CURTISS WRIGHT Flow Control Company

SCIENTECH

DC Cook Reactor Controls Instrumentation Replacement Project

2013 Scientech User's Symposium

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August 2013

Steam Generator Control System Replacement

Project

- Organizations
  - DC Cook (Utility)
  - Sargent & Lundy (A/E)
  - Scientech (Vendor)
    - Hurst Technology (Subcontractor)

Steam Generator Control System Replacement

Project

- Schedule (Original)
  - Contract Award (SGWL) – Dec 2012
  - Unit 1 Hardware Design Document (SGWL) – Apr 2013
  - Unit 1 System Staged (SGWL) – Oct 2013
  - Unit 1 FAT (SGWL) – Jan 2014
  - Unit 1 Simulator Install (SGWL) – Mar 2014
  - Unit 1 Plant Install (SGWL) – Oct 2014
  - Unit 2 FAT (SGWL) – Jun 2014
  - Unit 2 Simulator Install (SGWL) – Aug 2014
  - Unit 2 Plant Install (SGWL) – Apr 2015

Steam Generator Control System Replacement

Existing System

- Non Safety Reactor Controls Instrumentation
  - Steam Generator
    - Water Level Control
    - Pressure Control
  - Volume Control Tank Level Control
  - Letdown Heat Exchanger
    - Discharge Temperature Control
    - Discharge Pressure Control
  - Feedwater AP / MFP Speed Control
  - Pressurizer
    - Pressure Spray & Heater Control
    - Level & Charging Pumps Flow Control

RCI Control System Replacement

Existing System

- Non Safety Reactor Controls Instrumentation
  - Steam Dump Valves
  - Boric Acid & Primary Water Flow To Blender Control
  - Rod Control
  - Main Feedwater Pump Suction Pressure Control
  - East & West Feedwater Pump Steam Pressure Control
  - Manual Loading Stations
  - Hot Shutdown Panel Controllers

RCI Control System Replacement

Existing System

- Installed as a replacement for original Foxboro system ~1991
- 12 Control Group Cabinets
  - Separated in Control Groups 1-4
    - 2 – 4 cabinets per control group
  - Taylor / ABB Mod 30 Math Units
  - Taylor / ABB Mod 30 Controllers
- 2 Interface Cabinets
- Main Control Board
  - Taylor / ABB Mod 30 Controllers
  - Yokogawa Trend Recorders
  - Various Indicators
  - Devar controllers

RCI Control System Replacement

Existing System

- Main Control Board
  - 8 Control Panels
    - Steam Generator (SG)
    - Boric Acid (CVCS) (BA)
    - Safety Injection / Accumulators (SIS)
    - Containment Spray and Relief (SPY)
    - Delta T and Unit (DTU)
    - Residual Heat Removal (RHR)
    - Pressurizer (PZR)
    - Rod Control (RC)

RCI Control System Replacement

Original System

- Original Project Scope (Phase I)
  - Steam Generator Water Level Control
  - Steam Generator Pressure Control
- Subsequent Project Scope(s) (Phase II and later)
  - Remaining systems
- S&L
  - Based upon preliminary EC work recommended consolidating replacement into one activity
  - RCI individual systems intermixed in the control group cabinets
  - Phased project unable to maintain control group separation

RCI Control System Replacement

Original System

- SGWL Project
  - S&L EC Activity suspended
  - Scientech Activity slowed to that not affected by expansion
  - S&L RCI Functional Requirements Specification development
  - DC Cook pursued expanded project approval
    - Replace all RCI systems EXCEPT Hot Shutdown Controllers
  - S&L and Scientech contract modified for expanded scope
    - Scientech – expanded scope ~3 times original project scope

Reactor Controls Instrumentation (RCI) Control System Replacement

Updated Project

- Schedule (RCI)
  - Contract Award (RCI) – Jul 2012
    - Lead Unit changed to Unit 2
  - Unit 2 Hardware Design Document (RCI) – Sep 2013
  - Unit 2 System Staged (RCI) – Apr 2014
  - Unit 2 FAT (RCI) – Jul 2014
  - Unit 2 Simulator Install (RCI) – Oct 2014
  - Unit 2 Plant Install (RCI) – Apr 2015
  - Unit 1 Hardware Design Document (RCI) – Jan 2014
  - Unit 1 FAT (RCI) – Jul 2015
  - Unit 1 Simulator Install (RCI) – Sep 2015
  - Unit 1 Plant Install (RCI) – Apr 2016

RCI Control System Replacement

Project Objectives

- Like System Replacement (Except…)
  - Maintain Control Group Separation
- Increased System Redundancy and Availability
  - New Feedwater Regulating Valve positioner
    - Redundant demand inputs
    - Redundant positioner outputs
    - Diagnostic output
  - Redundant Input Power
    - Control Room Inverter (CRID) (primary - existing)
    - Lighting power (secondary – new)
    - Auto Transfer Switch in the control group cabinets for non redundant input power devices
  - Redundant I/O
    - All inputs and outputs are redundant I/O
  - Fully Redundant Controllers

