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O. W. DIXON, JR.
VICE PRESIDENT
NUCLEAR OPERATIONS

June 19, 1984

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Virgil C. Summer Nuclear Station
Docket No. 50/395
Operating License No. NPF-12
Reactor Coolant System Flow

Dear Mr. Denton:

South Carolina Electric and Gas Company hereby requests a revision to the Virgil C. Summer Nuclear Station Technical Specifications. This revision involves changes to Technical Specifications concerning the measurement uncertainty for the Reactor Coolant System (RCS) flow rate and defines allowable power levels for an RCS flow rate less than 100% of Thermal Design flow.

Attachment 1 contains the proposed amended pages to the Technical Specifications and Attachment 2 provides an explanation and justification for these proposed changes. Attachment 3 provides the results of an analysis, pursuant to 10 CFR 50.91, which concludes that the proposed changes do not involve a significant hazards consideration.

These changes have been reviewed and approved by the Plant Safety Review Committee and the Nuclear Safety Review Committee. A check in the amount of four thousand dollars ($4000.00) is enclosed for processing this change.

Should you have any questions, please contact us at your convenience.

Very truly yours,

O. W. Dixon, Jr.

AMM/OWD/gj
Attachments:

cc: (see page #2)

No Check
Rec'd

A001
1/1

cc: V. C. Summer
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POWER DISTRIBUTION LIMITS

3/4.2.3 RCS FLOW RATE AND NUCLEAR ENTHALPY RISE HOT CHANNEL FACTOR

LIMITING CONDITION FOR OPERATION

3.2.3 The combination of indicated Reactor Coolant System (RCS) total flow rate and R_1, R_2 shall be maintained within the region of allowable operation shown on Figure 3.2-3 for 3 loop operation.

Where:

a. $R_1 = \dfrac{F^N_{\Delta H}}{1.49\ [1.0 + 0.2\ (1.0 - P)]}$,

b. $R_2 = \dfrac{R_1}{[1 - RBP(BU)]}$,

c. $P = \dfrac{\text{THERMAL POWER}}{\text{RATED THERMAL POWER}}$,

d. $F^N_{\Delta H}$ = Measured values of $F^N_{\Delta H}$ obtained by using the movable incore detectors to obtain a power distribution map. The measured values of $F^N_{\Delta H}$ shall be used to calculate R since Figure 3.2-3 includes measurement uncertainties of ~~3.5%~~ 2.0% for flow and 4% for incore measurement of $F^N_{\Delta H}$, and

e. RBP (BU) = Rod Bow Penalty as a function of region average burnup as shown in Figure 3.2-4, where a region is defined as those assemblies with the same loading date (reloads) or enrichment (first core).

APPLICABILITY: MODE 1.

ACTION:

With the combination of RCS total flow rate and R_1, R_2 outside the region of acceptable operation shown on Figure 3.2-3:

a. Within 2 hours either:

1. Restore the combination of RCS total flow rate and R_1, R_2 to within the above limits, or
2. Reduce THERMAL POWER to less than 50% of RATED THERMAL POWER and reduce the Power Range Neutron Flux - High trip setpoint to less than or equal to 55% of RATED THERMAL POWER within the next 4 hours.

HEAT FLUX HOT CHANNEL FACTOR and RCS FLOWRATE and NUCLEAR ENTHALPY RISE HOT CHANNEL FACTOR (Continued)

c. The control rod insertion limits of Specifications 3.1.3.5 and 3.1.3.6 are maintained.

d. The axial power distribution, expressed in terms of AXIAL FLUX DIFFERENCE, is maintained within the limits.

