OPERATOR TRAINING PROGRAM
JOB PERFORMANCE MEASURE

STATION: SALEM

SYSTEM: Generic Admin - Conduct of Operations

TASK: Calculate Shutdown Margin IAW SC.RE-ST.ZZ-0002

TASK NUMBER: N1200030301

JPM NUMBER: 19-01 NRC RO-A1

ALTERNATE PATH: [ ] **K/A NUMBER:** 2.1.43

IMPORTANCE FACTOR: 4.1

APPLICABILITY: **RO** **SRO**

EO [ ] **RO** [X] **STA** [ ] **SRO** [ ]

EVALUATION SETTING/METHOD: Classroom / Perform

REFERENCES: SC.RE-ST.ZZ-0002(Q), Rev. 24 SHUTDOWN MARGIN CALCULATION
S2.RE-RA.ZZ-0016(Q), Rev. 11 CURVE BOOK (both checked 1-14-20)

TOOLS AND EQUIPMENT: Calculator

VALIDATED JPM COMPLETION TIME: 30 min

TIME PERIOD IDENTIFIED FOR TIME CRITICAL STEPS: 60 minutes

Developed By:	**R. Chan** **Instructor**	**Date: 1-14-20**
Validated By:	**Klein / Weidner** **SME or Instructor**	**Date: 1-16-20**
Approved By:	**N/A** **Training Department**	**Date:**
Approved By:	**N/A** **Operations Department**	**Date:**

ACTUAL JPM COMPLETION TIME:

ACTUAL TIME CRITICAL COMPLETION TIME:

PERFORMED BY:

GRADE: [ ] **SAT** [ ] **UNSAT**

REASON, IF UNSATISFACTORY:

EVALUATOR'S SIGNATURE: **DATE:**

OPERATOR TRAINING PROGRAM
JOB PERFORMANCE MEASURE

NAME: _____

DATE: _____

SYSTEM: Conduct of Operations

TASK: Calculate Shutdown Margin

TASK NUMBER: N1200030301

INITIAL CONDITIONS:

- Unit 2 Reactor Power is 100%.
- All Control Rod Group Demand Counters are at 225 steps.
- Current boron concentration is 300 ppm.
- Current core burnup is 10,000 EFPH.
- Control Rod 1D5 was been declared INOPERABLE at 1000 today due to not moving out during a rod exercise test.
- You have been directed to perform a Shutdown Margin Calculation IAW SC.RE-ST.ZZ-0002 to satisfy the action requirement of TSAS 3.1.3.1 Action c.3 for a misaligned rod.
- Control Rod 1D5 has been identified as **trippable** and is currently at 214 steps.

INITIATING CUE:

- You have been directed to perform a Shutdown Margin Calculation IAW SC.RE-ST.ZZ-0002 Attachment 3 to satisfy the **one (1) hour** action requirement of TSAS 3.1.3.1 Action c.3 to verify Shutdown Margin requirements is satisfied.
- When performing calculation, the CRS directs you to use **only the tables** as directed by SC.RE-ST.ZZ-0002, do not use Figures.
- **This is a Time Critical JPM.**

Successful Completion Criteria:

1. All critical steps completed
2. All sequential steps completed in order
3. All time-critical steps completed within allotted time
4. JPM completed within validated time. Completion time may exceed the validated time if satisfactory progress is being made.

Task Standard for Successful Completion:

1. **Perform SDM calculation ≤ 1 hour and determines SDM of -2398 (+/- 5 pcm) is satisfactory.**

