

### DC Cook Main Control Room Annunciator Replacement Project

#### 2013 Scientech User's Symposium

Robert Ammon / Scientech Tom Craven / DC Cook August 2013

#### Project

- Organizations
  - DC Cook (Utility)
  - Hurst Technology (Utility Agent and A/E)
  - Scientech (Vendor)
- Schedule
  - Contract Award Nov 2011
  - Unit 1 FAT Dec 2012
  - Unit 1 Simulator Install Sep 2012
  - Unit 1 Plant Install Apr 2013
  - Unit 2 FAT Jul 2013
  - Unit 2 Simulator Install Sep 2013
  - Unit 2 Plant Install Oct 2013

#### **Original System**

- Rochester Instruments Model AN-100
  - Original Plant Equipment (circa 1970)
  - 23 lampboxes
  - 6 logic cabinets
  - 3 control room horns

#### **Original System**

- 23 Annunciator Units
  - Mounted in the vertical control panels
  - Composed of "lampboxes"
    - Individual lighted windows
    - Engraved and colored caps
    - Bulls eye indicator lamp
    - Mechanical buttons for acknowledgment
      - Must acknowledge each alarm individually
    - Organized in <u>10 x 10</u>, <u>5 x 10</u>, <u>10 x 5</u>, <u>4 x 6</u> and <u>4 x 12</u> configurations

#### **10 x 10 Original Annunciator Unit**

### STA. AUX AB Annunciator #119



#### **5 x 10 Original Annunciator Unit**

### SG 1&2 Annunciator #113



#### **10 x 5 Original Annunciator Unit**

### Circ Water Annunciator #123



#### 4 x 6 Original Annunciator Unit

### Unit Annunciator #112





#### 4 x 12 Original Annunciator Unit

### Turbine Oil Annunciator #117



#### **Original System (cont.)**

- 6 Logic Cabinets
  - Located behind the main control board
  - ~1600 field inputs
  - Powered from 250 VDC station batteries (non safety)
  - Contains
    - Field termination wiring
    - 250 VDC to 125 VDC power supplies
    - Annunciator equipment
      - Annunciator logic cards (2 channels)
    - Ground Fault Detector

#### **Original System (cont.)**

- Audible Horns
  - 3 distinct horns
    - Based upon Annunciator location in the main control board
      - Left side, front or right side
  - Master lockout
    - Unit Supervisor desk

#### **Replacement System**

- 23 Annunciator Units
  - Lampboxes replaced with touchscreen monitor and computer
  - New 10x10, 5x10 and 10x5 VDUs
- 6 Logic Cabinets
  - Cabinet body and field termination wiring retained
  - Cabinet doors replaced
  - 250 VDC input power modified
    - New breakers
  - Annunciator equipment and power supplies replaced
  - Ground Fault Detector Replaced
- Audible Horns
  - Existing horns retained
  - Master lockout retained

- 23 Annunciator Units
  - Fit into existing 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

#### **10 x 10 Replacement Annunciator Unit**



#### 5 x 10 Replacement Annunciator Unit



#### **10 x 5 Replacement Annunciator Unit**



- 6 Logic Cabinets
  - Space behind main control board



- 6 Logic Cabinets
  - Cabinet had to be retained to retain field termination wiring



- 6 Logic Cabinets
  - Cabinet depth (~12")



- 6 Logic Cabinets
  - Field termination cable interference



- 6 Logic Cabinets
  - Intermediate field wiring
    - Original system only supported one input per annunciator window
    - Windows with multiple inputs required inputs to be electrically OR'd

- Project
  - Concurrent project with PPC replacement
    - Resource conflicts in all organizations
  - Change from a pure I&C system to a system with IT components
  - Operational requirements were not settled until after installation of Unit 1 Simulator
    - Caused partial repeat of FAT
  - Cyber Security requirements were not settled until after Unit 1 Installation
  - Unit 1 and Unit 2 systems are similar but not identical

- Project (cont.)
  - Plant documentation issues
    - Multiple errors in existing plant documentation
    - Operator Dispatch (Green) Alarms not documented (discovered requirement during Operator Interface Test)
  - Other plant changes which required Annunciator system changes occurring simultaneously

