

# Reactor Vessel Surveillance Capsule Evaluation and Fabrication Programs

## Background

Westinghouse provides post-irradiation testing and evaluation of the reactor vessel material specimens, thermal monitors and dosimeters contained in the surveillance capsules to monitor the effects of neutron irradiation on the reactor vessel beltline materials under actual operating conditions.

Westinghouse conducts the testing in accordance with the applicable revision of ASTM E185, "Conducting Surveillance Tests for Light Water Cooled Nuclear Power Reactor Vessels," and Appendix H of the U.S. Code of Federal Regulations, 10CFR50, "Reactor Vessel Material Surveillance Program Requirements." Appendix H of 10CFR50 requires the removal of a surveillance capsule at specific intervals and testing of the encapsulated specimens to monitor the changes in the fracture toughness and tensile properties of the reactor vessel materials.

## Description

The Westinghouse Reactor Vessel Surveillance Capsule Evaluation and Fabrication Program provides information on the effects of radiation on vessel materials under operating conditions. The capsules contain reactor vessel steel specimens (representative of plates, forgings, welds and HAZ material) and in some cases correlation monitors made from fully documented specimens of SA-302, Grade B or SA-533, Grade B, Class 1 material. Dosimeters, including pure Fe, Ni, Cu, Al-Co (0.15 percent Co) and Cd shielded Al-Co wires, along with U-238 and Np-237 (or Niobium), are placed within the surveillance capsule and evaluated to determine the measured fluence at the specific capsule location within the vessel.

Surveillance capsules containing specimens for use in Charpy V-notch, tensile and fracture mechanics tests are removed from the reactor during normal refueling periods over the design life of the plant. The schedule for the removal of the capsules is based on American Society for Testing and Materials (ASTM) E 185-82.

Specimens undergo post-irradiation testing in a shielded hot cell facility at the Westinghouse Hot Cell Facility in Pittsburgh, Pa. This facility has been actively involved in surveillance capsule material testing since 1974.

## Benefits

- Westinghouse operates one of the most complete commercial hot cell facilities in the United States.
- Westinghouse can customize testing and analyses programs to meet specific requirements.
- Westinghouse has experience in testing and analyzing more than 160 capsules from 63 different reactors, including both pressurized water reactors (PWRs) and boiling water reactors (BWRs).
- Westinghouse has fabricated multiple capsules in the past several years, utilizing previously irradiated test specimens and/or unirradiated test specimens.
- Westinghouse has the ability to handle multiple capsule programs (testing and/or fabrication) at the same time in the hot cell facility. This allows us to be more responsive to our customers' schedule demands during peak periods.
- Our technical personnel are actively involved in industry initiatives and committees in the reactor vessel surveillance capsule and reactor vessel integrity areas and have access to a wide range of materials testing programs in the Westinghouse Research and Development, Electric Power Research Institute (EPRI) and cooperative industry programs.
- Westinghouse can perform evaluations of surveillance capsule data to assess the impact of the data on reactor vessel integrity.
- All Westinghouse specimen testing procedures (tensile, Charpy V-notch and fracture mechanics) are developed in accordance with the latest appropriate ASTM standards.
- Westinghouse can develop revised pressure-temperature limits for normal heat-up and cool-down of the reactor pressure vessel, including criticality limits as supplied in the Technical Specifications, using the results of the irradiated capsule test specimens and the methods of Appendix G of the American Society of Mechanical Engineers (ASME) Code, Section XI (1998 Edition with the Summer 2000 addendum), as required by the U. S. Nuclear Regulatory Commission (NRC) 10CFR50, Appendix G.
- Westinghouse has led the effort to eliminate the flange requirement on P-T Curves (required by 10CFR50, Appendix G) and to develop ASME Code

Cases N-640 (use of  $K_{IC}$ ) and Code Case N-588 (use of circumferentially oriented flaws). Both Code Cases have subsequently been incorporated into the ASME Code, Appendix G.

- Westinghouse segregates the material samples by capsule and stores the samples. This is done to permit reconstitution of Charpy and/or fracture mechanics tests specimens at a later date, if needed. This procedure has been performed by Westinghouse to provide supplementary toughness data to more thoroughly assess the effects of irradiation on the vessel material toughness.
- Westinghouse can offer recommendations for a future capsule removal schedule based on ASTM E 185-82 and 10CFR50, Appendix H.

## Experience

Westinghouse has recently fabricated multiple surveillance capsules for several utilities. Two of these capsules were fabricated using previously irradiated materials and assembled remotely in the hot cell facility. A portion of those specimens were also re-constituted remotely as a part of this effort. Westinghouse has fabricated surveillance capsules to support several programs such as thermal annealing issues, low-lead factors in BWRs and fracture toughness programs.

Westinghouse has tested and analyzed the reactor vessel surveillance capsules in the following plants.

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| • Beaver Valley  | • Indian Point   | • Robinson     |
| • Big Rock Point | • Jose Cabrera   | • Salem        |
| • Braidwood      | • Kewaunee       | • San Onofre   |
| • Brunswick      | • Maanshan       | • Seabrook     |
| • Byron          | • Maine Yankee   | • Sequoyah     |
| • Callaway       | • McGuire        | • South Texas  |
| • Catawba        | • Millstone      | • Summer       |
| • Comanche Peak  | • North Anna     | • Trojan       |
| • Cook           | • Palisades      | • Turkey Point |
| • Diablo Canyon  | • Palo Verde     | • Vogtle       |
| • Dresden        | • Point Beach    | • Watts Bar    |
| • Farley         | • Prairie Island | • Wolf Creek   |
| • Ginna          | • Quad Cities    | • Zion         |