

Rod Worth Minimizer

Chapter 7.5

Learning Objectives

1. Identify the purpose of the Rod Worth Minimizer (RWM) System.

2. Recognize the purpose, function and operation of the following RWM signals/indications:
 - a. insert block
 - b. insert error
 - c. withdraw block
 - d. withdraw error
 - e. select error
 - f. latched group

Learning Objectives

3. Identify the conditions required to initiate a Control Rod Drop Accident and the potential consequences.
4. List the setpoints for the Low Power Set Point and Low Power Alarm Point.
5. Identify the RWM response for operation:
 - a. above the Low Power Alarm Point
 - b. in the Transition Zone
 - c. below the Low Power Set Point
6. Describe how the RWM system interrelates with the following systems/components:
 - a. Feedwater Level Control
 - b. Reactor Manual Control System
 - c. Process Computer

Purpose

The purpose of the Rod Worth Minimizer (RWM) is to:

- reinforce procedural controls
- limit control rod worth during low power operation
- The RWM prevents the operator from establishing control rod patterns that could create high rod worth values.
 - This is in the event of a control rod drop accident, during:
 - Startup
 - Shutdown
 - Low power level operation (< 20%)

RWM Indications

- **Select Error**
 - A control rod is selected in other than the currently latched group
- **Latched Group**
 - The program will latch a group upon selection of a rod within the group
 - Only if the rod selected is within the program insert and withdraw limits.

Example

When power is being lowered, the program will latch the next lower group when;

- all the rods in the presently latched group are inserted to the group insert limit
- a rod in the next group is selected.

RWM Indications

- **Insert Error**

- Current group – inserted past insert limit
- Lower group – inserted past withdraw limit

- **Withdraw Error**

- Current group – withdrawn past withdraw limit
- Higher group – withdrawn past insert limit

RWM Rod Blocks

- **Insert Block**
 - A third insert error is made.
 - A withdraw block has been imposed by the RWM and the operator selects a rod other than the one with the existing withdraw error.
- **Withdraw Block**
 - A single withdraw error has been made.
 - An insert block has been imposed by the RWM and the operator selects a control rod for movement other than those with existing insert errors.

