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BABCOCK & WILCOX CROSS TRAINING COURSE LESSON PLAN

Lesson Number: 326-6.2	esson Number: 326-6.1 Title: Control Rod Drive Mechanism - Construction			truction	
Written By: Bobby R. E	aton	Approved By	/:	Date:	10/15/1998
	3.0 Learn 3.1 L 3.2 E 3 3 3 3 3 3 3 3 3 1 1 1	ing Objectives ist the two type explain the func .2.1 Rotor a .2.2 Leadscr .2.3 Torque .2.4 Snubbe .2.5 Leadscr Describe the op ollowing a rea eadscrew guide	es of control rod drive me tions of the following: ssembly, rew, taker, r assembly, and rew guide assembly. peration of the control ector trip signal, includ assembly and hydraulic	rod d ding the damper	ms. rive mechanism e action of the ning.
	4.0 Prese	ntation			
Figure 1-1 and Figure 1-2	4.1 M 4 4 4 4 4 4.2 M	Aajor Compone .1.1 Motor (.1.2 Leadscr .1.3 Torque .1.4 Rotor a .1.5 Stator of Motor Tube Ass	nts tube assembly rew assembly tube assembly ssembly cooling water jacket asse	embly	
	2	A.2.1 Part of 2500 p A.2.2 Motor 4.2.2.1 4.2.2.2 4.2.2.3 4.2.2.4	the RCS pressure boun sig and 670°F. It is hyd tube assembly can be div Motor tube base Motor tube center sect Motor tube extension Motor tube extension	dary an ro tester vided in tion cap	d is designed for d to 3125 psig. to four sections:
		1.2.3 The bo control using 8	ottom of the motor tub rod drive flange on the bolts and a locating pin	top of to top of to to ensu	is bolted to the the reactor vessel are alignment.
	4	4.2.4 Two co mating	oncentric flexitallic gasl flanges.	kets are	used to seal the
		1.2.5 The mo the exc control constru	otor tube is constructed of eption of the motor tube rod drive stator is mo acted of 403 magnetic st	of 304 st center s ounted, ainless	tainless steel with section, where the and this area is steel.



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	· 4.: 4.: 4.: 4.:	 2.6 The mot control 1 4.2.6.1 4.2.6.2 2.7 The con cooling 4.2.7.1 4.2.7.2 4.2.7.3 4.2.7.3 4.2.7.4 2.8 Motor th 4.2.9.1 4.2.9.1 4.2.9.2 4.2.9.3 	or tube center section produces of the control rod drive stator. The control rod drive phase, reluctance stepp Electrical rating is 125 the holding mode of optrol rod drive motor st water jacket that cools to Control rod drive motor st water jacket that cools to Control rod drive cool Minimum of 2 gpm per CRD stator temperature extra rod drive must be deee ube extension provides ube extension cap close Cap is threaded into th Jacking screws and an the assembly Vent plug allows the v drives. Tygon tubing f waste gas system or per the control rod the control rod choice cap is the system of the system of the control rod choice cap is threaded into the control rod choice cap is threaded into the control control cap close cap is threaded into the control cap close cap	rovides mounting for the e stator is a 4-pole, six bing motor. Vdc, 8 amps per coil in peration. tator is surrounded by a the stator. ing water system er stator re alarms on the PMIS acceeds 180°F, the control energized. for leadscrew travel is the motor tube ne top of the motor tube ne o-ring are used to seal venting of the control rod from the vent assembly to oly bottle.			
	4.3 La 4. 4. 4. 4.	eadscrew 3.1 The lead the cont 3.2 The lead assembl 3.3 The lead 4.3.3.1 4.3.3.2 4.3.3.3 4.3.3.4 4.3.3.5 3.4 Male co 4.3.4.1 4.3.4.2	dscrew assembly is the trol rod spider and the n dscrew passes through t ly, and the thermal barr dscrew assembly is con Male coupling Lower extension Leadscrew Upper extension Three locking sleeves oupling Inserted into the con turned 45° to ensure of Male coupling length shorter than the mal control rod (6.21") to not coupled to a control	connecting link between notor rotor assembly. the torque tube, the rotor ier assembly. nprised of: htrol rod drive hub and engagement. n of the APSR (6.08") is le coupling length of a o ensure that an APSR is rol rod and vice versa.			

