LOW WATER LEVEL

LIMITING CONDITION FOR OPERATION

3.9.8.2 Two independent residual heat removal (RHR) loops shall be OPERABLE, and at least one RHR loop shall be in operation.*

APPLICABILITY: MODE 6, with irradiated fuel in the vessel when the water level above the top of the reactor vessel flange is less than 23 feet.

ACTION:

a. With less than the required RHR loops OPERABLE, immediately initiate corrective action to return the required RHR loops to OPERABLE status or to establish greater than or equal to 23 feet of water above the reactor vessel flange as soon as possible.

b. With no RHR loop in operation, suspend all operations involving a reduction in boron concentration of the Reactor Coolant System and immediately initiate corrective action to return the required RHR loop to operation. Close all containment penetrations providing direct access from the containment atmosphere to the outside atmosphere within 4 hours.

SURVEILLANCE REQUIREMENTS

4.9.8.2.1 At least one RHR loop shall be verified in operation and circulating reactor coolant at a flow rate of greater than or equal to 2500 gpm at least once per 12 hours whenever the water level is at or above the reactor vessel flange

4.9.8.2.2 At least one RHR loop shall be verified in operation and circulating reactor coolant at a flow rate of greater than or equal to 900 gpm at least once per 12 hours whenever the water level is below the reactor vessel flange.

*The operating RHR loop may be removed from operation for up to 1 hour per 2-hour period during the performance of CORE ALTERATIONS and core loading verification in the vicinity of the reactor vessel hot legs.

3/4.9.6 REFUELING MACHINE

The OPERABILITY requirements for the refueling machine ensure that: (1) refueling machine will be used for movement of drive rods and fuel assemblies, (2) each crane has sufficient load capacity to lift a drive rod or fuel assembly, and (3) the core internals and reactor vessel are protected from excessive lifting force in the event they are inadvertently engaged during lifting operations.

3/4.9.7 CRANE TRAVEL - FUEL HANDLING BUILDING

The restriction on movement of loads in excess of the nominal weight of a fuel and control rod assembly and associated handling tool over other fuel assemblies in the storage pool ensures that in the event this load is dropped: (1) the activity release will be limited to that contained in a single fuel assembly, and (2) any possible distortion of fuel in the storage racks will not result in a critical array. This assumption is consistent with the activity release assumed in the safety analyses.

3/4.9.8 RESIDUAL HEAT REMOVAL AND COOLANT CIRCULATION

The requirement that at least one residual heat removal (RHR) loop be in operation ensures that: (1) sufficient cooling capacity is available to remove decay heat and maintain the water in the reactor vessel below 140°F as required during the REFUELING MODE, and (2) sufficient coolant circulation is maintained through the core to minimize the effect of a boron dilution incident and prevent boron stratification.

The requirement to have two RHR loops OPERABLE when there is less than 23 feet of water above the reactor vessel flange ensures that a single failure of the operating RHR loop will not result in a complete loss of residual heat removal capability. With the reactor vessel head removed and at least 23 feet of water above the reactor pressure vessel flange, a large heat sink is available for core cooling. Thus, in the event of a failure of the operating RHR loop, adequate time is provided to initiate emergency procedures to cool the core.

3/4.9.9 CONTAINMENT VENTILATION ISOLATION SYSTEM

The OPERABILITY of this system ensures that the containment purge makeup and exhaust penetrations will be automatically isolated upon detection of high radiation levels within the containment. The OPERABILITY of this system is required to restrict the release of radioactive material from the containment atmosphere to the environment.

Insert new ¶:

The minimum RHR flow requirement is reduced to 900 gpm when the reactor water level is below the reactor vessel flange. The 900 gpm limit reduces the possibility of cavitation during operation of the RHR pumps and ensures sufficient mixing in the event of a MODE 6 boron dilution incident.

LOW WATER LEVEL

LIMITING CONDITION FOR OPERATION

3.9.8.2 Two independent residual heat removal (RHR) loops shall be OPERABLE, and at least one RHR loop shall be in operation.*

APPLICABILITY: MODE 6, with irradiated fuel in the vessel when the water level above the top of the reactor vessel flange is less than 23 feet.

