reactivity insertion upon ejection greater than 0.3% $\Delta k/k$ at rated power. Inoperable rod worth shall be determined within 4 weeks.

b. A control rod shall be considered inoperable if
(a) the rod cannot be moved by CRDM, or
(b) the rod is misaligned from its bank by more than 15 inches, or
(c) the rod drop time is not met.

c. If a control rod cannot be moved by the drive mechanism, shutdown margin shall be increased by boron addition to compensate for the withdrawn worth of the inoperable rod.

5. CONTROL ROD POSITION INDICATION

If either the power range channel deviation alarm or the rod deviation monitor alarm is not operable, rod positions shall be logged once per shift and after a load change greater than 10% of rated power. If both alarms are inoperable for two hours or more, the nuclear overpower trip shall be reset to 93% of rated power.

6. POWER DISTRIBUTION LIMITS

a. Hot channel factors:

(1) F_Q Limit

The hot channel factors (defined in Bases) must meet the following limits at all times except during low power physics tests:

$$F_Q(Z) \leq ([F_Q]_L/P) \times K(Z), \text{ for } P > 0.5$$

$$F_Q(Z) \leq (2 \times [F_Q]_L) \times K(Z), \text{ for } P \leq 0.5$$

$$F^N_{\Delta H} \leq 1.55 [1.0 + 0.2 (1 - P)]$$

Where P is the fraction of rated power at which the core is operating; K(Z) is the function given in Figure 3.2-3; Z is the core height location of F_Q. $[F_Q]_L$ and K(Z) are dependent on the steam generator tube plugging level as follows:

Plugging level	$[F_Q]_L$	Figure Number for K(Z)
$\leq$ 28%	2.125	3.2-3

(2) Augmented Surveillance (MIDS)

If $[F_Q]_P$, as predicted by approved physics calculations, exceeds $[F_Q]_L$ then the power will be limited to a turnon power fraction, P_T, equal to the ratio of $[F_Q]_L$ divided by $[F_Q]_P$, or, for operation at power levels above P_T, augmented surveillance of hot channel factors shall be implemented, except in Base Load

operation (Section 3.2.6.a(3)) or Radial Burndown operation (Section 3.2.6.a(4)).

For operation at power levels between P_T and 1.00, the following shall apply when not in baseload or radial burndown operation:

1. The axial power distribution shall be measured by MIDS when the thermal power is in excess of P_T such that the limit of $[F_Q]_L/P$ times Figure 3.2-3 is not exceeded. $F_j(Z)$ is the normalized axial power distribution from thimble j at core elevation (Z).

   (1) If $F_j(Z)$ exceeds $[F_j(Z)]_S$ as defined in the bases by $\leq$ 4%, immediately reduce thermal power one percent for every percent by which $[F_j(Z)]_S$ is exceeded.

   (2) If $F_j(Z)$ exceeds $[F_j(Z)]_S$ by > 4% immediately reduce thermal power below P_T. Corrective action to reduce $F_j(Z)$ below the limit will permit return to thermal power not to exceed current P_L as defined in the bases.

2. $F_j(Z)$ shall be determined to be within limits by using MIDS to monitor the thimbles required per specification 6.a.2.3 below at the following frequencies:

   (1) At least once every 24 hours, and

   (2) Immediately following and as a minimum at 2, 4 and 8 hours following the events listed below and every 24 hours thereafter

      1) Raising the thermal power above P_T, or
      2) Movement of control-bank D more than an accumulated total of 15 steps in any one direction.

3. MIDS shall be operable when the thermal power exceeds P_T with:

   (1) At least two thimbles available for which $\overline{R}_j$ and σ_j as defined in the bases have been determined.

   (2) At least two movable detectors available for mapping F_j (Z).

   (3) The continued accuracy and representativeness of the selected thimbles shall be verified by using the most recent flux map as per Table 4.1-1 to update the $\overline{R}$ for each selected thimble.

(3) Base Load Operation

1. Base Load operation may be used at power levels between P_T and P_{BL} or P_T and 1.00 (whichever is most limiting). The maximum relative power permitted under Base Load operation,

P_{BL}, is equal to the minimum value of the ratio of $[F_Q(Z)]_L/[F_Q(Z)]_{BL}^{Meas}$ where $[F_Q(Z)]_{BL}^{Meas}$ is equal to

$[F_Q(Z)]_{Map}^{Meas}$ x W(Z) x 1.09, and $[F_Q(Z)]_L$ is equal to $[F_Q]_L$ X K(Z).