- Installation
  - Outage based
  - Operations requirement for "temporary" alarm system during installation
  - Equipment clearance issues
    - Had to find right angle connectors for just about every type of connections
    - Routing of cables to minimize EMI/RFI
  - Air Conditioning
    - Behind Control Panel
      - Some logic cabinets receive minimal room air conditioning cause higher cabinet temperatures
    - TSC Computer Room
      - Loss of A/C multiple times has almost caused system shutdown

#### **Replacement System**

- 23 Annunciator Video Display Units
  - CyberResearch touchscreen monitor
    - Custom enclosure containing commercial components
    - Pinch plate through hole control board mounting
    - Integration of "bullseye" indicator
  - Polywell small form factor computer
    - Direct 12 VDC power
    - Mounted to backside of VDU monitor
  - Converted 4 x 6 and 4 x 12 configurations to 5 x 10

- 6 Logic Cabinets
  - Replacement Cabinet Doors and new cabinet door offsets
  - New Equipment
    - 125 VDC power supplies
      - Equipment power
      - I/O whetting voltage
    - 12 VDC power supplies
      - VDU power
    - RTP 3000 I/O equipment
      - 125 VDC direct digital input cards
        - Field inputs
      - 24 VDC digital output cards
        - VDU bulls eye indicators
        - Horn relays
      - Analog input card
        - PS Monitoring

- 6 Logic Cabinets (cont.)
  - New Equipment (cont.)
    - Network Switches
    - Ground Fault Detector

- Network
  - Plant Data Network fiber infrastructure added to support both ANN and PPC
  - Connections to BOP desk and US desk for ANN
  - Network switches in back control room for VDUs and Logic Cabinets
  - Connections to TSC Computer Room
  - Annunciator system is an isolated network, no connections to any other systems and no connection to the Business LAN

- Server Computers
  - HP DL 360
  - Located in new cabinet in the new TSC Computer Room
- Workstations
  - Control Room
    - BOP desk
    - Unit Supervisor desk
  - TSC Computer Room

- Cyber Security
  - Additional Equipment
    - Initially Unit 2 only
    - System Log Monitor
    - Network Intrusion Detection System
  - RJ-45 Port Locks
  - USB Port Locks
  - Cabinet door alarms
  - Network port alarms

- VDU functions
  - Augmented Modes
    - Disabled
      - Disables the alarm window
    - Silenced
      - Don't activate alarm horn for this alarm
    - Test
      - Automatically acknowledge and don't activate alarm horn
    - Normalized Input
      - Enable or disable a single field input for alarm windows that have multiple inputs.
  - Acknowledge All per VDU
    - New button to acknowledge all alarms on a VDU rather than individually acknowledging them

- Control Room Workstations
  - Function as backup VDUs
  - System Monitoring
    - Alarm Summary Display
  - Reports
    - All alarms
    - All failed inputs
    - All silenced / disabled / test alarms
- System Monitoring Function
  - Annunciator Trouble Alarm
  - Annunciator Failure Alarm

- Unit Supervisor Function
  - VDU Groups
    - Disabled
    - Silenced
    - Test
    - Flags (Notations)
- Maintenance Functions
  - Alarm History
  - SOE Message History

- Multiple Input Alarm Windows
  - Previous system required electrically OR-ing inputs
    - Caused additional cabinet wiring
  - Replacement system supports multiple inputs in software
    - Eliminates wiring
    - Ability to see which of the multiple inputs triggers the alarm
- Either input state (0 or 1) can be an alarm state

#### **Development Process**

- Display Creation
  - 23 unique displays at 3 different video resolutions and 2 different video orientations
- Database Creation
  - Because the original system was not a computer based system, it had to be created from scratch

### Temporary Logic Cabinets

- Duplicate cabinets with the same size and field wiring layout as the plant cabinets were created
  - Support staging of the replacement cabinet doors in Idaho Falls
  - Pre termination to length of the I/O wiring cables