OPERATOR TRAINING PROGRAM **NAME:**_____

JOB PERFORMANCE MEASURE **DATE:**_____

System: Conduct of Operations

Task: Calculate Shutdown Margin

*	STEP NO.	STEP (* Denotes a Critical Step)	STANDARD	EVAL S/U	COMMENTS (Required for UNSAT evaluation)
		Obtains copy of procedure SC.RE-ST.ZZ-0002(Q). Obtains copy of S2.RE-RA.ZZ-0016 Curve Book.	Provide **Rev. 24** of surveillance. Provide **Rev. 11** of Curve Book.		
	CUE:	When the operator acknowledges ready to start JPM RECORD START TIME. **START:**_____			
	3.0	Reviews and signs off Precautions and Limitations Section 3.0	Reviews Precautions & Limitations and signs off Steps 3.1 – 3.7.		
	5.1	**SELECT** the applicable step below (e.g. 5.1.1.A):	Determines 5.1.1.C is the correct step for the current conditions, which is to complete Attachment 3.		
	5.1.1.C	IF SDM is to be verified (per T/S 4.1.1.1.1.a) with reactor critical (Mode 1 or 2) and one or more control rods are inoperable, THEN **COMPLETE** Attachment 3.	Refers to Attachment 3.		
	Att. 3 2.1	The reactor is in Mode 1 or Mode 2 with $k_{eff} \geq 1.0$	Determines Unit is in Mode 1.		

OPERATOR TRAINING PROGRAM **NAME:**_____

JOB PERFORMANCE MEASURE **DATE:**_____

System: Conduct of Operations

Task: Calculate Shutdown Margin

*	STEP NO.	STEP (* Denotes a Critical Step)	STANDARD	EVAL S/U	COMMENTS (Required for UNSAT evaluation)
	Att. 3 3.0	Precautions and Limitations: Section 3.0	Reviews and signs steps 3.1-3.5.		
*	Section 4.1	Critical Conditions	**Determines the following data and calculations:** **4.1.1 100%** **4.1.2 300 ppm** **4.1.3 D @ 225 steps** **4.1.4 10,000 EFPH** **4.1.5 0** **4.1.6 1**		
*	Section 4.2	Calculation of Rod Worth **Examiner's Note**: Step 4.2.6 is determined based on the position of the rod BANK and not the position of the misaligned rod. Since all rods are at ARO position, penalty is 0 pcm.	**4.2.1 -3697** **4.2.2 -3581** **4.2.3 920** **4.2.4 0** **4.2.5 500** **4.2.6 0** **4.2.7 -5858**		
*	Section 4.3	Calculation of SDM	**4.3.1 -5858** **4.3.2 636** **4.3.3 120** **4.3.4 2704** **4.3.5 -2398**		

OPERATOR TRAINING PROGRAM **NAME:**_____

JOB PERFORMANCE MEASURE **DATE:**_____

System: Conduct of Operations

Task: Calculate Shutdown Margin

*	STEP NO.	STEP (* Denotes a Critical Step)	STANDARD	EVAL S/U	COMMENTS (Required for UNSAT evaluation)
	4.4	Acceptance Criteria	Reviews required SDM in MODE 1 or 2 of –1300 pcm and initials 4.4.1.		
*		4.4.1 IS THE SDM (Item 4.3.5) EQUAL TO OR MORE NEGATIVE THAN (-)1300 PCM?	**Determines calculated SDM is SAT and initials SAT.** **Evaluator Note**: See Answer Key for completed Attachment 3		
	CUE	MARK stop time of JPM when procedures are returned to proctor. **STOP:**_____	JPM is Complete when operator submits Attachment to Evaluator.		

Table G Data Points for Curvebook Figure 15

Total Control Bank Worth versus Core Exposure for HZP and CZP Conditions

Cycle Burnup (EFPH)	Control Bank Worth (pcm)		
	68 °F	350 °F	547 °F
0.0	3098	3448	3878
100.0	3098	3454	3886
1000.0	3002	3347	3777
2000.0	2896	3227	3657
3000.0	2840	3163	3594
4000.0	2823	3143	3576
5000.0	2809	3126	3562
6000.0	2822	3141	3580
7000.0	2835	3156	3598
8000.0	2859	3180	3627
9000.0	2887	3209	3661
10000.0	2916	3240	3697
11000.0	2950	3276	3739
12000.0	2985	3312	3782
12502.7	3002	3330	3803

Table H Data Points for Curvebook Figure 16

Total Shutdown Bank Worth versus Core Exposure for HZP and CZP Conditions

Cycle Burnup (EFPH)	Shutdown Bank Worth (pcm)		
	68 °F	350 °F	547 °F
0.0	2258	2394	2552
100.0	2250	2378	2541
1000.0	2425	2546	2703
2000.0	2618	2732	2883
3000.0	2776	2880	3023
4000.0	2906	2999	3131
5000.0	3033	3115	3235
6000.0	3139	3205	3313
7000.0	3245	3295	3391
8000.0	3340	3375	3458
9000.0	3429	3451	3521
10000.0	3516	3524	3581
11000.0	3593	3589	3633
12000.0	3671	3654	3686
12502.7	3710	3686	3712