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	4.3.5	Lower extension - an unthreaded s that runs from the male coupling to	section to the least mate	of the leadscrew eadscrew section		
	4.5.0	nuts on the rotor segment arms	ai maw	e with the folier		
	4.3.7	Upper extension - an unthreaded set that runs from the leadscrew sec leadscrew assembly. The upper e 4.3.7.1 Torque taker 4.3.7.2 Position indication mage 4.3.7.3 "Buffer" piston	section ction t extension net	of the leadscrew o the top of the ion contains:		
	4.3.8	Torque taker - coupled directly t extension and rides on the torqu rotary motion of the leadscrew.	to the le tube	leadscrew upper e key preventing		
	4.3.9	The position indication magnet side of the torque taker to operate	is inco e the re	orporated in one eed switches		
	4.3.1	The buffer piston or snubber as decelerate the leadscrew near the a trip condition.	ssembl e full ir	y is designed to position during		
	4.3.1	 There are three locking sleeves ins assembly 4.3.11.1 One between the male c extension 	stalled couplii	on the leadscrew		
		4.3.11.2 One between the low leadscrew	ver ext	tension and the		
		4.3.11.3 One between the lead extension	lscrew	and the upper		
		4.3.11.4 The leadscrew assembly	y is ab	out 303" long.		
4.4	Roto	Assembly				
	4.4.1	 Rotor assembly components 4.4.1.1 Rotor tube 4.4.1.2 Segment arms 4.4.1.3 Roller nuts 4.4.1.4 Radial bearing 4.4.1.5 Synchronizing bearing 4.4.1.6 Thrust bearing 4.4.1.7 Segment arm springs 4.4.1.8 Pivot pins 				

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	4.	4.2 4.3	Rotor tube 4.4.2.1 The w tube 4.4.2.2 A journ rotor tu 4.4.2.3 A journ rotor tu 4.4.2.4 The th of the fill 4.4.2.5 The up segment arms a Segment arms 4.4.3.1 Mount allowin rotor tu 4.4.3.2 The up 4-pole 4.4.3.3 The loc collapt and un 4.4.3.4 Buttor arms p tripped Four compressi from the leadso greater than th segment arms b	chole rotor assem mal bearing is location ube nal bearing is location ube rust bearing is also rotor tube oper end of the ro- nt arm stop (lip) as proper clearance and the motor tube ted on rotor tube oper portion of the collapsible motor ower portion of the collapsible motor ower portion of sible split nut de latch the leadscr- ns on the bottom prevent disengage d. on springs hold the crew. To engage the spring force ro- py the motor's mate	ably is ocated a ated at t so locat otor tub ped fla ce betw de wall. e by for e with a segm or rotor the seg esigned ew of the A ment w he roller e the le nust bo agnetic	called the roto at the top of the he bottom of the ed at the bottom or incorporates nge). The stop een the segmen our pivot pins and pivot on th ent arms forms gment arms is to latch, drive APSR's segmer hen the reactor is muts disengage adscrew, a force e applied to th field.
	4.5 T	orque	Tube			
	4.	.5.1	The torque tube long and 3-3/8' motor tube.	e is a cylinder ap " in diameter loca	proximated on	ately 151 inche the inside of th
	4.	.5.2	A key runs the e with the key wa	entire length of th ay of the leadscre	ne torqu ew asse	e tube and mate mbly
	4.	.5.3	Belleville sprin cushions the le	gs located at the b adscrew on a trip	oottom	of the torque tub
	4.	.5.4	The torque tube rod during refu	e also plays a part eling	in the u	incoupling of th

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	4.6 T	Therma	l Barrier		
	F tl c	Four spi he RC preated	ring check valves that will restrict S into the drive housing and re within the drive during a trip cor	the flow clieve the dition.	w of coolant from ne pressure drop
	5.0 Opera	ations			
	5.1 L 5 5 5	atchin 5.1.1 5.1.2 5.1.3	g All trip signals are cleared Trip breakers are closed Control rod drives are inserted that the lands of the roller nuts	in JOG are prop	speed to ensure perly engaged
~	5.2 F 5 5	Reactor 5.2.1 5.2.2	trip Control rod drive motor is de-e of the trip circuit breakers Springs in segment arms ov magnetic field - the roller nu leadscrew and the leadscrew is	energize vercome uts dise free to	d by the opening the collapsing engage from the drop
	5	5.2.3 5.2.4	The leadscrew is decelerated by and comes to rest on the Bellev The hydraulic lock of the lead spring check valves in the therr	the acti ville spri screw i nal barr	on of the snubber ings s relieved by the ier

