PALO VERDE
NUCLEAR GENERATING STATION

I&C Program

Classroom Lesson

I&C Program	**Date: 7/16/2010 8:10:39 AM**
LP Number: NID16L000103	**Rev Author: DANIEL R. REED**
Title: Start-up / Control Excore System	**Technical Review:** Jones, Warren H(Z54741) Digitally signed by Jones, Warren H (Z54741) DN: cn=Jones, Warren H(Z54741) Reason: I have reviewed this document Date: 2010.07.16 11:06:31 -07'00'
Duration : 10 HOURS	
	Teaching Approval: Steinmetz, Tim P(Z99348) Digitally signed by Steinmetz, Tim P (Z99348) DN: cn=Steinmetz, Tim P(Z99348) Reason: I am approving this document Date: 2010.07.16 13:02:28 -07'00'

INITIATING DOCUMENTS

Site Maintenance Training Program Description

REQUIRED TOPICS

None

CONTENT REFERENCES

TCS 94-1098 CRDR 24-0094 Control Channel HV Attached to discharge jack

TCS 97-1927 Reactivity Management

VTM-C490-0002 Excore Neutron Flux Monitoring System

TCS 2831584: CRDR 2692430 The Startup Channel Meter Pegged High After Replacing a J7 Connector

OE 31444 Automatic Reactor Trip during Nuclear Instrument Calibration (Arkansas Nuclear One)

LESSON PLAN REVISION DATA

Jul 16, 2010	Dan Reed	01 Added OE31444 Content

Tasks and Topics Covered

The following tasks are covered in Start-up / Control Excore System :

Task or Topic Number*	**Task Statement**
Lesson:	Start-up / Control Excore System
SE13	Troubleshoot excore startup/control channel

Total task or topics: 1

TERMINAL OBJECTIVE:

1 Given the appropriate reference material and the necessary test equipment, the I&C Technician will , troubleshoot and maintain the Startup/Control Excore System. Mastery will be demonstrated by successfully completing a lab practical evaluations.

1.1 Describe the function and operation of the major circuits utilized in the Startup Range Excore System, including inputs and outputs

1.2 List the destinations of the output signals from the Startup Range Excore Channel

1.3 Describe the function and operation of the major circuits utilized in the Control Range Excore Channel, including inputs and outputs

1.4 List the destinations of the output signals from the Control Range Excore Channel

1.5 Describe the function and purposed of all front panel indications and controls on the Startup/Control Channel Drawer

1.6 Given a Corrective Maintenance Work Order describing a fault in a Startup/Control Channel Drawer, , troubleshoot the system in accordance with the applicable work order to determine the nature of the fault

TO: 1	**Given the appropriate reference material and the necessary test equipment, the I&C Technician will , troubleshoot and maintain the Startup/Control Excore System. Mastery will be demonstrated by successfully completing a lab practical evaluations.**

EO: 1.1 Describe the function and operation of the major circuits utilized in the Startup Range Excore System, including inputs and outputs

Main Idea

I. Excore Systems Overview

Excore provides fast monitor of power level. Calorimetric (i.e. calculation of power production using T_{hot}, T_{cold}, and mass flow rate) is more accurate, but slow due to RTD response.

A. Design Basis Requirements

TCS 97-1927 Reactivity Management

1. Monitor neutron flux from source range up to 200% power.

Single channel can, via design, monitor total range for perspective, especially in PASS environment.

2. Monitor neutron flux to verify reactivity control in the post-accident environment.

3. Provide, in the power operating range, safety grade signals to the PPS for power level, LPD, and DNBR protection.

Calorimetric can provide only indication of gross power output. Excore can indicate power distribution.

4. Provide continuous monitoring and indication for the rate of change of power level.

5. Provide, in the power operating range, control grade signals to the RRS for use during turbine load following operations.

6. Provide audio indications in the control room and containment to monitor source range neutron flux.

Another advantage of Excore over calorimetric is ability to monitor sub-critical neutron production (while in source range.)

7. Provide signals suitable for use with a reactivity computer during start-up and reload physics testing for both zero-power and at-power operation.

B. Ranges and overlap — T001-Excore Ranges; VTM page I-54

1. Startup range - 1 cps to 100,000 cps = 2 x $10^{-9\%}$ to 2 x $10^{-4\%}$ of full power
2. Control Range - 1% to 125% of full power
3. Linear Safety Range - 1% to 200% of full power
4. Logarithmic Safety Range - 2 X $10^{-8\%}$ to 200% of full power

C. Detector locations — Detector Location

1. Detectors are behind hydrogenous concrete for neutron thermalization even in the event of reactor downcomer voiding
2. Hanging by cable in 6 inch conduit, conductors for detector exit bottom of conduit — VTM I-29
3. Startup Range Detectors — VTM I-9
4. Control Range Detectors — VTM I-17
5. Safety Range Detectors - both linear and log are housed in same detector enclosure — VTM I-12

II. Startup/Control Range Excore System

A. Startup/Control Range Excore System Overview

1. Each drawer contains a startup channel and a control channel.
2. Startup channels provide source level neutron flux information during:
   a. Extended reactor shutdowns.
   b. Initial reactor startup.
   c. Reactor startup after shutdown.

