4C Control Rod Licensing Acceptance Criteria

4C.1 Introduction

A set of acceptance criteria has been established for evaluating new control rod designs. Control rod compliance with these criteria constitutes the basis for USNRC 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 NRC review and approval.*]*

4C.2 [Design requirements

4C.2.1 General

The general design requirements and applicable criteria for Westinghouse BWR control rods are:

(1) The control rod is compatible with the Control Rod Drive (CRD) system, coupling device, fuel, fuel channels, associated core internals, and rod handling equipment.

(2) The control rod is designed such that rod worth and transient operation (e.g., scram and free fall velocity) are consistent with the plant safety analyses.

(3) The control rod is designed with mechanical stability and materials such that scram capability is maintained throughout control rod life.

(4) The control rod is designed such that currently used tools can monitor core power distribution and burn-up.

(5) The control rod is designed such that total life cycle dose due to its use (activation product dose, direct dose, and disposal dose) is minimized.

(6) The design and manufacture of the control rod fulfill applicable codes and standards, including applicable parts of the ASME Boiler and Pressure Vessel Code.

4C.2.1.1 Mechanical Criteria

- *Stresses on the control rod handle due to normal loading and handling shall not exceed allowable values anytime in life.*

  This criterion ensures that the control rod can be safely moved during receipt, initial installation, shuffling, removal, and preparation for disposal.

- *Stresses in the control rod absorber wings due to pressure differences (ΔP) across the walls shall not exceed applicable design values any time in life. Fatigue in the Westinghouse*

* See Section 4.2.

control rod wings due to pressure differential cycles (ΔPcycle) across the walls shall not exceed allowable ASME values anytime in life.

This criterion ensures that allowable stress limits are met with the maximum outside to inside ΔP at beginning of life and maximum inside to outside ΔP at the end of life, throughout the complete lifetime of any Westinghouse control rod design.

- *Stresses and fatigue in control rods due to scram induced loads shall not exceed allowable values.*

  This criterion ensures that applicable stress limits, based on the intent of ASME Section III, are met with any plant specific scram load throughout the lifetime of any Westinghouse control rod design.

- *The control rod shall be capable of insertion into the core without structural damage in the presence of oscillatory fuel (channel) deflection under earthquake conditions.*

  This criterion ensures that control rods are capable of insertion into the core in the unlikely event of relatively large earthquake induced oscillations of fuel channels (bundles).

4C.2.1.2 Materials Criteria

- *Materials used shall be in accordance with the ALARA concept.*

  This criterion ensures that the control rod designs will have at least the same or better characteristics, compared to existing designs, with respect to cobalt release during operation, dose received during replacement and preparation for disposal, and disposal-related radiological parameters (dose and curie content).

- *The external control rod materials shall be capable of withstanding the reactor coolant environment as well as irradiation impact for the design life of the control rod.*

  This criterion ensures that the external materials have a corrosion resistance and resistance to changed properties due to irradiation such that the mechanical integrity is maintained for the design life.

- *Components shall be made of materials compatible with connected and interfacing materials and components.*

  This criterion ensures that the design will be compatible with existing in-reactor materials. Evaluation to confirm compliance with this criterion will ensure that materials related considerations (e.g., differences in thermal expansion, wear properties, etc.) do not create problems.

4C.2.1.3 Physics Criteria

- *The reactivity worth of the control rod shall be included in the safety analysis of the core.*

  This criterion ensures that the shut down margin is secured and the control rod drop occurrence is adequately handled.

- *The Nuclear End-of-Life (NEOL) for a control rod is reached when its rod worth in any quarter segment decreases to 90% of the initial worth.*

  This criterion helps ensure that core monitoring and reload related calculations which are assuming a fresh control rod remain valid, A value of 90% of initial worth in any quarter segment has been historically used for this limit in BWRs.

  Use of a control rod past this historical limit is acceptable as long as the control rod worth is explicitly monitored in appropriate reload and core monitoring codes, mechanical limits for the projected longer life are investigated, and appropriate inspections are carried out after the control rod exceeds the 10% reactivity loss threshold. For such use, end of life for the control rod would occur when either of the following occurs:

  – *The worth of the rod decreases to the point where fuel costs are negatively impacted (i.e., loading pattern cannot be optimized due to the decreased worth of the rod), or*

  – *A visual inspection detects an unacceptable crack.*

4C.2.1.4 Operational Criteria

- *The control rod socket shall be compatible with the existing CRD coupling device.*

  A good coupling design ensures that (1) the control rod can be coupled to the drive when initially installed, (2) the control rod will remain coupled during operation, and (3) the control rod can be uncoupled when the rod is to be shuffled or removed.

- *The control rod weight shall meet specified value.*

  This criterion ensures scram capability, scram times and free fall (rod drop) characteristics. It shall also ensure the settling capability, which depends on the weight of \the control rod to cause it to settle into its final position during normal insertion and withdrawal.

- *The control rod shall be compatible with existing fuel, fuel channels, and core internals.*

  This criterion is important to ensure that normal operation and scram capability are not impacted, i.e., the control rod will not damage surrounding fuel channels, and will fit in the core.

- *The control rod shall be compatible with control rod handling equipment.*

  Compatibility with rod handling equipment is not a safety issue but, nevertheless, must be considered to ensure that the handling equipment can move, install, and remove the control rods.

- *The control rod free fall velocity shall be consistent with the design basis velocity.*

  This criterion ensures that the control rod design is consistent with the control rod free fall assumptions in the plant's Safety Analysis for the Control Rod Drop Accident.

- *Flow-induced vibration of the control rod shall not cause detrimental fretting of the rod or fuel channels.*

  The criterion ensures that control rod vibration, which may be induced by coolant flow in guide tubes and/or in the core, does not have any adverse effect on the control rod or on adjacent fuel channels.

- *Leading control rods possessing new design features are recommended to be inspected to verify the design and establish operating guidelines.*

  Westinghouse has a policy to follow lead control rods of each design to high burn ups by performing inspections. From these inspections, guidelines for operation and the need for further inspections of the various designs are formulated.]*

* See Section 4.2