#### **Development Process**

- Equipment Testing
  - Seismic II/I for VDU monitors and computers
  - EMI/RFI for VDU monitors and computers
  - EMI/RFI for Logic Cabinet equipment
  - "Firestorm"
    - More than 900 inputs activated simultaneously
  - FAT test
    - Each of 1600 field inputs verified
    - Each VDU alarm window verified for all states and all operator actions (10 days of testing for Unit 1)

#### **Implementation Issues**

- Scientech Factory Staging
  - 250 VDC input power
    - Acopian 125 VDC and 25 VDC power supplies had significant inrush current, significant challenge to powering up all equipment

#### **VDU Displays**

- 100 (10 x 10) or 50 (10 x 5 or 5 x 10) alarms per display
- Tile Color
  - Red
  - Yellow
  - White
  - Green
- Annotations
  - Compensatory Action
  - Emergency Diesel Generator
  - Seal-In
- Alarm Types
  - Seal-In (clears when the input resets)
  - Non Seal-in (clears only when released by operator)

#### **VDU** Displays

Alarm Priority	Not in Alarm or Acknowledged Return to Normal	Unacknowledged Alarm	Acknowledged Alarm	Unacknowledge d Return to Normal	Failed
High	Solid Light Grey	Rapid Flashing Bright Red	Solid Bright Red	Slow Flashing Bright Red	Magenta
Medium	Solid Light Grey	Rapid Flashing Bright Yellow	Solid Bright Yellow	Slow Flashing Bright Yellow	Magenta
Low (Event)	Solid Light Grey	Rapid Flashing White	Solid Bright White	Slow Flashing Bright White	Magenta
Operator Dispatch	Solid Light Grey	Rapid Flashing Green	Solid Bright Green	Slow Flashing Bright Green	Magenta