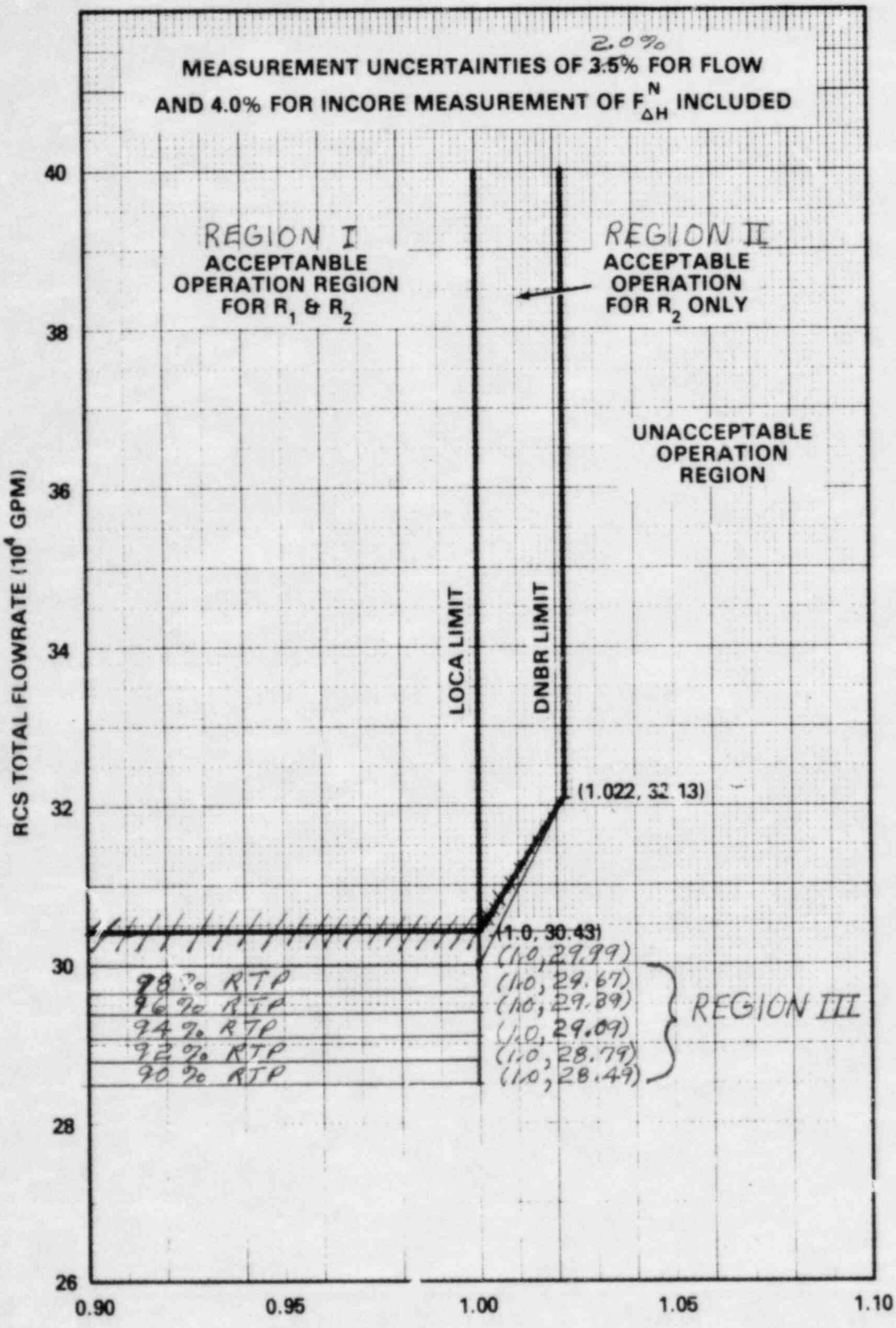
$F^N_{\Delta H}$ will be maintained within its limits provided conditions a. through d. above are maintained. As noted on Figures 3.2-3 and 3.2-4, RCS flow rate and $F^N_{\Delta H}$ may be "traded off" against one another (i.e., a low measured RCS flow rate is acceptable if the measured $F^N_{\Delta H}$ is also low) to ensure that the calculated DNBR will not be below the design DNBR value. The relaxation of $F^N_{\Delta H}$ as a function of THERMAL POWER allows changes in the radial power shape for all permissible rod insertion limits.

