NIAGARA MOHAWK POWER CORPORATION

NINE MILE POINT NUCLEAR STATION

UNIT II OPERATIONS

02-REQ-006-344-2-21 Revision 0

TITLE: CURVES AND LIMITS

	SIGNATURE	DATE
PREPARER	[signature]	8/30/90
TRAINING SUPPORT SUPERVISOR	[signature]	9-28-90
TRAINING AREA SUPERVISOR	[signature]	9/6/90
PLANT SUPERVISOR/ USER GROUP SUPERVISOR	[signature]	9/7/90

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Summary of Pages

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I. TRAINING DESCRIPTION

A. Title of Lesson: Curves and Limits

B. Lesson Description: This lesson will provide the student with an explanation of the development and basis for each of the operating Limits and Curves used in the EOPs.

C. Estimate of the Duration of the Lesson: 3 hours

D. Method of Evaluation, Grade Format, and Standard of Evaluation: Written Examination with 80% minimum passing grade.

E. Method and Setting of Instruction:

1. Classroom Lecture
2. Assign the Student Learning Objectives as review problems with the students obtaining answers from the text, writing them down and handing them in for grading.

F. Prerequisites:

1. Instructor:
   a. Qualified in instructional skills per NTP-16 and/or 16.1.
2. Trainee:
   a. In accordance with NTP-10 and NTP-11 or
   b. Be recommended for this training by the Operations Superintendent or his designee or by the Training Superintendent.

G. References:

BWROG Emergency Procedure Guidelines, Rev. 4,

II. REQUIREMENTS

A. AP-9, Administration of Training

B. NTP-10, Training of Licensed Operator Candidates

C. NTP-11, Licensed Operator Requalification Training

III. TRAINING MATERIALS

A. Instructor Materials:

1. Transparencies Package
2. Overhead Projector
3. Whiteboard and Felt Tip Markers
4. EOP Flowcharts

B. Trainee Materials:

1. EOP Flowcharts

IV. EXAM AND MASTER ANSWER KEYS

Will be generated and administered as necessary. They will be on permanent file in the Records Room.

V. LEARNING OBJECTIVES

A. Terminal Objectives:

TO-1.0 Correctly use each curve when presented in the Emergency Operating Procedure.

B. Enabling Objectives:

EO-1.0 Be able to define the following:

a. Maximum Subcritical Banked Rod Withdrawal Position
b. Boron Injection Initiation Temperature
c. Pump NPSH curve for;
   1) HPCS
   2) LPCS
   3) RHR
d. Pump Vortex Limit for;
   1) HPCS
   2) LPCS
   3) RHR
e. Drywell Spray Initiation Pressure
f. Heat Capacity Temperature Limit
g. Heat Capacity Level Limit
h. Maximum Core Uncovery Time Limit
i. Maximum Primary Containment Water Level Limit
j. Minimum RPV Flooding Pressure
k. Minimum Core Flooding Interval
l. Primary Containment Pressure Limit
m. RPV Saturation Pressure
n. SRV Tail Pipe Level Limit
o. Minimum RPV Flooding Pressure
p. Minimum Number of SRVs Required for Emergency Depressurization
q. Minimum Steam Cooling RPV Water Level
r. Minimum Zero Injection RPV Water Level
s. Suppression Chamber Spray Initiation Pressure

EO-2.0 Be able to discuss the function(s)/purpose of the curve or variable listed in Enabling Objective 1.

LESSON CONTENT	DELIVERY NOTES	OBJECTIVES/ NOTES

A. STUDENT LEARNING OBJECTIVES

B. PURPOSE

Provide a description of the variables and assumptions used in the development of the limits and curves used in the EOPs.

C. INTRODUCTION

Each curve developed from the EPGs is developed from certain engineering values and conservative assumptions, not from licensing information. Therefore conformance within a given curve does not mean compliance with Technical Specifications. While this seems contrary, it really isn't . The SRO is permitted to operate outside tech. specs., but only under the following criteria as quoted from 10 CFR 50.54:

(x) A licensee may take reasonable action that departs from a license condition or a technical specification (contained in a license issued under this part) in an emergency when this action is immediately needed to protect the public health and safety and no action consistent with license conditions and technical specifications that can provide adequate or equivalent protection is immediately apparent.