Table I Data Points for Curvebook Figure 14

Most Reactive Stuck Rod Worth versus Core Exposure for HZP and CZP Conditions

Cycle Burnup (EFPH)	Worst Stuck Rod Worth (pcm)		
	68 °F	350 °F	547 °F
0.0	1010	1038	992
100.0	1011	1046	1000
1000.0	882	925	900
2000.0	739	791	790
3000.0	712	740	757
4000.0	776	756	784
5000.0	839	772	812
6000.0	903	787	840
7000.0	977	806	861
8000.0	1052	825	881
9000.0	1124	850	901
10000.0	1191	882	920
11000.0	1258	915	939
12000.0	1325	947	958
12502.7	1359	964	968

Most Reactive Stuck Rod Location versus Core Exposure for HZP and CZP Conditions

Cycle Burnup (EFPH)	Worst Stuck Rod Location		
	68 °F	350 °F	547 °F
0.0	K-06	K-06	K-06
91.5	K-06	K-06	K-06
2439.6	K-06	K-06	K-06
6098.9	L-03	H-06	H-06
8538.5	L-03	K-08	H-06
12502.7	N-05	L-03	K-08

Table 1-6

Summary of Control Rod Worths

HZP, No Xe

Burnup (EFPH)		Control Banks (pcm)	Shutdown Banks (pcm)	Control and Shutdown Banks (pcm)
BOL	0.0	3877.5	2552.4	6429.9
MRDS	2439.6	3603.8	2961.7	6565.5
MOL	6098.9	3575.4	3325.8	6901.2
LFPC	11381.8	3753.3	3654.6	7407.9

Rod Worth Penalty to Use for Modes 1, 2

Event A	Rod Worth Penalty (pcm) BOL to < MOL (6098.9 EFPH)	Rod Worth Penalty (pcm) MOL (6098.9 EFPH) to EOL
One Untrippable RCCA	2005	2165

Event B	Rod Worth Penalty (pcm) BOL to EOL
Two or more Untrippable RCCAs	2165

Event C	Rod Worth Penalty (pcm)* BOL to EOL
Dropped RCCA	500

*In the event of a misaligned RCCA, apply dropped RCCA penalty.

Rod Worth Penalty to Use for Modes 3, 4, 5

Event D	Rod Worth Penalty (pcm) BOL to EOL
One or more Untrippable RCCA(s) OR One or more Failed IRPI	2980

Highest (ARI-1) Stuck Rod Worths for Cycle 24

Burnup (EFPH)		Rod Location	Temperature (°F)	Rod Worths (pcm)
BOL	0.0	K-06	547.0	1110.5*
MRDS	2439.6	K-06	547.0	836.4
MOL	6098.9	K-08	547.0	935.0
LFPC	11381.8	K-08	547.0	1062.2

*Highest stuck rod worth for all conditions

The EFPH to MWD/MTU conversion factor is 1.63964 MWD/MTU/EFPH

Table 2-1 (Continued)

Data Points for Curvebook Figure 17A
EOL Total Power Defect (pcm) as a Function of Power and Boron Concentration
Burnup = 11381.8 EFPH, Range = 8740.4 EFPH - EOL

