typically 820Vdc for a 480Vac Drive) **UV** – Undervoltage = DC Bus voltage (typically 400V for 480Vac drive)	Have class discuss prior to showing Power Point See fault codes starting on Pg 6-5

VFD Fault Codes: **Encoder Related Faults**: **PGO Fault (Pulse Generator)** • Pulse Generator Output = zero (no encoder feedback) Result: ○ Drive will trip on PGO Fault and do an immediate stop. ○ Base Block will occur and holding brakes will set. (F1-02 = 1) • Programmed Related Logic; ○ If no encoder feedback I seen in time of 0.5sec (F1-14 = 0.5sec)	Have class discuss prior to showing Power Point See fault codes on Pg 6-12

VFD Fault Codes: **Encoder Related Faults**: **OS Fault (Motor Overspeed)** • Motor Speed is 5% above what it should be. Result: ○ If based on encoder feedback, motor speed is 5% above max frequency. ○ Base Block will occur and holding brakes will set. (F1-03 = 1) • Programmed Related Logic; ○ If motor speed is 5% above max speed (F1-08 = 105%) with no command to do so (Ultra Lift) in time of 0sec (F1-09 = 0.0)	Have class discuss prior to showing Power Point See fault codes on Pg 6-12

VFD Fault Codes: **Encoder Related Faults**: **Dev Fault (Speed Deviation)** • Motor speed deviates beyond normal Result: o If based on encoder feedback, if conditions indicate motor speed deviates out of the norm. o Base Block will occur and holding brakes will set. (F1-04 = 5) • Programmed Related Logic; o If motor speed is off by 10% at any speed (F1-10 = 10%) in the time of 0.3 sec (F1-11 = 0.3sec)	Have class discuss prior to showing Power Point See fault codes on Pg 6-12

VFD Troubleshooting: **Power Off Checks**: **Basic Device Checks** • Common failure mode components include: o Input Bridge Rectifiers – Test on Diode Range o Bus Capacitors – Verify charging action o Output Transistors o Free Wheeling Diodes – Braking Diodes	Have class discuss prior to showing Power Point See chart on Pg 6-19

OE

CRDR 2831619

U1 Turbine Building Crane

Motor Drive Faults

10/26/2005

Introduction:

During the summer of 2005, the Unit 1 turbine building crane was upgraded with new controls, motor drives and motors. The new crane controls were tuned by the vendor totry to achieve optimal performance of the crane. During preparations for the U1R12 outage several motor drive faults were received on the aux hoist which interrupted crane operation.

Equipment Operation

The Unit 1 turbine building crane is used to support maintenance personnel during turbine overhauls and other turbine deck activities. The crane was supplied with new Magnetek Impulse VG+ Series 3 motor drives prior to U1R12. These are closed loop variable frequency drives that are fully programmable. To customize/program the drives, hundreds of parameters are programmed by the user. Parameters determine such drive characteristics as speed control, brake check, torque proving, acceleration speeds, maximum current, and positioning method.

Evaluation

While preparing for the U1R12 outage, crane hoist movement was interrupted when the hoist would not respond to a “Down” command when the operator would move the joystick in the downward direction. Normally this problem could be overcome by simply positioning the joystick back to zero and then proceeding to move the joystick again to the down position. The faulted condition would clear and hoist movement would resume.

This phenomenon would occur several times per shift. Maintenance and engineering investigated the problem and discovered that a BE3 fault

was being registered on the motor drive display. The BE3 fault is identified as the “Torque Proving Fault”. The BE3 fault indicates that the drive has released the brake and commanded the drive to run, but it has not detected the expected encoder feedback. A BE3 fault will occur if the pulses received from the encoder during the BE3 detection time (parameter C8-06) are less than the expected number of pulses (parameter C8-07).

The as-found settings for these parameters were 0.30 seconds for C8-06 and 25 pulses for C8-07.

