2102-1.2
Revision 6
02/05/79



# THREE MILE ISLAND NUCLEAR STATION
## UNIT #2 OPERATING PROCEDURE 2102-1.2
## APPROACH TO CRITICALITY

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Unit 1 Staff Recommends Approval

Approval NA Date —

Cognizant Dept. Head

Unit 2 Staff Recommends Approval

Approval NA Date —

Cognizant Dept. Head

Unit 1 PORC Recommends Approval

NA Date —

Chairman of PORC

Unit 2 PORC Recommends Approval

R.P Warren Date 2/2/79

√-Chairman of PORC

Unit 1 Superintendent Approval

NA Date —

Unit 2 Superintendent Approval

J.R Thomas Date 2/5/79

Manager Generation Quality Assurance Approval NA Date —

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THREE MILE ISLAND NUCLEAR STATION

UNIT #2 OPERATING PROCEDURE 2102-1.2

APPROACH TO CRITICALITY

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APPENDIX



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THREE MILE ISLAND NUCLEAR STATION

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APPROACH TO CRITICALITY

1.0 REFERENCES

1.1 Drawings Applicable for Operation

None

1.2 Operating Procedures Applicable for Operation

1.2.1 2105-1.9, Control Rod Drives

1.2.2 2103-1.2, Soluble Poison Concentration Control

1.2.3 2103-1.9, Reactivity Balance

1.2.4 2102-1, Unit Startup Procedures

1.2.5 2105-1.4, Integrated Control System

1.2.6 2101-1, Limits & Precautions

1.3 Manufacturers' Instruction Manuals

1.3.1 Control Rod Drive Control System (B&W)

1.4 Applicable System Descriptions

1.4.1 Control Rod Drive Control System

1.4.2 T.M.I. Unit 2 Technical Specifications

1.5 Curves and Tables

None

2.0 LIMITS AND PRECAUTIONS

2.1 If any conditions occur which physically or administratively delays criticality, the reactor will be maintained at least 1% $\Delta K/K$ subcritical while the conditions are being corrected. If such delay causes the time requirements of surveillance requirements 4.1.1.1.1(c) and 4.1.3.6(a) to be exceeded. These surveillance requirements must be reverified.

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2.2 All borating and deborating cycles will be performed in accordance with 2103-1.2, Soluble Poison Control.

2.3 Do not exceed a stable startup rate of 1 DPM.

2.4 During rod withdrawal closely monitor the nuclear instrumentation to insure correct response as core reactivity changes.

2.5 Verify that sufficient overlap exists, at least one (1) decade between source an intermediate range nuclear instrumentation.

2.6 If the reactor goes critical with less than the minimum predicted positive reactivity insertion, i.e. (prior to rods reaching 0.5% ΔK/K below the estimated critical position), insert rods to achieve a 1% ΔK/K shutdown position. Following rod insertion, recalculate the estimated critical position to determine the cause for error.

2.7 If the reactor is not critical with the allowable maximum predicted positive reactivity insertion, i.e. (when the rods are at 0.5% ΔK/K above the estimated critical position), insert the rods to 0.5% ΔK/K below estimated critical position. Following rod insertion recalculate the estimated critical position to determine the cause for error.

2.8 Prior to any rod withdrawal or boric acid dilution the source range nuclear instrumentation should be greater than 2 cps.

2.9 The Nuclear Instrumentation will be continously monitored during any reactivity addition. Subcritical source multiplication will be confirmed according to Appendix A or terminate the startup until an appropriate evaluation is made.

2.10 Safety rod groups shall be verified fully withdrawn within 15 min. prior to withdrawal of any regulating rod during the approach to criticality (Tech Spec 3.1.3.6) except as required by Physics Tests (Tech Spec 3.10.1 & 3.10.2).



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2.11 Reactor power shall not exceed 1 percent of rated power unless normal operating temperature pressure and rod configurations are established.

2.12 Axial power shaping rods may not normally be used for any purpose except axial power control.

2.13 If, during rod withdrawal, the count rate increase sharply stop rod withdrawal until the count rate stabilizes.

2.14 Two Intermediate Range Neutron Flux and Rate Channels shall be OPERABLE prior to entry into Mode 2 and during reactor criticality, in accordance with Tech. Spec. 3.3.1.1, Table 3.3-1.10.

NOTE: For Physics Testing an Intermediate Range detector can be connected to the reactimeter after Reactor Criticality.

3.0 PREREQUISITES

___3.1 Reactor coolant system temperature ($T_{avg}$) shall be $\geq 525^{o}F$ within 15 minutes prior to achieving criticality (Tech Spec 3.1.1.4).

___3.2 All precritical and prestartup checks are completed in accordance with Unit Startup Procedure 2102-1.3.

___3.3 Source range nuclear instrumentation indicating a minimum count rate of two (2) C.P.S.

___3.4 Reactivity balance calculation (2103-1.9) has been completed and a critical rod position (0.5% $\Delta K/K$ above and below critical position) determined.

___3.5 Source range (CPS) and intermediate range (amps) indication is available on strip chart recorder, if required, as determined by the Shift Supervisor.

