Section 6: Surveillance Program Status and Recommendations

A description of the surveillance materials and current RVSP of all the U.S. PWRs along with the recommended program for the CRVSP is contained in this section. For each plant, the existing RVSP and results to date (e.g., capsules tested, and fluence) are reviewed, and then the recommended changes (if any) are discussed. The following plants are not included in this section because these plants have no remaining capsules: Arkansas Nuclear One Unit 1, Oconee Units 1-3, and Three Mile Island Unit 1. A total of 16 capsules were tested at these plants and all of the withdrawal fluences were below 1.8×10^{19} n/cm^2, which is less than the fluence range of interest for this program (3×10^{19} to 10×10^{19} n/cm^2). These plants participate in the B&W Master Integrated Reactor Vessel Surveillance Program (MIRVP) [15, 16].

The CRVSP will continue to allow the MIRVP plants to participate in the B&W Master Integrated Reactor Vessel Surveillance Program. Surry Unit 2 and Turkey Point Unit 4 are the only MIRVP participants to which the CRVSP makes recommended changes to the plant specific RVSP. The MIRVP does not require Surry Unit 2 to test any additional capsules, so the CRVSP recommendation for Surry Unit 2 to test an additional capsule does not negatively impact the MIRVP. The MIRVP states that Turkey Point Unit 4 will test capsule X at the end of cycle 27, which is between once and twice the projected 60-year peak RPV fluence. The CRVSP recommends that Turkey Point Unit 4 test capsule X at the projected 80-year peak RPV fluence, which is between once and twice the projected 60-year peak RPV fluence. Since Turkey Point is the only MIRVP participant that will use the data from capsule X, this recommended change does not negatively impact the MIRVP.

Where changes to existing RVSPs have been recommended as part of this optimized, coordinated program, they are identified as bulleted items in the "Recommended Program" discussion for each plant.

When changes to a plant's RVSP capsule withdrawal schedule are recommended, those recommendations are expressed in terms of the plant's peak RPV fluence at some future time in life. For example, a recommendation may be made to defer capsule withdrawal from a planned date of 2016 to a future time when the capsule has attained a fluence equal to that plant's 80 year peak RPV fluence. To implement that recommendation, the plant determines the appropriate outage

(or year) to withdraw the capsule in order to achieve that fluence, based on its current fluence and capacity factor projections and using the same methodology that would be used to calculate, for example, the appropriate withdrawal date for its 60 year license renewal capsule.

After recommended changes are identified (bulleted items in the "Recommended Program" section for each plant), a "Discussion" is generally provided that describes the estimated withdrawal date(s) and capsule fluence(s) that would be achieved by implementation of the recommendations. These estimates are for coordinated planning purposes only – used by the CRVSP to estimate capsule data availability to fill high fluence data gaps - and are not meant for any other analysis. Final determination of the appropriate capsule withdrawal year that achieves the CRVSP recommendation is the responsibility of the plant, based on data deemed by the plant to be authoritative and appropriate.

For many plants, the statement provided in the "Recommended Program" section may be "No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments." This statement is intended to address whether or not a change is recommended in order to obtain the objectives of the CRVSP. The statement is not intended to discourage any plant from taking an appropriate action to increase the amount of surveillance data or the fluence level of surveillance data if the plant deems such an action to be in its best interest and compliant with 10 CFR 50 Appendix H [3] requirements. For example, this report may provide a discussion that consideration was given to asking a plant to move a capsule from the spent fuel pool back into the reactor for further irradiation, but that it was decided not to make that recommendation. Moving the capsule may be in the plant's best long-term interest, and there is no intent to discourage such an action, even though the CRVSP did not deem it necessary for the objectives of the CRVSP.

Arkansas Nuclear One Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533, Grade B, Class 1 (low Cu) and weld flux Linde 91 (low Cu) were inserted in the reactor prior to initial start-up [19, 20].