R_1, as calculated in 3.2.3 and used in Figure 3.2.3, accounts for $F^N_{\Delta H}$ less than or equal to 1.49. This value is used in the various accident analyses where $F^N_{\Delta H}$ influences parameters other than DNBR, e.g., peak clad temperature and thus is the maximum "as measured" value allowed. R_2, as defined, allows for the inclusion of a penalty for rod bow on DNBR only. Thus knowing this "as measured" values of $F^N_{\Delta H}$ and RCS flow allows for "tradeoffs" in excess of R equal to 1.0 for the purpose of offsetting the rod bow DNBR penalty.

When an F_Q measurement is taken, an allowance for both experimental error and manufacturing tolerance must be made. An allowance of 5% is appropriate for a full core map taken with the incore detector flux mapping system and a 3% allowance is appropriate for manufacturing tolerance.

The radial peaking factor $F_{xy}(Z)$ is measured periodically to provide assurance that the hot channel factor, $F_Q(Z)$, remains within its limit. The F_{xy} limit for Rated Thermal Power (F^{RTP}_{xy}) as provided in the Radial Peaking Factor Limit Report per specification 6.9.1.14 was determined from expected power control maneuvers over the full range of burnup conditions in the core.

When RCS flow rate and $F^N_{\Delta H}$ are measured, no additional allowances are necessary prior to comparison with the limits of Figures 3.2-3 and 3.2-4. Measurement errors of ~~3.5%~~ 2.0% for RCS total flow rate and 4% for $F^N_{\Delta H}$ have been allowed for in determination of the design DNBR value.



$$R_1 = F^N_{\Delta H} / 1.49 [1.0 + 0.2 (1.0 - P)]$$

$$R_2 = R_1 / [1.0 - RBP (BU)]$$

NOTE: When operating in Region III, the restricted power levels shall be considered to be 100% of Rated Thermal Power (RTP) for Figure 2.1-1.

