

1.1 FUEL CLADDING INTEGRITYApplicability

The Safety Limits established to preserve the fuel cladding integrity apply to those variables which monitor the fuel thermal behavior.

Objective

The objective of the Safety Limits is to establish limits below which the integrity of the fuel cladding is preserved.

Specifications

- A. Reactor Pressure  $\geq$  800 psia and Core Flow  $\geq$  10% of Rated

The existence of a minimum critical power ratio (MCPR) less than 1.07 for two recirculation loop operation (1.08 for single-loop operation greater than 24 hours), shall constitute violation of the fuel cladding integrity safety.

- B. Core Thermal Power Limit (Reactor Pressure  $<$  800 psia and/or Core Flow  $<$  10%)

When the reactor pressure is  $<$  800 psia or core flow is less than 10% of rated, the core thermal power shall not exceed 25% of rated thermal power.

- C. Power Transient

To ensure that the Safety Limit established in Specification 1.1.A and 1.1.B is not exceeded, each required scram shall be initiated by its expected scram signal. The Safety Limit shall be assumed to be exceeded when scram is accomplished by a means other than the expected scram signal.

2.1 FUEL CLADDING INTEGRITYApplicability

The Limiting Safety System Settings apply to trip settings of the instruments and devices which are provided to prevent the fuel cladding integrity Safety Limits from being exceeded.

Objective

The objective of the Limiting Safety System Settings is to define the level of the process variables at which automatic protective action is initiated to prevent the fuel cladding integrity Safety Limits from being exceeded.

Specifications

- A. Trip Settings

The limiting safety system trip settings shall be as specified below:

1. Neutron Flux Trip Settings

- a. APRM Flux Scram Trip Setting (Run Mode)

When the Mode Switch is in the RUN position, the APRM flux scram trip setting shall be:

$$S \leq 0.66 W + 54\% - .66\Delta W$$

where:

S = Setting in percent of rated thermal power (2381 MWt).

W = Two-loop recirculation flow rate in percent of rated (rated loop recirculation flow rate is that recirculation flow rate which provides 100% core flow at 100% power).

$\Delta W$  = Difference between two-loop and single-loop effective drive flow at the same core flow. This factor is applied for single loop operation greater than 24 hours.

$\Delta W = 0$  for two recirculation loop operation and single loop operation less than 24 hours.

## SAFETY LIMITS

## 1.1.D (Cont'd)

Whenever the reactor is in the cold shutdown condition with irradiated fuel in the reactor vessel, the water level shall not be less than 18 in. above the top of the normal active fuel zone (top of active fuel is defined in Figure 2.1.1).

## LIMITING SAFETY SYSTEM SETTINGS

## 2.1.A.1 (Cont'd)

- a. In the event of operation with a maximum fraction of limiting power density (MFLPD) greater than the fraction of rated power (FRP), the setting shall be modified as follows:

$$S \leq (0.66W + 54\% - 0.66\Delta W) \frac{FRP}{MFLPD}$$

where,

FRP = Fraction of rated thermal power (2381 MWt).

MFLPD = Maximum fraction of limiting power density where the limiting power density is 18.5 KW/ft for 7x7 fuel and 13.4 KW/ft for 8x8 fuel.

The ratio of FRP to MFLPD shall be set equal to 1.0 unless the actual operating value is less than the design value of 1.0, in which case the actual operating value will be used.

For no combination of loop recirculation flow rate and core thermal power shall the APRM flux scram trip setting be allowed to exceed 120% of rated thermal power.

- b. APRM Flux Scram Trip Setting (Refuel or Start and Hot Standby Mode)

When the reactor mode switch is in the REFUEL or STARTUP position, the APRM scram shall be set at less than or equal to 15% of rated power.

- c. IRM

The IRM flux scram setting shall be  $\leq 120/125$  of scale.

## 2.1.A.1 (Cont'd)

d. APRM Rod Block Trip Setting

The APRM rod block trip setting shall be:

$$S_{RB} \leq 0.66W + 42\% - .66\Delta W$$

where:

$S_{RB}$  = Rod block setting in percent of rated thermal power (2381 MWt).

W and  $\Delta W$  are defined in Specification 2.1.A.1.a

In the event of operation with a maximum fraction of limiting power density (MFLPD) greater than the fraction of rated power (FRP), the setting shall be modified as follows:

$$S_{RB} \leq (0.66W + 42\% - 0.66\Delta W) \frac{FRP}{MFLPD}$$

where,

FRP = Fraction of rated thermal power (2381 MWt).  
MFLPD = Maximum fraction of limiting power density where the limiting power density is 18.5 KW/ft for 7x7 fuel and 13.4 KW/ft for 8x8 fuel.

The ratio of FRP to MFLPD shall be set equal to 1.0 unless the actual operating value is less than the design value of 1.0, in which case the actual operating value will be used.

2. Reactor Water Low Level Scram and Isolation Trip Setting Except MSIV

$\geq + 12.5$  in. on vessel level instruments.

## 1.1 Bases:

### Fuel Cladding Integrity:

#### A. Fuel Cladding Integrity Limit at Reactor Pressure >800 psia and Core Flow >10% of Rated

The fuel cladding integrity safety limit is set such that no fuel damage is calculated to occur if the limit is not violated. Since the parameters which result in fuel damage are not directly observable during reactor operation the thermal and hydraulic conditions resulting in a departure from nucleate boiling have been used to mark the beginning of the region where fuel damage could occur. Although it is recognized that a departure from nucleate boiling would not necessarily result in damage to BWR fuel rods, the critical power at which boiling transition is calculated to occur has been adopted as a convenient limit. However, the uncertainties in monitoring the core operating state and in the procedure used to calculate the critical power result in an uncertainty in the value of the critical power. Therefore, the fuel cladding integrity safety limit is defined as the critical power ratio in the limiting fuel assembly for which more than 99.9% of the fuel rods in the core are expected to avoid boiling transition considering the power distribution within the core and all uncertainties.