Current Program

Two of the original six surveillance capsules (W-97 and W-104) have been removed and tested, [19]. The lead factor of 1.47 for capsule W-104 was calculated using the capsule fluence (2.937×10^{19} n/cm^2) and the peak RPV at the time of capsule removal (2.001×10^{19} n/cm^2) [19]. The lead factor for capsule W-284 is assumed to be the same as capsule W-104 based on the symmetry of the capsule locations [19]. Arkansas Nuclear One (ANO) Unit 2 received approval for a 60-year (48 EFPY) license renewal in 2005, which requires a standby capsule be removed at the fluence equivalent to EOL peak RPV fluence of 5.277×10^{19} n/cm^2 [21].

Using the capsule lead factor and the linear relationship between EFPY and the peak RPV fluence, the EFPY required for capsule W-284 to reach $5.277x10^{19}$ n/cm^2 was calculated to be 29.8. This linear relationship was based on $3.791x10^{19}$ n/cm^2 at 32 EFPY and $5.580x10^{19}$ n/cm^2 at 48 EFPY [19]. Assuming a capacity factor of 0.95 starting in 2001, capsule W-284 should reach the projected fluence in about 2016.

Table 6-1
ANO Unit 2 Current Withdrawal Schedule [19, 21]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
W-83	83°	---	Standby	---	---
W-97	97°	---	1 (1982)	1.69	$3.33 x10^{18}$
W-104	104°	1.47	14 (2001)	15.7	$2.937x10^{19}$
W-263	263°	---	Standby	---	---
W-277	277°	---	Standby	---	---
W-284	284°	1.47	Planned	29.8	$5.277x10^{19}$(a)

(a) Projected 60-year (48 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Beaver Valley Unit 1

Material Description

Eight surveillance capsules containing beltline materials fabricated from ASME SA-533, Grade B Class 1 (high Cu) and Linde 1092 flux (high Cu) were inserted in the reactor vessel prior to initial start-up [22].

Current Program

Half of the original eight surveillance capsules (V, U, W and Y) have been removed and tested, Table 6-2 [22]. Beaver Valley Unit 1 (BV1) was approved for a 60-year license renewal in 2009 [23]. Per utility input, the projected 60-year (50 EFPY) peak RPV fluence is $5.58x10^{19}$ n/cm^2. Capsule T was moved to 65° at the end of cycle 10 (10.8 EFPY). Capsule Z was moved to 165° at the end of cycle 10 (10.8 EFPY). These capsules were moved to increase the flux, thus producing higher fluence specimens. Based on utility input, capsule X is planned to be withdrawn at a fluence of $5.01x10^{19}$ n/cm^2 in 2013 (26.5 EFPY).

Per utility input, capsule Z will be withdrawn after reaching the projected 60-year (50 EFPY) peak RPV fluence, which is currently estimated to be at 36.6 EFPY. Assuming a capacity factor of 0.95 starting in 2000, capsule Z should reach 36.6 EFPY in 2023.

Table 6-2
Beaver Valley Unit 1 Current Withdrawal Schedule [22]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
V	165°	1.60	1	1.16	$3.23x10^{18}$
U	65°	1.05	4	3.59	$6.46x10^{18}$
W	245°	1.09	6	5.89	$9.86x10^{18}$
Y	295°	1.22	13 (2000)	14.3	$2.15x10^{19}$
X	285°	1.76	Planned	26.5	$5.01x10^{19}$
T	55°/65°	0.77/1.05	Standby	---	---
Z	305°/165°	0.77/1.60	Planned	>36.6	$>5.58x10^{19}$(a)
S	45°	0.63	Standby	---	---

(a) Approximate 60-year (50 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

High fluence data from BV1 surveillance materials will be obtained by the withdrawal and test of a supplemental capsule being irradiated in the Beaver Valley Unit 2 RVSP, discussed below.

Beaver Valley Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533, Grade B, Class 1 (low Cu) and Linde 91 flux (low Cu) were inserted in the reactor prior to initial start-up [24].

Per utility input, supplemental capsule A contains several different materials, including those previously irradiated in BV1 capsule Y.

Current Program

Four of the original six surveillance capsules (U, V, W and X) have been removed and tested, Table 6-3 [24]. Beaver Valley Unit 2 (BV2) was approved for a 60-year license renewal in 2009 [23]. Per utility input, the projected 60-year (54 EFPY) peak RPV fluence is $5.21x10^{19}$ n/cm^2 and the projected 80-year (72 EFPY) peak RPV fluence is $6.86x10^{19}$ n/cm^2.