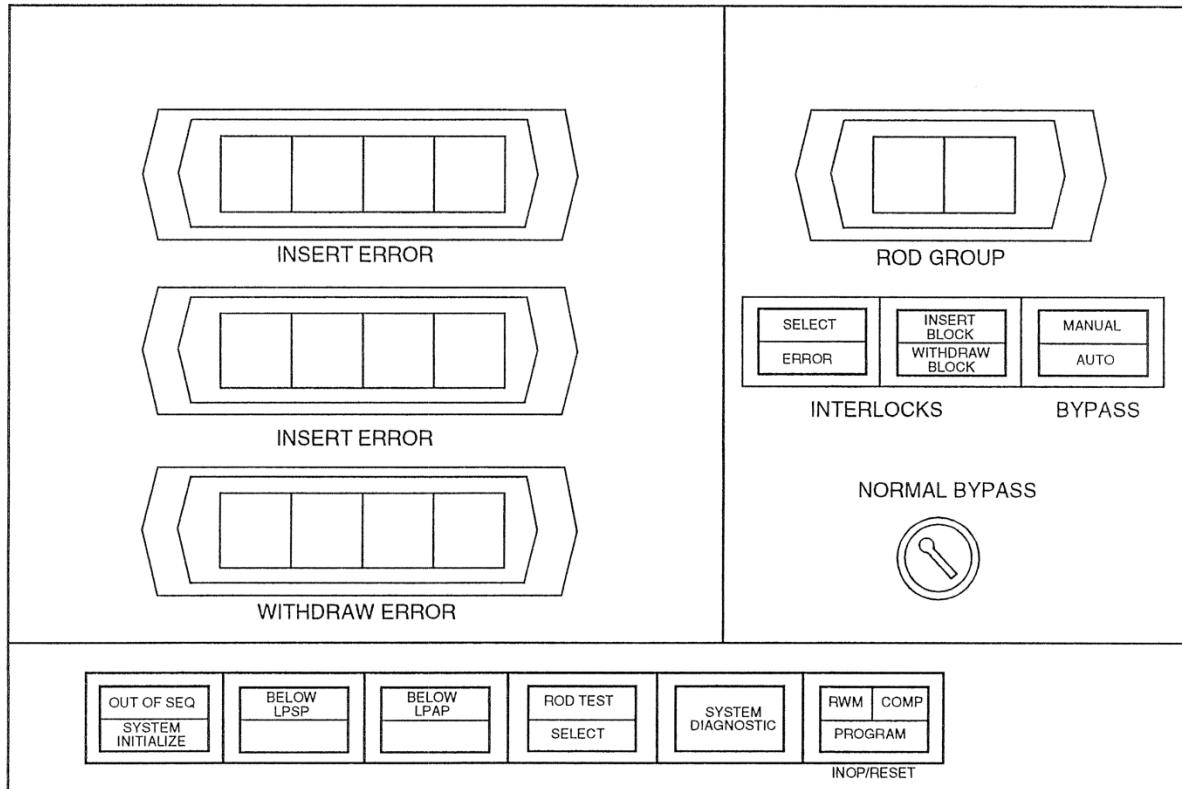


Figure 7.5-5 RWM Operator's Display Panel

RWM Areas of Operation

- **Below the Low Power Set Point**

- The Low Power Set Point (LPSP) is the power level below which the RWM program actively enforces adherence to the operating sequence

- **In the Transition Zone**

- The Transition Zone is the range of reactor power levels above the LPSP but below the LPAP.
- The RWM does not enforce the operating sequence, but the system alarms and displays errors.

- **Above the Low Power Alarm Point**

- The Low Power Alarm Point (LPAP) is the core power level above which all RWM alarms and displays are discontinued.

Rod Drop Accident

- The control rod blade must be uncoupled from its drive mechanism.
- The control rod blade must stick in the fully inserted location (00).
- The control rod mechanism must be fully withdrawn (48).
- The operator does not perform the technical specification required coupling check at position 48.
- The operator does not notice the lack of nuclear instrument response to the withdrawal of the control rod.
- The control rod blade is dislodged from the 00 position and falls to the 48 position with speed limited by the velocity limiter.

The RWM limits the fuel enthalpy from the transient to <280 cal/gm. Localized fuel damage can occur in a control rod drop accident.

Table 7.5-1 Fuel Behavior for Various Fuel Enthalpies

Fuel Enthalpy	Result
170 calories/gram	Threshold for cladding perforation
200-280 calories/gram	Fuel melting
425 calories/gram	Fuel melting complete; UO ₂ vapor pressure rise of 30 psi/second. (This enthalpy is the design limit)
450 calories/gram	UO ₂ vapor pressure rise of 600 psi/second