RCI Control System Replacement

Project Objectives

- Failover HMI
  - Control panel monitor organized into failover pairs
  - Failure of a monitor causes a combined display for both monitors on the remaining unit
- System Monitoring
  - All equipment automatically monitored for correct operation
  - Annunciator Alarms
    - RCI Failure
      - Loss of a system function
    - RCI Trouble
      - Loss of a redundant component
      - Non annunciator alarm

RCI Control System Replacement

Project Objectives

- Reduction in the number of system components
  - Control panel components
    - For example, eliminate 2/3 of the RCI physical components on the SG panel
- Diagnostics, Maintenance and Testing
  - Significant reduction in the number of system test points (and associated calibrations and surveillances)
- Data Historian
  - Millisecond archive data
- Standard R*TIME System Reports
  - Point Summaries
  - SOE messages
  - Alarm messages

RCI Control System Replacement

Replacement System

- System Architecture
  - RTP 3000 I/O Equipment
  - RTP NetArrays Control System Software
    - Scientech developed NetArrays control implementation
    - Only system component required for automatic control functions
  - R*TIME Server
    - Data Historian
    - System Monitoring
    - HMI functions
    - NO control system implementation
  - R*TIME Viewer HMI
    - Supervisory control
      - Manual / Auto functions
    - Data Display

RCI Control System Replacement

Replacement System

- Unit 1/2 Systems
  - Retain and reuse control group cabinets
  - Retain and reuse 80 VDC power supplies
  - Retain and reuse 120 VAC Annunciator system interposing relays
  - Retain and reuse PPC I/O resistors (current outputs to voltages inputs on PPC)
  - New I/O equipment
  - New 24 VDC power suppliers
  - New 120 VAC input power auto transfer switches
  - New servers and networking equipment
  - New control board HMI monitors, computers and KVM equipment

RCI Control System Replacement

Replacement System

- Simulator 1/2 Systems
  - New equipment cabinets
  - New servers and networking equipment
    - Same type, different quantities as Unit systems
  - New control board HMI monitors, computers and KVM equipment
    - Same as Unit systems

RCI Control System Replacement

Replacement System

- Maintenance, Training and Testing System
  - New equipment cabinets
  - New 80 VDC power supplies
  - New 24 VDC power suppliers
  - New I/O equipment (subset)
  - New servers and networking equipment (subset)
  - New control board HMI monitors, computers and KVM equipment (subset)
  - Two I/O systems
    - Maintenance and Training node
    - Testing node
    - Two nodes interconnected, outputs on M&T node connected to inputs on Test node and vice versa

RCI Control System Replacement

Replacement Equipment

- RTP I/O Equipment
  - Redundant Controllers
  - Redundant I/O
  - Redundant Power Supplies
  - Current inputs
    - 4-20 ma
    - 10-50 ma
  - Current outputs
    - 4-20 ma
    - 10-50 ma
    - +/- 10 VDC
  - Digital Inputs
    - 24 VDC
    - 120 VAC

RCI Control System Replacement

Replacement Equipment

- RTP I/O Equipment (cont.)
  - Digital Inputs
    - 24 VDC
    - 120 VAC
  - Digital Outputs
    - 24 VDC
    - 125 VDC
    - 120 VAC
  - Termination modules
  - 20% spare channels
  - Unit systems are 4 independent DAS nodes, one per control group

RCI Control System Replacement

Replacement Equipment

- Servers
  - Installed in the control group cabinets
  - Redundant servers
  - Environmental requirement is 104 °F
    - Unable to use main stream equipment (Dell, HP, IBM, etc.)
    - Built to order servers from Advantech
  - Unit systems are 4 independent systems, one per control group
  - Simulator systems are 1 system per simulator

RCI Control System Replacement

Replacement Equipment

- Networks
  - Network switches installed in the control group cabinets
  - Three separate networks
    - I/O network
    - HMI network
    - Display network
  - Dual Redundant switches (HMI / DAS network)
  - Triple Redundant switches (I/O network)
  - Servers connected directly to I/O network via separate VLAN configuration on I/O network switches

RCI Control System Replacement

Replacement Equipment

- Networks
  - HMI Network separated into A train and B train network switches
    - A train and B train network switch per control group
    - A train switches interconnected
    - B train switches interconnected
    - A and B train switches NOT interconnected
  - All network cabling new CAT-6 Ethernet

RCI Control System Replacement

Replacement Equipment

- HMI Equipment
  - Cyber Research panel mounted monitors
    - Touchscreen
    - Through panel mounting
    - 6”, 8” 10” and 21” sizes
    - Landscape and portrait orientation