The Safety Limit MCPR is generically determined in Reference 1 for two recirculation loop operation. This safety limit MCPR is increased by 0.01 for single-loop operation for a period greater than 24 hours as discussed in Reference 2.

#### B. Core Thermal Power Limit (Reactor Pressure <800 psia or Core Flow <10% of Rated)

At pressures below 800 psia, the core elevation pressure drop (0 power, 0 flow) is greater than 4.56 psi. At low power and all flows this pressure differential is maintained in the bypass region of the core. Since the pressure drop in the bypass region is essentially all elevation head, the core pressure drop at low power and all flows will always be greater than 4.56 psi. Analyses show that with a flow of  $28 \times 10^3$  lbs/hr bundle flow, bundle pressure drop is nearly independent of bundle power and has a value of 3.5 psi. Thus, the bundle flow with a 4.56 psi driving head will be greater than  $28 \times 10^3$  lbs/hr irrespective of total core flow and independent of bundle power for the range of bundle powers of concern. Full scale ATLAS test data taken at pressures from 14.7 psia to 800 psia indicate that the fuel assembly critical power at this flow is approximately 3.35 MWt. With the design peaking factors this corresponds to a core thermal power of more than 50%. Thus, a core thermal power limit of 25% for reactor pressures below 800 psi or core flow less than 10% is conservative.

#### C. Power Transient

Plant safety analyses have shown that the scrams caused by exceeding any safety setting will assure that the Safety Limit of Specification 1.1A or 1.1B will not be exceeded. Scram times are checked periodically to assure the insertion times are adequate. The thermal power transient resulting when a scram is accomplished other than by the expected scram signal (e.g., scram from neutron flux following closure of the main turbine stop valves) does not necessarily cause fuel damage. However, for this specification a Safety Limit violation will be assumed when a scram is only accomplished by means of a backup feature of the plant design. The concept of not approaching a Safety Limit provided scram signals are operable is supported by the extensive plant safety analysis.

## 1.1 Bases: (Cont'd)

The computer provided with Cooper has a sequence annunciation program which will indicate the sequence in which events such as scram, APRM trip initiation, pressure scram initiation, etc. occur. This program also indicates when the scram setpoint is cleared. This will provide information on how long a scram condition exists and thus provide some measure of the energy added during a transient. Thus, computer information normally will be available for analyzing scrams; however, if the computer information should not be available for any scram analysis, Specification 1.1.C will be relied on to determine if a Safety Limit has been violated.

### D. Reactor Water Level (Shutdown Condition)

During periods when the reactor is shutdown, consideration must also be given to water level requirements due to the effect of decay heat. If reactor water level should drop below the top of the active fuel during this time, the ability to cool the core is reduced. This reduction in core cooling capability could lead to elevated cladding temperatures and clad perforation. The core can be cooled sufficiently should the water level be reduced to two-thirds the core height. Establishment of the safety limit at 18 inches above the top of the fuel provides adequate margin.

### References

1. "Generic Reload Fuel Application," NEDE-24011-P (most current approved submittal).
2. "Cooper Nuclear Station Single-Loop Operation," NEDO-24258, May, 1980.



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## 2.1 Bases:

The abnormal operational transients applicable to operation of the CNS Unit have been analyzed throughout the spectrum of planned operating conditions up to 105% of rated steam flow. The analyses were based upon plant operation in accordance with Reference 3. In addition, 2381 MWt is the licensed maximum power level of CNS, and this represents the maximum steady-state power which shall not knowingly be exceeded.

The transient analyses performed each reload are given in Reference 1. Models and model conservatisms are also described in this reference. As discussed in Reference 2, the core wide transient analyses for one recirculation pump operation is conservatively bounded by two-loop operation analyses and the flow-dependent rod block and scram setpoint equations are adjusted for one-pump operation.

### A. Trip Settings

The bases for individual trip settings are discussed in the following paragraphs.

#### 1. Neutron Flux Trip Settings

##### a. APRM Flux Scram Trip Setting (Run Mode)

The average power range monitoring (APRM) system, which is calibrated using heat balance data taken during steady state conditions, reads in percent of rated thermal power (2381 MWt). Because fission chambers provide the basic input signals, the APRM system responds directly to average neutron flux. During transients, the instantaneous rate of heat transfer from the fuel (reactor thermal power) is less than the instantaneous neutron flux due to the time constant of the fuel. Therefore, during abnormal operational transients, the thermal power of the fuel will be less than that indicated by the neutron flux at the scram setting. Analyses demonstrate that with a 120 percent scram trip setting, none of the abnormal operational transients analyzed violate the fuel Safety Limit and there is a substantial margin from fuel damage. Therefore, the use of flow referenced scram trip provides even additional margin.

## 2.1 Bases: (Cont'd)

An increase in the APRM scram trip setting would decrease the margin present before the fuel cladding integrity Safety Limit is reached. The APRM scram trip setting was determined by an analysis of margins required to provide a reasonable range for maneuvering during operation. Reducing this operating margin would increase the frequency of spurious scrams which have an adverse effect on reactor safety because of the resulting thermal stresses. Thus, the APRM scram trip setting was selected because it provides adequate margin for the fuel cladding integrity Safety Limit yet allows operating margin that reduces the possibility of unnecessary scrams.