For the purpose of the specification, $[F_Q(Z)]_{Map}^{Meas}$ shall

be obtained between the elevations bounded by ± 10% of the active core height. The function W(Z) is determined analytically and accounts for the most perturbed power shapes which can occur under the constraints of Section 3.2.6.a(3)4. W(Z) corresponding to either ± 2% or ± 3% ΔI may be used to infer P_{BL}. The uncertainty factor of 9.0% accounts for manufacturing tolerances, measurement error, rod bow, and any burnup and power dependent peaking factor increases. Base Load operation can be utilized only if Section 3.2.6.a(3)2 or Section 3.2.6.a(3)3 is satisfied.

2. NOTE: For entering Base Load operation with power less than P_T.

Prior to going to Base Load operation, maintain the following conditions for at least 24 hours:

(1) Relative power must be maintained between P_T/1.05 and P_T.

(2) ΔI within ±2% or ± 3% ΔI target band for at least 23 hours per 24 hour period. The corresponding W(Z) is to have been used to determine P_{BL}.

After 24 hours have elapsed a full core flux map to determine $[F_Q(Z)]_{Map}^{Meas}$ shall be taken unless a valid full core flux map was taken within the time period specified in Section 4.1. P_{BL} is then to be calculated as per Section 3.2.6.a(3)1.

3. NOTE: For entering Base Load operation with power greater than P_T.

Prior to going to Base Load operation and prior to discontinuing augmented surveillance of hot channel factors, maintain the following conditions for at least 24 hours:

(1) Relative power must be maintained between P_T and the power limited by augmented surveillance of hot channel factors.

(2) ΔI within ± 2% or ± 3% ΔI target band. Corresponding W(Z) to have been used to determine P_{BL}.

After 24 hours have elapsed a full core flux map to determine $[F_Q(Z)]_{Map}^{Meas}$ shall be taken unless a valid full core flux map was taken within the time period specified in Section 4.1. P_{BL} is then to be calculated as per Section 3.2.6.a(3)1.

4. If the conditions of Section 3.2.6.a(3)2 or of Section 3.2.6.a(3)3 are satisfied, then Base Load operation may be utilized provided the following is maintained.

   (1) Power between P_T and P_{BL} or P_T and 1.00 (whichever is most limiting).

   (2) ΔI within $\pm$ 2% or $\pm$ 3% ΔI target band. Corresponding W(Z) to have been used to determine P_{BL}.

   (3) Subsequent full core flux maps are taken within the time period specified in Section 4.1.

5. If any of the requirements of Section 3.2.6.a(3)4 are not maintained, then power shall be reduced to less than or equal to P_T, or within 15 minutes augmented surveillance of hot channel factors shall be initiated if the power is above P_T.

(4) Radial Burndown Operation

1. Radial Burndown operation is restricted to use at powers between P_T and P_{RB} or P_T and 1.00 (whichever is most limiting). The maximum relative power permitted under Radial Burndown operation, P_{RB}, is equal to the minimum value of the ratio of $[F_Q(Z)]_L/[F_Q(Z)]_{RB}^{Meas}$ where $[F_Q(Z)]_{RB}^{Meas} = [F_{xy}(Z)]_{Map}^{Meas} \times F_z(Z) \times 1.09$, and $[F_Q(Z)]_L$ is equal to $[F_Q]_L] \times K(Z)$

2. A full core flux map to determine $[F_{xy}(Z)]_{Map}^{Meas}$ shall be taken within the time period specified in Section 4.1.

   For the purpose of the specification, $[F_{xy}(Z)]_{Map}^{Meas}$ shall be obtained between the elevations bounded by $\pm$ 10% of the active core height.

3. The function $F_z(Z)$ is determined analytically and accounts for the most perturbed axial power shapes which can occur under axial power distribution control. The uncertainty factor of 9% accounts for manufacturing tolerances, measurement error, rod bow, and any burnup dependent peaking factor increases.

4. Radial Burndown operation may be utilized at powers between P_T and P_{RB} or P_T and 1.00 (whichever is most limiting) provided that the indicated flux difference is within $\pm$ 5% ΔI of the target axial offset.

5. If any of the requirements of Section 3.2.6.a(4)4 are not maintained, then the power shall be reduced to less than or equal to P_T or within 15 minutes augmented surveillance of hot channel factors shall be initiated if the power is above P_T.

b. (1) The measurement of total peaking factor, $[F_Q(Z)]^{Meas}_{Map}$ shall be increased by three percent to account for manufacturing tolerances and further increased by five percent to account for measurement error. These uncertainties only apply if the map is taken for purposes other than determination of P_{BL} and P_{RB}.