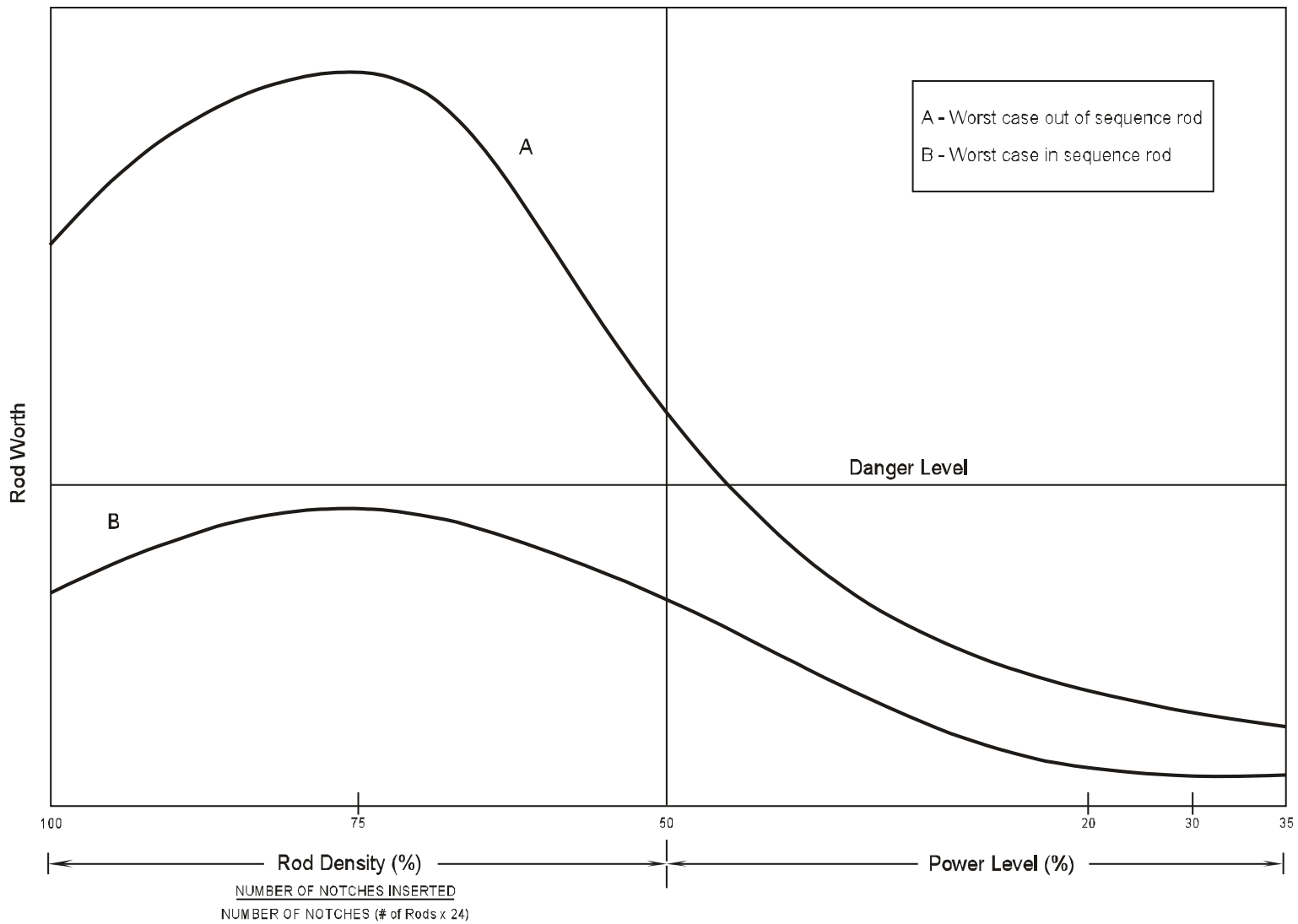


FIGURE 7.5-1 Rod Worth for Sequences of Rod Withdrawal or Insertion

			18-51		26-51		34-51					
			14-47		22-47		30-47		38-47			
			10-43		18-43		26-43		34-43		42-43	
		06-39		14-39		22-39		30-39		38-39		46-39
02-35		10-35		18-35		26-35		34-35		42-35		50-35
	06-31		14-31		22-31		30-31		38-31		46-31	
02-27		10-27		18-27		26-27		34-27		42-27		50-27
	06-23		14-23		22-23		30-23		38-23		46-23	
02-19		10-19		18-19		26-19		34-19		42-19		50-19
	06-15		14-15		22-15		30-15		38-15		46-15	
		10-11		18-11		26-11		34-11		42-11		
			14-07		22-07		30-07		38-07			
			18-03		26-03		34-03					