Power Level (%)	Boron Concentration (ppm)															
	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	177	175	174	172	170	169	167	166	164	163	161	160	158	157	156	154
10	347	343	340	337	333	330	327	324	321	318	315	313	310	307	305	302
15	509	505	500	495	490	486	481	477	472	468	464	460	456	452	448	444
20	666	660	654	647	641	635	629	623	618	612	607	601	596	591	586	581
25	818	810	802	795	787	780	773	765	758	752	745	738	732	725	719	713
30	965	956	947	938	929	920	912	903	895	887	879	871	863	856	848	841
35	1109	1098	1088	1077	1067	1057	1047	1037	1028	1018	1009	1000	991	983	974	965
40	1250	1238	1226	1214	1202	1191	1179	1168	1158	1147	1136	1126	1116	1106	1096	1087
45	1389	1375	1361	1348	1335	1322	1309	1297	1285	1273	1261	1250	1238	1227	1216	1205
50	1526	1510	1495	1480	1466	1451	1437	1424	1410	1397	1384	1371	1358	1346	1334	1322
55	1661	1644	1628	1611	1595	1579	1564	1549	1534	1519	1505	1491	1477	1463	1450	1436
60	1797	1778	1760	1742	1724	1707	1690	1673	1656	1640	1625	1609	1594	1579	1564	1550
65	1932	1912	1891	1872	1852	1833	1815	1796	1778	1761	1744	1727	1710	1694	1678	1662
70	2068	2045	2023	2002	1980	1960	1939	1920	1900	1881	1862	1844	1826	1808	1790	1773
75	2204	2180	2156	2132	2109	2087	2064	2043	2022	2001	1981	1961	1941	1922	1903	1884
80	2342	2315	2289	2264	2239	2214	2190	2167	2144	2121	2099	2078	2056	2036	2015	1995
83	2425	2397	2370	2343	2317	2291	2266	2241	2217	2194	2171	2148	2126	2104	2083	2062
85	2481	2452	2424	2396	2369	2343	2317	2291	2266	2242	2218	2195	2172	2150	2128	2106
90	2622	2590	2560	2530	2501	2472	2444	2417	2390	2364	2338	2313	2289	2265	2241	2218
95	2764	2731	2698	2666	2634	2603	2573	2544	2515	2487	2459	2432	2406	2380	2355	2330
99	2880	2844	2810	2775	2742	2709	2678	2646	2616	2586	2557	2528	2501	2473	2446	2420
100	2909	2873	2838	2803	2769	2736	2704	2672	2641	2611	2582	2553	2524	2497	2469	2443

ANSWER KEY

ATTACHMENT 3
SHUTDOWN MARGIN VERIFICATION
FOR MODES 1 OR 2

SALEM UNIT 2

1.0 **PURPOSE**

1.1 The purpose of this attachment is to determine the SDM with a critical reactor.

1.2 This attachment satisfies the surveillance requirements of T/S 4.1.1.1.1.a and 4.1.1.1.2.

1.3 This attachment **SHALL** be performed within 1 hour after detection of an inoperable control rod and at least once per 12 hours thereafter while the rod(s) is (are) inoperable.

1.4 This attachment is used to ensure adequate shutdown margin IAW SC.RE-ST.ZZ-0003(Q), Core Reactivity Balance Calculation.

1.5 To determine shutdown margin with a bank inserted beyond insertion limit specified in the COLR in accordance with T/S 3.1.3.4 and T/S 3.1.3.5.

2.0 **PREREQUISITES**

✓ 2.1 The reactor is in Mode 1 or Mode 2 with $k_{eff} \geq 1.0$.

3.0 **PRECAUTIONS AND LIMITATIONS**

✓ 3.1 All figures are located in S1(2).RE-RA.ZZ-0016(Q) Curvebook.

✓ 3.2 All data from the tables and figures should be taken as the absolute value. Any mathematical signs (+/-) should be propagated throughout the rest of the calculation.

✓ 3.3 This calculation does **NOT** consider the effects of RCS boron concentration, RCS average temperature, xenon concentration, or samarium concentration. Tave will decrease from the critical condition to the hot zero power shutdown condition. However, the reactivity effect of this will be accounted for in the power defect. The other factors will stay constant from the critical condition to the hot zero power shutdown condition.

✓ 3.4 The term "abs" found in some formulas refers to the absolute value of the item in question.

✓ 3.5 Inoperable RCCAs are further classified as untrippable, dropped or misaligned.