___3.6 Two or more reactor coolant pumps are operating (Tech Spec 3.4.1).

___3.7 The Reactor Protection Instrumentation Channels have had their trip setpoints verified per SP2311-6. (Tech Spec 4.4.1b).

___3.8 Reactor coolant chemistry within limits per Tech Spec 3.4.7.

4.0 PROCEDURE

This procedure defines the major steps involved in taking the reactor from a hot standby (Mode 3) condition to a startup condition (Mode 2). The procedure is applicable when no physical manipulation of core geometry (fuel changes, CRA swaps, etc) has occured since the previous shut down. Criticality will be attained by CRA group withdrawal following adjustment of soluble boron content. The prescribed critical CRA configuration will be dependent upon future operating expectations, xenon effects and soluble poison economies. A one over M (1/M) plot will be made during rod withdrawal.

CAUTION: During any evolution that can change core reactivity the operator will assume that criticality may be achieved and will monitor the Nuclear Instrumentation.

___4.1 Verify shutdown margin within 4 hours of achieving criticality, by verifying that the predicted critical control rod position is within the SHUTDOWN MARGIN limits of Figure 1.

_____ _____
Signature Date/Time

NOTE: Plot 1/M during rod withdrawal.

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___4.1.a Verify both Intermediate Channels operable and not feeding the reactimeter.

___4.2 Withdraw CRA safety groups 1-4 to the upper limit in sequence if not already withdrawn. Confirm subcritical source multiplication according to Appendix A as each safety group is withdrawn.

NOTE: Refer to 2105-1.9 for operation of the CRD system.

___4.3 Verify each safety rod is fully withdrawn within 15 minutes prior to withdrawal of the regulating rods. (Tech Spec 4.1.3.6a)

_____ _____
Signature Date/Time

___4.4 Announce over the paging system that a reactor startup has commenced.

NOTE: Plot 1/M during rod withdrawal. Refer to Appendix B.

___4.5 Manually withdraw CRA Group 5 to 75% WD.

___4.6 Position CRA group 8 (APSR) at approximately 32% WD or to a position determined by the Nuclear Engineer.

___4.7 Verify that the "ECP" has been completed per 2103-1.9.

___4.8 Adjust reactor coolant system boron concentration to the concentration calculated in 2103-1.9 for critical position.

___4.9 When deboration is completed and the Reactor coolant letdown and the pressurizer boron concentration are within 100 ppmB of the Makeup tank boron concentration proceed to step 4.10.

___4.10 Prior to step 4.14 verify that the shutdown margin calculated in step 4.1 is still valid, if not re-verify.

___4.11 Verify the reactor coolant system temperature (Tav) is $\geq$ 525°F within 15 minutes of achieving criticality (Tech Spec 4.1.1.4.a).

Signature _____ Date/Time _____

___4.12 Verify each safety rod is fully withdrawn within 15 minutes prior to withdrawal of the regulating rods (Tech Spec 4.1.3.6a)

Signature _____ Date/Time _____

___4.13 Obtain SP2311-2 and commence procedure after criticality if the RC Tave is less than 530°F.

NOTE: Plot 1/M during rod withdrawal. Refer to Appendix B.

___4.14 Continue to manually withdraw Group 5 control rods.

CAUTION: If the reactor goes critical with less than the minimum predicted positive reactivity insertions, i.e. (prior to rods reacing 0.5% Δk/k below the estimated critical position), insert rods to achieve a 1% Δk/k shutdown position. Following rod insertion, recalculate the estimated critical position to determine the cause for error.

CAUTION: If the reactor is not critical with the allowable maximum predicted positive reactivity insertion, i.e. (when the rods are at the 0.5% Δk/k valve above the estimated critical position), insert the rods to the 0.5% Δk/k below estimated critical position. Following rod insertion recalculate the estimated critical position to determine the cause for error.

___4.15 Verify that as Group 5 passes the 75% withdrawn position group 6/7 moves out with Group 5.

___4.16 Verify Group 5 stops when it reaches out limit and Group 6/7 continues to withdrawn.

___4.17 Slowly raise the reactor power to $10^{-8}$ amps on the intermediate range channels.

___4.18 Verify that the source range channels are de-energized at $10^{-9}$ amp indication on both intermediate range channels.

___4.19 When the reactor is stable at $10^{-8}$ amps with zero startup rate, record critical data, boron ppm, RCS temperature and rod position and time/date.

___4.20 Depending on planned operation, continue operation in accordance with the appropriate operating procedures.

___4.21 Attach completed 1/M calculations to procedure.

## APPENDIX A

### Method to Determine Subcritical Neutron Multiplication

Calculate

$$M = \frac{SDM1 \quad (100 - SDM2)}{SDM2 \quad (100 - SDM1)}$$

Where

M - Multiplication Factor

SDM1 = Shutdown Margin prior to reactivity change (% Δk/k)

SDM2 = Shutdown Margin after reactivity change (% Δk/k)

Note: SDM1 and SDM2 are negative values.