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BABCOCK & WILCOX CROSS TRAINING COURSE LESSON PLAN

Lesson Number: 326-6.2 Title: Control Rod Drive Control System					
Written By: Bobby R. E	aton	Approved By	<i>/</i> :	Date:	10/19/1998
Lesson Number: 326-6.2 Written By: Bobby R. E Figure 1-1 and Figure 1-2	2 aton 3.0 Learn 3.1 S 3.2 S 3 3 3 3.3 E 3.4 E 3 3.5 E 3.6 D n 4.0 Presen 4.1 D 4 4 4	Title: ControApproved Bying Objectivestate the purposetate the function2.1Safety r2.2Regulat2.3Axial p2.4Group p2.5Auxiliaxplain how rotaachieved.xplain the follo4.1Latchin4.2Clampixplain how indbescribe how pechanism.ntationDescription1.1Functionords to4.1.1.14.1.2.24.1.2.31.3The consubsystem4.1.3.14.1.3.24.1.3.24.1.3.3	e of the control rod drive ins of the following: ods, ing rods, ower shaping rods,, ower supply, and ry power supply. ating motion of the control wing terms: g and ng ividual rod motion is acl power is supplied to n is to provide for withdr achieve the desired reac In auto, controlled by to Can be controlled man rol rod assemblies and 8 a Groups 1 - 4 are the sa Group 8 is the APSR atrol rod drive control syst The drive mechanism, The motor control syst The system logic equit	Date: Date: Control col rod d hieved. the co hieved. the co rawal/in: tor pow the ICS nually by axial po offety rod ontrol ro system of tem, and poment.	10/19/1998 I system. I system. Introl rod drive sertion of control er output. y the operator. wer shaping rods is ods consists of three
		4.1.3.3	The system togic equi	pment.	



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- Number: 326-6.2	Title: Control Rod Drive Control System	

Lesson Number: 320-0.2	The: C							
Written By: Bobby R. E	Approv	ved By:		Date: 10	/19/1998			
	4.2 Th	ne Drive	e Drive Mechanism					
	4.: 4.:	2.1 4 tř uj sa tř 1 2.2 P fř 4	-pole (2 ne mech p 12 po ame loc ney are nagnetic Power su rom 120 .2.2.1	2 north and 2 south whanism), 6-phase (A, B, les with the A & AA, 1 eation but electrically v both energized, the fields out) reluctance upplied to each windin O Vac) For latching, 2 phase only one is required For holding rods static phases are used due to the stator	then power i C, AA, BB B & BB, and wired oppo- ey cancel type motor ing is 100 V is are used onary, a man potential h	s supplied to b, & CC make ad C & CC in site so that if each other's Vdc (rectified even though kimum of two eat damage to		
Leadscrew moves 3/4 " for each revolution Leadscrew travels 30	4.	2.3 R tl 1 n	Rotation hen 3 th .5° shift nechani otation	is accomplished by en en 2 then 3, etc. sequen t of the magnetic pole sm. Need 2 electrical r	ergized the ace. Each sl and a 15° r otations for	phases in a 2 nift is equal to otation of the 1 mechanical		
40 mechanical revolutions per minute	4.	2.4 F s r 4	Removin egment od into 1.2.4.1	ng power from the arms disengaging the the core Loss of one phase du cause a dropped rod, t phase	windings r leadscrew ring rod mo for example	esults in the dropping the otion can also e the loss of C		
	4.3 M	lotor Co	ntrol Sy	ystem				
Differential changes program motors from 60 to 40 rpm and from 6 to 4 rpm.	4.	.3.1] c (The pro one 60 r (3 inche optical o	grammed power suppl pm (30 inches per minu es per minute for jog) disk	y uses two ite for run) which are	drive motors, and one 6 rpm coupled to an		
Slotted disk rotates at 40 and 4 rpm	4	.3.2 T	The op redunda has one circuit. closes a on the S	tical disk has redun nt photo-detectors. Ea detector for each phase Output of photo-det contact in a 12 Vdc gat CRs to rectify the 120	dant light ach set of pl e and one fo ector drive te drive circ Vac to 100	sources and hoto-detectors or the 3-2 hold s a relay that uit. This turns) Vdc.		
	4	.3.3]	u rotati detector	on stops on 3 phases will jog in to 2 phases	energized, s energized	me / pnoto-		