Figure 3.2-3 RCS FLOW RATE VERSUS R

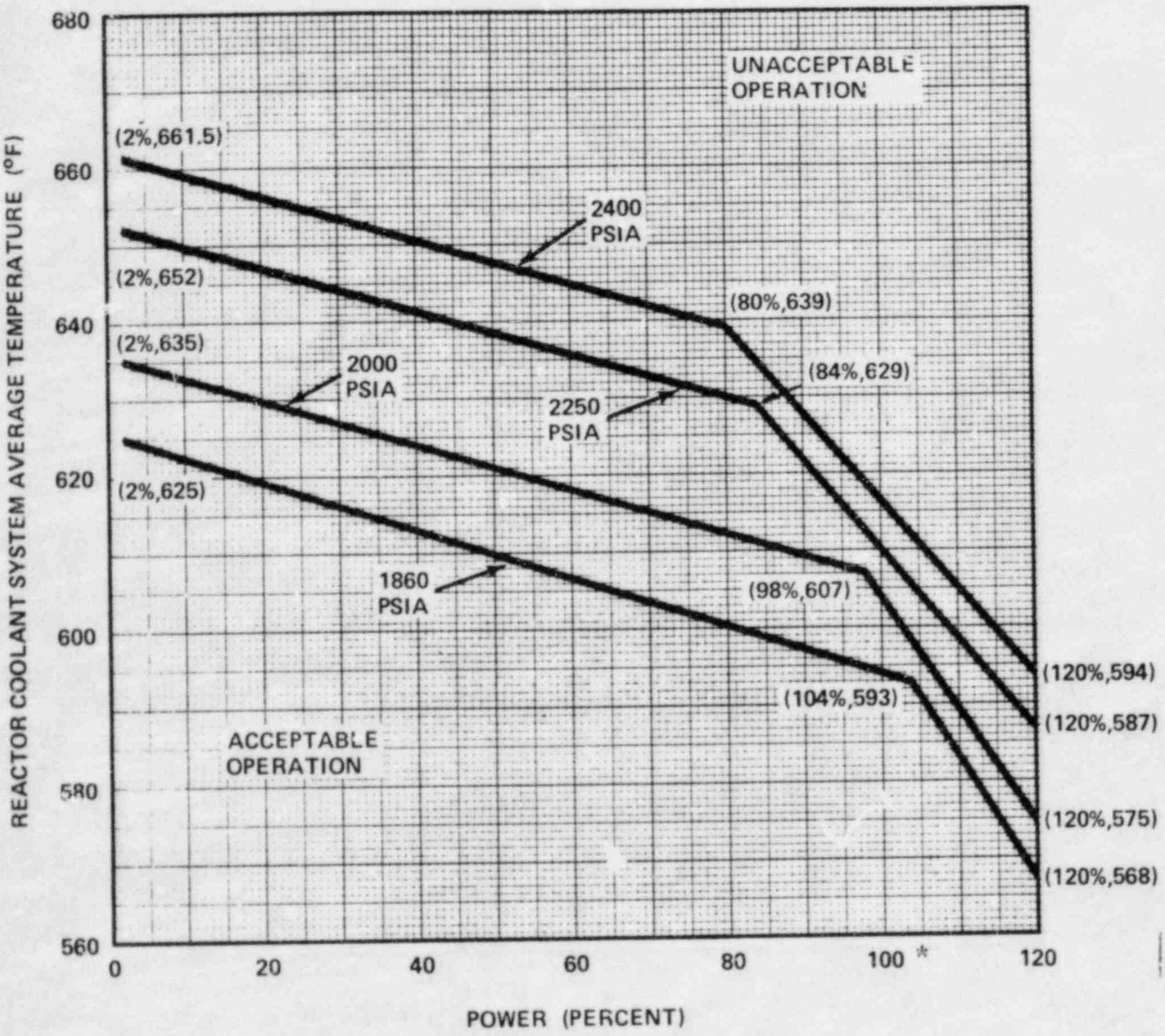


Figure 2.1-1
Reactor Core Safety Limit - Three Loops in Operation

* When operating in Region III of Technical Specificial 3.2.3 (Figure 3.2-3), the restricted power level must be considered 100% RTP for this figure.

ATTACHMENT 2

REACTOR COOLANT SYSTEM (RCS) FLOW RATE MEASUREMENT

The RCS flow rate measurement is required by Technical Specification 4.2.3.2 at least once every thirty-one (31) EFPD. This is accomplished with elbow tap flow instrumentation using the process computer display after normalizing the elbow tap flow measurement with a precision heat balance across the steam generators. The precision heat balance is performed once per eighteen (18) months according to Specification 4.2.3.5.

The elbow tap flow measurement is presently the basis for the Technical Specification total flow measurement uncertainty. Normalizing the elbow tap flow measurement with the precision heat balance reduces the uncertainty by eliminating errors due to the transmitter calibration and temperature and pressure effects. Thus, with a more accurate determination of RCS flowrate, the required measured flow rate can be reduced. Whenever the process computer display is unavailable, the RCS flow rate will be determined using digital voltmeter (DVM) readings from the elbow tap process racks.

Specification 3.2.3, RCS Flow Rate and Nuclear Enthalpy Rise Hot Channel Factor, in the Standard Technical Specifications requires that total reactor flow (total flow through the vessel from all loops) be above some minimum value. The minimum flow value is Thermal Design flow corrected for the total flow measurement uncertainties. Historically, the uncertainty has been specified as 3.5%. Flow measurement uncertainties much less than this can be achieved by using modern statistical error analyses and normalizing elbow tap flow indications with a precision calorimetric flow measurement. The accuracy achieved by this technique depends primarily on the measurement procedure employed and how well the instrument errors are understood and controlled by plant personnel. The normalization of the elbow tap flow measurement with the precision calorimetric flow calculation, the measurements required and the measurement uncertainty analyses are described in the following paragraphs and tables.

Reactor coolant loop flow is determined from the steam generator thermal output, corrected for the loop's share of the net pump heat input, and the enthalpy rise (Δh) of the coolant. Total reactor flow is the sum of the individual loop flows. Table 1 lists the calorimetric equations and defines the terms.