This type of motor drive fault actually puts the crane in a conservative state of operation. There is no possibility of dropping a load nor is there any other safety issue. To correct the BE3 fault condition, either the detection time (C8-06) can be increased or the expected number of pulses can be decreased. The Impulse VG+ Series 3 technical manual states that C8-06 can be adjusted to no more than 1.0 second and that C8-07 can be adjusted

to no less than 10 pulses. It was determined to adjust the time interval to 0.5 seconds based on the settings of the cask handling crane which uses the same motor drives. The resolution was discussed with the crane vendor and they concurred that this was a possible solution. Work order 2839790 was issued and the C8-06 parameter was adjusted to 0.50 seconds on both the main and aux hoist motor drives. The crane was operated for 36 hours without a drive fault.	

<u>PLC Fault Indications and Actions</u>: • Faults associated with PLC's can typically be troubleshot by simple indication that is present on the front face of the PLC and its associated modules. Sometimes the faults will be associated with connections (i.e. slots, I or O, I/O module terminals etc…). Sometimes the faults are associated with failed components within the PLC (i.e. memory modules). The SLC500 and RSLogix 500 Troubleshooting Guide may be able to help with simple faults (most common) associated with the following: o Processor faults o Power Supply faults o Discrete Outputs o Analog Outputs o Analog Inputs o Discrete I/O Modules o Noise Problems o Discrete Ladder Logic Conditions	Have class refer to the SLC500 and RSLogix 500 Troubleshooting Guide if applicable

PLC OE:	Have class discuss

CRDR 2583694

Cask Loading Crane Controls Lockup

3/03/03

Problem Identification:

On 2/11/03, while transferring the canister and the TFR from the cask loading pit the canister and TFR became temporarily suspended (six inches above the VCC) due to a loss of control function. Initial inspection of the Cask Handling Crane control cabinets and drives found that the Main contactor on the crane was “open”. All 480 VAC breakers for each crane drive were found to be normal and in the “on” position. Inspection of the crane 480 VAC collector rail and shoes found that they were in good working order. No obvious signs of arcing or damage of any kind were observed on the trolley or to the Saflift attached to the main hook. The crane programmable logic controller (PLC) appeared to have control

power, however, both radio control modules and the digital output modules had no visual indications on the front of each card. A red fault indicator was found flashing on the front of the processor module for the PLC. The crane brakes were set as per design on a loss of control function.

Attempts to re-energize the Main contactor from the crane radio controls were unsuccessful. After switching to cab control, the main contactor was re-energized using push buttons on the operator cab console. However, attempts to energize the Canister Hoist Enable (CHC) contactor to supply power to the Saflift controls were unsuccessful from the operators cab.

The crane vendor, ACECO, was contacted about probable causes for the loss of power to the Saflift. ACECO Engineering stated that the fault code for the PLC could be determined using a laptop computer. A probable cause scenario would be if the radio controls malfunctioned and resulted in the PLC controller faulting. The recommended course of action is to attempt to reset the PLC (after determining cause of initial fault)

and then determine what PLC modules, if any, are defective. An engineering game plan was developed and implemented. (See attachment) The correct cable for the PLC to laptop interface could not be obtained. So it was not possible to read the fault code. A complete walkdown of the crane was performed in which no problems were found other than the PLC. The PLC was then reset by cycling power to the PLC. After the PLC booted up, all crane functions were restored. The correct cable was eventually obtained, but there was no fault code available from the PLC since the fault was over-written upon power up. On 2/19/03 a similar PLC lock-up occurred to the Saflift PLC. This lock-up was caused when radio contact was interrupted when the operator used a back staircase to go from

the 120 foot level to the 140 foot level. The fault code read from the PLC was “Specialty I/O module in slot 1 has not responded to a command as being completed within the required time limit". The specialty I/O module in slot 1 is the radio module. Testing was performed with the radio to attempt to recreate the problem. The crane operator would enter the staircase and radio communications would be lost. The crane main contactor would open and the crane brakes would set per design. The actual lock-up of the PLC could not be duplicated. In addition to PLC lock-ups, “Uncommanded Move Faults” have also occurred to both the Main Hoist

and the Aux Hoist. The "Uncommanded Move Fault" is generated by the PLC ladder logic program and does not lock-up the PLC. To recover from an "Uncommanded Move Fault" requires merely to reset a key switch. (See attachment "Restoration Plan")	

