1.19 Reactor Shutdown

The reactor is shutdown if it is subcritical by at least one dollar in the reference core condition with the reactivity of all installed experiments included.

1.20 Reference Core Condition

The condition of the core when it is at ambient temperature (cold) and the reactivity worth of xenon is negligible (<.30 dollars).

1.21 Research Reactor

A research reactor is defined as a device designed to support a self-sustaining neutron chain reaction for research, development, educational, training, or experimental purposes, and which may have provisions for the production of radioisotopes.

1.22 Rod, Control

A control rod is a device fabricated from neutron absorbing material or fuel which is used to establish neutron flux changes and to compensate for routine reactivity loses. A control rod may be coupled to its drive unit allowing it to perform a safety function when the coupling is disengaged.

1.22.1 Shim Rod

A shim rod is a control rod with an electric motor drive that does not perform a special function such as automatic control or pulse control. The shim rod shall have scram capability.

1.22.2 Regulating Rod

A regulating rod is a control rod used to maintain an intended power level and may be varied manually or by a servo-controller. The regulating rod shall have scram capability.

1.22.3 Standard Rod

The regulating and shim rods are standard control rods.

1.22.4 Transient Rod

A transient rod is a control rod used to initiate a power pulse that is operated by a motor drive and/or air pressure. The transient rod shall have scram capability.

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3.2 Reactor Control and Safety System

3.2.1 Control Assemblies

Specification(s)

The reactor shall not be operated unless the control rods are operable, and

a. Control rods shall not be operable if damage is apparent to the rod or drive assemblies.

b. The scram time measured from the instant a simulated signal reaches the value of a limiting safety system setting to the instant that the slowest scrammable control rod reaches its fully inserted position shall not exceed 1 second.

c. Maximum reactivity insertion rate of a standard control rod shall be less than 0.2% $\Delta k/k$ per second.

3.2.2 Reactor Control System

Specification(s)

The reactor shall not be operable unless the minimum safety interlocks are operable. The following control system safety interlocks shall be operable:

Control Rod Drive Interlock Function	Number Operable	Control Rod	Effective Mode* M	A	S	P
a. Startup Withdrawal - prevent rod up movement if startup signal is less than 2 counts per second	3 1	Standard rods Transient rod	X X	X X		
b. Simultaneous Withdrawal - prevent rod up movement for two or more rods	3 2 1	Standard rods Shim rods Transient rod	X X	 X X		
c. Non pulse condition - prevent air actuation if rod drive is not down	1	Transient rod	X	X		
d. Pulse Withdrawal - prevent withdrawal of non pulse rods	3	Standard rods			X	X
e. Transient Withdrawal - prevent air actuation if linear power is more than 1 kilowatt	1	Transient rod			X	X

*Modes are: (M) Manual, (A) Auto, (S) Square Wave, and (P) Pulse

3.2.3 Reactor Safety System

Specification(s)

The reactor shall not be operable unless the minimum safety channels are operable. The following control rod scram safety channels shall be operable.

Safety System Function	Number Operable	Safety Channel	Effective Mode* M, A, S	P
a. Scram at ≤550°C	2	Fuel Temperature	X	X
b. Scram at ≤1.1 Mw	2	Power Level	X	
Scram at ≤2000Mw	1	Pulse Power		X
c. Scram on loss	2	High Voltage	X	X
d. Scram on loss	1	Magnet Current	X	X
e. Scram on demand	1	Manual Scram Console Button	X	X
f. Scram on loss of timer reset	2	Watchdog Trip Microprocessor scan rate	X	X

*Modes are: (M) Manual, (A) Auto, (S) Square Wave, and (P) Pulse

3.2.4 Reactor Instrument System

Specification(s)

A minimum configuration of measuring channels shall be operable. The following minimum reactor parameter measuring channels shall be operable:

Instrument System Function	Number Operable	Measuring Channel	Effective Mode* M, A, S	P
a. Temperature	2	Fuel Temperature	X	X
b. Power	2	Power Level	X	
c. Pulse	1	Pulse Power		X
d. Pulse	1	Pulse Energy		X

*Modes are: (M) Manual, (A) Auto, (S) Square Wave, and (P) Pulse

Interlocks applicable to the transient rod determine the proper rod operation during manual mode and pulse mode operation. The non pulse condition interlock determines the allowable position of the rod drive for actuation of the FIRE switch. Actuation of the switch applies the air impulse for removal of the transient rod from the reactor core.

Auto mode applies the same interlock controls as the manual mode to the shim and transient rods. Servo calculations limit reactivity insertions by controlling regulating rod drive speed. One limit, a reactor period of four decades per minute, restricts simultaneous up motion of the regulating rod with any other rod.

Two basic interlocks control rod movements for the pulse mode. The interlock to prevent withdrawal of the motor driven rods in the pulse mode is designed to prevent changing the critical state of the reactor prior to the pulse. A power level interlock controls potential fuel temperature changes by setting a limit of less than 1 kilowatt for initiation of any pulse.

Square wave mode applies the same interlock controls as the pulse mode to all control rods. A pulse transient terminates the mode by changing to auto or manual mode. The change to auto or to manual mode becomes effective when a preset condition (demand power) occurs or a preset time (ten seconds) expires.

A.3.2.3 Reactor Safety System

Applicability

These specifications apply to operation of the reactor safety system.

Objective

The objective is to determine the minimum safety system scrams operable for the operation of the reactor.

Bases

Safety system scram functions consist of three types. These scram types are the limiting safety system settings, operable system conditions, and the manual or program logic scrams. The scrams cause control rod insertion and reactor shutdown.

Scrams for limiting safety system settings consist of signal trip levels that monitor fuel temperature and power level. The trip levels are conservative by a significant margin relative to the fuel element temperature safety limit.

Operation without adequate control and safety system power supplies is prevented by scrams on neutron detector high voltage and control rod magnet current.

Manual action of the scram switch, key switch, or computer actuation of watchdog timers will initiate a protective action of the reactor safety system. Either of two watchdog circuits provide updating timers to terminate operation in the event that key digital processing routines fail, such as a display system. Each watchdog circuit with four resettable timers contains one trip relay and monitors one microcomputer.