To establish the overall flow measurement uncertainty, the accuracy and relationship to RCS flow of each instrument used for the calorimetric measurements must be determined. Instrumentation for the elbow tap flow indication is depicted in Figure 1. Table 2 provides the list of components involved in the precision calorimetric flow calculations. The overall loop flow measurement uncertainty is the statistical summation of individual uncertainties (accounting for interactive effects where necessary) and appears at the bottom of Table 2

To establish the overall uncertainty for the process computer and DVM elbow tap flow measurement, the accuracy and relationship of all instrumentation to the RCS flow must be determined. There are several components (transducer, converter, isolator, etc.) which contribute to the overall uncertainty of the measurement. Tables 3 and 4 list and define uncertainties from the elbow tap flow transmitters to the process computer and DVM using three (3) taps (one (1) per loop). The overall loop flow measurement uncertainty is the statistical summation of individual uncertainties and appears in Table 3 and 4.

Table 5 statistically combines the overall precision calorimetric measurement uncertainty and the uncertainty of the elbow tap flow indication using three (3) taps. The total flow uncertainty using three (3) normalized elbow taps (1 per loop) with the process computer display is 2.0%. The total flow uncertainty using three (3) normalized elbow taps (1 per loop) with the DVM reading is ±1.99%. Based upon this, the RCS flow measurement uncertainty included in Techncial Specification 3/4.2.3 is conservatively chosen to be 2.0%

In summary, individual loop flow is determined by performance of a precision calorimetric and these values are used to normalize elbow tap measurements. The loop flow measurements are summed to arrive at the total RCS flow. The measurement uncertainty is determined by statistically combining precision calorimetric and elbow tap flow measurement uncertainties. A precision calorimetric flow measurement must be performed to normalize the elbow taps to take credit for this particualr measurement uncertainty.

This proposed change has no adverse safety implications since the Thermal Design flow rate which is utilized in various safety analyses is unchanged.

TABLE 1

REACTOR COOLANT LOOP FLOW CALCULATION

$$W_L = \frac{(Y)[Q_{SG} - Q_p + \frac{(Q_L)}{N}](Vc)}{[h_H - h_C]}$$

Where:
W_L = Loop flow (gpm)
Q_{SG} = Steam generator thermal output (Btu/hr.)
Q_L = Primary system net heat losses (Btu/hr.)
N = Number of loops
Q_p = Reactor coolant pump heat added (Btu/hr.)
h_H = Hot leg enthalpy (Btu/lb.)
h_C = Cold leg enthalpy (Btu/lb.)
V_c = Cold leg specific volume (cu. ft./lb.)
Y = 0.1247 gpm/(ft^3/hr)

$$Q_{SG} = (h_s - h_f)W_F$$

Where:
h_s = Steam enthalpy (Btu/lbm)
h_F = Feedwater enthalpy (Btu/lbm)
W_F = Feedwater flow (LBM/Hr)

$$W_F = (K)\ (Fa)\sqrt{p_F\ \Delta P}$$

Where:
K = Feedwater venturi flow coefficient
Fa = Feedwater venturi correction for thermal expansion
p_F = Feedwater density (lb/cu.ft.)
ΔP = Feedwater venturi pressure drop (inches H_2O)