(y) Licensee action permitted by paragraph (x) of this section shall be approved, as a minimum, by a licensed senior operator prior to taking the action.

D. LIMITS AND CURVES

1. Maximum Subcritical Banked Rod Withdrawal Position.

Defined as the lowest control rod position to which all control rods may be withdrawn in a bank and still ensure the Reactor will remain shut down under all conditions.

EO-1.0a

This position is utilized to assure the Reactor will remain shut down irrespective of RPV water temperature.

Assumptions:

a. Reactor core is at most reactive exposure.
b. No xenon is present in the core.
c. No voids are present in the core.
d. RPV water temperature is at its most reactive temperature.

All of these indicate that negative reactivity other than by rods is minimized.

2. Boron Injection Initiation Temperature

Defined to be the greater of:

a. That Suppression Pool temperature at which Tech. Specs. require initiation of a manual scram, OR, — EO-1.0b

b. The maximum Suppression Pool temperature at which initiation of SLC will achieve Reactor shut down before Suppression Pool temperature exceeds the Heat Capacity Temperature Limit.

This limit is a function of Reactor power and is utilized in establishing the conditions before which Boron injection must begin if RPV depressurization with the Reactor at power is to be prevented. — EO-2.0

Assumptions:

Lesson Content	Delivery Notes
1) Reactor power remains constant during boron injection.	In reality power will decrease.
2) RPV pressure remains at the lowest SRV lift setpoint.	Will really decrease due to power going down (max heat energy deposited to pool using this assumption).
3) Water is injected from the Condensate Storage Tank.	Coldest source. (CST at lowest expected temp.)

4) All steam generated by the Reactor is rejected into the Suppression Pool.	Maximum heat up of pool.	
5) Suppression Pool level is at low LCO when boron injection starts.	Minimum amount of mass to heat up.	
6) Suppression Pool Cooling is not available.	Heat stays in the pool, also for Max. heat up of the pool.	
7) SLC boron concentration is the minimum allowed for unrestricted operation.	Prolong the time heat is added, (ie. max time to effect shut down).	
3. HPCS Pump NPSH Limit Defined to be the highest Suppression Pool temperature which provides adequate NPSH for the HPCS pump taking a suction on the Suppression Pool.		EO-1.c.1
A function of HPCS pump flow and Suppression Chamber overpressure (airspace pressure plus the hydrostatic head of water over the suction strainer on the pump).	Remind students that hydrostatic head is elevation and density, ie. temperature of pool.	EO-2.0
4. HPCS Pump Vortex Limit Defined to be the lowest Suppression Pool level above which air entrainment is not expected to occur in the HPCS.		EO-1.d.1

LESSON CONTENT	DELIVERY NOTES	OBJECTIVES/ NOTES
5. LPCS Pump NPSH Limit Defined to be the highest Suppression Pool temperature which provides adequate NPSH for the LPCS pump taking a suction on the Suppression Pool.		EO-1.c.2
A function of LPCS pump flow and Suppression Chamber overpressure (airspace pressure plus the hydrostatic head of water over the suction strainer of the pump).	Remind students that hydrostatic head is elevation and density, ie. temperature of pool.	EO-3.0
6. LPCS Vortex Limit Defined to be the lowest Suppression Pool level above which air entrainment is not expected to occur in the LPCS.		EO-1.d.2
7. RHR Pump NPSH Limit Defined to be the highest Suppression Pool temperature which provides adequate NPSH for the RHR pump taking a suction on the Suppression Pool.		EO-1.c.3
A function of RHR pump flow and Suppression Chamber overpressure (airspace pressure plus the hydrostatic head of water over the suction strainer of the pump).	Remind students that hydrostatic head is elevation and density, ie. temperature of pool.	EO-3.0

8. RHR Vortex Limit — EO-1.d.3

Defined to be the lowest Suppression Pool level above which air entrainment is not expected to occur in the RHR system.