ACTION:

a. With less than the required RHR loops OPERABLE, immediately initiate corrective action to return the required RHR loops to OPERABLE status or to establish greater than or equal to 23 feet of water above the reactor vessel flange as soon as possible.

b. With no RHR loop in operation, suspend all operations involving a reduction in boron concentration of the Reactor Coolant System and immediately initiate corrective action to return the required RHR loop to operation. Close all containment penetrations providing direct access from the containment atmosphere to the outside atmosphere within 4 hours.

SURVEILLANCE REQUIREMENTS

4.9.8.2.1 At least one RHR loop shall be verified in operation and circulating reactor coolant at a flow rate of greater than or equal to 2500 gpm at least once per 12 hours whenever the water level is at or above the reactor vessel flange.

4.9.8.2.2 At least one RHR loop shall be verified in operation and circulating reactor coolant at a flow rate of greater than or equal to 900 gpm at least once per 12 hours whenever the water level is below the reactor vessel flange.

*The operating RHR loop may be removed from operation for up to 1 hour per 2-hour period during the performance of CORE ALTERATIONS and core loading verification in the vicinity of the reactor vessel hot legs.

3/4.9.6 REFUELING MACHINE

The OPERABILITY requirements for the refueling machine ensure that: (1) refueling machine will be used for movement of drive rods and fuel assemblies, (2) each crane has sufficient load capacity to lift a drive rod or fuel assembly, and (3) the core internals and reactor vessel are protected from excessive lifting force in the event they are inadvertently engaged during lifting operations.

3/4.9.7 CRANE TRAVEL - FUEL HANDLING BUILDING

The restriction on movement of loads in excess of the nominal weight of a fuel and control rod assembly and associated handling tool over other fuel assemblies in the storage pool ensures that in the event this load is dropped: (1) the activity release will be limited to that contained in a single fuel assembly, and (2) any possible distortion of fuel in the storage racks will not result in a critical array. This assumption is consistent with the activity release assumed in the safety analyses.

3/4.9.8 RESIDUAL HEAT REMOVAL AND COOLANT CIRCULATION

The requirement that at least one residual heat removal (RHR) loop be in operation ensures that: (1) sufficient cooling capacity is available to remove decay heat and maintain the water in the reactor vessel below 140°F as required during the REFUELING MODE, and (2) sufficient coolant circulation is maintained through the core to minimize the effect of a boron dilution incident and prevent boron stratification.

The requirement to have two RHR loops OPERABLE when there is less than 23 feet of water above the reactor vessel flange ensures that a single failure of the operating RHR loop will not result in a complete loss of residual heat removal capability. With the reactor vessel head removed and at least 23 feet of water above the reactor pressure vessel flange, a large heat sink is available for core cooling. Thus, in the event of a failure of the operating RHR loop, adequate time is provided to initiate emergency procedures to cool the core.

The minimum RHR flow requirement is reduced to 900 gpm when the reactor water level is below the reactor vessel flange. The 900 gpm limit reduces the possibility of cavitation during operation of the RHR pumps and ensures sufficient mixing in the event of a MODE 6 boron dilution incident.

3/4.9.9 CONTAINMENT VENTILATION ISOLATION SYSTEM

The OPERABILITY of this system ensures that the containment purge makeup and exhaust penetrations will be automatically isolated upon detection of high radiation levels within the containment. The OPERABILITY of this system is required to restrict the release of radioactive material from the containment atmosphere to the environment.

ENCLOSURE 5

SHEARON HARRIS NUCLEAR POWER PLANT
DOCKET NO. 50-400/LICENSE NO. NPF-63
SUPPLEMENT TO REQUEST FOR LICENSE AMENDMENT
REFUELING OPERATIONS - LOW WATER LEVEL

SUMMARY OF WESTINGHOUSE EVALUATION

The following is a summary of the Westinghouse evaluation providing verification that a minimum RHR flow of 900 gpm during Mode 6 mid-loop operation is sufficient to ensure adequate mixing for a boron dilution event. In performing this evaluation, the following Model assumptions were used.