Capsules Y or Z will be removed and tested between the projected 80-year peak RPV fluence of $8.48x10^{19}$ n/cm^2 and twice the projected 60-year fluence [23]. Per utility input, this is projected to occur at 26.1 EFPY in 2018. The other capsule will remain in the RPV.

Per utility input, supplemental capsule A was inserted into location 107° after cycle 8 and has a lead factor of 3.58.

Table 6-3
Beaver Valley Unit 2 Current Withdrawal Schedule [24]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	343°	3.17	1	1.24	6.082×10^{18}
V	107°	3.64	5	5.98	2.629×10^{19}
W	110°	3.29	8	9.77	3.625×10^{19}
X	287°	3.68	11 (2005)	13.94	5.601×10^{19}(a)
Y	290°	3.25	Planned	26.1	8.48×10^{19}(b)
Z	340°	3.25	Standby	---	---
A	107°	3.58	Standby	---	---

(a) Approximate 60-year (54 EFPY) peak RPV fluence.

(b) Between the projected 80-year (72 EFPY) peak RPV fluence and the 2x60-year fluence.

Recommended Program

The following changes to the current capsule withdrawal plan, test schedule, or related commitments are recommended:

- Supplemental capsule A should be removed during the first scheduled outage after the capsule is estimated to attain a fluence equal to the BV1 projected 80-year peak RPV fluence. At a minimum, the BV1 capsule Y Linde 1092 weld metal contained in capsule A should then be tested.

Discussion

BV2 Capsule A:

The following information was provided by the utility for the purpose of developing the CRVSP. The projected 80-year (68 EFPY) peak RPV fluence for BV1 is 7.62×10^{19} n/cm^2. Capsule A will reach a fluence of 7.67×10^{19} n/cm^2 in 2025 (32 EFPY). The previously irradiated material from BV1 capsule Y contained in capsule A will have an approximate cumulative fluence of 9.72×10^{19} n/cm^2 in 2025. The projections resulting from these estimations are shown in the table below.

Testing additional BV1 surveillance material is not required for the BV1 60-year license, but it could support a potential BV1 license renewal to 80 years. Testing the BV1 capsule Y Linde 1092 weld metal contained in capsule A will help fill high fluence data gaps in the Linde 1092 (high Cu) material group, as shown in Figure 4-13.

BV2 Capsule Y:

As noted above, plant personnel provided input during development of the CRVSP that testing of Capsule Y is already planned by the plant. Therefore, testing Capsule Y is not identified as a recommended change because it is not a change from the current program. However, testing Capsule Y makes a valuable contribution to the CRVSP and warrants additional discussion. Although testing an additional capsule is not required for the BV2 60-year license, testing capsule Y or Z as currently planned will help fill high fluence data gaps in the SA-533 (low Cu) and Linde 91 (low Cu) material groups, as shown in Figure 4-1 and Figure 4-9.

Table 6-4
Beaver Valley Unit 2 Estimated Results of Recommended Changes to Withdrawal Schedule

Capsule	Location	Lead Factor	Estimated Removal Year	Removal (EFPY)	Estimated Fluence (n/cm^2)
A	107°	3.58	2025	32	7.67×10^{19}(a) 9.72×10^{19}(b)

(a) Approximate BV1 80-year (68 EFPY) peak RPV fluence.
(b) Approximate cumulative fluence of previously irradiated BV1 capsule Y material in BV2-A.

Braidwood Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-508 Class 3 (low Cu) and Linde 80 flux (low Cu) were inserted in the reactor prior to initial start-up [25].

Current Program

Half of the original surveillance capsules (U, X and W) have been removed and tested, Table 6-5 [25]. Capsules Z and Y were removed at 12.01 EFPY [26]. Per utility input, capsule V was removed at the end of cycle 14 (17.69 EFPY). Braidwood Unit 1 has not submitted a 60-year license renewal application.

The fluence for capsules Z, V and Y were estimated using the capsules' lead factors and the linear relationship between the reported peak RPV fluences and their corresponding EFPY values. This linear relationship was based on a fluence of 1.97×10^{19} n/cm^2 at 32 EFPY, 2.94×10^{19} n/cm^2 at 48 EFPY and 3.3×10^{19} n/cm^2 at 54 EFPY [25].