<u>RWM Group #</u>	<u>Rods in the Group</u>
1	26-31, 34-39, 42-31, 34-23, 26-15, 18-23, 10-31, 18-39, 26-47, 42-47, 50-39, 50-23, 42-15, 34-07, 18-07, 10-15, 02-23, 02-39, 10-47, 18-55, 34-55, 58-31
2	34-31, 26-23, 18-31, 26-39, 34-47, 42-39, 50-31, 42-23, 34-15, 18-15, 10-23, 10-39, 18-47, 26-55, 42-55, 50-47, 58-39, 58-23, 50-15, 42-07, 26-07, 02-31
3	30-35, 38-27, 30-19, 22-27, 14-35, 22-43, 30-51, 38-43, 46-35, 54-27, 46-19, 38-11, 22-11, 14-19, 06-27, 06-43, 14-51, 22-59, 38-59, 46-51, 54-43, 30-03
4	30-27, 22-35, 30-43, 38-35, 46-27, 38-19, 30-11, 22-19, 14-27, 14-43, 22-51, 38-51, 46-43, 54-35, 54-19, 46-11, 38-03, 22-03, 14-11, 06-19, 06-35, 30-59
5	58-43, 42-03, 02-19, 18-59, 58-19, 18-03, 02-43, 42-59
6	50-11, 10-11, 10-51, 50-51
7	42-19, 18-19, 18-43, 42-43
8	34-27, 26-27, 26-35, 34-35
9	34-03, 02-27, 26-59, 58-35, 26-03, 02-35, 34-59, 58-27
10	14-07, 06-47, 46-55, 54-15, 06-15, 14-55, 54-47, 46-07
11	18-27, 26-43, 42-35, 34-19, 18-35, 34-43, 42-27, 26-19
12, 13, 15, 19, 21, 25,28, 31, 35, 40	18-11, 10-43, 42-51, 50-19, 42-11, 10-19, 18-51, 50-43
14, 16, 20, 22, 26, 29, 32, 36, 41, 47	26-11, 10-35, 34-51, 50-27, 34-11, 10-27, 26-51, 50-35
17, 23, 27, 30, 33, 38, 45, 49, 52	22-47, 46-39, 38-15, 14-23, 22-15, 14-39, 38-47, 46-23
18, 24, 34, 39, 46, 50, 53,	30-23, 22-31, 30-39, 38-31
37, 42, 54, 58, 65	30-07, 06-31, 30-55, 54-31
43, 48, 55, 62, 70	14-15, 14-47, 46-47, 46-15
44, 56, 61,	30-31, 22-39, 38-39, 38-23, 22-23
51, 59, 63	22-07, 06-39, 38-55, 54-23, 38-07, 06-23, 22-55, 54-39
57, 60, 69	14-31, 30-15, 46-31, 30-47
64, 72	38-07, 06-23, 22-55, 54-39
66	22-47, 46-39, 38-15, 14-23
67	22-15, 14-39, 38-47, 46-23
68	30-23, 22-31, 30-39, 38-31
71	22-07, 06-39, 38-55, 54-23

Figure 7.5-3 Typical RWM Groups (for Sequence A)

RWM Group	Withdraw Position	Check	RWM Group	Withdraw Position	Check
1	00-48		37	00-04	
2	00-48		38	20-24	
3	00-48		39	14-18	
4	00-48		40	42-48	
5	00-48		41	36-42	
6	00-48		42	04-08	
7	00-48		43	00-04	
8	00-48		44	00-04	
9	00-48		45	24-28	
10	00-48		46	18-22	
11	00-48		47	42-48	
12	00-04		48	04-08	
13	04-08		49	28-32	
14	00-04		50	22-26	
15	08-12		51	00-04	
16	04-08		52	32-36	
17	00-04		53	26-30	
18	00-04		54	08-12	
19	12-16		55	08-12	
20	08-12		56	04-08	
21	16-20		57	00-04	
22	12-16		58	12-16	
23	04-08		59	04-08	
24	04-08		60	04-08	
25	20-24		61	08-12	
26	16-20		62	12-16	
27	08-12		63	08-12	
28	24-30		64	08-12	
29	20-24		65	16-12	
30	12-16		66	36-42	
31	30-36		67	36-42	
32	24-30		68	30-36	
33	16-20		69	08-12	
34	08-14		70	16-20	
35	36-42		71	12-16	
36	30-36		72	12-16	



System Interrelations

Feedwater Level Control System

- The feedwater level control system provides the main steam line flow signal to the RWM that is used to initiate/bypass the LPSP and LPAP.

Reactor Manual Control System

- The feedwater level control system provides the main steam line flow signal to the RWM that is used to initiate/bypass the LPSP and LPAP.

Process Computer

- The process computer is the central component of the RWM containing the control rod sequences.

Objective review

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 - insert error
 - withdraw block
 - withdraw error
 - select error
 - latched group

Objective Review

3. Identify the conditions required to initiate a Control Rod Drop Accident and the potential consequences.
4. List the setpoints for entry in to and identify the system response for the following RWM areas of operation:
 - above the Low Power Alarm Point
 - in the Transition zone
 - below the Low Power Set Point
5. Describe how the RWM system interrelates with the following systems/components:
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