Homogeneous Mixing ("Perfect Mixing") Model

The homogeneous mixing of the RCS contents during a boron dilution event has been modelled as a continuous "feed and bleed" process with the "feed and bleed" rate equal to the dilution rate (at 0 ppm):

$$C_c = C_o \times e^{\frac{-(Q\Delta t)}{V}}$$

where C_c = Core/RCS concentration at any time, ppm

C_o = initial core/RCS concentration at t = o

Q = feed and bleed rate, gpm

Δt = time, minutes

V = total RCS/RHRS volume, gallons

Slug Flow Model

The slug flow model utilized by Westinghouse assumes the following system simplifications.

1. The core is located midway in the RCS/RHRS volume. So, one half of the RCS/RHRS volume is between the RHR cold leg return (also assumed as the point of dilution) and the core, and one half of the RCS/RHRS volume is between the core and the RHR hot leg suction.

2. The letdown rate equals the dilution flow rate (this avoids the complication of mass accumulation in the RCS).

3. The core (RCS) concentration is assumed to be instantaneously changed by the mixing of the dilution fluid with the RHR fluid.

4. At the beginning of the transient, the concentration of the core equals the concentration of the RCS and RHRS until the first dilution front (or slug) reaches the core (i.e., travels one half of the RCS volume). Then for each successive pass, the core concentration remains at the same concentration until the dilution front passes around the circuit again (i.e., travels through the whole RCS volume). This results in step changes in core concentration equivalent to:

$$C_c = C_o \, (Q_{RHR}/Q_c)^n$$

where C_c = Core/RCS concentration, ppm

C_o = initial Core/RCS concentration, ppm

Q_{RHR} = RHR flow rate, gpm

Q_c = core flow rate, gpm (sum of RHR and dilution flow rate)

n = number of passes

at a frequency equal to the RCS volume sweep time (total RCS/RHRS volume divided by Core flow rate).

Model Comparison

Westinghouse compared the slug flow model with the homogeneous mixing model by plotting core concentration as a fraction of initial concentration versus time for the dilution flowrate (173 gpm) and the total RCS/RHRS volume at mid-loop (3754 ft^3) assumed in the boron dilution analysis for Mode 6 and the proposed 900 gpm RHRS flow rate. As shown in Figure 1, the shaded triangles are those regions where the RCS dilution caused by the homogeneous mixing model is more conservative than the slug flow model. The unshaded triangles are those for which the homogeneous mixing model is less conservative than the slug flow model. The current boron dilution analysis has shown that 46 minutes is available for operator action before the loss of plant shutdown margin occurs. Figure 1 shows that, within this time period, the time that the homogeneous mixing model is more conservative than the slug flow model is approximately equal to the time that the slug flow model is more conservative.

The utilization of a homogeneous mixing model for the boron dilution analysis implies the need for forced circulation flow so that the model is accurate. The greater the ratio of RHR flow to dilution flow, the more accurate the homogeneous mixing model becomes relative to a slug flow model. Sufficient forced circulation flow precludes any intentional or unintentional change in boron concentration resulting from a boron concentration gradient or "front" passing through the RCS. An RHR flow rate which is substantially larger than the boration or the dilution flow rate on the first pass through the RCS, as well as on successive passes, serves to reduce the magnitude of the stepwise change in boron concentration with time.

Based on a slug flow versus perfect mixing model comparison, it has been shown that an RHR flow rate of 900 gpm provides sufficient mixing of the RCS volume used in the Mode 6 boron dilution Analysis. Therefore, the conclusions presented in the FSAR for the boron dilution analysis remain valid.