PLC OE: **Background:** The quality function of the cask handling crane is to ensure that the fuel is not damaged from loss of control. This is accomplished through a single failure proof braking system and other features that have been incorporated into the design of the crane and replacement trolley. There are both shoe brakes and drum brakes associated with each wire rope drum on the main hoist. The primary shoe brakes are spring set and electrically released and cycle with hoist operation. The secondary drum brakes are spring set and hydraulically released and are opened when the crane is energized and only close when crane power is shut down or if a main hoist fault is detected. Power is required to pressurize the hydraulic system and release the drum brake calipers. Factory testing was performed to verify that either of the two shoe brakes or the hydraulic drum brakes could stop and hold a 100% test load (300,000 lbs.) within 3 inches. Crane control and monitoring is accomplished through an Allen-Bradley SLC-500 Programmable Logic Controller (PLC). Direct motor control is provided by variable frequency motor drives (VFD). To initiate a raise or lower signal to the VFD when operating from the cab, a single-axis control joystick is moved on the cab control console. The cab console joysticks are comprised of separate up and down directional contacts along with a variable potentiometer to supply a 0-10V speed reference signal. The cab joysticks are configured so that the up and down contacts are wired directly to the VFD. The potentiometer output is sent to the PLC for scaling and is then sent to the VFD as a variable speed reference. In order for the hoist VFD to initiate brake release and hoist movement, a hard-wired directional contact closure from the joystick must be received at the VFD. The PLC only supplies a variable speed reference to the frequency drive. The PLC cannot command the motor drive to move without the raise or lower contact closure and therefore does not initiate hoist movement by itself while in the cab operating mode. Dedicated radio receiver and relay output modules are provided with the PLC to allow for control of the crane from a remote radio control transmitter. These specialized control modules are each designed with two watchdog timer circuits to ensure that any failure in the PLC or either of the modules is quickly detected and all control outputs are shut down. The redundancy designed into the radio control system prevents any single failure or even multiple failures from causing uncommanded crane motion. In addition, the operator controlled emergency stop pushbutton and all hoist limits are hard wired and do not require the PLC to function. The PLC only monitors the status of the crane limits in both cab and radio operation modes. If a PLC lockup occurs, the crane controls revert to a fail-safe mode with brakes set. Crane movement is halted.	Have class discuss

OE Evaluation: The loss of control function was caused by the crane PLC going into a fault mode. The fault mode occurred due to an interruption in communications with the radio controller. This is substantiated by a similar lock-up of the saflift PLC in which the fault code obtained from the PLC indicated that the radio module was unable to respond. Normally a loss of communications with the radio module would cause the main contactor to open which would in turn set the brakes and cause crane operation to stop. When communications with the PLC occurs at the precise instant during a radio/PLC communications cycle, a fault will be generated by the PLC. This fault causes all zeroes to be written to the output files which causes the brakes to set and motion to stop. This is the fail-safe mode for the crane. This communications fault has occurred once to the crane PLC and once to the saflift PLC. The crane manufacturer as well as the radio controller manufacturer have been contacted and concur with the root cause. A restoration plan has been written by engineering in case this lock-up should occur in the future. (See attachment) A software modification to the PLCs is being developed and will be implemented at the soonest opportunity. This modification will ensure that a loss of radio communications will only cause the main contactor to open which will in turn set the brakes and cause crane operation to stop. The modification will ensure that inadvertent PLC lockups do not occur when communications are lost. A Drum Uncommanded Move Fault occurs when drum motion is sensed by one of the drum encoders which sends electrical pulses to the overspeed/uncommanded move detectors. The move detectors then energize the “uncommanded move fault relay” which in turn de-energizes the main hoist fault contactor shutting off power to the main hoist motor drive. The “uncommanded fault relay” also sends an Uncommanded Fault signal to the PLC which processes the information and updates both cab and radio controller display screens where the fault is displayed. This nuisance fault is caused by crane vibration agitating the drum encoders such that a false speed signal is sent to the overspeed/uncommanded move detectors. The electronic circuitry falsely determines that the drum is moving without a valid move command. A modification was made to the encoder mounting bracket on the main hoist. The fault has not occurred since the modification was installed and is not expected to occur again. A similar modification will be made to the Aux hoist.	Have class discuss