Table 6-5
Braidwood Unit 1 Current Withdrawal Schedule [25, 26]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	58.5°	4.37	1	1.10	$3.87x10^{18}$
X	238.5°	4.23	4	4.234	$1.24x10^{19}$
W	121.5°	4.20	7	7.61	$2.09x10^{19}$(a)
Z	301.5°	4.20	Storage	12.01	$3.21x10^{19}$(b)
V	61.0°	3.92	Storage	17.69	$4.34x10^{19}$(c)
Y	241.0°	3.92	Storage	12.01	$2.99x10^{19}$

(a) Approximate 40-year (32 EFPY) peak RPV fluence.
(b) Approximate 60-year (54 EFPY) peak RPV fluence.
(c) Approximate 80-year (73 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

The value of reinserting Capsule V and continuing irradiation to achieve a higher fluence was assessed, but that action is not recommended because the benefit to the plant or the PWR surveillance database (SDB) is low. The remaining capsules contain low copper SA-508 base metal and low copper Linde 80 weld metal. High fluence surveillance data will be well represented in the low copper SA-508 category above the projected 2x60-year peak RPV fluence of $6.6x10^{19}$ n/cm^2 without the Capsule V data. The low copper Linde 80 weld metal is unique to Braidwood and Byron units. Therefore, reinsertion of Capsule V for further irradiation provides minimal benefit to the PWR fleet SDB. Furthermore, the data will be available when the capsule is tested for license renewal, if the plant applies for a renewed license. Therefore, there is no need for the CRVSP to recommend any change to the Braidwood 1 RVSP. When the need develops in the future to test a capsule, however, it is suggested that preferential consideration be given to testing the capsule with highest fluence.

Braidwood Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-508 Class 3 (low Cu) and Linde 80 flux (low Cu) were inserted in the reactor prior to initial start-up [27].

Current Program

Half of the original surveillance capsules (U, X and W) have been removed and tested while capsules Z and Y have been removed without testing, Table 6-6 [26]. Per utility input, capsule V was removed at the end of cycle 14 (18.42 EFPY). Braidwood Unit 2 has not submitted a 60-year license renewal application.

The fluences for capsules Z, V and Y were estimated using the capsules' lead factors and the linear relationship between the reported peak RPV fluences and their corresponding EFPY values. This linear relationship was based on a fluence of 1.96×10^{19} n/cm^2 at 32 EFPY, 2.94×10^{19} n/cm^2 at 48 EFPY and 3.3×10^{19} n/cm^2 at 54 EFPY [27].

Table 6-6
Braidwood Unit 2 Current Withdrawal Schedule [26, 27]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	58.5°	4.41	1 (1991)	1.15	4.00×10^{18}
X	238.5°	3.85	~4 (1995)	4.215	1.23×10^{19}
W	121.5°	4.17	7 (2000)	8.53	2.25×10^{19}(a)
Z	301.5°	4.17	Storage	12.78	3.29×10^{19}(b)
V	61.0°	3.92	Storage	18.42	4.44×10^{19}(c)
Y	241.0°	3.92	Storage	12.78	3.09×10^{19}

(a) Approximate 40-year (32 EFPY) peak RPV fluence.
(b) Projected 60-year (54 EFPY) peak RPV fluence.
(c) Approximate 80-year (73 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

The basis for not re-inserting capsules for further irradiation is the same as that provided for Braidwood Unit 1.

Byron Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-508 Class 2 (low Cu) and Linde 80 flux (low Cu) were inserted in the reactor prior to initial start-up [28].

Current Program

Half of the original surveillance capsules (U, X and W) have been removed and tested, Table 6-7 [29]. Per utility input, capsules Z and V were removed at the end of cycle 12 (14.6 EFPY) and capsule Y was removed and the end of cycle 15 (18.8 EFPY). Byron Unit 1 has not submitted a 60-year license renewal application.