9. Drywell Spray Initiation Pressure Limit — EO-1.0e

Defined to be the highest Drywell temperature at which initiation of Drywell sprays will not result in an evaporative cooling pressure drop to below either:

Delivery notes: Evaporate cooling is the cooling of the Drywell atmosphere by evaporation of the spray droplets.

a. The Drywell below Suppression Chamber differential pressure capability, OR

Delivery notes: Depressurization rates can exceed 10 to 20 psi/second.

b. The high Drywell pressure Scram setpoint.

This temperature is to preclude containment failure. — EO-2.0

Assumptions:

a. Drywell spray water temperature is 40°F.

Delivery notes: Max. cooling effect.

b. Drywell humidity is zero when sprays are initiated.

Delivery notes: Max. evaporation/cooling. More heat is removed by the evaporative process than just by convective cooling.

c. Suppression Chamber and Drywell are at the same pressure when sprays are initiated.

d. The evaporative cooling transient is over before the Suppression Chamber to Drywell vacuum breakers open.

No credit is given for volume of gas in Suppression Chamber.

10. Heat Capacity Temperature Limit

Defined to be the highest Suppression Pool temperature at which initiation of RPV depressurization will not exceed either: EO-1.0f

a. The Suppression Chamber design temperature.
b. The Primary Containment Pressure Limit before the rate of energy transfer from the RPV to the containment is within the capacity of the Primary Containment vent.

This temperature is a function of RPV pressure, and the limit is to preclude failure of the Primary Containment or equipment necessary for the safe shut down of the plant. EO-2.0

Assumptions:

a. Reactor has been shut down for two minutes when RPV Depressurization is initiated.

Maximum amount of decay heat available for depositing in the pool.

b. RPV water level is at the high level trip setpoint when RPV depressurization is initiated.

c. No water is injected into the RPV during the depressurization. — EO-2.0

d. The Minimum Number of SRVs for Emergency Depressurization are used to effect the depressurization.

e. An SRV will pass 100% of nameplate floe at 103% of nameplate pressure.

f. All steam from the RPV is rejected to the Suppression Pool.

g. Suppression Pool water level is at the low LCO when RPV depressurization is initiated. — Minimum mass available to absorb the heat.

h. Suppression Pool cooling is not available.

i. The RPV, internals, and fuel are in thermal equilibrium with the water in the RPV when RPV pressure reaches the Minimum RPV Flooding Pressure.

j. All noncondensibles in the containment are in the Suppression Chamber when RPV pressure reaches the Minimum RPV Flooding Pressure.

k. The Suppression Chamber atmosphere and the pool are in thermal equilibrium when RPV pressure reaches the Minimum RPV Flooding Pressure.

11. Heat Capacity Level Limit EO-1.0g

Defined to be the higher of either:

a. Downcomer openings, OR

b. The lowest Suppression Pool water level at which the initiation of RPV depressurization will not result in exceeding the Heat Capacity Temperature Limit.

This water level is a function of the margin to the Heat Capacity Temperature Limit, and the Level Limit is utilized in conjunction with the Temperature Limit to preclude failure of the containment or equipment necessary for the safe shut down of the plant and to preclude loss of the pressure suppression function of the containment. EO-2.0

Assumptions:

NONE

The Heat Capacity Level Limit starts at the low LCO and as the volume of the pool diminishes so does the amount of heat the pool can absorb, down to the elevation of the downcomer openings.

Studies have shown that 95% condensation will occur at the downcomer openings even with pool level 6 inches below the downcomer opening.

12. Maximum Core Uncovery Time Limit EO-1.0h
    Defined to be the greatest amount of time the Reactor core can remain completely uncovered and uncooled without resulting in a peak clad temperature in excess of 1500°F.

    This amount of time is a function of time after Reactor shutdown, and the limit is utilized to preclude fuel damage during recovery from the RPV Flooding evolution. EO-2.0

    Assumptions:

    a. The Reactor has been shut down from rated power.
    b. Recovery from the RPV Flooding evolution is not initiated until the Minimum Core Flooding Interval has expired.
    c. The Reactor core is instantaneously and completely uncovered when recovery from the RPV Flooding evolution commences.
    d. Fuel clad temperature is 545°F when the core is initially uncovered.