Calculate

$CR_2 = M(CR_1)$ where $CR_2$ = new count rate

$CR_1$ = initial count rate

Example:

Condition: The reactor is 10% subcritical. 5.3% reactivity is added by withdrawing safety rods. The initial count rate is 10 cps. The reactor is now 4.7% subcritical.

Calculation:

SDM1 = -10%: SDM2 = -4.7%

$$M = \frac{10\ (100 + 4.7)}{4.7\ (100 + 10)} = \frac{10\ (104.7)}{4.7\ (110)} = 2.025$$

$CR_2 = 2.025\ (10) = 20.25$ cps.

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## APPENDIX B

1/M vs. Rod Position Plot

M - Subcritical Multiplication

$C_o$ - Initial Count Rate

C - Count Rate

Cp - Final Count Rate

Used to Predict Criticality.

Criticality is achieved when Keff = 0, M = ∞ or $\frac{1}{M} = 0$.

Plot 1/M vs. Rod Position

Record $C_o$ (from NI 1 or 2). Withdraw Rods at given interval ( 5%, 10% or 25%). Stop rod withdraw and wait for count rate to stabilize. Record final count rate. Calculate $\frac{1}{M}$ by dividing $C_o$ by $C_F$ and record on Data Sheet. Note Rod Position and plot 1/M vs. Rod position on Data Sheet. Using a straight edge connect point 0 to point 1 and extend line to intersect rod position axis ( if it will). The rod position at this intersection is the predicted Critical position. Withdraw rods another increment and repeat the above procedure to locate subsequent points and continue the plot. Compare predicted Critical positions to ECP. Refer to L & P 2.6 and 2.7.



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Appendix B cont. Sect

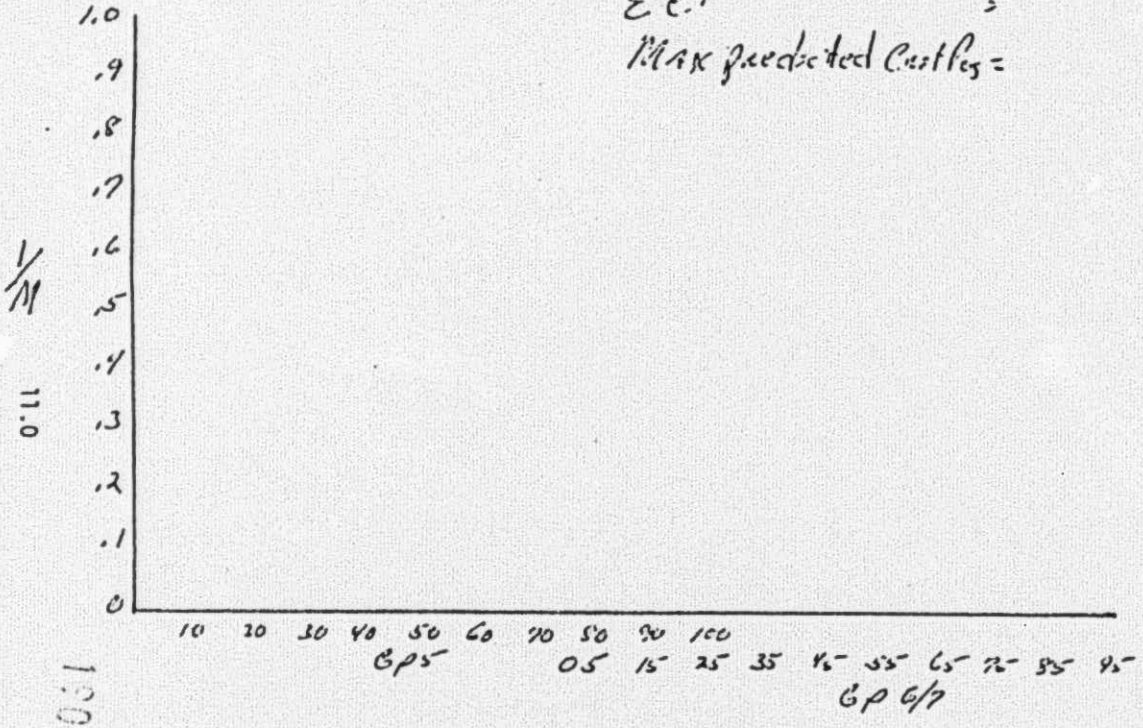
## 1/m vs. Rod Position Plot

$C_0$ =

Min. predicted Cust. Pos =

E.C.P =

Max predicted Cust Pos =




| Gps | $C_0$ | Rod Pos | Eps | $\frac{1}{m}$ |
|---|---|---|---|---|
| | $C_1$ | 0 | | |
| | | 10 | | |
| | $C_2$ | 20 | | |
| | $C_3$ | 30 | | |
| | | 40 | | |
| | | 50 | | |
| | | 60 | | |
| | | 70 | | |
| | | 80/5 | | |
| | | 90/6 | | |
| | | 100/25 | | |
| | | 35 | | |
| GpG/7 | | 45 | | |
| | | 55 | | |
| | | 65 | | |
| | | 75 | | |
| | | 85 | | |
| | | 95 | | |

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