The scram trip setting must be adjusted to ensure that the LHGR transient peak is not increased for any combination of maximum fraction of limiting power density (MFLPD) and reactor core thermal power. The scram setting is adjusted in accordance with the formula in Specification 2.1.A.1.a, when the MFLPD is greater than the fraction of rated power (FRP). This adjustment may be accomplished by increasing the APRM gain and thus reducing the slope and intercept point of the flow referenced APRM High Flux Scram Curve by the reciprocal of the APRM gain change.

Analyses of the limiting transients show that no scram adjustment is required to assure MCPR above the safety limit when the transient is initiated from the operating MCPR limit.

### b. APRM Flux Scram Trip Setting (Refuel or Start & Hot Standby Mode)

For operation in the startup mode while the reactor is at low pressure, the APRM scram setting of 15 percent of rated power provides adequate thermal margin between the setpoint and the safety limit, 25 percent of rated. The margin is adequate to accommodate anticipated maneuvers associated with power plant startup. Effects of increasing pressure at zero or low void content are minor, cold water from sources available during startup is not much colder than that already in the system, temperature coefficients are small, and control rod patterns are constrained to be uniform by operating procedure backed up by the rod worth minimizer, and the rod sequence control system. Worth of individual rods is very low in a uniform rod pattern. Thus, of all possible sources of reactivity input, uniform control rod withdrawal is the most probable cause of significant power rise. Because the flux distribution associated with uniform rod withdrawals does not involve high local peaks, and because several rods must be moved to change power by a significant percentage of rated power, the rate of power rise is very slow. Generally, the heat flux is in near equilibrium with the fission rate. In an assumed uniform rod withdrawal approach to the scram level, the rate of power rise is no more than 5 percent of rated power per minute, and the APRM system would be more than adequate to assure a scram before the power could exceed the safety limit. The 15 percent APRM scram remains active until the mode switch is placed in the RUN position. This change can occur when reactor pressure is greater than Specification 2.1.A.6.



## 2.1 Bases (Cont'd)

### c. IRM Flux Scram Trip Setting

The IRM system consists of 8 chambers, 4 in each of the reactor protection system logic channels. The IRM is a 5-decade instrument which covers the range of power level between that covered by the SRM and the APRM. The 5 decades are covered by the IRM by means of a range switch and the 5 decades are broken down into 10 ranges, each being one-half of a decade in size. The IRM scram trip setting of 120 divisions is active in each range of the IRM. For example, if the instrument were on range 1, the scram setting would be 120 divisions for that range; likewise, if the instrument were on range 5, the scram would be 120 divisions on that range. Thus, as the IRM is ranged up to accommodate the increase in power level, the scram trip setting is also ranged up. The most significant sources of reactivity change during the power increase are due to control rod withdrawal. For in-sequence control rod withdrawal, the rate of change of power is slow enough due to the physical limitation of withdrawing control rods, that heat flux is in equilibrium with the neutron flux and an IRM scram would result in a reactor shutdown well before any Safety Limit is exceeded.

In order to ensure that the IRM provided adequate protection against the single rod withdrawal error, a range of rod withdrawal accidents was analyzed. This analysis included starting the accident at various power levels. The most severe case involves an initial condition in which the reactor is just subcritical and the IRM system is not yet on scale. This condition exists at quarter rod density. Additional conservatism was taken in this analysis by assuming that the IRM channel closest to the withdrawn rod is by-passed. The results of this analysis show that the reactor is scrammed and peak power limited to one percent of rated power, thus maintaining MCPR above the MCPR fuel cladding integrity safety limit. Based on the above analysis, the IRM provides protection against local control rod withdrawal errors and continuous withdrawal of control rods in sequence and provides backup protection for the APRM.

### d. APRM Rod Block Trip Setting

Reactor power level may be varied by moving control rods or by varying the recirculation flow rate. The APRM system provides a control rod block which is dependent on recirculation flow rate to limit rod withdrawal, thus protecting against a MCPR of less than the MCPR fuel cladding integrity safety limit. The flow variable trip setting provides substantial margin from fuel damage, assuming a steady-state operation at the trip setting, over the entire recirculation flow range. The margin to the Safety Limit increases as the flow decreases for the specified trip setting versus flow relationship; therefore the worst case MCPR which could occur during steady-state operation is at 108% of rated thermal power because of the APRM rod block trip setting. The actual power distribution in the core is established by specified control rod sequences and is monitored continuously by the in-core LPRM system. As with the APRM scram trip setting, the APRM rod block trip setting is adjusted downward if the maximum fraction of limiting power density exceeds the fraction of rated power, thus preserving the APRM rod block safety margin. As with the scram setting, this may be accomplished by adjusting the APRM gain.

## 2.1 Bases: (Cont'd)

### 2. Reactor Water Low Level Scram and Isolation Trip Setting (except MSIV)

The set point for low level scram is above the bottom of the separator skirt. This level has been used in transient analyses dealing with coolant inventory decrease. The results reported in FSAR Subsection 14.5 show that scram at this level adequately protects the fuel and the pressure barrier, because MCPR remains well above the MCPR fuel cladding integrity safety limit in all cases, and system pressure does not reach the safety valve settings. The scram setting is approximately 25 in. below the normal operating range and is thus adequate to avoid spurious scrams.