3. Startup channel consists of:

   a. Dual section BF_3 proportional counter.

   b. One preamplifier

   c. Signal processing drawer.

4. Control channel provides power range neutron flux level information.

   a. 0% to 125% power.

   b. Input to Reactor Regulating System. Control Range Interface

5. Control Channel consists of:

   a. Dual section UIC

   b. Signal conditioning drawer.

6. Independent of Safety Channels

B. Detector Assemblies

1. Startup Range Detectors

   a. Each channel consists of:

      1) Two independent sections of BF_3 proportional counters.

      2) Each independent section contains two BF_3 counters connected in parallel.

   b. Each independent section is connected by triaxial cable to a preamplifier.

      1) Within the preamplifier, individual high voltage connections are made for each section.

2) Failure of one section should not affect the performance of the other section.

c. Startup detector is about 38 inches in length.

2. Preamplifier Assembly

a. Inverts negative pulse to provide positive pulse to DWR located on 90' Stanchion outside bio shield

b. Served as an interface between the detector and the control room equipment.

C. Startup Channel Circuit Operation

1. Consist of: (1 channel) Dwg: N001-13.04-125.

a. Dual section BF_3 detector

b. Pre-amp Dwg: N001-13.04-237

c. Signal Processing drawer containing:

1) Discriminator/Driver

2) Log Count Rate Circuit

3) Audio Count Rate Circuit

4) Output buffers

5) Output Bistables

6) High and Low voltage power supplies

7) Test circuit

2. Internal hardware

   a. Card cage - contains all circuit boards for both Startup Range and Control Range.

   b. Power Supplies — Dwg: N001-13.04-125

      1) High voltage

         a) PS5 (-)1000 vdc (Control Range detectors) — Actual setting is - 800 vdc.

         b) PS4 (+)3.0 kv (Startup Range detectors) — Actual setting is +2000 vdc.

      2) Low voltage

         a) PS1 (+)5 vdc – TTL logic

         b) PS2 (±) 15 vdc – Op amps

         c) PS3 (+)28 vdc – Pre-amps/relays

         d) PS6 Filament Transformer - lamp

      3) Low voltage power supplies are shared by startup and control.

3. Discriminator/Driver Card Description — VTM IIB-14

   a. Input to card is the analog pulses from the pre-amp.

   b. Purpose of the discriminator circuit

      1) Gamma production in source range provides error, therefore discrimination used to process neutrons only

2) Convert input pulses into TTl for the Log count rate circuit, scaler output and the audio count rate circuit.

   a) The first stage amp (A1) buffers the comparator amp (A2) from the pre-amp and provides some noise filtering.

   b) The second stage is a comparator amp (A2) which eliminates all input pulses which are below the discriminator threshold.

c. Circuit Description — VTM IIB-27; Dwg N001-13.04-112.

1) A1 is high speed pulse amp.

   a) Buffers comparator amp (A2) from input.

   b) Provides noise filtering.

2) A2 is analog comparator amp.

   a) Eliminates all input pulses which are below the discriminator threshold.

   b) CR1 provides negative input protection.

   c) Output pulses are applied to two one shot circuits.

   d) Results in .5 micro second pulses for scaler and .1 micro second pulses to the LCR.

d. Discriminator Threshold Adjustment

1) R6 is the discriminator threshold adjustment. (discriminator setpoint)

2) It adjusts for the voltage amplitude of pulses which pass through the discriminator driver.

4. Log Count Rate circuit Description VTM IIB-15

a. Purpose - to provide an analog output proportional to the log of the input pulses.

b. Input - TTL pulse from 1 to 100,000 cps.

c. Output - Analog voltage of 1 to 10 vdc which is proportional to log of the input pulses to:

1) Output buffer

2) Front panel meter

3) Hi CPS Bistable

4) Example:

Input	Output
1 cps	0 vdc
10^1 cps	2 vdc
10^2 cps	4 vdc
10^3 cps	6 vdc
10^4 cps	8 vdc
10^5 cps	10 vdc

5) The ZERO and SPAN pots are located on this board.

d. Circuit Description VTM IIB-27; Dwg N001-13.04-111

1) Accept the square pulse count from the DD1 card.

2) A1 produces a 10 meg clock, which is fed to decade dividers A3, 5, 7, 9, 11, 13, 15, & 17.