13. Maximum Primary Containment Water Level Limit — EO-1.0i

Defined to be the lesser of either:

a. The elevation of the highest containment vent capable of rejecting all decay heat, OR
b. The highest containment water level which will NOT result in exceeding the pressure capability of the containment.

This water level is a function of Suppression Chamber pressure and temperature, and the Limit is utilized to preclude containment failure. — EO-2.0

Assumptions:

a. Decay heat rejected is that which is generated ten minutes after Reactor shut down.
b. The temperature in the Drywell may vary between 100°F and 545°F.
c. The temperature in the Suppression Chamber may vary between 70°F and 350°F.

14. Minimum Alternate RPV Flooding Pressure — EO-1.0j

Defined to be the lowest RPV pressure at which steam flow through open SRVs is sufficient to preclude any clad temperature from exceeding 1500°F even if the Reactor core is NOT completely covered.

This pressure is a function of the number of open SRVs, and is utilized to preclude fuel damage during the RPV flooding evolution when the Reactor may not be shut down. EO-2.0

. Assumptions:

a. The Reactor core is completely uncovered and therefore shut down. — No moderator, no thermalization, no reaction.

b. The Reactor has been shut down from rated power for ten minutes.

c. The Reactor axial power shape was the most limiting top peaked power shape prior to core uncovery.

d. All of the steam which has flowed through the SRVs has passed through the core.

e. An SRV will pass 110% of nameplate flow at 103% of nameplate pressure.

15. Minimum Core Flooding Interval EO-1.0k

Defined to be the greatest amount of time required to flood the RPV to the Top of Active Fuel with RPV pressure at the Minimum RPV Flooding Pressure and at least the Minimum Number of SRVs Required for Emergency Depressurization open.

This interval is a function of the SRVs which are actually open, and is utilized to assure the Reactor core has been covered before recovery from the RPV Flooding evolution is initiated. EO-3.0

Assumptions:

a. The Reactor has been shut down from rated power for ten minutes when the RPV Flooding evolution commences.

b. The RPV is completely devoid of water when the RPV Flooding evolutions is initiated.

c. The temperature of the fuel is 1500°F when the RPV Flooding evolution starts.

d. The temperature of the RPV and internals is at the saturation temperature equivalent to the lowest SRV lift setpoint when the RPV Flooding evolution is initiated.

e. An SRV will pass 110% of nameplate flow at 103% of nameplate pressure.

f. The temperature of the water injected into the RPV is the temperature at the low-pressure endpoint of the Heat Capacity Temperature Limit.

g. The temperature of the water in the RPV is the saturation temperature for the Minimum RPV Flooding Pressure.

h. The RPV, internals, and fuel are in thermal equilibrium with the water in the RPV when RPV water level reaches Top of Active Fuel.

16. Primary Containment Pressure Limit EO-1.01

Defined to be the lesser of either:

a. The pressure capability of the containment, OR

b. The maximum containment pressure at which vent valves can be opened and closed to reject all decay heat from the containment, OR

c. The maximum pressure at which SRVs can be opened and will remain open, OR

d. The maximum containment pressure at which vent valves can be opened and closed to vent the RPV.

This pressure is a function of Primary Containment water level and temperature, and the Limit is utilized to preclude containment failure and core damage. EO-2.0

Assumptions:

a. The decay heat rejected is that which is generated ten minutes after shut down from rated power.

b. The temperature in the Drywell may vary between 100°F and 545°F.

17. RPV Saturation Pressure
Defined to be the saturation table for water at expected RPV pressures and temperatures. EO-1.0m

Utilized to determine usability of RPV water level instruments at elevated Drywell temperatures.

Assumptions:
NONE EO-2.0

18. SRV Tail Pipe Level Limit
Defined to be the highest Suppression Pool water level at which opening an SRV will NOT result in exceeding the capabilities of the SRV Tailpipe, Tailpipe Supports, Quencher, or Quencher Supports. EO-1.0n

The Limit is utilized to preclude SRV System damage and containment failure. EO-2.0

Assumptions:

a. The SRV tail pipe is flooded to elevation of the Suppression Pool water level.

b. The SRV tail pipe system load increases by 10% for each two foot increase in length of flooded tail pipe.

c. The SRV tail pipe system load decreases by 10% for each 100 psig decrease in RPV pressure.