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Lesson Number: 326-6.2	2	Titl	e: Contro	l Rod Drive Control Sys	stem	
Written By: Bobby R. E	aton	App	proved By	7:	Date:	10/19/1998
	4. 4. 4.	3.4 3.5 3.6	Power is breakers A & B. DC pow rods. C DC brea AC pow supplies 4.3.6.1	s supplied from two plan s (A & B). UV coils pow wer is supplied to A & Only one needs to be end akers are tripped by RPS wer is also supplied to t s and the auxiliary power Aux power supply ca individual rod or any g Removing power from through contactors E & by RPS channels C &	t source vered fro CC pha ergized S channe he regul of supply n be us group of program e rods. H & F, whi D.	es through ac trip om RPS channels ses of the safety to hold the rods. els C & D. lating rod power y. sed to move any Frods. nming lamps will Power is supplied ch are controlled
	4.4 R	eacto	r Trip			-
	4.	.4.1	In order breaker B, C & opening	r to cause a reactor trip, r rs in each power supply (D, or C & B). The con g when the associated C	must op for exan tactors a & D br	en one of the two nple, A & D, A & are considered as eakers open.
,	4.5 R	od Oj	peration			
	R	ods and one	re divideo e APSRs.	d into 8 groups, 4 safet Regulating rods are op	y rods, 3 erated w	8 regulating rods, vith 25% overlap.
	4.6 C	ontro	l Panel			
	4	.6.1	Discuss	s the basics of the contro	ol panel	and Table 6.2-2
	4.7 L	atchir	ng Operat	ions		
	L n s(atchin noved econd	ng is acc , bypassin s.	omplished by selecting ng the in limit, and inse	g a grou erting at	up of rods to be jog speed for 30
	4.8 P	ower	supply tra	ansfer		

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BABCOCK	& WILCO		OSS TRAINING COURSE LE	SSON J	PLAN		
Lesson Number: 326-6.	Title: Control Rod Position Indication			<u> </u>			
Written By: Bobby R. Eaton			Approved By: Date: 10/20/1998				
,	3.0 Learn	ing O	bjectives				
	3.1 S 3.2 E 3.3 E 11 3 3 3 3 3 3 3	tate th Explain Cxplain Ine foll .3.1 .3.2 .3.3 .3.4 .3.5	ne purposes of the control rod pose in the two methods used to determ in how the two rod position indicator owing: Asymmetric rod determination In, out limits, Regulating group sequence ena Inhibit circuits, and Sequence monitoring.	ition ind ine cont ation sys , , , ,	lication systems rol rod position stems are used in		
	4.0 Prese	ntatio	n				
	4.1 C	Genera	l Description				
· .	r r	'wo m elativo	ethods of rod position indication e position.	are abso	lute position an		
	4.2 A	bsolu	te Position Indication				
	4	.2.1	Absolute position uses 72 high located 2" apart and the signa divider network. The reed sw permanent magnet on the torqu	differen l goes tl vitches a ue taker.	tial reed switche hrough a voltag re operated by		
	4	.2.2	Two channel averaging used 48 in a 2-1-2-1 open-close seque when in the 1 close condition w rod runback to 60% power b dropped rod, and there was po	switche nce. Fa ould cau because	es. They operate niled reed switc se an asymmetri it looked like		
	4	.2.3	Four channel averaging uses boards of 36 switches each div The output of the 4 channels a The channels are isolable, so c With all channels, switches clo Normal accuracy is 2.62 inch open the accuracy is 3.56 inche	the 72 s vided int re avera an opera ose in a 3 nes, with s, and w	witches on 2 p o the 4 channel ge for indication the on 3 channel 3-2-3-2 sequence n a switch faile ith one channel i		
	4	.2.4	Reference switches are at IN 75%, 100%, and OUT LIMIT reach in or out limit stops all r	LIMIT, LIMIT, J. First	0%, 25%, 50% rod in a group ne group.		