#### **VDU Displays (Normal Inputs)**

C 1 O	11	21	31	C 41	C 51	C 61	C 71	81	C 91
DG1AB 100 PSI	DG1AB FUEL	DG1AB	DG1AB	DG1AB	DG1AB	DG1AB OUTPUT CB	TR1AB	TR1AB OR	TR101AB EMER
SUPPLY AIR	OIL DAY TANK	LUBE OIL	JACKET WATER	INCOMPLETE	DIFFERENTIAL	T11A11 OR T11B4	4KV CB 1A7	TR101AB CLG	4KV CB 1A5
PRESSURE LOW	LEVEL HIGH	TEMP HI-HI	TEMP HI-HI	START	OPERATED	LOCKED OUT	OVERLOAD TRIP	MTR VOLT FAIL	OVERLOAD TRIP
C 2	C 12	22	32	42	52	C 62	C 72	82	C 92
DG1AB COMPR	DG1AB FUEL	DG1AB	DG1AB	CO2 FIRE	DG1AB TRIP	DG1AB 4KV	TR1AB	TR1AB OR	TR101AB EMER
AIR RECEIVER	OIL DAY TANK	LUBE OIL	JACKET WATER	SYSTEM	DEVICE AT SP	CB T11A11	4KV CB 1B7	TR101AB RELF	4KV CB 1B5
PRESSURE LOW	LEVEL LOW	TEMP HIGH	TEMP HIGH	DG1AB TRIP	(DISABLED)	OVERLOAD TRIP	OVERLOAD TRIP	OR OIL LVL LO	OVERLOAD TRIP
3	13	23	33	C 43	53	63	73	83	C 93
AIR FILTR HTR	DG1AB FUEL	DG1AB	DG1AB	DG1AB CTRL SW	DG1AB	SWITCHGEAR	TR1AB	TR1AB OR	TR101AB
VOLT FAIL OR	OIL MANIFOLD	LUBE OIL	JACKET WATER	STATUS INCOMP	TRIPS	COOLING FAN	OIL FLOW	TR101AB OIL	HEA
TEMP HI OR LO	PRESSURE LOW	PRESSURE LOW	TEMP LOW	OR VOLT FAIL	DISABLED	FAILURE	LOW	TEMP HIGH	OPERATED
4	14	24	34	C 44	54	64	74	84	94
DG1AB	DG1AB	DG1AB	DG1AB JKT WTR	DGTAB LOAD	DG1AB OVERSPEED	DG1AB	4KV BUS 1A	TR1AB OR	TR101AB
AIR CHEST	FUEL TRANSFER	LUBE OIL	PUMP FAIL	SHED RELAYS	OR BRG PROT	CB 1DGTAB	PARALLEL	TR101AB COIL	LTC
PRESSURE HIGH	DP HIGH	FILTER DP HI	OR PRESS LOW	DISABLED	ABNORMAL	INSTANT TRIP	OPERATION	TEMP HIGH	TROUBLE
5	15	25	35	45	55	65	C 75	85	95
DG1AB	DG1AB FUEL	DG1AB L.O.	DG1AB JKT WTR	DG1AB	DG1AB L.O.	DG1AB	4KV BUS T11A	4KV BUS 1B	
AIR CHEST	OIL XFER PUMP	STRAINER	SURGE TANK	IN LOCAL	CONTROL BUS	CB 1DGTAB	CB T11A9	PARALLEL	
TEMP HIGH	ABNORMAL	DP HIGH	LEVEL LOW	CONTROL	UNDERVOLTAGE	OVERLOAD TRIP	TRIP	OPERATION	
6	16	26	36	46	C 56	66	76	C 86	C 96
DG1AB	69/4KV YARD	DG1AB L.O.	DG1AB VALVE	DG1AB VOLTAGE	DG1AB	DG1AB NEG SEQ	4KV BUS T11A	4KV BUS T11A	4KV CB T11B1
SUMP PIT	48V BATT CHG	TANK LEVEL	GEAR LUBE OIL	REGULATOR	CONTROL BUS	4KV CB 1DGTAB	PARALLEL	CB T11A12	LOW SET
LEVEL HIGH	FAILURE	HIGH OR LOW	FAILURE	IN MANUAL	VOLT FAILURE	TRIP	OPERATION	TRIP	TRIP
7	17	27	37	47	57	67	77	87	97
DG1AB	69/4KV YARD	DG1AB L.O.	DG1AB VALVE	DG1AB	DG1AB TRIP	DG1AB OR DG2AB	CONTROL ROOM	4KV BUS T11B	600V BUS
SUMP PUMP	48V BATTERY	HEATER PUMP	GR EXCESS OIL	ROOM VENT	RELAY BUS	FEED TO LOAD BK	EMERGENCY	PARALLEL	11A & 11C
OPN ABNORMAL	GROUND	FAILURE	(STANDBY)	ABNORMAL	VOLT FAILURE	ENERGIZED	LIGHTING ON	OPERATION	PARALLEL OPN
8	18	28	38	48	58	68	78	C 88	C 98
PLANT	PLANT BATTERY	DG1AB L.O.	DG1AB VALVE	DG1AB ROOM	CB 1DGTAB	TRP CB 1DGTAB	TR11BMC	TR11A	TR11B
BATTERY 1AB	CROSSTIE	BEFORE & AFTER	GR L.O. PRESS	VENT DAMPER	CONTROL SW	LOAD BANK CLG	DIFFERENTIAL	DIFFERENTIAL	DIFFERENTIAL
GROUND	ENERGIZED	PUMP ABNORMAL	LOW (RUNNING)	ABNORMAL	CLOSE POS	FAN AIR FLO LO	OPERATED	OPERATED	OPERATED
9	19	29	C 39	49	59	69	79	C 89	C 99
BATTERY	BATTERY	CRID 3	DG1AB	DG1AB ROOM	LOAD BANK CLG	DG1AB	TR11BMC 600V	TR11A	TR11B
CHARGER 1AB1	CHARGER 1AB1	INVERTER	INVERTER	TEMPERATURE	FAN CONTROL	LOAD BANK CLG	CB 11BMC1	600V CB 11A11	600V CB 11B11
FAILURE	ABNORMAL	ABNORMAL	FAILURE	LOW	BUS FAILURE	FAN FAILURE	TRIP	TRIP	TRIP
10 BATTERY CHARGER 1AB2 FAILURE	20 BATTERY CHARGER 1AB2 ABNORMAL	30 CRID 4 INVERTER ABNORMAL	40 4KV BUS T11A OVERVOLTAGE	50 ANN 118 FAIL	60 RESET	70 ANN 119 ACKNOWLEDGE	80 600V BUS 11BMC GROUND	90 600V BUS 11A GROUND	100 600V BUS 11B GROUND

