The calculations below are intended to partially address question 13-7 (correct value for beta) and question 13-12 of the draft RAIs. All analyses provided below were calculated by hand. These two revised sections will need to replace sections 13.1.1.1.1 and 13.1.1.1.2 of the SAR.

13.1.1.1.1 Uncontrolled Withdrawal of a Control Rod

Operator error or failure of the automatic power level control system could cause one of the control rods to be driven out, starting at either high or low power levels. The maximum speed of a control rod is 1.78 cm/sec (42. in./min). The maximum single rod worth for the reference loadings of Section 4.5.5 is ~$2.90, but a rod worth of $3.00 for the 5 fuel followed control rod and $2.50 for the transient rod was used here to allow for reasonable variations about the reference loadings. The differential reactivity worth was assumed to be equal the measured differential worth of the most reactive control rod between 50% and 55% withdrawn from the core (then normalized to correspond to a $3.00 total rod worth) as this is the largest differential worth expected to be encounter while the reactor is critical. This maximum differential rod worth was determined to be 0.274 $/in or 0.192 $/s for a rod speed equal to 42 inches per minute. Note the actual administratively limited rod speed is 24 in/min, the control rods are interlocked so the operator can only withdraw one at a time, and when in automatic power demand a maximum of 3 rods can be withdrawn at one time.

The initial reactor power levels of 100 W or 1.0 MW were analyzed using the single delayed neutron group model with the prompt jump approximation, a linear (ramp) reactivity increase results in the following equation for power as a function of time:

$$\frac{P(t)}{P_o} = \left(e^{-\lambda t}\right)[\beta/(\beta - \gamma t)]^{\left(1+\frac{\lambda\beta}{\gamma}\right)} \quad (6)$$

where: P(t) = power at time t
P_0 = initial power level
β= total delayed neutron fraction 0.0075
λ= one group decay constant = 0.405 (sec^{-1})
t = time (sec)
γ= linear insertion rate of reactivity (Δk/k-sec^{-1})

The SCRAM set point is 1.1 MW and a delay of 0.5 seconds is assumed between the set point being reached and the initiation of the controls dropping into the core.

Beginning at power level of 100 W a single rod being withdrawn until the SCRAM set point is reacted takes 5.08 seconds plus an additional 0.50 seconds for control drop to initiate. This corresponds to a reactivity insertion of $1.07.

Beginning at power level of 1.0 MW a single rod being withdrawn until the SCRAM set point is reacted takes 0.44 seconds plus an additional 0.50 seconds for control drop to initiate. This corresponds to a reactivity insertion of $0.18.

This reactivity insertion is much less than the limiting reactivity insertion derived in Section 13.2.2.2.1 for the prompt criticality accident.

13.1.1.1.2 Uncontrolled Withdrawal of All Control Rods

Utilizing the same approach as in section 13.2.2.2.2 the consequences of the uncontrolled simultaneous withdrawal of all control rods is evaluated below. Since three control rods can be banked for reactor control, uncontrolled withdrawal of three control rods could be considered credible, but is bounded by the accidents analyzed.

Beginning at power level of 100 W all rods being withdrawn until the SCRAM set point is reacted takes 0.87 seconds plus an additional 0.50 seconds for control drop to initiate. This corresponds to a reactivity insertion of $1.58.

Beginning at power level of 1.0 MW all rods being withdrawn until the SCRAM set point is reacted takes 0.08 seconds plus an additional 0.50 seconds for control drop to initiate. This corresponds to a reactivity insertion of $0.67.

This reactivity insertion is much less than the limiting reactivity insertion derived in Section 13.2.2.2.1 for the prompt criticality accident.