

# BABCOCK & WILCOX CROSSTRaining COURSE LESSON PLAN

Lesson Number: 326-21

Title: Advanced Control System

Written by: G. O. Schneider

Approved by:

Date: 10/15/1998

## 1.0 References

- 1.1 B&W Crosstraining Manual, Chapter 21
- 1.2 Oconee Lesson Plan

## 2.0 Training Aids

- 2.1 Transparency package for Lesson 326-21

## 3.0 Objectives

### 3.1 Explain the function of the following ICS subsystems

- 3.1.1 Core Thermal Power Demand (CTPD)
- 3.1.2 Integrated Master
- 3.1.3 Feedwater Control
- 3.1.4 Reactor Control

### 3.2 Define the following terms:

- 3.2.1 Tracking
- 3.2.2 Runback
- 3.2.3 Cross Limit

### 3.3 Using a diagram of the ICS, discuss the following:

- 3.3.1 Normal power increase and decrease
- 3.3.2 Runback
- 3.3.3 Placing an ICS station in manual
- 3.3.4 Load rejection
- 3.3.5 Turbine trip
- 3.3.6 Reactor trip

## Fig. 21-1 4.0 Presentation

### 4.1 Introduction - Function of ICS is to match reactor thermal power with core thermal power demand while maintaining a balance between heat production and removal. This is accomplished by the four subsystems of the ICS:

- 4.1.1 Core Thermal Power Demand (ULD) - generation of setpoint
- 4.1.2 Integrated Master (IM) - steam header pressure control
  - 4.1.2.1 Turbine governor valve control
  - 4.1.2.2 Turbine bypass valve control
  - 4.1.2.3 Generate FW and RX control signals
- 4.1.3 FW Control
  - 4.1.3.1 Main and startup FW valve control
  - 4.1.3.2 MFP speed control

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Fig. 21-1	<ul style="list-style-type: none"> <li>4.1.4 RX Demand                             <ul style="list-style-type: none"> <li>4.1.4.1 Rod control</li> <li>4.1.4.2 <math>T_{avg}</math> control</li> </ul> </li> </ul>
Fig. 21-2	<ul style="list-style-type: none"> <li>4.2 Core Thermal Power Demand (CTPD)                             <ul style="list-style-type: none"> <li>4.2.1 Function - setpoint generator for the rest of the ICS</li> <li>4.2.2 Pushbuttons on Load Control Panel (LCP) for increase or decrease of target setpoint.</li> <li>4.2.3 Target setpoint appears in lower window called "CTPD SET"</li> <li>4.2.4 The setpoint being used by the rest of the ACS appears in the upper window called "CTP DEMAND"</li> <li>4.2.3 Rate is set by using thumbwheels on the LCP. Values from zero to 9.9%, and units % per minute or per hour. Hold pushbutton prevents changes during setpoint or rate entry, and stop power changes.</li> <li>4.2.4 Automatic Load Limiting - limits maximum target setpoint. Transfer function T1 selects setpoint and T11 selects rate. Operator input is blocked.</li> <li>4.2.5 Tracking - ACS cannot function normally. Heat balance cannot be maintained. Target setpoint is the tracking parameter selected by transfer function T2. Operator input and automatic load limiting are blocked.                                     <ul style="list-style-type: none"> <li>4.2.5.1 Tracking conditions:   <ul style="list-style-type: none"> <li>(a) Cross Limits</li> <li>(b) SG Master in manual with at least one SG <u>not</u> on LLL.</li> <li>(c) Blocking <u>both</u> feedwater loop flow control paths with at least one SG <u>not</u> on LLL.</li> <li>(d) RX demand or rod control in manual.</li> <li>(e) turbine master in manual.</li> </ul> </li> <li>4.2.5.2 Tracking rate is 20% per minute.</li> <li>4.2.5.3 Tracking parameters:   <ul style="list-style-type: none"> <li>(a) FW control independent - FW flow</li> <li>(b) Turbine independent - generated electrical power</li> <li>(c) RX independent - NI flux</li> <li>(d) If more than one system independent, tracking parameter is the highest priority (a, b, c) except when FW and RX are both independent, CTP Best is selected.</li> </ul> </li> </ul> </li> </ul> </li> </ul>
Table 21-1 Page 21-13	
Page 21-2	
Fig. 21-2	<ul style="list-style-type: none"> <li>4.3 Integrated Master                             <ul style="list-style-type: none"> <li>4.3.1 Functions                                     <ul style="list-style-type: none"> <li>4.3.1.1 Sends demand signals to RX and FW subsystems.</li> <li>4.3.1.2 Controls the turbine and the turbine bypass valves.</li> </ul> </li> </ul> </li> </ul>