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	4. 4. 4.	3.4 3.5 3.6	 Power is supplied from two p breakers (A & B). UV coils p A & B. DC power is supplied to A rods. Only one needs to be DC breakers are tripped by p AC power is also supplied to supplies and the auxiliary power is also supplies and the auxiliary power supply individual rod or an 4.3.6.2 Removing power for through contactors by RPS channels C 	blant sources through ac trip powered from RPS channels & CC phases of the safety energized to hold the rods. RPS channels C & D. to the regulating rod power ower supply. T can be used to move any my group of rods. Tom programming lamps will the rods. Power is supplied E & F, which are controlled C & D.
	4.4 R	eacto	r Trip	
	4.	4.1	In order to cause a reactor tribreakers in each power supp B, C & D, or C & B). The opening when the associated	ip, must open one of the two ly (for example, A & D, A & contactors are considered as d C & D breakers open.
,	4.5 R	od O	peration	
	R	ods and on	re divided into 8 groups, 4 sa e APSRs. Regulating rods are	fety rods, 3 regulating rods, operated with 25% overlap.
	4.6 C	ontro	l Panel	
	4	.6.1	Discuss the basics of the co	ntrol panel and Table 6.2-2
	4.7 L	atchi	ng Operations	
	L n se	atchi noved econd	ng is accomplished by selec , bypassing the in limit, and i s.	ting a group of rods to be inserting at jog speed for 30
•	4.8 P	ower	supply transfer	

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BABCOCK	& WILCO		USS TRAINING COURSE LE	SSON I	'LAN		
Lesson Number: 326-6.	Number: 326-6.3 Title: Control Rod Position Indication						
Written By: Bobby R. Eaton			Approved By: Date: 10/20/1998				
	3.0 Learn	ing O	bjectives				
	3.1 S 3.2 E 3.3 E tl 3 3 3 3 3 3 3	tate th xplain xplain e foll .3.1 .3.2 .3.3 .3.4 .3.5	the purposes of the control rod pose in the two methods used to determ in how the two rod position indication owing: Asymmetric rod determination In, out limits, Regulating group sequence ena Inhibit circuits, and Sequence monitoring.	ition ind ine cont ation sys , bling,	lication systems frol rod position stems are used i		
	4.0 Prese	ntatio	n				
	4.1 0	Genera	l Description				
	Г г	`wo m elativo	ethods of rod position indication e position.	are absc	lute position an		
	4.2 <i>A</i>	bsolu	te Position Indication				
	4	.2.1	Absolute position uses 72 high located 2" apart and the signa divider network. The reed sw permanent magnet on the torqu Two channel averaging used 48 in a 2-1-2-1 open-close segue	differen l goes ti vitches a le taker. switche	tial reed switche hrough a voltag are operated by es. They operate piled reed switc		
	4	.2.3	when in the 1 close condition w rod runback to 60% power k dropped rod, and there was no Four channel averaging uses boards of 36 switches each div The output of the 4 channels a The channels are isolable, so c	ould cau because bypass the 72 s vided int re avera an opera	ise an asymmetr it looked like capability. switches on 2 p to the 4 channel ge for indicatio ate on 3 channel		
	2	.2.4	With all channels, switches clo Normal accuracy is 2.62 incl open the accuracy is 3.56 inche bypass the accuracy is 3.69 inc Reference switches are at IN 75%, 100%, and OUT LIMIT reach in or out limit stops all r	ose in a 2 nes, with s, and w ches. LIMIT, '. First ods in th	3-2-3-2 sequences in a switch faile ith one channel 0%, 25%, 509 rod in a group ne group.		

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	4.3 R	elativ	lative Position Indication						
	P p tl ·p d	Pulse stepping motor connected in parallel with the A, C, & BB phases of power to each mechanism. As the phases are energized, the motor drives a potentiometer which provides indication of rod position. Shows demanded rod position and does not show dropped or misaligned rods. A method of manually adjusting the relative position is provided.							
	4.4 P	Position Indication Panel							
	L p	Discuss the indications and controls on the position indication panel.							
	4.5 0	Group Meters							
	P n re	rovide neters. egulat	es indication of the average o . Selected by the pushbutton of ing rods or for safety rods.	f the gro on the dia	ups API on four mond station for				
	5.0 Opera	tions							
	5.1 U	Uses of API							
	5	.1.1	Asymmetric Rod - Each rod p average for the group. If asymmetric alarm, if more tha on diamond and runback to 6 rod gives asymmetric light on	position is more tha in 6.5% ap 60%. Sho n all rods	s compared to the n 5% apart, get part, get fault light w how a dropped in the group.				
-	5	.1.2	Group out limits - comes from prevents any further out moti	n out refe on for the	erence switch and group.				
	5	.1.3	Group in limits - comes from prevents any further in moti bypassed by in limit bypass for latching.	m in refe on for th switch on	rence switch and e group. Can be diamond station				
	5	.1.4	Inhibit circuits						
	5	.1.5 .1.6	Sequence enable logic Feed and bleed permit						

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		5.2 Applications of Relative Position Indication							
		Sequence monitor looks for too much overlap.							

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