TABLE 2

CALORIMETRIC FLOW MEASUREMENT UNCERTAINTIES

COMPONENT	INSTRUMENT ERROR	UNCERTAINTY % POWER OR % FLOW
Feedwater Flow		
Venturi K	± 0.5% K	± 0.5%
Thermal Expansion coefficient		
Temperature	± 0.54°F	± 0.06%
Material	± 5.0%	
Density		
Temperature	± 0.54°F	± 0.04%
Pressure	± 60 psi	
DP Cell Calibration	± 0.5%	± 0.39%
DP Cell Reading Uncertainty	± 1.0%	± 0.78%
Feedwater Enthalpy		
Temperature	± 0.54°F	± 0.08%
Pressure	± 60 psi	
Steam Enthalpy		
Transducer Calibration	± 1.5 psi	0.006%
Moisture Carryover	± 0.25%	± 0.22%
Primary Enthalpy		
T_H RTD	± 0.5°F	± 0.95%
T_H RTD Bridge	± 0.554°F	± 1.044
T_H Temperature Streaming	± 1.2°F	± 2.27%
T_H Pressure Effect (including drift allowance)	± 12.8 psi	± 0.102
T_C RTD	± 0.5°F	± 0.775
T_C RTD Bridge	± 0.554°F	± 0.868
T_C Pressure Effect (including drift allowance)	± 12.8 psi	± 0.026
Net Pump Heat Addition	± 20%	± 0.085%
Total Loop Flow Uncertainty	$\sqrt{\Sigma e^2}$	3.096
Total Reactor Flow Uncertainty		1.788