3) These outputs are fed in parallel to "D" flip flop inputs A2, 6, 10, 14, & 16.

    a) D inputs are tied to logic 1.

    b) Each clock pulse will cause its associated F/F to set - (Q to 1)

4) Square pulses from the DD1 circuit feeds all the F/F reset inputs in parallel.

5) All F/F receive the same reset (neutron pulse) frequency, but different clock pulse frequencies.

6) Each F/F "Q Not" outputs are sent to a NAND Gate which inverts the signal then sends it to the input of A19 in parallel with the other NAND gates.

7) A19 Sums the inputs and provides an inverted output.

8) With no counts inputted from the DD1, all the F/F outputs remain set and the "Q not" is 0, NAND gate output is 1.

9) As pulses are inputted, each F/F is reset, "Q not" goes to 1, causing the NAND gate output to go to 0.

    a) The clock pulses at different frequencies will cause the F/F circuits to set at various frequencies.

10) The ratio of clock frequencies to input pulse frequencies in each stage will determine how long each stage remains reset.

11) Each NAND gate will exhibit an average output voltage that is related to the input count rate.

12) The output of A19 is biased to 0 VDC at very low count rates.

13) A18, with R38 provides the scaling adjustment so that a slope of two volt output for each decade increase in input can be achieved.

5. Audio Count Rate Circuit VTM IIB-19

a. Accepts the TTL pulses from the Discriminator.

b. Provides audible indication of the startup channel in the Control Room and Containment (refueling area).

1) Has frequency divider on tone select circuits.

2) Frequency for tone ranges are:

Frequency	Tones
1 cps	870 Hz
10 cps	963 Hz
100 cps	1.22 KHz
1,000 cps	1.64 KHz
10,000 cps	2.02 KHz

3) A TONE SELECT switch is in the Control Room.

4) Audio ON/OFF switch in back of drawer.

c. Circuit Description VTM IIB-29; Dwg N001-13.04-116

1) Q1 serves as a frequency driver for the input signal from the Discriminator.

2) Frequency dividers A11 through A14 provide divide by 10 outputs to NAND gates A2 and A3.

3) A1 is a Schmitt Trigger Circuit.

4) A1, A2, and A3 provide a means of selecting different frequencies.

5) A1 also selects and closes one of the bilateral switches (A6 or A7).

6) A5 is a one-shot multivibrator - actuates on positive edge.

7) Bilateral switch A7 energizes on the positive pulses from A5.

8) R11 through R15 form a voltage divider network.

9) With a bilateral switch closed, a voltage is applied to A9 through A8.

   a) Each voltage level causes A9 to generate a different frequency.

   b) These frequencies are generated through switch A7 and amp A10 as pulsed audio signals.

6. Output Buffer Card Description — VTM IIB-15 and 28; Dwg: N001-13.04-145

   a. Four optically coupled isolation amplifiers.

   b. Outputs to:

      1) Control Room recorder

      2) Control Room Indicator

      3) Boron dilution alarm.

7. Bistable Trip Card Description — VTM IIB-15

   a. Provided for:

      1) Hi CPS (2000 cps)

      2) Startup High voltage low.

   b. Circuit Description — VTM IIB-28; Dwg N001-13.04-57

      1) Each card contains three independent bistables - each can be arranged such that contact will close above or below setpoint

      2) R1 and R2 provide the divide by 3 attenuators.

      3) With jumpers straight through, relay energized above setpoint.

      4) With jumpers crossed, relay is energized below setpoint.

      5) Q2 and Q3 provide current source to drive SCR2 and Q4 which actuates K1.

      6) CR3 and CR4 provide transient protection of K1 turnoff.

8. Test/Monitor Circuit Card Description VTM IIB-29

   a. Purpose

      1) Provides tests for:

         a) Startup channel HV

         b) Control channel HV

         c) Startup channel circuit integrity.

   b. Circuit Description for the Startup HV Monitor. Dwg N001-13.04-120.

      1) Provides a 0 to 10 VDC signal which corresponds to 0 to 3000 VDC.

      2) If startup HV P/S drops to 1600 $\pm$ 100 VDC, bistable will trip.

      3) Startup HV LOW Lamp will light and relay will energize.

      4) A12 drives the bistable and meter.

   c. Circuit Description for the Control HV Monitor.

      1) Provides a 0 to 10 VDC signal which corresponds to 0 to -1000 VDC.

      2) If Control HV P/S drops to -650 $\pm$ 33 VDC, bistable will trip.

      3) Startup HV LOW lamp will light and relay will de-energize.

      4) A12 drives the bistable and meter.

   d. Circuit Description for the Control HV Monitor.

      1) Provides a 0 to 10 VDC signal which corresponds to 0 to 1000 VDC.