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Table 21-3

### 4.3.7 Turbine loading and unloading

4.3.1 Reactor power 10% to 20%, TBVs controlling at 885 psig, turbine rolled to synchronous speed. When breakers are closed, turbine automatically picks up 30 MW. Turbine can now be loaded using the turbine master or the load button on the LCP. When TBVs are closed, status flag becomes TRUE. TBV bias becomes 50 psi. The unload button will make the status flag FALSE.

Fig. 9-2

### 4.4 FW Control

#### 4.4.1 Demand corrections

4.4.1.1 Calibrating integral - normally CTP error. If RX in manual,  $T_{ave}$  error. If turbine in manual (status flag TRUE), THP error.

4.4.1.2 THP error - up to  $\pm 50$  psi.

4.4.1.3  $T_{ave}$  error - with  $\pm 1.2^\circ\text{F}$  deadband unless FW takes control of  $T_{ave}$ .

4.4.1.4 RCS pressure error - when pressure exceeds 2250 psig.

4.4.1.5 CTP error

4.4.1.6 RX crosslimit - neutron error  $> 5\%$

4.4.1.7 FW temperature

#### 4.4.2 Loop demands

4.4.2.1 Loop A demand is determined by a multiplier, which is controlled by RCS loop flow error and  $\Delta T_C$ .

4.4.2.2 Loop B demand is the difference between total demand and loop A demand.

4.4.2.3 RCS loop flow error works all the time.

4.4.2.4  $\Delta T_C$  is blocked when the control station is in manual, either loop master is in manual, either valve controller is in manual, or either SG is on level control.

4.4.3 Level errors - Normally, flow error is used to drive the valve controllers, but abnormal conditions can cause level errors to be used.

4.4.3.1 High level limit - operating range, setpoint 92% to 96%, low select unit, maintain level  $<$  aspirating ports.

4.4.3.2 Startup level  $< 25''$  and LLL - (LLL is SU level  $< 25''$  and loop  $T_{ave} <$  setpoint.) LLL stays in effect until both conditions clear.

(a) LLL on both SGs releases  $T_{ave}$  from control priority and  $T_{ave}$  will not increase RX power when  $T_{ave} <$  setpoint.

(b) LLL on both SGs limits CTPD rate to 1% per minute.

(c) LLL on both SGs prevents feedwater tracking.

(d) Either SG on LLL blocks  $\Delta T_C$  correction.

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Table 21-4  
T6  
Fig. 21-3

- 4.4.3.3 Natural circulation level error - operating range level < 50% or 95% (RB pressure > 3 psig).
- 4.4.4 Valve sequencing - Main valves have about 10 times the capacity of the startup valves. Startup valves control up to about 15% power, main valves from 15% and up. During startup, the startup valves open as power increases. At about 90%, main block valve opens. At about 98%, sequencing bias causes startup valve to ramp down to 10% and the main valve to open enough to compensate. From this point, the valves open together, startup valves 10 times faster. The shutdown sequence is similar.
- 4.4.5 FW pump speed control - based on sum of loop demands and differential pressure error.
- 4.5 Reactor Control Subsystem
  - 4.5.1 Demand corrections
    - 4.5.1.1 Calibrating integral - normally  $T_{ave}$  error. If both SGs on LLL, CTP error unless the steam system is also unavailable, then THP error.
    - 4.5.1.2 THP error - up to  $\pm 20$  psi.
    - 4.4.1.3  $T_{ave}$  error - (When both SGs on LLL,  $T_{ave}$  error can only decrease RX demand if  $T_{ave}$  is above setpoint.)
    - 4.4.1.4 RCS pressure error - when pressure exceeds 2250 psig.
    - 4.4.1.5 RX demand limit of 101%.
    - 4.4.1.6 FW crosslimit - FW demand > flow by > 5%. FW flow becomes the tracking parameter.

Fig. 9-2