FIGURE 1

FLOW INDICATION INSTRUMENTATION

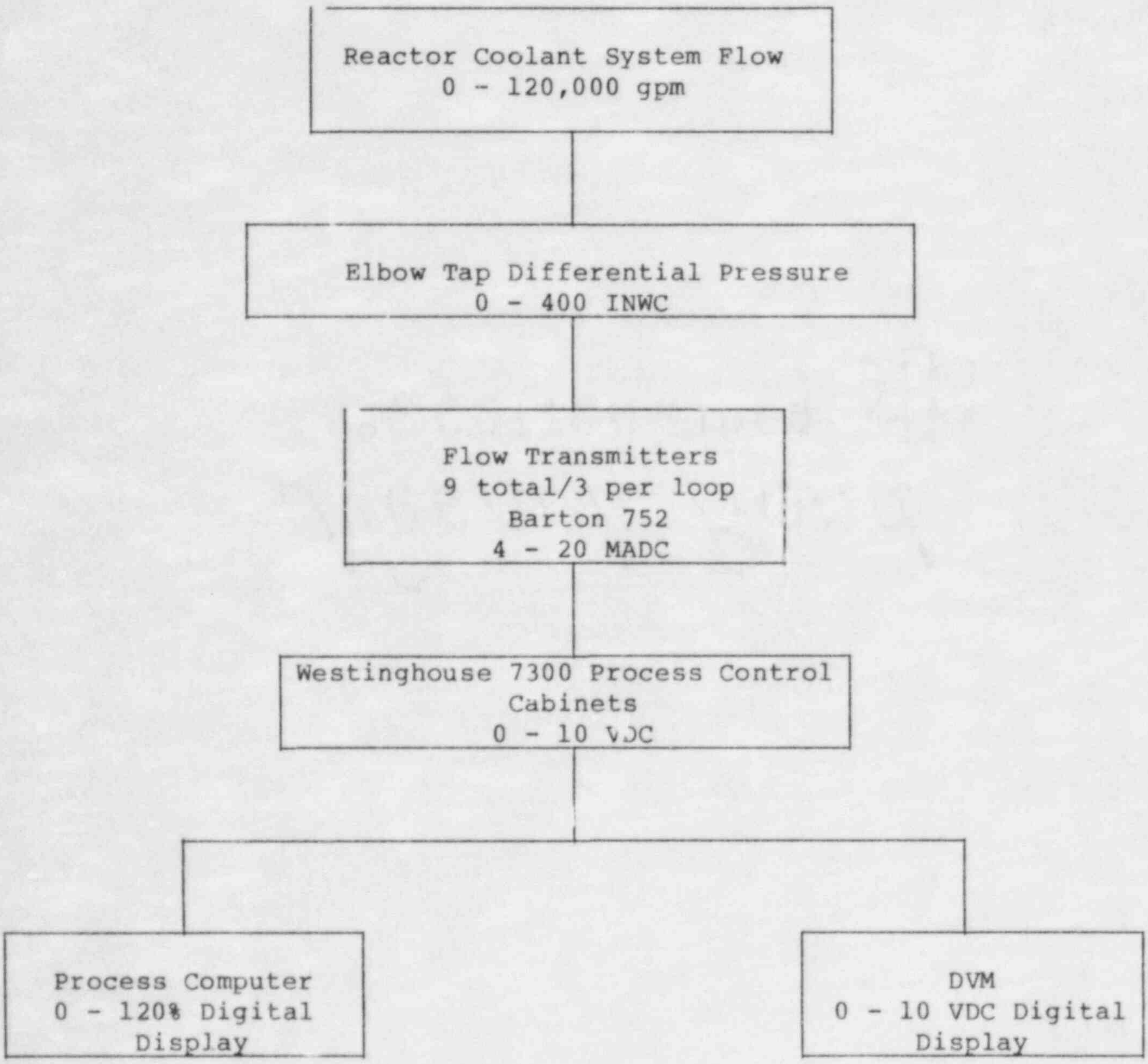


TABLE 3

PROCESS COMPUTER ELBOW TAP RCS FLOW INDICATION UNCERTAINTY

Parameter	%RCS Flow Uncertainty
PMA	±0.30%
PEA	±0.36%
SCA	±0.00%
SPE	±0.00%
STE	±0.00%
SD	±0.72%
RCA	±0.50%
RTE	±0.00%
RD	±0.72%
ID	±0.36%
RO	±0.36%

$$CU = \left[[(PMA)^2 + (PEA)^2 + (SCA+SD)^2 + (STE)^2 + (SPE)^2 + (RCA+RD)^2 + (RTE)^2 + (ID)^2 + (RO)^2 \right]^{1/2}$$

Where:

CU = Channel Uncertainty
PMA = Process Measurement Accuracy
PEA = Primary Element Accuracy
SCA = Sensor Calibration Accuracy
SPE = Sensor Pressure Effects
SD = Sensor Drift
STE = Sensor Temperature Effects
RCA = Rack Calibration Accuracy
RD = Rack Drift
ID = Computer Isolator Drift
RO = Allowance for Noisy Signal
RTE = Rack Temperature Effects

Total Loop Channel Uncertainty with 1 tap = ±1.577%
Total RCS Channel Uncertainty w/3 loops = ±0.910%

TABLE 4

DVM ELBOW TAP RCS FLOW INDICATION UNCERTAINTY

Parameter	%RCS Flow Uncertainty
PMA	±0.30%
PEA	±0.36%
SCA	±0.00%
SPE	±0.00%
STE	±0.00%
SD	±0.72%
RCA	±0.50%
RTE	±0.00%
RD	±0.72%
RO	±0.36%
DVM	±0.25%

$$CU = \left[\begin{array}{l} [(PMA)^2 + (PEA)^2 + (SCA+SD)^2 + (STE)^2 + (SPE)^2 + \\ (RCA+RD)^2 + (RTE)^2 + (RO)^2 + (DVM)^2] \end{array} \right]^{1/2}$$

Where:

CU = Channel Uncertainty
PMA = Process Measurement Accuracy
PEA = Primary Element Accuracy
SCA = Sensor Calibration Accuracy
SPE = Sensor Pressure Effects
SD = Sensor Drift
STE = Sensor temperature Effects
RCA = Rack Calibration Accuracy
RD = Rack Drift
RO = Allowance for Noisy Signal
DVM = Digital Voltmeter Uncertainty
RTE = Rack Temperature Effects

Total Loop Channel Uncertainty with 1 tap = ±1.535%
Total RCS Channel Uncertainty w/3 loops = ±0.886%

TABLE 5

TOTAL RCS FLOW UNCERTAINTY

Total Precision Calorimetric RCS Flow Uncertainty	=	±1.788%	(Table 2)
Total RCS Elbow Tap Channel Uncertainty utilizing process computer display	=	±0.910%	(Table 3)
Total RCS Elbow Tap Channel Uncertainty utilizing DVM readings	=	±0.866%	(Table 4)

By Sum of Squares Method:

Total RCS Uncertainty using process computer display	=	+2.00%
Total RCS Uncertainty using DVM readings	=	+1.99%

Based on the above:

Total RCS Uncertainty included in Specification 3/4.2.3	=	+2.0%

RCS FLOW RATE LESS THAN THERMAL DESIGN (TD) FLOW

Current Technical Specification 3.2.3, Figure 3.2-3 limits operation to less than 5% of Rated Thermal Power (RTP) should measured RCS Flow be less than the TD flow used in the plant safety analyses. This Technical Specification does not recognize the possibility of a long term reduction in flow, nor the various trade-offs allowed by the relationships between flow, departure from nucleate boiling (DNB), and core power.

