4C Control Rod Licensing Acceptance Criteria

4C.1 Introduction

A set of acceptance criteria is presented here for evaluating new control rod designs. Control rod compliance with these criteria constitutes the basis for ROC-AEC acceptance and approval of the design. The control rod licensing acceptance criteria and their bases are provided below. Any change to these criteria must have prior ROC-AEC review and approval.

4C.2 General Criteria

Control rod designs must meet the following acceptance criteria:

(1) The control rod stresses, strains, and cumulative fatigue shall be evaluated to not exceed the ultimate stress or strain of the material.

(2) The control rod shall be evaluated to be capable of insertion into the core during all modes of plant operation within the limits assumed in the plant analyses.

(3) The material of the control rod shall be shown to be compatible with the reactor environment.

(4) The reactivity worth of the control rod shall be included in the plant core analyses.

(5) A surveillance program shall be implemented if a change in design features such as new absorber material or structural material not previously used in reactor cores could impact the function of the control rod.

4C.3 Basis for Acceptance Criteria

The following comprise the basis for the licensing acceptance criteria given in Section 4C.2.

4C.3.1 Stress, Strain and Fatigue

The control rod is evaluated to assure that it does not fail because of loads due to shipping, handling, and normal, abnormal, emergency, and faulted operating modes. To assure that the control rod does not fail, these loads must not exceed the ultimate stress and strain limit of the material including irradiation effects for its design life. Fatigue must not exceed a fatigue usage factor of 1.0.

The loads evaluated include those due to normal operational transients (scram and jogging), pressure differentials, thermal gradients, flow- and system-induced vibration, and irradiation growth in addition to the lateral and vertical loads expected for each condition. Fatigue usage is based upon the cumulative effect of the cyclic loadings. The analyses include corrosion and crud deposition as a function of time as appropriate.

Conservatism is included in the analyses by including margin to the limit or by assuming loads greater than expected for each condition. Higher loads can be incorporated into the analyses by increasing the load itself or by statistically considering the uncertainties in the value of the load.

4C.3.2 Control Rod Insertion

The control rod is evaluated to be sure that it can be inserted during normal, abnormal, emergency and faulted modes of operation, to include the safe shutdown earthquake event combined with LOCA event within the limits assumed in the plant analyses and throughout its design life. These evaluations include a combination of analyses of the geometrical clearance and actual testing. The analyses consider the effects of manufacturing tolerances, swelling and irradiating growth. Tests may be performed to demonstrate control rod insertion capability for conditions such as control rod or fuel channel deformation and vibrations due to safe shutdown earthquakes.

4C.3.3 Control Rod Material

The external control rod materials must be capable of withstanding the reactor coolant environment for the design life of the control rod. Effects of crudding, crevices, stress corrosion and irradiation upon the material must be included in the control rod and core evaluations. Irradiation effects to be considered include material hardening and absorber depletion and swelling.

4C.3.4 Reactivity

The reactivity worth of the control rod is determined by the initial amount and type of absorber material and irradiation depletion. Scram time insertion performance and control rod drop times affect the total reactivity inserted into the core. All of these affected must be included in the plant core analyses including abnormal operational occurrences, infrequent events, and accidents. The reactivity worth of the rod must provide, under conditions of normal operation (including abnormal operational occurrences), appropriate margin for malfunctions, such as two stuck control rods or accidental control rod withdrawal, without exceeding specified acceptable fuel design limits.

4C.3.5 Surveillance Criteria

Visual inspection of the lead depletion control rod design possessing the new design feature and three additional control rods of such design that are within 15% of the estimated fast fluence of the lead control rod shall be performed. If fewer than three control rods are within 15% of the estimated fast fluence of the lead control rod, only those within 15% shall be inspected. Should evidence of a problem arise, arrangements will be made to inspect additional control rods to the extent necessary to identify the root cause of the problem.