CRITERIA FOR CONTROL RODS

In a thermal reactor employing a usual control rod system, the following general principles apply:

1. Reliance for safety and control should not rest on one rod only.

2. Each single rod should have a limited value of reactivity, usually not more than 3 or 4% Δ k.

3. The rate of reactivity addition by rod movement should be limited; 10^{-5} to 10^{-4}% Δ k/sec is customary.

4. The total amount of reactivity capable of being added by the automatic control system independently of normal action of the operator, should be limited to values not substantially larger than Beta.

5. The maximum value of any single rod, the value of the regulating rod, the permissible rate of manual and automatic reactivity addition, and the speed of response of the emergency scram system, must be related to the inherent shutdown characteristics and the speed of the transient behavior of the reactor.

6. Rod withdrawal schedules and sequences necessary to safety should be insured by design features and interlocks, not left to administrative instructions and procedures.

7. Switches for manual rod withdrawal should be spring--loaded to open; i.e., requiring operation of continuous operator effort during rod withdrawal.

8. At least some of the rods, representing sufficient reactivity capacity for shutdown, must be provided with mechanisms and devices which will achieve rapid insertion in case of emergencies. The response times of these devices should be related to the potential inadvertent Δ k insertions.

9. There should be some dependable back-up mechanism in addition to the primary rod insertion device to assist rod insertion in emergencies, e.g., gravity, springs, pneumatic pressure, etc.

10. There should be provided adequate shut-down capacity; e.g., never less than 4% Δ k below critical.

11. The power level of the reactor should be continuously indicated on appropriate instruments during operation and during shutdown when any manipulations whatever on the reactor are in progress.

12. Attention must be given to:

    (a) Positioning channels or guides which insure reproducibility of location but provides freedom of movement, particularly during scrams.

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(b) Mechanical adequacy of rod structures.

(c) Thermal stresses and distortions of rods.

(d) Corrosion or solubility of rod components.

(e) Buoyancy or flow effects of coolant or moderator.

(f) Nuclear burning of rod poison.

(g) Radiation damage in rod materials.