The fluences for capsules Z, V and Y were estimated using the capsules' lead factors and the linear relationship between the reported peak RPV fluences and their corresponding EFPY values. This linear relationship was based on $0.579x10^{19}$ n/cm^2 at 9.24 EFPY, $2.02x10^{19}$ n/cm^2 at 32 EFPY and $2.91x10^{19}$ n/cm^2 at 48 EFPY [29].

Table 6-7
Byron Unit 1 Current Withdrawal Schedule [29]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	58.5°	4.22	---	1.15	$4.04x10^{18}$
X	238.5°	4.27	---	5.64	$1.57x10^{19}$
W	121.5°	4.20	---	9.24	$2.43x10^{19}$(a)
Z	301.5°	4.20	Storage	14.6	$3.87x10^{19}$
V	61.0°	3.97	Storage	14.6	$3.66x10^{19}$(b)
Y	241.0°	3.97	Storage	18.8	$4.67x10^{19}$(c)

(a) Approximate 40-year (32 EFPY) peak RPV fluence.
(b) Approximate 60-year (54 EFPY) peak RPV fluence.
(c) Approximate 80-year (73 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

The value of reinserting Capsule Y to continue irradiation before testing the capsule was assessed, but that action is not recommended because the benefit to the plant and the PWR SDB is low. The remaining capsules contain low copper SA-508 base metal and low copper Linde 80 weld metal. High fluence data is

well represented in the low copper SA-508 category. The low copper Linde 80 weld metal is unique to Braidwood and Byron units. Therefore, reinsertion of Capsule Y for further irradiation provides minimal benefit to the PWR fleet SDB. Furthermore, the data will be available when the capsule is tested for license renewal, if the plant applies for a renewed license. Therefore, there is no need for the CRVSP to recommend any change to the Byron Unit 1 RVSP.

Byron Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-508 Class 3 (low Cu) and Linde 80 flux (low Cu) were inserted in the reactor prior to initial start-up [30].

Current Program

Half of the original surveillance capsules (U, X and W) have been removed and tested, Table 6-8 [31]. Per utility input, capsules Z and V were removed at the end of cycle 11 (14.28 EFPY) and capsule Y was removed at the end of cycle 15 (20.02 EFPY). Byron Unit 2 has not submitted a 60-year license renewal application.

The fluences for capsules Z, V and Y were estimated using the capsules' lead factors and the linear relationship between the reported peak RPV fluences and their corresponding EFPY values. This linear relationship was based on 0.541×10^{19} n/cm^2 at 8.57 EFPY, 2.06×10^{19} n/cm^2 at 32 EFPY and 2.98×10^{19} n/cm^2 at 48 EFPY [31].

Table 6-8
Byron Unit 2 Current Withdrawal Schedule [31]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	58.5°	4.40	---	1.15	4.05×10^{18}
W	121.5°	4.25	---	5.64	1.27×10^{19}
X	238.5°	4.25	---	9.24	2.30×10^{19}(a)
Z	301.5°	4.21	Storage	14.28	3.77×10^{19}
V	61.0°	3.97	Storage	14.28	3.56×10^{19}(b)
Y	241.0°	3.97	Storage	20.02	4.97×10^{19}(c)

(a) Approximate 40-year (32 EFPY) peak RPV fluence.
(b) Approximate 60-year (54 EFPY) peak RPV fluence.
(c) Approximate 80-year (73 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

The basis for not re-inserting capsules for further irradiation is the same as that provided for Byron Unit 1.

Callaway Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 0124 flux (low Cu) were inserted in the reactor prior to initial start-up [32].

Current Program

Four of the original six surveillance capsules (U, Y, V and X) have been removed and tested, Table 6-9 [32]. Callaway Unit 1 plans to submit a 60-year license renewal application at the end of 2011. The projected 60-year (54 EFPY) peak RPV fluence is 3.07×10^{19} n/cm^2 [32].

Capsule Z was placed in storage after 16.53 EFPY [33]. Using on the removal EFPY of 16.53 and the linear relationship between the peak RPV fluence and the corresponding EFPY, the fluence of capsule Z was calculated to be 4.23×10^{19} n/cm^2. This linear relationship was based on 1.40×10^{19} n/cm^2 at 24 EFPY, 1.85×10^{19} n/cm^2 at 32 EFPY and 3.07×10^{19} n/cm^2 at 54 EFPY [32].