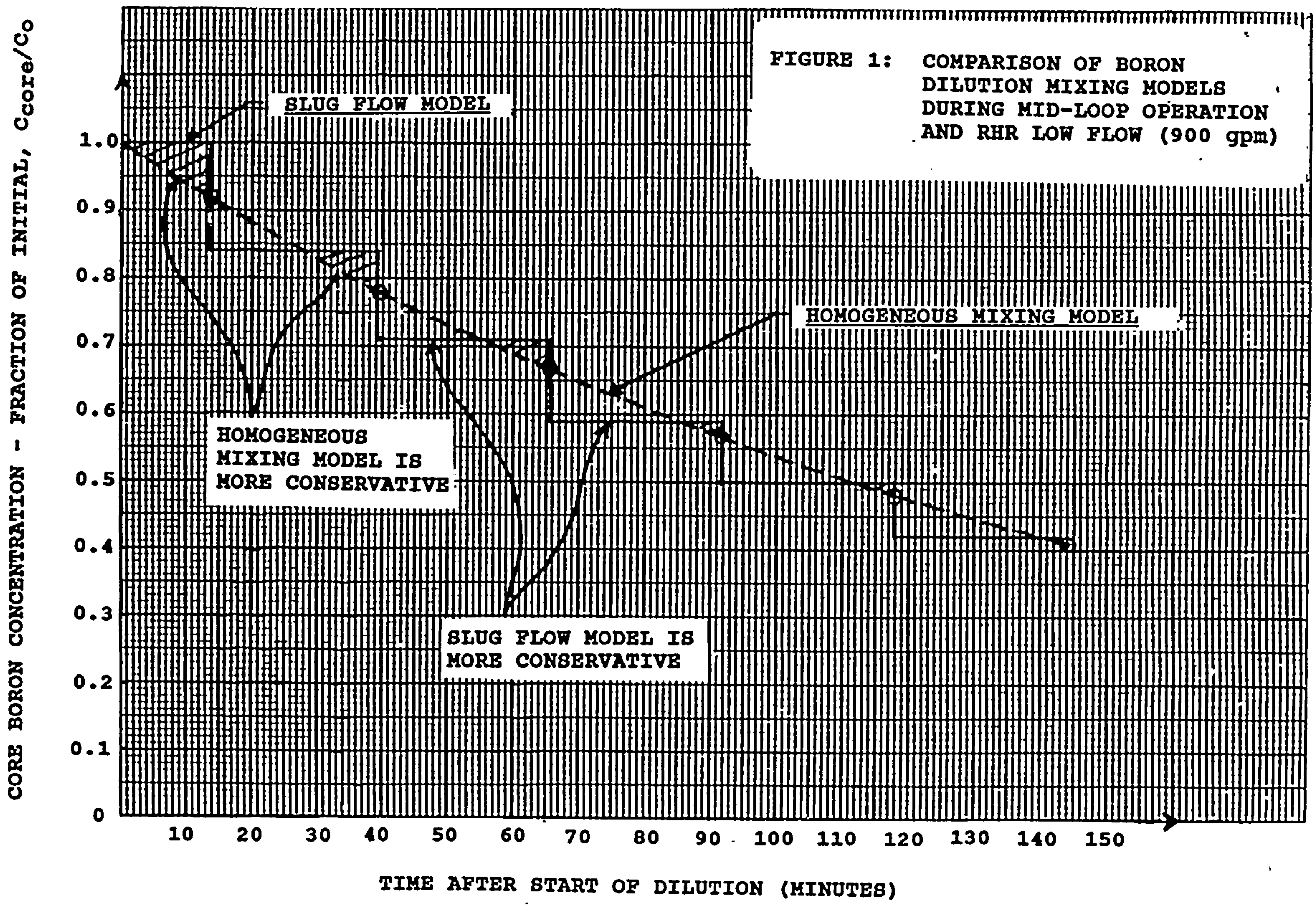

FIGURE 1: COMPARISON OF BORON DILUTION MIXING MODELS DURING MID-LOOP OPERATION AND RHR LOW FLOW (900 gpm)
SLUG FLOW MODEL
HOMOGENEOUS MIXING MODEL
HOMOGENEOUS MIXING MODEL IS MORE CONSERVATIVE
SLUG FLOW MODEL IS MORE CONSERVATIVE
CORE BORON CONCENTRATION - FRACTION OF INITIAL, Ccore/Co
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
TIME AFTER START OF DILUTION (MINUTES)