### 3. Turbine Stop Valve Closure Scram Trip Setting

The turbine stop valve closure scram trip anticipates the pressure, neutron flux and heat flux increase that could result from rapid closure of the turbine stop valves. With a scram trip setting of  $\leq 10$  percent of valve closure from full open, the resultant increase in surface heat flux is limited such that MCPR remains above the MCPR fuel cladding integrity safety limit even during the worst case transient that assumes the turbine bypass is closed. This scram is bypassed when turbine steam flow is below 30% of rated, as measured by turbine first stage pressure.

### 4. Turbine Control Valve Fast Closure Scram Trip Setting

The turbine control valve fast closure scram anticipates the pressure, neutron flux, and heat flux increase that could result from fast closure of the turbine control valves due to load rejection exceeding the capability of the bypass valves. The reactor protection system initiates a scram when fast closure of the control valves is initiated by the loss of turbine control oil pressure as sensed by pressure switches. This setting and the fact that control valve closure time is approximately twice as long as that for the stop valves means that resulting transients, while similar, are less severe than for stop valve closure. No significant change in MCPR occurs. Relevant transient analyses are presented in Paragraph 14.5.1.1 of the Final Safety Analysis Report.

### 5. Main Steam Line Isolation Valve Closure on Low Pressure

The low pressure isolation of the main steam lines (Specification 2.1.A.6) was provided to protect against rapid reactor depressurization.

## B. Reactor Water Level Trip Settings Which Initiate Core Standby Cooling Systems (CSCS)

The core standby cooling subsystems are designed to provide sufficient cooling to the core to dissipate the energy associated with the loss-of-coolant accident and to limit fuel clad temperature, to assure that core geometry remains intact and to limit any clad metal-water reaction to less than 1%. To accomplish their intended function, the capacity of each Core Standby Cooling System component was established based on the reactor low water level scram set point. To lower the set point of the low water level scram would increase the capacity requirement for each of the CSCS components. Thus, the reactor vessel low water level scram was set low enough to permit margin for operation, yet will not be set lower because of CSCS capacity requirements.

## 2.1 Bases: (Cont'd)

The design for the CSCS components to meet the above guidelines was dependent upon three previously set parameters: The maximum break size, low water level scram set point and the CSCS initiation set point. To lower the set point for initiation of the CSCS may lead to a decrease in effective core cooling. To raise the CSCS initiation set point would be in a safe direction, but it would reduce the margin established to prevent actuation of the CSCS during normal operation or during normally expected transients.

Transient and accident analyses reported in Section 14 of the Final Safety Analyses Report demonstrate that these conditions result in adequate safety margins for the fuel.

## C. References

1. "Generic Reload Fuel Application," NEDE-24011-P, (most current approved submittal).
2. "Cooper Nuclear Station Single-Loop Operation," NEDO-24258, May 1980.
3. "Supplemental Reload Licensing Submittal for Cooper Nuclear Station Unit 1," (applicable reload document).
4. Final Safety Analysis Report (Section XIV).

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TABLE 3.1.1  
REACTOR PROTECTION SYSTEM INSTRUMENTATION REQUIREMENTS

Reactor Protection System Trip Function	Applicability Conditions Mode Switch Position				Trip Level Setting	Minimum Number of Operable Channels Per Trip Systems (1)	Action Required When Equipment Operability is Not Assured (1)
	Shutdown	Startup	Refuel	Run			
Mode Switch in Shutdown	X(7)	X	X	X		1	A
Manual Scram	X(7)	X	X	X		1	A
IRM (17) High Flux	X(7)	X	X	(5)	$\leq$ 120/125 of in- dicated scale	3	A
Inoperative		X	X	(5)		3	A
APRM (17) High Flux (Flow biased)				X	$\leq$ (0.66W + 54% - 0.66ΔW) (14) (18)	FRP 2 MFLPD	A or C
High Flux	X(7)	X(9)	X(9)	(16)	$\leq$ 15% Rated Power		A or C
Inoperative		X(9)	X(9)	X	(13)	2	A or C
Downscale		(11)		X(12)	$\geq$ 2.5% of indi- cated scale	2	A or C
High Reactor Pressure NBI-PS-55 A,B,C, & D		X(9)	X(10)	X	$\leq$ 1045 psig	2	A
High Drywell Pressure PC-PS-12 A,B,C, & D		X(9) (8)	X(8)	X	$\leq$ 2 psig	2	A or D
Reactor Low Water Level NBI-LIS-101 A,B,C, & D		X	X	X	$\geq$ + 12.5 in. indi- cated level	2	A or D
Scram Discharge Volume High Water Level CRD-LS-231 A,B,C, & D		X	X(2)	X	$\leq$ 36 gallons	2	A



11. The APRM downscale trip function is only active when the reactor mode switch is in run.
12. The APRM downscale trip is automatically bypassed when the mode switch is not in RUN.
13. An APRM will be considered inoperable if there are less than 2 LPRM inputs per level or there is less than 11 operable LPRM detectors to an APRM.
14. W is the recirculation flow in percent of rated flow.
15. This note deleted.
16. The 15% APRM scram is bypassed in the RUN mode.
17. The APRM and IRM instrument channels function in both the Reactor Protection System and Reactor Manual Control System (Control Rod Withdraw Block, Section 3.2.C.). A failure of one channel will affect both of these systems.
18.  $\Delta W$  is the difference between two-loop and single-loop effective drive flow and is used for single recirculation loop operation for periods greater than 24 hours.  $\Delta W=0$  for two recirculation loop operation and single loop operation less than 24 hours.

## LIMITING CONDITIONS FOR OPERATION

### 3.1 BASES (Cont'd.)

there is proper overlap in the neutron monitoring system functions and thus, that adequate coverage is provided for all ranges of reactor operation.