Table 6-9
Callaway Unit 1 Current Withdrawal Schedule [32]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	58.5°	4.42	1	1.05	3.31×10^{18}
Y	241°	3.85	4	4.6	1.27×10^{19}
V	61°	3.97	8	9.85	2.52×10^{19}
X	238.5°	4.34	10 (1999)	12.4	3.33×10^{19}(a)
W	121.5°	4.29	Standby	--	--
Z	301.5°	4.29	13 (2004)	Storage	4.23×10^{19}(b)

(a) Approximate 60-year (54 EFPY) peak RPV fluence.
(b) Approximate 80-year (72 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Calvert Cliffs Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (high Cu) and Linde 91 flux (high Cu) were inserted in the reactor prior to initial start-up [34].

Current Program

Three of the original six surveillance capsules (97°, 263° and 284°) have been removed and tested, Table 6-10 [34, 35]. Confirmation that capsule 284° was tested was provided by the utility. Calvert Cliffs Unit 1 received a 60-year license renewal in 2000. The projected 60-yearpeak RPV fluence is 5.26×10^{19} n/cm^2 [35]. Capsule 104° was supposed to be removed and tested in 2010, but it was found to have a problem with the lock/latch mechanism. Capsule 284°, which has a similar lead factor, was removed in place of capsule 104° [35]. Capsule 277° is to be placed in storage after removal.

Table 6-10
Calvert Cliffs Unit 1 Current Withdrawal Schedule [34, 36]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
83°	83°	1.28	(2020)	Planned	5.26×10^{19}(a)
97°	97°	1.34	10 (1992)	11.07	2.64×10^{19}
104°	104°	0.96	--	Standby	--
263°	263°	--	3 (1979)	1.39	6.2×10^{18}
277°	277°	1.28	(2032)	Planned	6.59×10^{19}
284°	284°	0.96	(2010)	--	3.06×10^{19}

(a) Approximate 60-year peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Calvert Cliffs Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (high Cu) and Linde 91 flux (high Cu) were inserted in the reactor prior to initial start-up [37].

Current Program

Two of the original six surveillance capsules (97° and 263°) have been removed and tested, Table 6-11 [35]. Calvert Cliffs Unit 2 received approval for a 60-year license renewal in 2000. The projected 60-year peak RPV fluence is 6.16×10^{19} n/cm^2 [35].

Capsule 277° is to be placed in storage after removal.

Table 6-11
Calvert Cliffs Unit 2 Current Withdrawal Schedule [35, 37]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
83°	83°	1.29	(2025)	Planned	6.16×10^{19}(a)
97°	97°	1.29	9 (1993)	10.97	1.85×10^{19}
104°	104°	0.97	(2011)	(b)	3.24×10^{19} (b)
263°	263°	1.48	4 (1982)	---	8.06×10^{18}
277°	277°	1.29	(2033)	Planned	7.46×10^{19}
284°	284°	0.97	Standby	---	---

(a) Between once and twice projected 60-year peak RPV fluence.

(b) Capsule was removed as planned in 2011; EFPY and final fluence data are not yet available.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Catawba Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-508 Class 2 (low Cu) and Grau Lo LW320 flux were inserted in the reactor prior to initial start-up [38].

Current Program

Half of the original surveillance capsules (Z, Y and V) have been removed and tested, Table 6-12 [39]. Per utility input, capsules X and U have been removed and disassembled, with the dosimeters being read and the specimens (not analyzed) placed in storage. Capsule W was removed from the vessel and placed in the spent fuel pool. Catawba Unit 1 received approval for ~59-year (51 EFPY) license renewal in December 2003.

Table 6-12
Catawba Unit 1 Current Withdrawal Schedule [39]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
Z	301.5°	4.15	1 (1986)	0.793	$2.99x10^{18}$
Y	241.0°	4.10	6 (1992)	4.98	$1.318x10^{19}$
W	121.5°	4.26	Storage	14.68	$3.0x10^{19}$(a)
X	238.5°	4.26	Storage	9.29	$2.439x10^{19}$
U	58.5°	4.26	Storage	9.29	$2.439x10^{19}$
V	61.0°	4.08	10 (1997)	9.29	$2.334x10^{19}$

(a) Approximate 60-year (51 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

There is insufficient benefit to the PWR SDB to justify a CRVSP recommendation to reinsert the stored specimens.