4.0 **PROCEDURE**

4.1 **CRITICAL CONDITIONS**

4.1.1 POWER LEVEL 100 %RTP

4.1.2 BORON CONCENTRATION 300 ppm

Answer Key

ATTACHMENT 3
SHUTDOWN MARGIN VERIFICATION
FOR MODES 1 OR 2
Page 2 of 4

SALEM UNIT 2

4.1.3 BANK POSITION

CONTROL BANKS:	SHUTDOWN BANKS
BANK A at 225 STEPS	BANK A at 225 STEPS
BANK B at 225 STEPS	BANK B at 225 STEPS
BANK C at 225 STEPS	BANK C at 225 STEPS
BANK D at 225 STEPS	BANK D at 225 STEPS

4.1.4 BURNUP 10,000 EFPH

4.1.5 # OF UNTRIPPABLE RCCA(s) 0 RCCA(s)

4.1.6 # OF DROPPED OR MISALIGNED RCCA(s) 1 RCCA(s)

4.2 **CALCULATION OF ROD WORTH**

4.2.1 TOTAL CONTROL BANK WORTH (Figure 15/Table G) (-) 3697 pcm

4.2.2 TOTAL SHUTDOWN BANK WORTH (Figure 16/Table H) (-) 3581 pcm

4.2.3 MOST REACTIVE STUCK ROD WORTH (Figure 14/Table I) 920 pcm

NOTE
The reactivity worth for a single or multiple untrippable RCCAs and dropped or misaligned RCCAs comes from Table 1-6 S1(2).RE-RA.ZZ-0016, Curve Book. For multiple untrippable RCCAs, the penalty in 4.2.4 should have a maximum value of the sum of the total shutdown and control bank worths in steps 4.2.1 and 4.2.2.

4.2.4 PENALTY FOR UNTRIPPABLE RCCA(s) 0 pcm

0 (Item 4.1.5) x _____ (Table 1-6) =

4.2.5 PENALTY FOR DROPPED OR MISALIGNED RCCA(s) 500 pcm

1 (Item 4.1.6) x 500 (Table 1-6) =

Answer Key

ATTACHMENT 3
SHUTDOWN MARGIN VERIFICATION
FOR MODES 1 OR 2
Page 3 of 4

SALEM UNIT 2

NOTE
If control bank B or C is inserted ≤ 10 steps beyond the rod insertion limit, the value in step 4.2.6 should be the integral rod worth from Table 1-8 at the violating bank's current position. This is a conservative estimate of the rod worth of any violation allowed in T.S. 3.1.3.5 Action 1.

CAUTION
Shutdown margin may only be calculated with 1 shutdown bank or control bank A, B, or C inserted beyond the RIL.

4.2.6 INTEGRAL ROD WORTH INSERTED AT POSITION IN ITEM 4.1.3 (If ARO, use zero) (HFP: Figure 2C/Table 1-7 or HZP: Figure 2A/Table 1-8) — 0 pcm

4.2.6.a **IF** any shutdown bank or control bank A is inserted ≤ 10 steps, record 90 pcm, otherwise record 0 pcm. — 0 pcm

4.2.6.b INTEGRAL ROD WORTH and Penalty (Item 4.2.6) + (Item 4.2.6.a) = — 0 pcm

NOTE
The penalties for untrippable RCCAs include the most reactive stuck rod worth. The most reactive stuck rod worth from step 4.2.3 is not needed when calculating the trippable rod worth with at least one untrippable RCCA.

4.2.7 **CHOOSE** the appropriate calculation below. **MARK** the calculation not used "N/A."

TRIPPABLE ROD WORTH (Item 4.2.1) + (Item 4.2.2) + (Item 4.2.3) + (Item 4.2.5) + (Item 4.2.6.b) = -5858 pcm

OR

TRIPPABLE ROD WORTH WITH UNTRIPPABLE RCCA(s) (Item 4.2.1) + (Item 4.2.2) + (Item 4.2.4) + (Item 4.2.5) + (Item 4.2.6.b) = NA pcm

4.3 **CALCULATION OF SDM (Note: See Precaution 3.4)**

4.3.1 TRIPPABLE ROD WORTH (Item 4.2.7) — -5858 pcm

4.3.2 TEN PERCENT ROD WORTH PENALTY (3697 + 3581 - 920) x 0.10 = (+) 636 pcm
abs(Item 4.2.1) abs(Item 4.2.2) (Item 4.2.3)