These trade-offs can be used to justify continued operation at some reduced maximum allowed power if the measured RCS flow is less than the TD flow.

It is widely recognized that the relationships between core power, flow, and DNB are:

$$\frac{\partial \text{ Flow}}{\partial \text{ DNB}} = \frac{1\%}{1\%} \qquad \text{(Eq. 1)}$$

$$\frac{\partial \text{ Power}}{\partial \text{ DNB}} = \frac{1\%}{1.8\%} \qquad \text{(Eq. 2)}$$

Thus the relationship between Power and Flow is:

$$\frac{\partial \text{ Power}}{\partial \text{ Flow}} = \frac{1\%}{1.8\%} \qquad \text{(Eq. 3)}$$

Based on a conservative assumption that the measured RCS flow will be no lower than 95% of TD flow, it is requested that a region of acceptable operation be added to Figure 3.2.3 for:

95% TD Flow $\leq$ RCS Flow $\leq$ 100% TD Flow

Considering the relationship given by Equation 3, it is recommended that the maximum power level for this region be reduced by 2% for each 1% reduction in measured flow below TD flow. This conservative restriction of core power is the equivalent of an RCS flow increase ranging from approximately 2.6% - 13.0% in terms of DNB margin for flow deficits up to 5%. Operation of the plant in this region within the specified power restriction does not result in increased Tavg, thus there is no temperature impact on the DNB margin.

The Technical Specifications and accident analyses results have been evaluated to determine the impact of operating within the defined new region of Figure 3.2-3 with the imposed restrictions. In all cases, sufficient margin exists to allow continued plant operations. No Technical Specification limits require modification, including core limits, OTΔT, OPΔT, and Power Range Neutron Flux High setpoints.

The core limits remain the same due to the increased margin to DNB afforded by the power reduction and interpretation that they will be valid for the restricted power levels. This implies that under these conditions the restricted power level should be considered to be 100% of Rated Thermal Power (RTP) for Figure 2.1-1. With this restriction applied to the Safety limits, there is no change in the core limits thus the OTΔT and OPΔT trip setpoints remain unchanged. Utilizing the latest Westinghouse data, the uncertainty in the instrumentation for the Power Range Neutron Flux High trip function is 4.7% span (or 5.7% RTP). With a normal assumption of reactor trip at 109% RTP, the uncertainty analysis verifies that a trip will take place at 109% RTP plus 5.7% uncertainty or 114.7% RTP. A 5% reduction in RCS flow requires a trip at 115.2% RTP. Therefore, adequate margin exists in the instrumentation such that no change in the nominal setpoint is necessary.

If the measured RCS flow is equal to or greater than TD flow, operation will be in the acceptable region of the present Figure 3.2-3 and the requirements of this specification will remain unchanged. The addition of the new region to Figure 3.2-3 is only requested to preclude a needless reduction to 5% RTP should the measured RCS flow be less than TD flow.

ATTACHMENT 3

SIGNIFICANT HAZARDS CONSIDERATION

The proposed amendment to the Technical Specifications does not involve a significant hazards consideraton for the following reasons.

The proposed change to Figure 3.2-3 to account for a reduction in measurement uncertainties (3.5% to 2.0%) for RCS flow has no effect on the Thermal Design flow. The Thermal Design flow which is utilized in the various safety analyses remains unchanged. In regard to the change which defines allowable power levels for an RCS flow rate less than 100% of Thermal Design flow, thermal-hydraulic sensitivity studies have shown that this power/flow tradeoff is conservative with respect to DNB margin.