Catawba Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 91 flux (low Cu) were inserted in the reactor prior to initial start-up [40].

Current Program

Half of the original surveillance capsules (Z, X and V) have been removed and tested, Table 6-13 [39]. Per utility input, capsule Y was removed and disassembled with dosimetry being read and the specimens (not analyzed) put in storage. Capsule W was removed from the vessel and placed in the spent fuel pool. Capsule U is not available. Catawba Unit 2 received approval for ~58 years (51 EFPY) license renewal in December 2003.

Table 6-13
Catawba Unit 2 Current Withdrawal Schedule [39]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
Z	301.5°	4.13	1 (1987)	0.86	$3.23x10^{18}$
X	241.0°	4.14	5 (1993)	4.52	$1.23x10^{19}$
W	121.5°	4.28	Storage	15.7	$3.0x10^{19}$(a)
U	58.5°	---	---	---	(b)
Y	238.5°	4.33	Storage	9.24	$2.49x10^{19}$
V	61.0°	4.13	9 (1998)	9.24	$2.38x10^{19}$

(a) Approximate 60-year (51 EFPY) peak RPV fluence.
(b) Not available for irradiation or testing.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

There is insufficient benefit to the PWR SDB to justify a CRVSP recommendation to reinsert the stored specimens.

Comanche Peak Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 91 flux (low Cu) were inserted in the reactor prior to initial start-up [41].

Current Program

Half of the original surveillance capsules (U, Y and X) have been removed and tested, Table 6-14 [42]. Per utility input, capsule Z was removed at the same time as capsule X, but it was put in storage without testing. Comanche Peak Unit 1 has not submitted a 60-year license renewal application. The projected 60-year (54 EFPY) peak RPV fluence is $3.33x10^{19}$ n/cm^2 [42].

Table 6-14
Comanche Peak Unit 1 Current Withdrawal Schedule [42]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	58.5°	4.01	1 (1991)	0.91	$3.18x10^{18}$
Y	241.0°	3.86	6 (1998)	6.24	$1.49x10^{19}$
X	238.5°	3.97	11 (2005)	13.10	$3.24x10^{19}$(a)
Z	301.5°	3.93	Storage	13.10	~$3.24x10^{19}$(a)
W	121.5°	3.99	Storage	10.42	$2.23x10^{19}$
V	61.0°	3.74	Storage	10.42	$2.07x10^{19}$

(a) Approximate 60-year (54 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

Testing capsule Z at the 80-year peak RPV fluence is not recommended by the CRVSP based on the discussion in section 4.

Comanche Peak Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 124 flux (low Cu) were inserted in the reactor prior to initial start-up [43].

Current Program

Three of the six surveillance capsules (U, X and W) have been removed and tested, Table 6-15 [44]. Comanche Peak Unit 2 has not submitted a 60-year license renewal application. The projected 60-year (54 EFPY) peak RPV fluence is $3.14x10^{19}$ n/cm^2 [44]. Per utility input, capsules X, V, and Y were removed in 2003 and only X was tested. Capsules W and Z were removed in 2009 and only W was tested.

Table 6-15
Comanche Peak Unit 2 Current Withdrawal Schedule [44]

Capsule	Location	Lead Factor	Year Removed	Removal (EFPY)	Fluence (n/cm^2)
U	58.5°	3.96	1994	0.91	$3.17x10^{18}$
X	238.5°	3.92	2003	8.83	$2.16x10^{19}$(a)
W	121.5°	3.86	2009	14.51	$3.38x10^{19}$(b)
Z	301.5°	3.86	Storage	14.51	$3.38x10^{19}$(b)
V	61.0°	3.66	Storage	8.83	$2.02x10^{19}$
Y	241.0°	3.66	Storage	8.83	$2.02x10^{19}$

(a) Approximate 40-year (36 EFPY) peak RPV fluence.
(b) Approximate 60-year (54 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

The basis for this position is the same as that provided for Comanche Peak Unit 1.

