Global Engineering Services

Upflow Conversion of Reactor Vessel Lower Internals

Background

Westinghouse-designed nuclear steam supply system units that have a downflow reactor vessel lower internals configuration contain an axial gap between the vertical baffle plates in the lower reactor internals. These vertical baffle plates are bolted (using baffle-to-former bolts) to horizontal plates called formers, which in turn are bolted (using former-to-barrel bolts) to the cylindrical core barrel. The core barrel contains flow holes located in the upper core region elevations, which permit a small amount of reactor coolant to flow downward through the region between the baffle plates and the core barrel, causing a significant drop in pressure. This leakage of coolant can cause flow-induced vibration (FIV) of fuel rods close to the baffle gaps. This FIV causes wear and, in some cases, fuel rod failures. Changing the configuration in these plants from downflow to upflow reduces the pressure drop across the baffle plates, significantly reducing the potential for fuel rod failure due to baffle jetting.

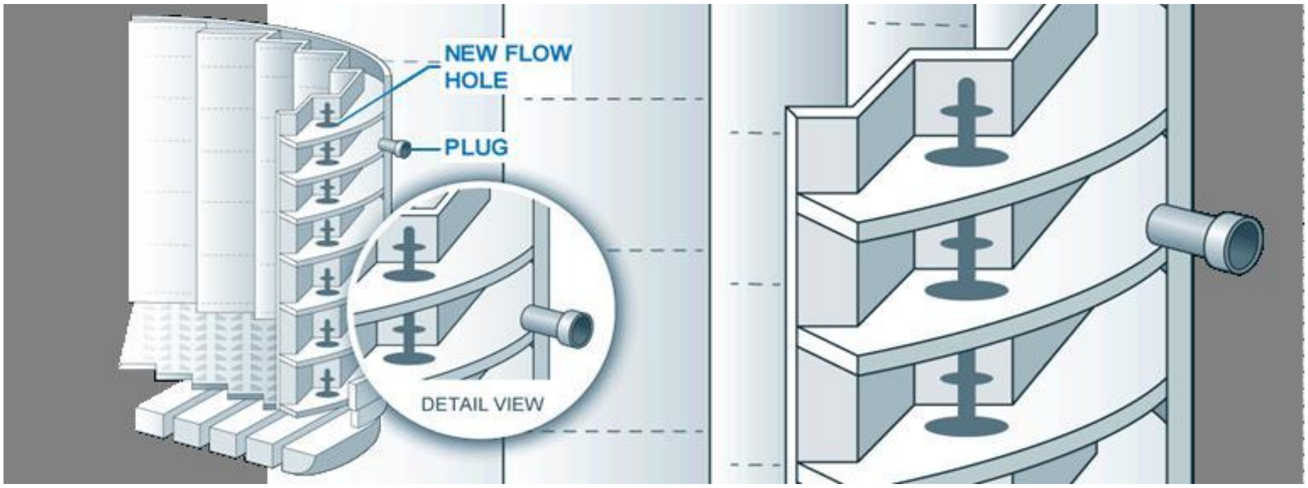
Later generations of commercial nuclear power plants incorporated an upflow configuration in the original design and construction. Baffle jetting fuel failure has not occurred in any plants of the upflow configuration in over 30 years of experience. Existing plants that have been converted to upflow also have not experienced any baffle jetting fuel failures.

Description

The Westinghouse process for converting downflow plants to an upflow configuration begins with the machining of flow holes in the top former plate. Westinghouse uses electro-discharge machining (EDM) to machine a series of flow holes in the top former plate to allow upward flow. The EDM process generates a very fine material called "dross" rather than the chips generated from other machining processes. The dross, which is collected in filters, has the consistency of talcum powder and will not damage fuel assemblies or any other reactor coolant loop component.

The existing flow holes in the core barrel are plugged using a specially designed, mechanically activated locked plug. Using long-handled tools, these custom-designed plugs are inserted into each of the flow holes and then activated via hydraulic pressure. The activation causes hardened steel lock-rings to be embedded in the core barrel flow hole surface and then locked in place. The Westinghouse upflow plugs are designed to be highly resistant after installation, even during a postulated loss-of coolant accident (LOCA) event, and are specifically designed for installation in the annulus between the core barrel and the thermal neutron shield for those plants with thermal neutron shields or for those plants with neutron panels.

All processes are monitored by underwater video camera with specific hold points for video inspections and verification of various sub-steps.



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Benefits

- Significantly reduces risk of fuel failures caused by baffle jetting
- Reduces the loads on baffle-to-former bolts, allowing the plant to operate within its design basis with a significantly fewer number of intact bolts versus downflow configuration
- The Westinghouse upflow plug design helps to prevent potential leakage, even during a postulated LOCA event
- On plants with thermal neutron shields, the Westinghouse upflow plug eliminates the need to machine access holes in the thermal neutron shield
- Eliminates the need to use fuel clips (installation time and additional radiation exposure) or fuel armoring if baffle jetting fuel damage is experienced

Deliverables

- Upflow plugs with manufacturing data package
- Engineering analysis to define the new thermal-hydraulic configuration of the plant
- Qualified field procedures
- Qualified machining and installation equipment

Experience

Westinghouse has performed upflow conversions on over 15 units since 1983, and has performed two conversions in the last three years from 2017.

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