Global Engineering Services

Reactor Coolant Vacuum Refill System

Background

As nuclear utilities continue to focus on driving down operating costs, there has been an increased focus on refueling outage efficiency. Plant staffs seek to reduce the required labor force by optimizing the duration of refueling outages, increasing the predictability of refueling outages and reducing the accumulated radiological doses during the refueling outages.

The Westinghouse reactor coolant vacuum refill system (RCVRS) reduces operating and maintenance costs as compared to conventional reactor coolant system (RCS) fill and venting processes. Westinghouse's RCVRS does this by removing air from the RCS during plant start-up from mid-loop conditions without repeated reactor coolant pump bumping and RCS venting. A vacuum package within the RCVRS extracts air from the steam generator tubes and the reactor vessel head during the RCS refill process, and then the RCS is pressurized. The reactor coolant pumps (RCPs) are started only once for plant start-up.

Description

Specific hardware and engineering packages comprise the base-scope RCVRS, which is a temporary system that allows plant operations staff to extract air from the RCS during plant startup without using conventional dynamic venting techniques. There are two basic parts to the RCVRS: Primary – a vacuum package (pump or ejector) that transfers the air from the RCS to the plant vent system; and Secondary – a variety of essential hose assemblies and custom hardware that connect the vacuum system to the RCS and various plant support systems.

At the conclusion of plant shutdown operations, the RCS is closed and the RCS water level is established near mid-loop. The RCVRS is started and air is evacuated from the entire RCS, including the reactor vessel head, inverted steam generator U-tubes and pressurizer. Depending on the RCS configuration and the RCVRS design, evacuation time can be less than two hours.

After the RCVRS expels the air, normal filling operations are initiated, the RCVRS is stopped and isolated and the RCS is pressurized. Subsequently, with little or no air in the RCS, the RCPs start only once, with no concern for limited net positive suction head (NPSH) or air voids

Benefits

As a result of the air removal by the RCVRS, the following benefits are realized:

- **Reduction in critical path time during startup**

  By eliminating the traditional repeated RCS pressurization, RCP bumping and manual RCS venting, the RCVRS significantly reduces the time required to vent the RCS.

  This process also eliminates the need for individual, manual venting of the control element drive mechanism housings, which has the added benefit of reduced personnel dose.

- **Reduction in plant maintenance costs**

  By eliminating RCP bumping, wear and tear on the RCP motor, shaft and seals is reduced.

- **Simplified plant chemistry operations**

  The RCVRS significantly reduces the amount of dissolved oxygen in the reactor coolant, meaning fewer hydrazine additions and associated samples and analyses are required to scavenge oxygen and verify that the reactor coolant dissolved oxygen specification for start-up is met.

Deliverables

- Vacuum package, including drawings and manuals
- Interconnecting hoses and custom hardware
- Engineering analyses to support system design and interface with outage conditions

Westinghouse

Options

- **Mid-Loop Ultrasonic Level Measurement Service**

  Westinghouse will install a temporary ultrasonic level measurement system on the RCS hot leg to serve as the primary or backup mid-loop level measurement system. This system is unaffected by the vacuum conditions in the RCS.

- **Steam Bubble Start-up Guidelines**

  Westinghouse conducts an analysis and establishes operating guidelines to allow the plant to eliminate water solid pressurizer operation and to pressurize the RCS by forming a pressurizer steam bubble immediately after vacuum refill.

- **Loops-filled Analysis**

  This analysis allows the unit to take credit in the plant technical specifications for natural circulation following a loss of decay heat removal with an adequate level of vacuum pressure, the steam generator tubes can be shown to be sufficiently full and that when pressurized, spill-over will occur when the hot leg side temperature increases, thus initiating natural circulation.

- **Plant Documentation Support**

  Westinghouse can provide support to the plant for generation of a License Amendment Request to extend the pressure range for the heat-up and cool-down limits beyond the current limit of 0 psig and to provide detailed operating instructions and modification packages.

Experience

Westinghouse has provided the RCVRS in various levels of scope to 15 plants worldwide, encompassing both typical W-NSSS and CE-NSSS designs, and has incorporated the system into its own AP1000® plant design.

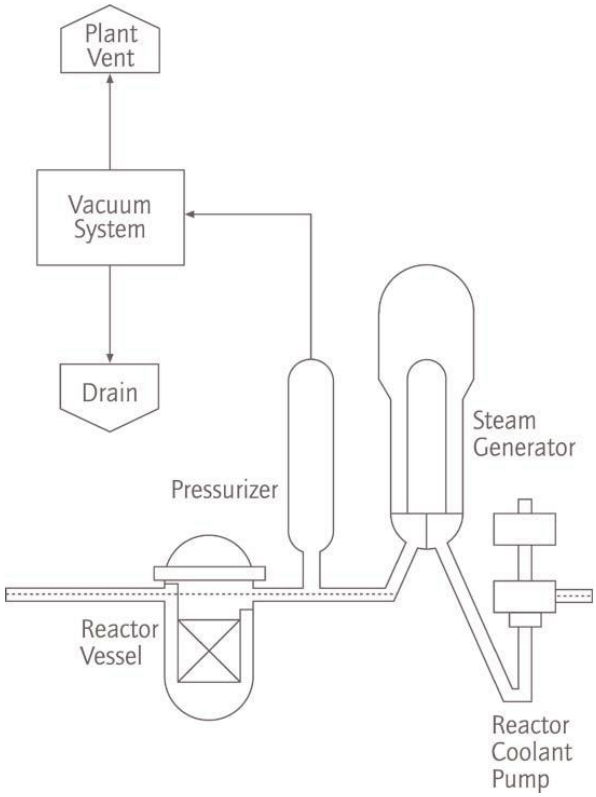

Illustration of the Reactor Coolant Vacuum Refill System arrangement.

AP1000 is a registered trademark of Westinghouse Electric, LLC.

Westinghouse Electric Company
1000 Westinghouse Drive
Cranberry Township, PA 16066

March 2018 / NS-ES-0034

Westinghouse Electric Company
1000 Westinghouse Drive
Cranberry Township, PA 16066

March 2018 / NS-ES-0034

www.westinghouse**nuclear**.com