

Advanced BWR Control Rod CR 99™

Background

The boiling water reactor (BWR) control rod (CR) of today must meet high operational demands while at the same time contribute to decreased operational costs for the plant operator.

Westinghouse BWR Control Rod Design

The Westinghouse BWR control rod design consists of four stainless steel sheets welded together to form a cruciform-shaped rod. Due to this configuration, the product is also known as control rod blade (CRB). Each sheet has horizontally drilled holes to contain absorber material, boron carbide (B_4C) and hafnium. These horizontal holes allow significantly more B_4C in the rod, offering a longer service life versus traditional control rods in most reactors.

CR 99™ Design

The CR 99 control blade, an all- B_4C design, utilizes hot isostatic pressed (HIP) B_4C pins as absorber material. A gap is designed between the pins and the walls of the drilled holes such that the B_4C , which swells due to neutron capture, does not interact with the structural material to create detrimental stresses that lead to stress corrosion cracking. In the tip of the CR 99, an extra-large gap is designed to accommodate swelling by using pins with small diameter. The basis for this design was the identification that neutron irradiation of the tip occurs also when the control rod is fully withdrawn from the core.



Westinghouse CR 99 control rod design

Benefits

- High-duty control rod with hot isostatic pressed (HIP) B₄C pins as absorber material
- Extended service lifetime
- Reactivity worth equal to or higher than the original control rods
- Structural material with high resistance to stress corrosion cracking (SCC)
- Low-cobalt content to minimize activation
- Horizontally drilled absorber holes proven to retain B₄C
- Easy waste disposal

Experience

Westinghouse began developing BWR control rod designs in the mid-1960s. The first control rod – an all-B₄C rod called CR 70 – started operation in 1970. Many original rods have been operated well above 40 years, with full integrity maintained, proving the robustness of the Westinghouse BWR control rod design.

Westinghouse developed the hafnium tip after recognizing that CR 70 control rods, although fully withdrawn from the core, were subjected to neutron fluence at the tip. The introduction of the CR 99 provided an alternative to the use of hafnium by leveraging B₄C pins with engineered gaps and tolerances. The CR 99 design was introduced in Scandinavian BWR's in 1999, featuring the HIP B₄C pin.

Westinghouse has delivered more than 7,000 BWR control rods. CR 99 has become a standard product and almost 1200 CR 99 rods have been delivered to BWRs worldwide.

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