## SURVEILLANCE REQUIREMENTS

### 4.1 BASES (Cont'd.)

For the APRM system, drift of electronic apparatus is not the only consideration in determining a calibration frequency. Change in power distribution and loss of chamber sensitivity dictate a calibration every seven days. Calibration on this frequency assures plant operation at or below thermal limits.

A comparison of Tables 4.1.1 and 4.1.2 indicates that two instrument channels have not been included in the latter table. These are: mode switch in shutdown and manual scram. All of the devices or sensors associated with these scram functions are simple on-off switches and, hence, calibration during operation is not applicable.

- B. The MFLPD is checked once per day to determine if the APRM scram requires adjustment. This will normally be done by checking the LPRM readings. Only a small number of control rods are moved daily and thus the MFLPD is not expected to change significantly and thus a daily check of the MFLPD is adequate.

The sensitivity of LPRM detectors decreases with exposure to neutron flux at a slow and approximately constant rate. This is compensated for in the APRM system by calibrating once a week using a heat balance data and by calibrating individual LPRM's every six weeks of power operation above 20% of rated power.

It is highly improbable that in actual operation with  $MFLPD < FRP$  that MCPR will be as low as the MCPR fuel cladding integrity safety limit. Usually with power densities of this magnitude the peak occurs low in the core in a low quality region where the initial heat

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TABLE 3.2.C  
CONTROL ROD WITHDRAWAL BLOCK INSTRUMENTATION

Function	Trip Level Setting	Minimum Number Of Operable Instrument Channels/Trip System(5)
APRM Upscale (Flow Bias)	$\leq (0.66W + 42\% - 0.66\Delta W)$ FRP (2) (13)	2(1)
APRM Upscale (Startup)	$\leq 12\%$ MFLPD	2(1)
APRM Downscale (9)	$\geq 2.5\%$	2(1)
APRM Inoperative	(10b)	2(1)
RBM Upscale (Flow Bias)	$\leq (0.66W + 40\%)$ (2)	1
RBM Downscale (9)	$\geq 2.5\%$	1
RBM Inoperative	(10c)	1
IRM Upscale (8)	$\leq 108/125$ of Full Scale	3(1)
IRM Downscale (3)(8)	$\geq 2.5\%$	3(1)
IRM Detector Not Full In (8)		3(1)
IRM Inoperative (8)	(10a)	3(1)
SRM Upscale (8)	$\leq 1 \times 10^5$ Counts/Second	1(1)(6)
SRM Detector Not Full In (4)(8)	( $\geq 100$ cps)	1(1)(6)
SRM Inoperative (8)	(10a)	1(1)(6)
Flow Bias Comparator	$\leq 10\%$ Difference In Recirc. Flows	1
Flow Bias Upscale/Inop.	$\leq 110\%$ Recirc. Flow	1
SRM Downscale (8)(7)	$\geq 3$ Counts/Second (11)	1(1)(6)
SDV Water Level High	$\leq 18$ gallons	1(12)

NOTES FOR TABLE 3.2.C (Continued)

b. APRM

- (1) Mode switch not in operate
- (2) Less than 11 LPRM inputs
- (3) Circuit boards not in circuit

c. RBM

- (1) Mode switch not in operate
- (2) Circuit boards not in circuit
- (3) RBM fails to null
- (4) Less than required number of LPRM inputs for rod selected

- 11. During spiral unloading/reloading, the SRM count rate will be below 3 cps for some period of time. See Specification 3.10.B.
- 12. With the number of OPERABLE channels less than required by the Minimum Number of Operable Instrument Channels/Trip System requirements, place the inoperable channel in the tripped condition within one hour.
- 13.  $\Delta W$  is the difference between two-loop and single-loop effective drive flow and is used for single recirculation loop operation for periods greater than 24 hours.  $\Delta W=0$  for two recirculation loop operation and single loop operation less than 24 hours.

## LIMITING CONDITIONS FOR OPERATION

## 3.3.C (Cont'd.)

3. The maximum scram insertion time for 90% insertion of any operable control rod shall not exceed 7.00 seconds.

D. Reactivity Anomalies

At a specific steady state base condition of the reactor actual control rod inventory will be periodically compared to a normalized computer prediction of the inventory. If the difference between observed and predicted rod inventory reaches the equivalent of 1%  $\Delta k$  reactivity, the reactor will be shut down until the cause has been determined and corrective actions have been taken as appropriate.

E. Recirculation Pumps

1. A recirculation pump shall not be started while the reactor is in natural circulation flow and reactor power is greater than 1% of rated thermal power.
2. With one recirculation loop out of service for greater than 24 hours the reactor shall not be operated at a rated thermal power greater than 50%.
3. With extended one pump operation (greater than 24 hours), observe APRM flux and core plate delta P noise fluctuations at a rated thermal power of  $\leq 40\%$  and determine average peak to peak fluctuations. Operation at up to 50% of rated thermal power is permitted provided the average peak to peak fluctuations do not exceed those previously determined at  $\leq 40\%$  power by more than 50%.

- F. If Specifications 3.3.A through D above cannot be met, an orderly shutdown shall be initiated and the reactor shall be in the Shutdown condition within 24 hours.

## SURVEILLANCE REQUIREMENTS

## 4.3.C (Cont'd.)

D. Reactivity Anomalies

During the startup test program and startup following refueling outages, the critical rod configurations will be compared to the expected configurations at selected operating conditions. These comparisons will be used as base data for reactivity monitoring during subsequent power operation throughout the fuel cycle. At specific power operating conditions, the critical rod configuration will be compared to the configuration expected based upon appropriately corrected past data. This comparison will be made at least every full power month.