(2) The measurement of the enthalpy rise hot channel factor $F^N_{\Delta H}$, shall be increased by four percent to account for measurement error.

If either measured hot channel factor exceeds its limit specified under Item 6a, the reactor power shall be reduced so as not to exceed a fraction of the rated value equal to the ratio of the F_Q or $F^N_{\Delta H}$ limit to measured value, whichever is less, and the high neutron flux trip setpoint shall be reduced by the same ratio. If subsequent in-core mapping cannot, within a 24 hour period, demonstrate that the hot channel factors are met, the reactor shall be brought to a hot shutdown condition with return to power authorized only for the purpose of physics testing. The reactor may be returned to higher power levels when measurements indicate that hot channel factors are within limits.

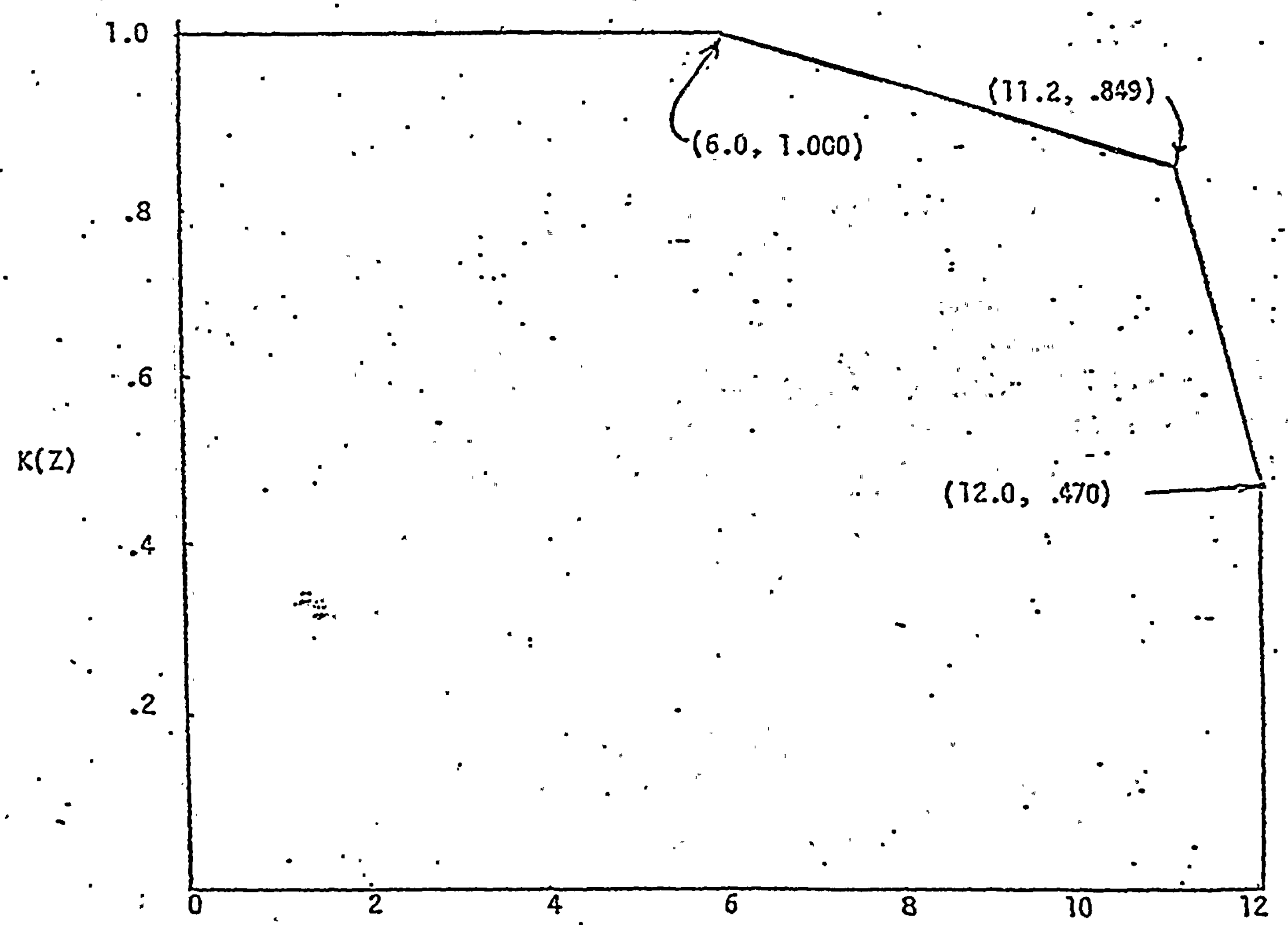
c. The reference equilibrium indicated axial flux difference as a function of power level (called the target flux difference) shall be measured at least once per effective full power quarter. If the axial flux difference has not been measured in the last effective full power month, the target flux difference must be updated monthly by linear interpolation using the most recent measured value and the value predicted for the end of the cycle life.