19. Minimum RPV Flooding Pressure EO-1.0o

Defined to be the greater of either:

a. The Minimum SRV re-opening pressure, OR,

b. The lowest differential pressure between the RPV and the Suppression Chamber at which steam flow through the Minimum Number of SRVs Required for Emergency Depressurization is sufficient to remove all decay heat from the core.

This Limit is utilized to assure sufficient liquid injection into the RPV to maintain SRVs open and to flood the RPV to the elevation of the main steam lines during the RPV Flooding evolution when the Reactor is shut down. EO-2.0

Assumptions:

a. Heat is transferred from the core by boiling.

b. The decay heat removed is that which is generated ten minutes after shut down from rated power.

c. An SRV will pass 110% of nameplate flow at 103% of nameplate pressure.

d. The temperature of the water injected into the RPV is the temperature at the low-pressure endpoint of the Heat Capacity Temperature Limit.

20. Minimum Number of SRVs Required for Emergency Depressurization EO-1.0p

Defined to be the greater of either:

a. The least number of SRVs which, if opened, will remove all decay heat from the core at a pressure sufficiently low that the ECCS with the lowest head will be capable of making up the SRV steam flow, OR,

b. The least number of SRVs which correspond to a Minimum Alternate Flooding Pressure sufficiently low that the ECCS with the lowest head will be capable of making up the SRV steam flow at the corresponding Minimum Alternate Flooding Pressure.

This Number is utilized to assure the RPV will depressurize and remain depressurized when emergency depressurization is required. EO-2.0

Assumptions:

a. The decay heat removed is that which is generated two minutes after shut down from rated power.
b. An SRV will pass 110% of nameplate flow at 103% of nameplate pressure.
c. The temperature of the water injected into the RPV is the temperature at the low-pressure endpoint of the Heat Capacity Temperature Limit.

21. Minimum Steam Cooling RPV Water Level EO-1.0q

Defined to be the lowest RPV water level at which the covered portion of the Reactor core will generate sufficient steam flow to preclude any clad temperature in the uncovered portion of the core from exceeding 1500°F.

This Water Level is utilized to preclude fuel damage when RPV water level is lowered to below the Top of Active Fuel. EO-2.0

Assumptions:

a. The Reactor has been shut down from rated power for ten minutes.

b. The Reactor axial power shape was the most limiting top-peaked power shape prior to Reactor shut down.

c. The temperature of the water injected into the RPV is 70°F.

22. Minimum Zero Injection RPV Water Level EO-1.0r

Defined to be the lowest RPV water level at which the covered portion of the Reactor core will generate sufficient steam flow to preclude any clad temperature in the uncovered portion of the core from exceeding 1800°F.

This limit is utilized to preclude significant fuel damage and hydrogen generation for as long as possible. EO-2.0

Assumptions:

a. The Reactor has been shut down from rated power for ten minutes.

b. The Reactor axial power shape was the most limiting top-peaked power shape prior to Reactor shut down.

c. No water is injected into the RPV.

23. Suppression Chamber Spray Initiation Pressure (EO-1.0s)

Defined to be the lowest Suppression Chamber pressure which can occur when 95% of the non-condensibles in the Drywell have been transferred to the Suppression Chamber.

This Pressure is utilized to preclude "Chugging." (EO-2.0)

Chugging is the cyclic condensation of steam at the water surface in the downcomer. The resulting mechanical motion to occur which may cause fatigue failure at the top of the Suppression Chamber, which would cause a loss of the suppression function.

Assumptions:

a. The Suppression Pool temperature is the minimum normal operating pool temperature.

b. The Suppression Pool and Suppression Chamber atmosphere are in thermal equilibrium.

E. WRAP UP

Each curve and limit used in the EOPs is conservatively developed in an effort to anticipate the many possibilities that may warrant their use. This conservatism can be seen in the assumptions used to develop each limit.