3.10 Fuel Element and Core Component Handling and Storage

Applicability

This specification applies to the operations of storing and handling fuel elements and core components.

Objective

To assure that fuel elements and core components will be handled at all times in a manner to protect the health and safety of reactor personnel and the public.

Specification

1. Fuel elements shall be stored in accordance with the requirements of the MITR Security Plan.

2. Unirradiated fuel elements may be stored at any of the following locations, subject to the MITR Security Plan and to Specification 4 below:

a. In the reactor core provided the reactivity is below the shutdown margin given by specification 3.9-1,

b. In the cadmium-lined fuel storage ring attached to the flow shroud,

c. In the dry storage holes on the reactor top (one element/hole),

d. In the storage safe in the Reactor Containment Building (Fuel plates also).

3. Irradiated fuel elements can be stored in any of the following locations:

a. in the reactor core provided the reactivity is below the shutdown margin given by Specification 3.9-1,

b. in the cadmium-lined fuel storage ring attached to the flow shroud,

c. in the dry storage holes on the reactor top,

d. in the spent fuel storage tank in the basement of the reactor building,

e. in the fuel element transfer flask or other proper shield within the controlled area.

4. Handling of fuel elements: Only one fuel element at a time shall be moved in or out of the reactor core. Not more than four of the MITR fuel elements or the equivalent of two fuel elements including loose plates (maximum of 15 loose fuel plates) shall be outside of the storage areas as designated in items 2 and 3a, b, c, d except during the processes of receiving or shipping fuel from the site in approved containers. In all cases of fuel element storage outside of the reactor core, the value of k_{eff} must be kept less than 0.90. Records of fuel element transfers shall be maintained. Prior to transferring an irradiated element from the reactor vessel to the transfer flask, the element shall not have been operated in the core at a power level above 100 kW for at least four days.

5. Removal of control blades: A control blade may be removed from the core only if the minimum shutdown margin relative to the cold, Xe-free critical condition with the most reactive operable blade and the regulating rod fully withdrawn is 1% $\Delta k/k$ after the control blade has been removed.

Basis

The principal problem in regard to fresh fuel elements is that of accidental criticality. The locations specified in 2 and 3a, b, c, d provide for complete criticality control. The reactor itself is, of course, shielded and appropriate written procedures assure that it is loaded properly. The fuel elements in the cadmium containing storage ring in the shroud tank are neutronically isolated from the reactor core by the cadmium of each individual box and by the six control blades surrounding the reactor core. The dry storage holes in the reactor top are separate pipes poured in the concrete of the reactor shielding. The pipe sizes and spacings are such as to be safe from criticality when fully loaded with fuel. The fresh fuel storage safe and the spent fuel storage pool both have carefully designed geometric arrays to assure that criticality will not occur. The rows of storage positions in the safe are separated by cadmium, and each fuel element box in the pool is lined with cadmium. The specification of no more than four elements outside of the designated storage areas of 2 and 3a, b, c, d thus assures that no criticality will occur elsewhere. Calculations have been made, by using the methods described in Section 3 of the SAR, which indicate that at least 8 1/3 MITR fuel elements with optimum spacing and total reflection are required for criticality. Similar calculations show that 72 fuel plates with 27 grams U-235 are required for criticality, giving a safe handling limit of about 30. No calculations have been done for 34 gram plates, and so a conservative limit of 15 unassembled plates is established.

It has been calculated that fuel elements when stored in the locations specified in 2b, 2c, 2d, 3b, 3c, and 3d will have a calculated effective multiplication (k_{eff}) factor of less than 0.9 under optimum conditions of water moderation.

These specifications are also conservative for criticality safe handling of MITR-I fuel alone or in combination with MITR-II fuel.

The chief additional problems with spent fuel are those of shielding personnel from the emitted fission product gamma rays and preventing melting from afterheat. The shielding requirement is met by utilizing a shielded transfer flask for movements and temporary storage and more permanent shielding as indicated in 3a, b, c, and d. The requirement to prevent melting is met by specifying that four days elapse between use of the fuel element in a core operating above 100 KW and removal of the element from the reactor pool. This decay time was determined from experience with the MITR-I combined with a conservative assumption of doubling the power density for the MITR-II.

The specification on removal of control element provides that the stuck rod criteria will always be met, even when one blade is removed for repair. Thus, the reactor still would not go critical on the removal of a second control element.