G. Scram Discharge Volume

1. The scram discharge volume (SDV) vent and drain valves shall be cycled and verified open at least once every 31 days and prior to reactor start-up.
2. The SDV vent and drain valves shall be verified to close within 30 seconds after receipt of a signal for control rod scram once per refueling cycle.
3. SDV vent and drain valve operability shall be verified following any maintenance or modification to any portion (electrical or mechanical) of the SDV which may affect the operation of the vent and drain valves.



### 3.3 and 4.3 BASES: (Cont'd)

the control rod motion is estimated to actually begin. However, 200 milliseconds is conservatively assumed for this time interval in the transient analyses and this is also included in the allowable scram insertion times of Specification 3.3.C. The time to deenergize the pilot valve scram solenoid is measured during the calibration tests required by Specification 4.1.

#### D. Reactivity Anomalies

During each fuel cycle excess operative reactivity varies as fuel depletes and as any burnable poison in supplementary control is burned. The magnitude of this excess reactivity may be inferred from the critical rod configuration. As fuel burnup progresses, anomalous behavior in the excess reactivity may be detected by comparison of the critical rod pattern at selected base states to the predicted rod inventory at that state. Power operating base conditions provide the most sensitive and directly interpretable data relative to core reactivity. Furthermore, using power operating base conditions permits frequent reactivity comparisons.

Requiring a reactivity comparison at the specified frequency assures that a comparison will be made before the core reactivity change exceeds 1%  $\Delta k$ . Deviations in core reactivity greater than 1%  $\Delta k$  are not expected and require thorough evaluation. One percent reactivity limit is considered safe since an insertion of the reactivity into the core would not lead to transients exceeding design conditions of the reactor system.

#### E. Recirculation Pumps

Until analyses are submitted for review and approval by the NRC which prove that recirculation pump startup from natural circulation does not cause a reactivity insertion transient in excess of the most severe coolant flow increase currently analyzed, Specification 3.3.E.1 prevents starting recirculation pumps while the reactor is in natural circulation above 1% of rated thermal power. Specifications 3.3.E.2 and 3 were imposed based upon single loop operation experience at Browns Ferry 1 in 1978. Since the noise levels at CNS may vary from other BWR's, Specification 3.3.E.3 was written to allow CNS to determine plant specific operating margins for flux noise and core plate delta P noise based upon arbitrary conservatisms acceptable to the NRC staff.

#### G. Scram Discharge Volume

To ensure the Scram Discharge Volume (SDV) does not fill with water, the vent and drain valves shall be verified open at least once every 31 days. This is to preclude establishing a water inventory, which if sufficiently large, could result in slow scram times or only a partial control rod insertion.

The vent and drain valves shut on a scram signal thus providing a contained volume (SDV) capable of receiving the full volume of water discharged by the control rod drives at any reactor vessel pressure. Following a scram the SDV is discharged into the reactor building drain system.

#### REFERENCES

1. Licensing Topical Report GE-BWR Generic Reload Fuel Application, NEDE-24011-P, (most current approved submittal).
2. "Supplemental Reload Licensing Submittal for Cooper Nuclear Station Unit 1," (applicable reload document).

## LIMITING CONDITIONS FOR OPERATION

### 3.6.E. Jet Pumps

1. Whenever the reactor is in the start-up or run modes, all jet pumps shall be operable. If it is determined that a jet pump is inoperable, or if two or more jet pump flow instruments failures occur and cannot be corrected within 24 hours, an orderly shutdown shall be initiated and the reactor shall be in a Cold Shutdown Condition within 24 hours.

### F. Jet Pump Flow Mismatch

1. Deleted.
2. Following one-pump operation, the discharge valve of the low speed pump may not be opened unless the speed of the faster pump is equal to or less than 50% of its rated speed.

### G. Structural Integrity

The structural integrity of the primary system boundary shall be maintained at the level required to assure safe operation throughout the life of the station. The reactor shall be maintained in a Cold Shutdown condition until each indication of a defect has been investigated and evaluated.

## SURVEILLANCE REQUIREMENTS

### 4.6.E. Jet Pumps

1. Whenever there is recirculation flow with the reactor in the startup or run modes, jet pump operability shall be checked daily by verifying that the following conditions do not occur simultaneously:
  - a. The recirculation pump flow differs by more than 15% from the established speed flow characteristics.
  - b. The indicated value of core flow rate varies from the value derived from loop flow measurements by more than 10%.
  - c. The diffuser to lower plenum differential pressure reading on an individual jet pump varies from the mean of all jet pump differential pressures by more than 10%.

### F. Jet Pump Flow Mismatch

1. Deleted.

### G. Structural Integrity

The nondestructive inspections listed in Table 4.6.1 shall be performed as specified. The results obtained from compliance with this specification will be evaluated after 5 years and the conclusions of this evaluation will be reviewed with the NRC.

### 3.6.E & 4.6.E BASES (Cont'd)

jet pump body; however, the converse is not true. The lack of any substantial stress in the jet pump body makes failure impossible without an initial nozzle riser system failure.

#### F. Jet Pump Flow Mismatch

Requiring the discharge valve of the lower speed loop to remain closed until the speed of faster pump is equal to or less than 50% of its rated speed provides assurance when going from one to two pump operation that excessive vibration of the jet pump risers will not occur.