OE In the meantime it is acceptable to operate the crane based on the following facts: 1. A PLC lock-up puts the crane in fail-safe mode with the brakes set. 2. An Uncommanded Move Fault puts the crane in fail-safe mode with the brakes set. 3. Inadvertent crane operation can not occur when there is a loss of communications with the radio. 4. Recognizing and verifying a radio lock-up is a relatively easy operation and is explained in the restoration plan. 5. Resetting a radio lock-up is a relatively easy operation and is explained in the restoration plan. 6. At no time during a PLC lock-up and reset operation is the crane load at risk. 7. A modification is being developed to ensure that an interruption in communications does not cause and inadvertent PLC lock-up. 8. A restoration plan has been developed in case a lock-up or fault should ever occur in the future. 9. PLC lock-ups and Uncommanded Move Faults rarely occur.	Have class discuss

EO: 1.10 Describe the safety and human performance factors associated with the Turbine Building Crane.

LESSON PLAN	METHODS AND ACTIVITIES
EO 1.10 Discuss Safety, HU and FME while working on the Turbine Building Crane	
• **Generic Personal Safety Aspects with the Turbine Building Crane** ○ Energized Equipment – Use 01DP-0IS13 for electrical safety requirements ○ Fall Hazards – Fall Protection required when working outside of the walkway (i.e. motor inspect/lube, trolley platform work, etc…) ○ Keep hands free when climbing up or down ladders. Articles too large for the pockets or belts should be lifted to or lowered from the crane by a hand line. Take care that loose parts and tools do not fall to the floor beneath. Secure tools and test equipment to the crane if conditions require such action. Do not wear loose or torn clothing which may be caught in the movable parts of the crane. ○ During operational verification observe: ▪ Pinch points and crush potentials ▪ Clearance areas (overhead) ▪ tools are secure (dropped items)	See power point

• **Personal Safety and HU Aspects associated with the PLC Controls.** o Troubleshooting of PLC equipment in most cases must be performed in an energized condition, ensure the following: ▪ Ensure that personnel remain clear of rotating and moving equipment and proper fall protection is worn in the event that unexpected motion occurs. If the processor is in RUN mode, motion can occur as soon as faults are cleared. Also, when the faults are cleared, several outputs will most likely become energed at this point in time. ▪ Follow the guidance of Electrical Safe Work Practices when any interaction may occur with voltages $\geq$50V. ▪ Take precautions for stored energy in the form of capacitance. ▪ Ensure an adequate prejob brief and two minute drill is performed prior to working on the equipment. ▪ Use extreme caution when Forcing Points. All Force Points will be enabled at the same time so be careful to verify the status of Forces prior to proceeding.	See power point

• **Personal Safety and HU Aspects associated with the VFD controls.** ○ Energized Equipment – Use 01DP-0IS13 for electrical safety requirements as our VFD's operate off of 480Vac and have a DC bus voltage that can exceed 800Vdc ○ VFD's contain capacitors, ensure that internal charge indicator light is off and voltage has been verified prior to working on a deenergized drive. ○ If operation of a drive is performed locally, be aware of potential for injury as the drive may supply power to its associated motor as soon as the RUN command is selected. ○ In the event of certain brake faults (BE6), ensure the crane is placed in a safe condition and the load is placed on the floor prior to denenergizing the associated VFD. A loss of load control may be the result as the drive is now holding the load in a safe condition.	See power point

SUMMARY OF MAIN PRINCIPLES

The following items are things to consider in your lesson summary. They are not mandatory. You should develop your own summary.,

Objectives Review

Review the Lesson Objectives

Topic Review

Restate the main principles or ideas covered in the lesson. Relate key points to the objectives. Use a question and answer session with the objectives.

Questions and Answers

Oral questioning

Ask questions that implement the objectives. Discuss students answers as needed to ensure the objectives are being met.

Problem Areas

Review any problem areas discovered during the oral questioning, quiz, or previous tests, if applicable. Use this opportunity to solicit final questions from the students (last chance).

Concluding Statement

If not done in the previous step, review the motivational points that apply this lesson to students needs. If applicable, end with a statement leading to the next lesson.

You may also use this opportunity to address an impending exam or practical exercise.

Should be used as a transitional function to tie the relationship of this lesson to the next lesson. Should provide a note of finality.