#### **VDU Displays (Alarm Inputs)**

1 MAIN TRANSFORMER FIRE	11 WATER FIRE SYSTEM HEADER PRESSURE LOW 1	21 FIRE PP HOUSE SUBPANEL ALARM	31 FIRE PP HOUSE SPRINKLER ACTUATED	G 41 FIRE	51 SCREEN HOUSE FIRE PUMP RM SPR ACTUATED	61 DIESEL GEN FUEL PP ROOM CO2 SYS ACT	71 TURB LUBE OIL TREATMENT RM CO2 SYS ACT	81 RX CABLE TNL Q1 CO2 SYS ACTUATED	31 CONTAINMENT FIRE
2	12	22	32	42	52	62	72	82	92
MAIN XFMB	TURB BLDG 609	TURB BLDG 609	FIRE PP HOUSE	AUX BUILDING	SCREEN HOUSE	DIESEL GEN RM	TURB LUBE OIL	RX CABLE TNL	CNTMT CABLE
DELUGE	SOUTH END	SOUTH END	SPRINKLER	FIRE HEADER	FIRE PUMP RM	1CD CO2 SYS	TREATMENT RM	Q1CO2 SYS	TRAY FIRE SYS
ACTUATED	SPR ACTUATED	SPR ACTUATED	ABNORMAL	PRESSURIZED	SPR ABNORMAL	ACTUATED	CO2 SY'S ABN	ABNORMAL	ABNORMAL
3	13	23	33	43	53	53	73	83	93
AUX XFMR 1AB	TURB BLDG 591	TUPB BLDG 591	ELECTRIC	EAST DIESEL	WEST DIESEL FIRE	DIESEL GEN RM	MAIN TURB LUB	RX CABLE TNL	CNTMT CABLE
DELUGE	N END & CNDSR	SOUTH END	FIRE PUMP	FIRE PUMP CTRLR	PUMP	1AB CO2 SYS	OIL TANK ROOM	Q2 CD2 SYS	TRAY FIRE SYS
ACTUATED	PIT SPR ACT	SPR ACTUATED	LOSS OF POWER	SW OFF	CTRLR SW OFF	ACTUATED	CO2 SYS ACT	ACTUATED	ALARMACK
4	14	24	34	44	54	64	74	84	94
AUX XFMR 1CD	TURB BLDG 591	TURB BLDG 591	ELECTRIC	EAST DIESEL	WEST DIESEL FIRE	DESEL GEN &	MAIN TURB LUB	RCT Q2 CO2	REACTOR
DELUGE	OR 609 N END	OR 609 S END	FIRE PUMP	FIRE PUMP	PUMP	FUEL PP ROOMS	OIL TANK ROOM	VOLT FAIL OR	COOLANT PUMP
ACTUATED	SPR ABNORMAL	SPR ABNORMAL	RUNNING	RUNNING	RUNNING	CO2 SY'S ABN	CO2 SY'S ABN	SY'S ARMED	FIRE OR ABN
5	15	25	35	45	55	65	75	85	95
START-UP XFMR	TURB BLDG 609	TURB BLOG 609	ELECTRIC	EAST DESEL	WEST DIESEL FIRE	U1&U2 TURB	U1&U2 TURB	RX CABLE TNL	
101AB DEL UGE	N END CABLE	S END CABLE	FIRE PUMP	FIRE PUMP	PUMP	LUBE OIL ROOMS	LUBE OIL ROOMS	Q3N CO2 SYS	
ACTUATED	OR OIL SPR ACT	DR OIL SPR ACT	PHASE REVERSAL	CTRLR ABNORMAL	CTRLR ABNORMAL	CO2 HDR PRZN	CO2 VOLT FAIL	ACTUATED	
6	18	28	36	46	56	66	76	66	96
START-UP XFMR	TURB BLOG 591	TUPB BLDG 591	AES FAN 1	CNTMT ACCESS	CTRL RMCABLE	SWG RM CABLE	4KV SWGR ROOMS	RX CABLE TNL	
101CD DELUGE	N END CABLE	S END CABLE	CHAR FILTER	BLDG	VAULT HALON	VAULT CD2 SYS	CO2 SYSTEM	Q3M CO2 SYS	