#### G. Structural Integrity

A preservice inspection of accessible components listed in Table 4.6.1 will be conducted before initial fuel loading to assure the system is free of gross defects and as a reference base for later inspections. Construction oriented nondestructive testing is being conducted as systems are fabricated to assure applicable code requirements are met. Prior to operation, the primary system boundary will be free of gross defects. In addition, the facility has been designed such that gross defects should not occur throughout the life of the station. The inspection program given in Table 4.6.1 is based on the requirements of Section IS-242: Table IS-251, Components, Parts and Methods of Examination, and Table IS-251, Examination Categories, all of Section XI of the 1970 ASME Boiler and Pressure Vessel Code, except where accessibility for inspection was not provided. The initial program was revised to update to the summer 1972 Addendum Table IS-261. Modifications were made to vessel nozzle insulation and nozzle blackout removable shielding designs with the intent to make the inspection areas more accessible by reducing the personnel radiation exposure required for inspection utilizing available equipment.

The inspection program and the modifications described above were developed

## LIMITING CONDITIONS FOR OPERATION

### 3.11 FUEL RODS

#### Applicability

The Limiting Conditions for Operation associated with the fuel rods apply to those parameters which monitor the fuel rod operating conditions.

#### Objective

The Objective of the Limiting Conditions for Operation is to assure the performance of the fuel rods.

#### Specifications

##### A. Average Planar Linear Heat Generation Rate (APLHGR)

During steady state power operation, the APLHGR for each type of fuel as a function of average planar exposure shall not exceed the limiting value shown in Figure 3.11-1 for two recirculation loop. For single-loop operation greater than 24 hours, the values in these curves are reduced by 0.84 for 7x7 fuel, 0.86 for 8x8 fuel, 0.77 for 8x8R fuel and 0.77 for P8x8R fuel. If at any time during steady state operation it is determined by normal surveillance that the limiting value for APLHGR is being exceeded action shall be initiated within 15 minutes to restore operation to within the prescribed limits. If the APLHGR is not returned to within the prescribed limits within two (2) hours, the reactor shall be brought to the Cold Shutdown condition within 36 hours. Surveillance and corresponding action shall continue until the prescribed limits are again being met.

##### B. Linear Heat Generation Rate (LHGR)

During steady state power operation, the linear heat generation rate (LHGR) of any rod in any fuel assembly at any axial location shall not exceed the maximum allowable LHGR as calculated by the following equation:

$$LHGR_{\max} \leq LHGR_d [1 - \{(\Delta P/P)_{\max} (L/LT)\}]$$

$$LHGR_d = \text{Design LHGR} = \frac{G}{N} \text{ KW/ft.}$$

$$(\Delta P/P)_{\max} = \text{Maximum power spiking penalty} = \frac{N}{N}$$

## SURVEILLANCE REQUIREMENT

### 4.11 FUEL RODS

#### Applicability

The Surveillance Requirements apply to the parameters which monitor the fuel rod operating conditions.

#### Objective

The Objective of the Surveillance Requirements is to specify the type and frequency of surveillance to be applied to the fuel rods.

#### Specifications

##### A. Average Planar Linear Heat Generation Rate (APLHGR)

The APLHGR for each type of fuel as a function of average planar exposure shall be determined daily during reactor operation at  $\geq 25\%$  rated thermal power.

##### B. Linear Heat Generation Rate (LHGR)

The LHGR as a function of core height shall be checked daily during reactor operation at  $\geq 25\%$  rated thermal power.

## LIMITING CONDITIONS FOR OPERATION

## SURVEILLANCE REQUIREMENT

## 3.11.B (Cont'd)

LT = Total core length - 12 feet

L = Axial position above bottom of core

G = 18.5 kW/ft for 7x7 fuel bundles

= 13.4 kW/ft for 8x8 fuel bundles

N = 0.038 for 7x7 fuel bundles

= 0.0 for 8x8 fuel bundles

If at any time during steady state operation it is determined by normal surveillance that the limiting value for LHGR is being exceeded action shall then be initiated to restore operation to within the prescribed limits. Surveillance and corresponding action shall continue until the prescribed limits are again being met.

C. Minimum Critical Power Ratio (MCPR)

During steady state power operation the MCPR for each type of fuel at rated power and flow shall not be lower than the limiting value shown in Figure 3.11-2 for two recirculation loop operation. If, at any time during steady state operation it is determined by normal surveillance that the limiting value for MCPR is being exceeded, action shall then be initiated within 15 minutes to restore operation to within the prescribed limits. If the steady state MCPR is not returned to within the prescribed limits within two (2) hours, the reactor shall be brought to the Cold Shutdown condition within 36 hours. Surveillance and corresponding action shall continue until the prescribed limits are again being met.

For core flows other than rated the MCPR shall be the operating limit at rated flow times  $K_f$ , where  $K_f$  is as shown in Figure 3.11-3.

For one recirculation loop operation greater than 24 hours the MCPR limits at rated flow are 0.01 higher than the comparable two-loop values.

## 4.11 (Cont'd)

C. Minimum Critical Power Ratio (MCPR)

MCPR shall be determined daily during reactor power operation at > 25% rated thermal power and following any change in power level or distribution that would cause operation with a limiting control rod pattern as described in the bases for Specification 3.3.B.5.



### 3.11 BASES

#### A. Average Planar Linear Heat Generation Rate (APLHGR)

This specification assures that the peak cladding temperature following the postulated design basis loss-of-coolant accident will not exceed the limit specified in the 10CFR50, Appendix K.

