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OPERATING SAFETY LIMITS
FOR THE OAK RIDGE NATIONAL LABORATORY RESEARCH REACTOR (ORR)

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(With the Assistance of the Operations Division Staff)

ABSTRACT

The operating safety limits designate the limits within which the reactor can be operated safely. The limits specified were determined by design or experience. The limits are listed according to the functional components. One section indicates what limitations are placed on experiments, and another section specifies the limitation placed on administration of the operation.

CONTENTS

INTRODUCTION

The intent 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 ORR operating procedures are prepared so as to provide reasonable assurance that the reactor will be operated within the stated operating safety limits. AEC approval is required for changes to the operating safety limits.

OPERATING LIMITS

A. Reactor Building

1. Inleakage will be maintained during normal operation by means of roof fans and the building ventilation system (via ducts and the 250-ft stack). When in containment, inleakage will be maintained by means of the building ventilation system only.
    a. Minimum exhaust rate--Sufficient to maintain inleakage through all building openings corresponding to approximately 4,000 cfm.
    b. Minimum frequency filter or scrubber efficiency tests--Bianually or after any major design change.
    c. Minimum frequency of operational tests of filter bank--Operational tests of the containment system must be performed prior to the start of each operating cycle.
    d. Tests of building ventilation filter bank. R
        (1) High efficiency particulate filters--99.95% for particles of >0.3 μ.
        (2) Charcoal filters--97% for elemental iodine.
2. Conditions which must cause activation of the emergency containment system:
    a. General radiation background in the vicinity of the monitor located in upper half of reactor building--150 mr/hr β-γ.
    b. Radiation background at the monitor on building exhaust line--50 mr/hr β-γ.

B. Reactor Core

1. Maximum fuel loading--The maximum total mass of fuel in the core is adjusted so that the ganged rods will have to be withdrawn at least 50% of their worth before criticality is achieved for full-power operation.
2. Maximum steady-state power level--30,000 kw nominal (administrative limit).
3. Safety power level scram limit--Set at 150% of nominal maximum flux-power level (administrative limit).
4. Maximum heat flux in core (calculated for normal flow--the allowable heat flux must be reduced proportionately for conditions of reduced flow)--2,125,000 Btu hr^{-1} ft^{-2}.*

C. Primary Cooling System

1. Maximum differential pressure across the core--38 psi.
2. Maximum outlet water temperature--150°F.
3. Minimum flow rate for full-power operation--8,000 gpm.*
4. Maximum flow rate--22,000 gpm.
5. The reactor cooling water is monitored periodically and necessary adjustments made to maintain a pH value slightly acidic.
6. Maximum activity of coolant water--the radioactivity of the water will be maintained at a level sufficiently low that no excessive exposure to personnel will occur as specified in AEC Manual, Chapter 0524.

D. Secondary Cooling System

1. Maximum operating pressure--115 psi.
2. Minimum flow rate for full-power operation--1,500 gpm (administrative limit--no control action until the temperature in the primary cooling system reaches designated point [C.2]).

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*This is below the calculated burnout heat flux using W. R. Gambill's correlation presented in Chemical Engineering Progress Symposium Series 59, (41) 71-87 (1963) but is within the boiling range.

E. Reactor Pool

1. The water level in the reactor pool will be 8 ft above the top of the reactor tank (17 ft above the core) for full-power operation.
2. The water level shall be at least at the top of the reactor tank during the performance of critical tests.

F. Emergency Cooling System (for afterheat removal)

1. Minimum emergency cooling capacity and time--500 gpm for 30 min.
2. Minimum emergency power system--A minimum of two auxiliary units of the emergency cooling system must be operating at all times during operation at 30,000 kw. (Any one of the four emergency-powered units will provide adequate coolant flow.)

G. Control and Safety Systems

1. Mechanical control system.
   a. Minimum number of control elements--4.
   b. Minimum number of control rods to attain criticality--The reactor will be so arranged that criticality cannot be achieved by complete withdrawal of any of the control rods while the others are completely inserted.
   c. Maximum release time of control elements (magnet and latch combined) during full-flow conditions--35 msec.
   d. Maximum scram time (maximum time of flight from full withdrawn to bottom seat) during full-flow conditions--500 msec.
   e. Maximum rate of addition of reactivity--0.1% $\Delta k/k$ per sec.
   f. Servo control--The amount of positive reactivity that the servo system is permitted to control is limited to approximately 0.5% $\Delta k/k$.
   g. Operational checks--The release time and scram time are checked before the start of each operating cycle.
2. Control and safety instrumentation--Most of these instrument channels are so installed as to initiate a reactor scram or a reactor setback action whenever certain predetermined conditions exist.

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

(1) Two level safety channels.

(2) One log-N-period channel (to initiate reactor scram at period shorter than one second).

(3) One fission-chamber channel (if log-N confidence does not exist; when used during startup it must have a minimum neutron count rate of 1.5 counts per sec).

(4) One ΔT channel.

(5) One reactor water exit temperature channel.

(6) One primary coolant flow channel.

(7) One north facility flow channel.

(8) Two south facility flow channels.

(9) One normal off-gas monitor and one pressurizable off-gas monitor.

(10) One operating radiation detection monitor associated with the reactor cooling system.

(11) Instrumentation on building ventilation system as described in A.2, above.

b. Minimum safety and control instrumentation required during power operation.

(1) Two level safety channels.

(2) One ΔT channel.

(3) One reactor water exit temperature channel.

(4) One primary coolant flow channel.

(5) One north facility flow channel.

(6) Two south facility flow channels.

(7) One normal off-gas monitor and pressurizable off-gas monitor.

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*The sensitivity of the safety channels is increased by a factor of 45 for operation with primary coolant flow less than 14,000 gpm. Under this condition a reactor shim control-rod reverse is initiated when a power level of 1.8 N_L (~550 kw) is reached and a fast scram is initiated if the power exceeds a nominal 1000 kw.

(8) One operating radiation detection monitor associated with the reactor cooling system.

(9) Building ventilation monitors (see A.2).

c. Control and safety instrument checks--An operational check must be made of both the control and safety instrumentation before the start of each operating cycle.

H. Radiation Monitoring Systems

1. Radiation level monitors--A minimum of three operable radiation monitors will be located at appropriate points within the reactor building.

2. Gas discharge monitors and alarm points.

a. Exhaust duct monitors (described in A.2.b)--50 mr/hr.

b. Pressurizable off-gas monitor--50 mr/hr.

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

1. An experiment is approved more or less 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.

2. Experiments having reactivity worths greater than that in I.1 are considered in more detail--in particular if failure or malfunction of the experiments may cause changes in these values. Considerations are with respect to total worth, rates of change, and to particular situations that may be associated with these changes. No experiment is approved if, for any credible reason, it can cause changes in reactivity that cannot be safely handled by the reactor control system.

3. Experimental installations in the engineering test facilities will be restricted such that upon failure or malfunction of the installation no more than 1.4% reactivity will be added to the reactor.

J. Administrative and Procedural Safeguards

1. Personnel qualifications--The reactor will be operated only by qualified personnel approved by the Operations Division Superintendent.
2. Minimum staff requirement for reactor operation during any shift.
    a. One supervisor must be present in the control room during a startup.
    b. One supervisor on duty.
    c. Two operators on duty.
    d. The control room must be attended by at least one of the persons named above at all times during operation.
3. Procedures--The reactor is operated in conformance with documented operating procedures. In no instance will the operating procedures designate authorization to operate the reactor to excess of any operating safety limits listed above.

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