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OPERATING SAFETY LIMITS

FOR THE POOL CRITICAL ASSEMBLY (PCA)

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INTRODUCTION

The Pool Critical Assembly (PCA) operating safety limits designate limits within which the reactor can be operated safely. The limits specified were determined by design or experience and are listed according to the functional components. Included are limitations placed on experiments and those placed on administration of the operation. AEC approval is required for changes to the operating safety limits.

The purpose of this document is to establish a limit for each operating variable which has direct reactor-safety significance. Each limit designates a realistic boundary to the operating range of the variable; therefore, each limit can be approached with confidence that the safety of the reactor will not be compromised. The operating procedures shall be prepared so as to provide reasonable assurance that the reactor will be operated within the stated operating safety limits.

The PCA does not operate continuously but on an "as-needed" basis for research and training. The power level is limited to 10 kw (administratively), but most of the operation is at very low power levels.

OPERATING LIMITS

A. Reactor Core.

1. Maximum fuel loading - The maximum total mass of fuel in the core shall be adjusted so that the ganged shim-safety rods will have to be withdrawn at least 50% of their worth before criticality is achieved. At no time shall the reactor be allowed to continue critical operation with the ganged rods inserted more than 50% of their worth.
2. Maximum steady-state power level - 10 kw nominal (administrative limit.)
3. Safety power-level scram limit - Maximum setting (nominal) shall be 150% of maximum steady-state power level (administrative limit.)

4. Maximum heat flux in the core for natural-convection flow and 120°F inlet water temperature - 0.96×10^5 Btu hr^{-1} ft^{-2}.*
5. The separation distance between the BSR core and the PCA core shall be maintained at more than 10 in. by means of permanently fixed mechanical stops on the rails carrying the BSR core.

B. Primary Cooling System.

1. Maximum pool-water bulk temperature - 120°F.
2. Minimum flow rate - natural convection.
3. The reactor cooling water is monitored periodically and necessary adjustments are made to maintain a pH of between 5.5 and 6.5.**
4. Maximum radioactivity of coolant water - The radioactivity of the water shall be maintained at a level such that no excessive exposure to personnel will occur, as specified in AEC Manual Chapter 0524.
5. The water level in the reactor pool normally shall be >12 ft above the reactor core.

C. Emergency Cooling Facility.

It has been determined experimentally that the heat-generation rate following shutdown is sufficiently low that no special provisions for afterheat removal are required.

D. Control and Safety Systems.

1. Mechanical control system.
   a. Minimum number of control elements - three.
   b. Minimum number of control rods withdrawn to attain criticality - The reactor shall be so arranged that criticality cannot be achieved by complete withdrawal of any one control rod while the others are completely inserted.

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*This value is 15% below the burnout heat flux interpolated from the experimental data of W. R. Gambill and R. D. Bundy described in ORNL-3026, Burnout Heat Fluxes for Low-Pressured Water in Natural Circulation, and is approximately a factor of 6 greater than the highest heat flux to be expected during operation.

**These are nominal limits which may be exceeded for short periods of time without requiring a reactor shutdown.

c. Maximum release time of control elements (magnet and latch combined) - 30 msec.

d. Maximum scram time (maximum time-of-flight from fully withdrawn to bottom seat) - 800 msec (includes release time).

e. Maximum rate of increase of reactivity (using control rods) - 0.15% $\Delta k/k$ per sec.

f. Servo control - The amount of positive reactivity controlled by the servo system shall be limited to 0.5% $\Delta k/k$.

g. Operational checks - Maximum time between successive checks of the release time and the scram time shall be 3 months or before reactor operation is required (whichever is longest).

2. Control and safety instrumentation.

a. Minimum reactor control and safety instrumentation required for startup.*

(1) Two power-level safety channels.

(2) One log-N period channel (to initiate a reactor scram at periods less than 1 sec).

(3) One neutron-level detection channel (log-N or fission chamber) that is reliably detecting the neutron level in the reactor.

(4) One radiation monitor located in the reactor room.

(5) One continuous air monitor located in the reactor room.

b. Minimum safety and control instrumentation required during steady-state operation.

(1) Two power-level safety channels.

(2) One radiation monitor located in the reactor room.

(3) One continuous air monitor located in the reactor room.

c. Control and safety instrument checks.

(1) Functional checks of instruments - Prior to each reactor startup which occurs more than eight hours following a shutdown.

*When more than one instrument of the same kind is specified, it is to be understood that either instrument will provide the required safety action.

(2) Maximum period between comprehensive instrument calibration and checkout tests - Three months or before reactor operation is required (whichever is longest).

E. Radiation Monitoring Systems.

Radiation level monitors - A minimum of two operable radiation monitors which provide audible alarms shall be located at appropriate points within the reactor building.

F. Experiments.

Each in-reactor experiment is subjected to comprehensive reviews and hazards evaluations by the Laboratory's Reactor Experiment Review Committee and/or the Operations Division. In this way, an experiment is approved for operation within safety limits applicable only to that specific experiment. Appropriate limits are placed upon any materials, systems, or components that may (for any credible reason) affect the reactor reactivity in such a manner or to such a degree that unsafe conditions could result.

1. With respect to reactivity effects, experiments* are considered and approved as follows:

   a. An experiment is approved routinely if the maximum change in reactivity that can be caused by the experiment is conservatively less than the total amount of reactivity controlled by the servo system (less than 0.5% $\Delta k/k$).

   b. Experiments having reactivity worths greater than that in item F.1.a are considered in more detail--particularly if failure or malfunction of the experiments may cause changes in these worths. Consideration is given to the total worth, rates of change of reactivity, and to particular situations that may be associated with these changes. Experiments shall be approved only if it is found incredible that the experiment could cause unacceptable hazards. Review by the Laboratory's Reactor Experiment Review Committee is required.

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*These limits on reactivity effects of experiments apply to those experiments for which the reactor is used only as a source of radiation. Those experiments in which the reactor itself is part of the experiment (e.g., approach-to-critical-loading experiments) are limited by item A.1.

2. With respect to energy release, experiments are considered and approved as follows:
   a. The amount of any explosive or mixture of materials (such as hydrogen and oxygen) to be placed in or near the reactor shall be limited to the equivalent of 1 g of TNT (1.1 kcal).
   b. The energy release which might result from the reaction of any of the so-called reactive materials, such as Na, Li, or K, with the reactor coolant or with the experiment coolant by any credible mechanism shall be limited to 100 kcal unless a monitored double barrier exists between the material and the coolant. Experiments of this type in which the potential energy release is greater than 500 kcal shall not be installed without prior approval by the AEC.

G. Administrative and Procedural Safeguards.
   1. Personnel qualifications - The reactor shall be operated only by qualified personnel approved by the Operations Division Superintendent.
   2. Minimum staff requirements for the PCA operation during any shift - One supervisor qualified to operate the PCA shall be in the operating area whenever the reactor is operating.
   3. Procedures - The reactor is operated in conformance with documented operating procedures. In no instance shall the operating procedures authorize operation of the reactor in excess of any operating safety limit listed above.

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