d. Except during physics tests or during excore calibration procedures and as modified by items 6e through 6g below, the indicated axial flux difference shall be maintained within a $\pm$ 5% band about the target flux difference (this defines the target band on axial flux difference).

e. If the indicated axial flux difference at a power level greater than 90% of the rated power deviates

HOT CHANNEL FACTOR NORMALIZED OPERATING ENVELOPE

(for ≤ 28% steam generator tube plugging and $[F_Q]_L = 2.125$)



6.9.3 SPECIAL REPORTS

Special reports shall be submitted covering the activities identified below pursuant to the requirements of the applicable reference specification where appropriate.

Twenty copies of the following reports should be sent to the Director, Nuclear Reactor Regulation.

a. In-service inspection, reference 4.2.

b. Tendon surveillance, reference 4.4.

c. Fire protection systems, reference 3.14.

d. Peaking Factor Limit Report - The W(Z) function(s) for Base-Load Operation corresponding to a ±2% band about the target flux difference and/or a ±3% band about the target flux difference, the Load-Follow function $F_Z(Z)$ and the augmented surveillance turnon power fraction, P_T, shall be provided to the Director, Nuclear Reactor Regulations, Attention Chief of the Core Performance Branch, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555 at least 60 days prior to cycle initial criticality. In the event that these values would be submitted at some other time during core life, it will be submitted 60 days prior to the date the values would become effective unless otherwise exempted by the Commission.

6.9.4 UNIQUE REPORTING REQUIREMENTS

a. Radioactive Effluent Releases

A report of the quantities of radioactive effluents released from the plant, with data summarized on a monthly basis following the format of U.S. NRC Regulatory Guide 21.

The report shall be submitted within 60 days after January 1 and after July 1 specifying quantities of radioactive effluents released during the previous 6 months of operation.

1. Gaseous Releases

(a) Total radioactivity (in curies) releases of noble and activation gases.

(b) Maximum noble gas release rate during any one-hour period.

(c) Total radioactivity (in curies) released by nuclide, based on representative isotopic analyses performed.

(d) Percent of technical specification limit.

2. Iodine Releases

(a) Total (I-133, I-135) radioactivity (in curies) released.

(b) Total radioactivity (in curies) released, by nuclide, based on representative isotopic analyses performed.

An upper bound envelope as defined by normalized peaking factor axial dependence of Figure 3.2-3, has been determined to be consistent with the technical specifications on power distribution control as given in Section 3.2.

The results of the loss of coolant accident analyses based on this upper bound envelope indicate a peak clad temperature could theoretically exceed the 2200°F limits. To ensure the criteria are not violated, MIDS will be used to provide a more exact indication of F_Q. Note that MIDS and a penalty on F_Q are only required above P_T to meet the acceptance criteria as justified in the analyses. Below P_T, the nuclear analyses of credible power shapes consistent with these specifications have shown that the limit of $[F_Q]_L/P$ times Figure 3.2-3 is not exceeded provided the limits of Figure 3.2-3 are applied.

When an F_Q measurement is taken, both experimental error and manufacturing tolerance must be allowed for. Five percent is the appropriate allowance for a full core map taken with the movable incore detector flux mapping system and three percent is the appropriate allowance for manufacturing tolerance. These uncertainties only apply if the map is taken for purposes other than the determination of P_{BL} and P_{RB}.

In the specified limit of $F^N_{\Delta H}$, there is an 8 percent allowance for uncertainties which means that normal operation of the core is expected to result in $F^N_{\Delta H} \leq 1.55/1.08$. The logic behind the larger uncertainty in this case is that (a) normal perturbations in the radial power shape (e.g., rod misalignment) affect $F^N_{\Delta H}$, in most cases without necessarily affecting F_Q, (b) although the operator has a direct influence on F_Q through movement of rods, and can limit it to the desired value, he has no direct control over $F^N_{\Delta H}$ and(c) an error in the prediction for radial power shape, which may be detected during startup physics tests can be compensated for in F_Q by tighter axial control, but compensation for $F^N_{\Delta H}$ is less readily available. When a measurement of $F^N_{\Delta H}$ is taken, experimental error must be allowed for and 4% is the appropriate allowance for a full core map taken with the movable incore detector flux mapping system.