RCI Control System Replacement

Development Process

- Display Creation
  - 30 unique displays at 4 different video resolutions and 2 different video orientations
  - Normal displays and failover displays
- Database Creation
  - Because the original system was not a computer based system, it has to be created from scratch
- Temporary Control Group Cabinets
  - Support staging of the replacement system in Idaho Falls

RCI Control System Replacement

Development Process

- Equipment Testing
  - Seismic II/I for control panel monitors and KVM extenders
  - EMI/RFI for control panel monitors and KVM extenders
  - EMI/RFI for Control Group Cabinet equipment
    - Representative cabinet configuration (12 different cabinet configurations, will use a “maximum” cabinet configuration)
- System Testing
  - Simulator Development Test
    - Unit 2 Simulator system delivered early
    - Interfaced to Simulator inline with existing system
    - Full suite of “operational” and “upset” test conditions
    - Comparison of replacement system to existing system

RCI Control System Replacement

Development Process

- System Testing
  - FAT test
    - Each of I/O input and output verified
    - Each control system function verified
    - Each HMI display verified
      - Data display
      - Failover
      - Operator supervisory control actions
    - System redundancy verified
      - Servers
      - Networks
      - I/O equipment
      - System monitoring

RCI Control System Replacement

Development Process

- System Testing
  - SAT test
    - Restage replacement system at DC Cook
    - Near repeat of the FAT test

RCI Control System Replacement

Implementation Issues

- Scientech Factory Staging
  - 125 VDC power
    - Reuse variable power supplies purchased to support ANN system
  - 80 VDC control loop power supplies
    - Purchase units for use in Idaho Falls and deliver to DC Cook as spares
  - 120 VAC interposing relays
    - TBD

RCI Control System Replacement

Replacement System Challenges

- I/O Equipment
  - New I/O cards required
    - 10-50 ma analog current input
      - new termination module
    - 4-20 ma analog current output
      - 600 Ohm load
    - 10-50 ma analog current output
      - 600 Ohm load

RCI Control System Replacement

Replacement System Challenges

- HMI Equipment
  - Control panel mounting of monitors
  - No space for HMI computers in or behind control panel
    - Computer mounted in the control group cabinets
    - KVM extenders connect monitor and computer
      - Rack mounted units in control group cabinets
      - Mini adapter (no power required) on monitor in control panel

RCI Control System Replacement

Replacement System Challenges

RCI Control System Replacement

Replacement System Challenges

- Environmental Requirements
  - 104 °F requirement
  - No control group cabinet ventilation
  - New model of server computers, HMI computers and engineering workstation
    - Advantech Industrial Computers

RCI Control System Replacement

Replacement System Challenges

- Control Algorithm
  - 4 separate NetArrays project implementations (Unit)
    - Common components (Steam Generator)
    - Different components (Other systems)
  - Use same control implementation in the Simulator
    - No I/O equipment or controllers
    - Same control algorithm
      - Build single NetArrays project by merging the 4 separate unit projects and remove controller and I/O equipment specifics
    - Limitation on single RTP Simulator
      - Multiple instances of RTP Simulator not supported on a single computer
    - Limitation on RTP Simulator interface
      - RTP Simulator accepts connections from local computer only
      - Utilize DCMNODE for R*TIME Interface
      - Develop proxy agent for Simulator interface

RCI Control System Replacement

Replacement System Challenges

- System Staging
  - Temporary cabinets
  - Temporary 80 VDC power supplies
  - Temporary 120 VAC interposing relays
  - New Feedwater Regulating Valve positioner
  - Mounting 30 control panel monitors

RCI Control System Replacement

Replacement System Challenges

- 30 Control Panel Monitors
  - New control panel cutouts
  - Clearance with front side control board controls
  - Clearance with back side control board supports
  - No redundant AC power available
  - No location available for computers

RCI Control System Replacement

Replacement System Challenges

- Control Group Cabinets
  - Cabinets have to be retained to retain field termination wiring
  - Test panels need redesigned / replaced

RCI Control System Replacement

Replacement System Challenges

- Project
  - Change from a pure I&C system to a system with IT components
  - Cyber Security requirements still not defined
  - Unit 1 and Unit 2 systems are similar but not identical
  - Aggressive Schedule
  - Utilize lessons learned from PPC and ANN projects

RCI Control System Replacement

Replacement System Challenges

- Installation
  - SAT Test
    - Restage complete system in temporary location for testing prior to physical installation
  - Outage based
    - Significant concern on the amount of work required to be performed
  - Air Conditioning
    - Back Control Panel
      - Some control group cabinets receive minimal room air conditioning cause higher cabinet temperatures

RCI Control System Replacement

Questions?