

Advanced Boiling Water Reactor Control Rod CR 99

Background

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

Description

The Westinghouse BWR control rod concept consists of four stainless steel sheets welded together to form a cruciform-shaped rod. Each sheet has horizontally drilled holes to contain the absorber material. In the case of CR 99, heat isostatic pressed (HIP) B4C pins allow significantly more B4C in the rod compared to the original control rods of most reactors. CR 99 is an improvement from the CR 82M-1 control rod in that it has a longer service life when used in high-duty operation.

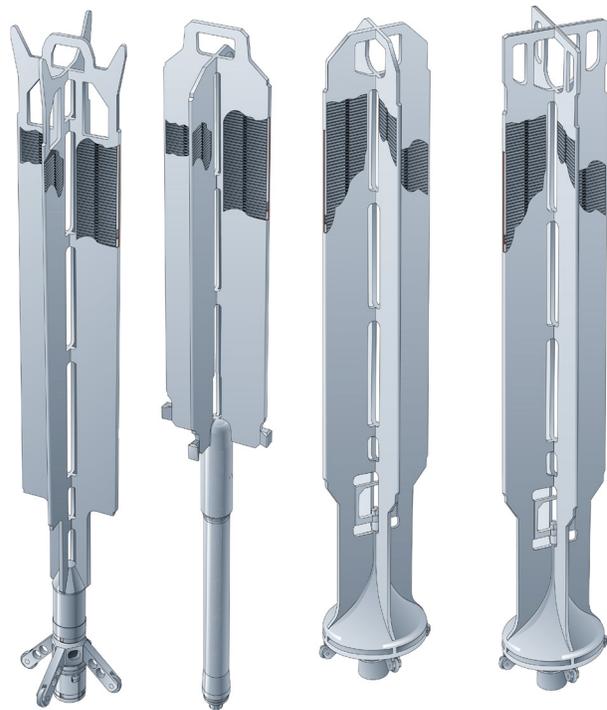
CR 99 Design

The HIP B4C pins of the CR 99 design have the theoretical density of B4C. Between the B4C pin and the stainless steel wall, a gap is designed to prevent hard contact between the swelling absorber material and the stainless steel wall under operation through the nuclear end of life. The flexible B4C inventory allows for either matched or high-reactivity worth control rods. As structural material, American Iron and Steel Institute (AISI) 316L stainless steel is an irradiation-resistant steel, not readily sensitized to irradiation-assisted stress corrosion cracking (IASCC). With an extremely low-cobalt content (< 0.02%) in the wing material, these control rods can play a significant role in as-low-as-reasonably-achievable (ALARA) efforts.

The design, with horizontally drilled absorber holes, together with the very limited specific surface of the B4C pins, limits the washout of B4C in case of an anomaly in a wing, thus maintaining full reactivity worth.

Benefits

- High-duty control rod with HIP B4C pins as absorber material
- Long-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
- Horizontally drilled absorber holes proven to retain B4C
- Easy waste disposal



Westinghouse CR 99 control rod for all types of BWRs

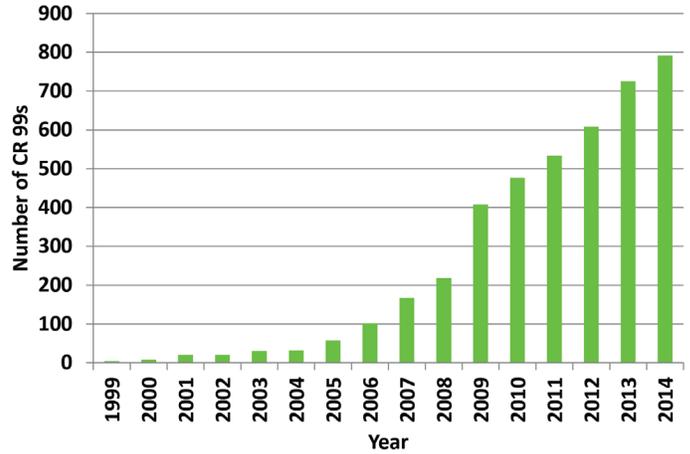
Experience

Westinghouse began developing BWR control rods in the mid-1960s. The first control rod, the CR 70, was in operation in 1970. Many original rods are still in operation after up to 45 years of operation.

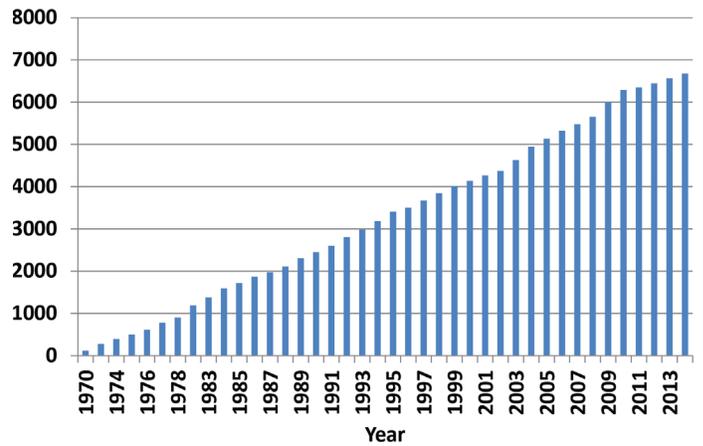
A vast majority of hafnium-tipped rods (CR 82), the first of which was introduced in the United States in 1983, are still in operation. The CR 82M-1 design was introduced in 1995. The main feature of the CR 82M-1 rod is the change of structural material to 316L stainless steel, with high resistance to SCC and a very low-cobalt content. The CR 99 design was introduced in Scandinavian BWRs in 1999. The main feature of the CR 99 is the HIP B4C pin.

Westinghouse has delivered more than 6,700 BWR control rods. CR 99 has become a standard product and almost 800 CR 99s have been delivered to BWRs worldwide.

Westinghouse BWR control rods are licensed in the United States, Germany, Spain, Switzerland, Sweden, Finland and Taiwan.



Deliveries of CR 99
(accumulated to December 2014)



Deliveries of Westinghouse BWR control rods
(accumulated to December 2014)