Measurements of the hot channel factors are required as part of start-up physics tests, at least once each full power month of operation, and whenever abnormal power distribution conditions require a reduction of core power to a level based on measured hot channel factors. The incore map taken following initial loading provides confirmation of the basic nuclear

$$W(Z) = \text{Max}\left(\frac{F_Q(Z)\left(\text{Base Load Case(s), 150 MWD/T}\right)}{F_Q(Z)\left(\text{ARO, 150 MWD/T}\right)}, \frac{F_Q(Z)\left(\text{Base Load Case(s), 85\% EOL BU}\right)}{F_Q(Z)\left(\text{ARO, 85\% EOL BU}\right)}\right)$$

For Radial Burndown operation the full spectrum of possible shapes consistent with control to a $\pm$ 5% ΔI band needs to be considered in determining power capability. Accordingly, to quantify the effect of the limiting transients which could occur during Radial Burndown operation, the function $F_z(Z)$ is calculated from the following relationship:

$$F_z(Z) = [F_Q(Z)]_{FAC\ Analysis}/[F_{xy}(Z)]_{ARO}$$

As discussed above, the essence of the procedure is to maintain the xenon distribution in the core as close to the equilibrium full power condition as possible. This can be accomplished without part length rods* by using the boron system to position the full length control rods to produce the required indicated flux difference.

For Operating Transient events, the core is protected from overpower and a minimum DNBR of less than 1.30 by an automatic protection system. Compliance with operating procedures is assumed as a precondition for Operating Transients, however, operator error and equipment malfunctions are separately assumed to lead to the cause of the transients considered.

Above the power level of P_T, additional flux shape monitoring is required. In order to assure that the total power peaking factor, F_Q, is maintained at or below the limiting value, the movable incore instrumentation will be utilized. Thimbles are selected initially during startup physics tests so that the measurements are representative of the peak core power density. By limiting the core average axial power distribution, the total power peaking factor F_Q can be limited since all other components remain relatively fixed. The remaining part of the total power peaking factor can be derived based on incore measurements, i.e. an effective radial peaking factor $\bar{R}$, can be determined as the ratio of the total peaking factor results from a full core flux map and the axial peaking factor in a selected thimble.

* Any reference to part-length rods no longer applies after the part-length rods are removed from the reactor.

REFERENCES

FSAR - Section 14.3.2

The limiting value of $[F_j(Z)]_S$ is derived as follows:

$$[F_j(Z)]_S = \frac{[F_Q]_L [K(Z)]}{P_L \bar{R}_j (1+\sigma)(1.03)(1.07)}$$

Where:

a) $F_j(Z)$ is the normalized axial power distribution from thimble j at elevation Z.

b) P_L is reactor thermal power expressed as a fraction of 1.

c) K (Z) is the reduction in limit as a function of core elevation (Z) as determined from Figure 3.2-3.

d) $[F_j(Z)]_S$ is the alarm setpoint for MIDS.

e) $\bar{R}_j$, for thimble j, is determined from n=6 incore flux maps covering the full configuration of permissible rod patterns at the thermal power excore limit of P_T

$$\bar{R}_j = \frac{\sum_{i=1}^{n} R_{ij}}{n}$$

where

$$\bar{R}_{ij} = \frac{F_{Qi}^{meas}}{[F_{ij}(Z)]^{MAX}}$$

and $F_{ij}(Z)$ is normalized axial distribution at elevation Z from thimble j in map i which has a measured peaking factor without uncertainties or densification allowance of F_{Qi}^{Meas}.

f) σ_j is the standard deviation, expressed as a fraction or percentage of $\bar{R}_j$, and is derived from n flux maps and the relationship below, or 0.02 (2%), whichever is greater.

$$\sigma_j = \frac{\left[\frac{1}{n-1}\sum_{i=1}^{n}(R_{ij}-\bar{R}_j)^2\right]^{1/2}}{\bar{R}_j}$$

g) The factor 1.03 reduction in the Kw/ft limit is the engineering uncertainty factor.

h) The factors $(1 + \sigma_j)$ and 1.07 represent the margin between $[F_j(Z)]_L$ limit and the MIDS alarm setpoint $[F_j(Z)]_S$. Since $(1 + \sigma_j)$ is bounded by a lower limit of 1.02, there is at least a 9% reduction of the alarm setpoint. Operations are permitted in excess of the operational limit $\leq$ 4% while making power adjustment on a percent for percent basis.