ACTUATED	OR OIL SPR ACT	OR OIL SPR ACT	FIRE OR ABN	FIRE	OR CO2 ACT	ACTUATED	ACTUATED	ACTUATED	
7	17	27	37	47	57	57	77	87	97
TRANSFORMER	TURBINE BLDG	TURBINE BLDG	AES FAN 2	CNTMT ACCESS	CTRL RM CABLE	AUX CABLE VAULT	ESS MEZZ & E	RXCABLE TNL	CNTMT PRESS
DELUGE	N END CABLE	S END CABLE	CHAR FILTER	BLDG	VAULT CO2 SYS	CO2 SYS	600V XFMR RM	Q3SCO2 5/S	RELF FANFLTR
ABNORMAL	OR OIL SPR ABN	OR OIL SPR ABN	FIRE OR ABN	FIRE SYS ABN	ACTUATED	ACTUATED	CO2 SYS ACT	ACTUATED	FIRE OR ABN
8	18 TURB LAGGING FIRE	28 UNIT 1 PYRALARM ABN OR FIRE	38 17 TON CO2 TANK PRESSURE HIGH OR LOW	48 AUX BUILDING CO2 HEADER PRESSURIZED	58 CTRL RM CABLE VAULT HALON ABNORMAL	68 CABLE VAULTS CO2 SYSTEM ABNORMAL	78 CRDM INVERTER 8 V 600V XFMR ROOM CO2 ACT	88 RX CABLE TNL 04 C02 SYS ACTUATED	98 CNTMT INSTN RM PRG FAN FLTR FIRE OR ABN
9	19	29	39	49	59	69	79	89	99
TDAFP ROOM	TURB LAGGING	VENT FAN TRIP	HOSEREEL	UTAUX BLDG	CTRL RM PRZN	CTRL RMCABLE	4KV AREA CO2	RX CABLE TNL	RX CABLE TNL &
SPRINKLER	WATER SPRAY	RELAY BUS FEA	CO2 HEADER	CO2 SYSTEMS	CHAR FILTER	VAULT HATCH	VOLT FAIL OR	Q3 AND Q4 CO2	SWGR CABLE RM
ACTUATED	ACTUATED	VOLT FAILURE	PRESSURIZED	VOLT FAILURE	FIRE OR ABN	OR DOOR OPEN	SYS ARMEDIABN	SYS ABNORMAL	STANDPIPE FLO
10 TDAFP ROOM SPRINKLER ABNORMAL	20 TURB LAGGING WATER SPRAY ABNORMAL	30 VENT FAN TRIP RELAY BUS FEB VOLT FAILURE	40 HOSEREEL CO2 SYSTEM VOLT FAILURE	50 ANN 123 FAIL	60 RESET	70 ANN 101 ACKNOWLEDGE	80 SWGR AREA AND CABLE VAULT CO2 SYS ISOL	90 RX CABLE TNL Q1 OR Q3 OR Q4 CO2 SYS ARMED	100 UNIT TEIRE SYSTEM LOGIC VOLT FAILURE

#### **VDU Displays (Indicators)**



#### **Augmented Alarm Modes**



#### **Unit Supervisor Function**

DEV-A			ANNUNCIATOR GROUP	VDU: 101 102	103 104 105 106 107 108 10	9 110 111 8/22/12
REDU	SCI-LDAJZ4KT	UNIT 1		ANN_GROUP		1 122 123 1.5.42.00
Select Group:				Duplicate Group	Delete Group	Save Group
Description:				Flag:	Color:	
Visual Display Unit		Drop:	Add Drop		Enable Group	Disable Group
Remove	Drop ID Descri	ption		Test	Silent D	Disable Previous
						Next
				Print Group	Print All Groups	Print Enabled

#### **Annunciator Overview Function**





# Questions?