4.3.3 ROD MISALIGNMENT RELAXATION PENALTY — (+) 120 pcm

4.3.4 POWER DEFECT (Figure 17A/Table 2-1) — 2704 pcm

4.3.5 SDM (Item 4.3.1) + (Item 4.3.2) + (Item 4.3.3) + (Item 4.3.4)= — -2398 pcm

Answer Key

ATTACHMENT 3
SHUTDOWN MARGIN VERIFICATION
FOR MODES 1 OR 2

SALEM UNIT 2

4.4 **ACCEPTANCE CRITERIA**

NOTE
REQUIRED SDM (per T/S 3.1.1.1) MODE 1 OR 2:
(-)1.3 % Δk/k = (-)1300 PCM

✓ / $ 4.4.1 IS THE SDM (Item 4.3.5) EQUAL TO OR MORE NEGATIVE THAN (-) 1300 PCM?

YES: then surveillance is SAT: ✓

NO: then surveillance is UNSAT: _____

NOTE
If the required power defect in step 4.4.2.A is negative, then it is not possible to meet SDM by lowering reactor power and step 4.4.2.B will be 0%.

NA 4.4.2 IF the SDM is UNSAT, THEN **PERFORM** the following:

A. **CALCULATE** the power defect required to achieve required SDM.

_____ (abs(Item 4.3.1)) - _____ (Item 4.3.2) - 120 pcm (Item 4.3.3) - 1300 pcm = _____ pcm

B. **DETERMINE** Reactor Power Level based on power defect in 4.4.2.A and boron concentration in 4.1.2. (Figure 17A/Table 2-1)

_____ %RTP

NA C. **NOTIFY** SM/CRS to initiate rapid boration, IAW S1(2).OP-SO.CVC-0008(Q), Rapid Boration, and reduce reactor power UNTIL the required SDM is attained.

Completed by: _____ Date: _____ Time: _____

Reviewed by: _____ Date: _____ Time: _____

JOB PERFORMANCE MEASURE VALIDATION CHECKLIST

NOTE: All steps of this checklist should be performed upon initial validation. Prior to JPM usage, revalidate JPM using steps 8 and 11 below.

RC 1. Task description and number, JPM description and number are identified.

RC 2. Knowledge and Abilities (K/A) references are included.

RC 3. Performance location specified. (in-plant, control room, or simulator)

RC 4. Initial setup conditions are identified.

RC 5. Initiating and terminating Cues are properly identified.

RC 6. Task standards identified and verified by SME review.

RC 7. Critical steps meet the criteria for critical steps and are identified with an asterisk (*).

RC 8. Verify the procedure referenced by this JPM matches the most current revision of that procedure: Procedure Rev. __24___ Date ____1-14-20_____

RC 9. Pilot test the JPM:
a. verify Cues both verbal and visual are free of conflict, and
b. ensure performance time is accurate.

N/A 10. If the JPM cannot be performed as written with proper responses, then revise the JPM.

N/A 11. When JPM is revalidated, SME or Instructor sign and date JPM cover page.

SME/Instructor: R. Chan Date: 1-14-20

SME/Instructor: J. Klein Date: 1-16-20

SME/Instructor: Z. Weidner Date: 1-16-20

INITIAL CONDITIONS:

- Unit 2 Reactor Power is 100%.
- All Control Rod Group Demand Counters are at 225 steps.
- Current boron concentration is 300 ppm.
- Current core burnup is 10,000 EFPH.
- Control Rod 1D5 was been declared INOPERABLE at 1000 today due to not moving out during a rod exercise test.
- You have been directed to perform a Shutdown Margin Calculation IAW SC.RE-ST.ZZ-0002 to satisfy the action requirement of TSAS 3.1.3.1 Action c.3 for a misaligned rod.
- Control Rod 1D5 has been identified as **trippable** and is currently at 214 steps.

INITIATING CUE:

- You have been directed to perform a Shutdown Margin Calculation IAW SC.RE-ST.ZZ-0002 Attachment 3 to satisfy the **one (1) hour** action requirement of TSAS 3.1.3.1 Action c.3 to verify Shutdown Margin requirements is satisfied.
- When performing calculation, the CRS directs you to use **only the tables** as directed by SC.RE-ST.ZZ-0002, do not use Figures.
- **This is a Time Critical JPM.**