The peak cladding temperature following a postulated loss-of-coolant accident is primarily a function of the average heat generation rate of all the rods of a fuel assembly at any axial location and is only dependent secondarily on the rod to rod power distribution within an assembly. Since expected local variations in power distribution within a fuel assembly affect the calculated peak clad temperature by less than  $+ 20^{\circ}\text{F}$  relative to the peak temperature for a typical fuel design, the limit on the average linear heat generation rate is sufficient to assure that calculated temperatures are within the 10CFR50 Appendix K limit. The limiting value for APLHGR is shown in Figure 3.11-1.

#### B. Linear Heat Generation Rate (LHGR)

This specification assures that the linear heat generation rate in any rod is less than the design linear heat generation if fuel pellet densification is postulated. The power spike penalty specified is based on the analysis presented in Section 5 of Reference 1 and assumes a linearly increasing variation in axial gaps between core bottom and top, and assures with a 95% confidence, that no more than one fuel rod exceeds the design linear heat generation rate due to power spiking. The LHGR as a function of core height shall be checked daily during reactor operation at  $\geq 25\%$  power to determine if fuel burnup, or control rod movement has caused changes in power distribution. For LHGR to be a limiting value below 25% rated thermal power, the MTPF would have to be greater than 10 which is precluded by a considerable margin when employing any permissible control rod pattern. Pellet densification power spiking in 8x8 fuel has been accounted for in the safety analysis presented in Reference 3; thus no adjustment to the LHGR limit for densification effects is required for 8x8 fuels.

#### C. Minimum Critical Power Ratio (MCPR)

The required operating limit MCPR's at steady state operating conditions as specified in Specification 3.11C are derived from the established fuel cladding integrity Safety Limit and an analysis of abnormal operational transients (Reference 3). For any abnormal operating transient analysis evaluation with the initial condition of the reactor being at the steady state operating limit it is required that the resulting MCPR does not decrease below the Safety Limit MCPR at any time during the transient assuming instrument trip setting given in Specification 2.1.

To assure that the fuel cladding integrity Safety Limit is not exceeded during any anticipated abnormal operational transient, the more limiting transients have been analyzed to determine which result in the largest reduction in critical power ratio (CPR). The models used in the transient analyses are discussed in Reference 1.

### 3.11 Bases: (Cont'd)

The purpose of the  $K_f$  factor is to define operating limits at other than rated flow conditions. At less than 100% flow, the required MCPR is the product of the operating limit MCPR and the  $K_f$  factor. Specifically, the  $K_f$  factor provides the required thermal margin to protect against a flow increase transient. The most limiting transient initiated from less than rated flow conditions is the recirculation pump speed up caused by a motor-generator speed control failure.

For operation in the automatic flow control mode, the  $K_f$  factors assure that the operating limit MCPR will not be violated should the most limiting transient occur at less than rated flow. In the manual flow control mode, the  $K_f$  factors assure that the Safety Limit MCPR will not be violated for the same postulated transient event.

The  $K_f$  factor curves shown in Figure 3.11-3 were developed generically which are applicable to all BWR/2, BWR/3, and BWR/4 reactors. The  $K_f$  factors were derived using the flow control line corresponding to rated thermal power at rated core flow as described in Reference 1.

The  $K_f$  factors shown in Figure 3.11-3, are conservative for Cooper operation because the operating limit MCPR's are greater than the original 1.20 operating limit MCPR used for the generic derivation of  $K_f$ .

#### D. Thermal-hydraulic Stability

The calculations, regarding reactor core stability, presented in Reference 3 show that the reactor is in compliance with the ultimate performance criteria, including the most responsive condition at natural circulation and rod block power. However, to preclude the possibility of operation under conditions which could result in reactor core instability, the NRC requested the incorporation of a specification limit.

The power level specified results in a decay ratio ( $X_2/X_0$ ) which is significantly less than the ultimate stability limit of 1.0.

#### References for Bases 3.11

1. "Generic Reload Fuel Application," NEDE-24011-P, (most current approved submittal).
2. "Cooper Nuclear Station Single-Loop Operation," NEDO-24258, May 1980.
3. "Supplemental Reload Licensing Submittal for Cooper Nuclear Station Unit 1," (applicable reload document).
4. General Electric Company Analytical Model for Loss-of-Coolant Analysis in Accordance with 10CFR50, Appendix K, NEDO-20566, dated January, 1976.

### 4.11 Bases:

#### A&B. Average and Local LHGR

The LHGR shall be checked daily to determine if fuel burnup, or control rod movement has caused changes in power distribution. Since changes due to burnup are slow, and only a few control rods are moved daily, a daily check of power distribution is adequate.

#### 4.11 Bases: (Cont'd.)

##### C. Minimum Critical Power Ratio (MCPR) - (Surveillance Requirement)

At core thermal power levels less than or equal to 25%, the reactor will be operating at less than or equal to minimum recirculation pump speed and the moderator void content will be very small. For all designated control rod patterns which may be employed at this point, operating plant experience indicated that the resulting MCPR value is in excess of requirements by a considerable margin. With this low void content, any inadvertent core flow increase would only place operation in a more conservative mode relative to MCPR. During initial start-up testing of the plant, a MCPR evaluation was made at 25% thermal power level with minimum recirculation pump speed. The MCPR margin was thus demonstrated such that subsequent MCPR evaluation below this power level was shown to be unnecessary. The daily requirement for calculating MCPR above 25% rated thermal power is sufficient since power distribution shifts are very slow when there have not been significant power or control rod changes. The requirement for calculating MCPR when a limiting control rod pattern is approached ensures that MCPR will be known following a change in power or power shape (regardless of magnitude) that could place operation at a thermal limit.