2) If Control HV P/S drops to 650 ± 33 VDC, bistable will trip.

3) TROUBLE lamp will light and relay will de-energize.

4) All drives the bistable and meter.

5) TROUBLE lamp will also light and relay will also de-energize when:

   a) A PC card is removed or

   b) All calibrate switches are not in OPERATE or

   c) All Trip switches are not in OFF.

e. Circuit Description of Startup Channel Test Circuit

1) Clock A1 procedures 9.216 MHz signal.

2) Frequency dividers A2, A3, A4, A5 and A6 generate the desired frequencies.

3) Correct frequency is selected by NAND gate A8 and inventer A7.

4) Selected frequency is fed to A9 (one-shot mulitivibrator) and A10 (driver).

5) Outputs from A10

   a) 1 micro second pulses at 92.16 Hz in TEST LOW.

   b) 1 micro second pulses at 92.16 KHz in TEST HIGH.

EO: 1.2 List the destinations of the output signals from the Startup Range Excore Channel

Main Idea

D. Startup Channel Outputs Dwg: N001-13.04-125

1. Indications (Visual)
   a. Main Control Room Indicator
   b. Main Control Room Recorder – shared with the Control Channel
   c. Boron Dilution
2. Audible
   a. Control Room
   b. Containment
3. Alarms
   a. Hi CPS - 2000 cps prompts operators per procedure to de-energize detector hi volts
   b. Startup Hi Voltage Low – 1600 vdc
4. Other - Count rate signal to the Boron dilution alarm.

EO: 1.3 Describe the function and operation of the major circuits utilized in the Control Range Excore Channel, including inputs and outputs

Main Idea

E. Control Channel Circuit Operation

1. Consist of: (1 channel)
    a. Dual section UIC detector.
    b. Signal processing drawer containing:
        1) Linear amp and summer card.
        2) Common components with Startup Channel:
            a) Output buffer card
            b) Test card
            c) Low voltages power supplies.
2. Control Range Detectors
    a. Consists of a dual section UIC>
    b. Each section is 70 inches in length, and has a separate signal cable.
    c. High voltage supply cable is common to both sections.
    d. Detector output signal is transmitted directly to signal processing drawer.
    e. Produces a DC current level which is proportional to reactor level.

3. Linear Amp and Summer Card Description (LASI-2) VTM IIB-24; Dwg N001-13.04-117.

   a. Has two input signals: one from each detector section.

   b. Each signal feeds a linear amp A1 or A3 which is an I/E converter. CR1/CR2 provide amplifier failure protection. (Clamps input to 0.7 VDC of common)

   c. Output from each linear amp is applied to a non-inverting amp (A2 and A4) which is adjusted to produce a +10 VDC signal at 125% power.

   d. The power summer amp A7 averages and inverts the outputs from both A2 and A4.

   e. The power amp A7 feeds the Cal sum amp A8 which inverts the signal.

      1) The Cal sum amp A8 has a variable gain which is adjusted by the Control Gain Pot on the front panel.

      2) This pot is set to plant thermal power (determined by a calorimetric).

   f. Potentiometers R36 and R39 provide test current inputs to the linear amp.

EO: 1.4 List the destinations of the output signals from the Control Range Excore Channel

Main Idea

F. Control Channel Outputs Dwg: N001-13.04-125

1. Analog Outputs (from the output buffer.)
   a. 0 - 10 VDC to:
      1) RRS - Power Mismatch
      2) FWCS - Control gain + level compensation.
      3) SBCS - AMI generation
2. Indications
   a. Control Room Indicator
   b. Control Room Recorder
3. Alarms - Trouble light

EO: 1.5 Describe the function and purposed of all front panel indications and controls on the Startup/Control Channel Drawer

Main Idea

G. Startup/Control Channel Controls and Indications Dwg N001-13.04-131, 132.

1. Startup CPS indicator (1 to 10^5 cps).
2. Control Power indicator (1% to 125% pwr.)
3. Startup calibrate switch.
4. High CPS alarm (Startup) (2000 cps).
5. Scaler output.
6. Startup Trip Test Pot.
7. HV or HV Permit - Switch/Indicator.
8. SU HV low.
9. HV indicator with range switch.
10. AC power - lighted switch.
11. Trouble light
12. Output select switch.
13. Control/Calibrate/Operate switch.
14. Trip Test Pots
    a. Sub Channel 1
    b. Sub Channel 2
15. Cal Gain Pot

EO: 1.6 Given a Corrective Maintenance Work Order describing a fault in a Startup/Control Channel Drawer, , troubleshoot the system in accordance with the applicable work order to determine the nature of the fault

Main Idea

III. The instructor will insert faults into the Start-Up/Control simulator for the student to properly diagnose

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.