Crystal River Unit 3

Material Description

The original six surveillance capsules (A, B, C, D, E and F) contained beltline materials fabricated from ASME SA-533 Grade B Class 1 (high Cu) and Linde 80 flux (high Cu) [15].

Two supplementary weld metal surveillance capsules (TMI2-LG1 and TMI2-LG2) containing Linde 80 weld metals (high Cu) were inserted at the end of cycle six [16]. Two high fluence supplementary weld metal surveillance capsules (A2 and A4) containing Linde 80 weld metal (high Cu) were inserted at the end of cycle seven [16].

Two Oconee capsules also remain in CR-3 (OC3-F and OC1-D). Removal has been unsuccessful and is not currently planned.

Current Program

CR-3 is a participant in the B&W MIRVP. All of the original six surveillance capsules and the low fluence supplemental capsules have been removed, Table 6-16 [16]. Capsules A and E were disposed without testing [45]. Capsules A2 and A4 have a planned removal at the end of cycle 29. Crystal River Unit 3 submitted a 60-year (54 EFPY) license renewal application in December 2008.

Table 6-16
Crystal River Unit 3 Current Withdrawal Schedule [16]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
A	---	---	---	---	$1.23x10^{19}$
B	---	---	1	---	$0.117x10^{19}$
C	---	---	5	---	$0.656x10^{19}$
D	---	---	5	---	$0.750x10^{19}$(a)
E	---	---	---	---	$1.240x10^{19}$
F	---	---	6	---	$1.08x10^{19}$
TMI2-LG1	---	---	---	---	$0.585\text{-}0.992x10^{19}$
TMI2-LG2	---	---	---	---	$1.17\text{-}2.01x10^{19}$(b)
OC3-F	---	---	---	Standby	---
OC1-D	---	---	---	Standby	---
A2	---	---	7-29 (2033)	Planned	$6.6\ x10^{19}$
A4	---	---	7-29 (2033)	Planned	$6.6\ x10^{19}$

(a) Approximate 40-year (32 EFPY) peak RPV fluence.
(b) Approximate 60-year (54 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

There are already plans to test additional capsules and moving capsules would not produce high fluence data more quickly.

Davis-Besse Unit 1

Material Description

Six surveillance capsules (A, B, C, D, E and F) containing beltline materials fabricated from ASME SA-508 Class 2 (low Cu) and Linde 80 flux (high Cu) were inserted in the reactor prior to initial start-up [15].

Two supplementary weld metal surveillance capsules (DB1-LG1 and DB1-LG2) containing Linde 80 weld metals were inserted at the end of cycle one [15,16].

Five high fluence supplementary weld metal surveillance capsules (A1, A3, A5, L1 and L2) containing Linde 80 weld metals were inserted in Davis-Besse [15]. Capsule A5 was inserted at the end of cycle seven while the rest were inserted at the end of cycle six.

Current Program

Davis-Besse is a participant in the B&W MIRVP. All of the original six surveillance capsules, the low fluence supplemental capsules and the high fluence supplemental capsules have been removed, except A1 and L2 [16], Table 6-17. Withdrawal of A1 and L2 is not planned. Davis-Besse submitted an application for a 60-year (52 EFPY) license in 2010.

Table 6-17
Davis-Besse Current Withdrawal Schedule [16]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
A	---	---	4	---	$1.29x10^{19}$
B	---	---	3	---	$5.92x10^{18}$
C	---	---	Storage	---	$1.81x10^{19}$
D	---	---	6	---	$9.62x10^{18}$
E	---	---	Disposed	---	$9.80x10^{18}$
F	---	---	1	---	$1.96x10^{18}$
DB1-LG1	---	---	1-4	---	$0.661\text{-}1.03x10^{19}$
DB1-LG2	---	---	1-11	---	$1.10\text{-}1.65x10^{19}$
A1	---	---	Standby	---	---
A3	---	---	6-12	---	$1.166x10^{19}$
A5	---	---	7-11	---	$0.637\text{-}1.042x10^{19}$
L1	---	---	6-12	---	$1.26x10^{19}$
L2	---	---	Standby	---	---

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

DC Cook Unit 1

Material Description

Eight surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (high Cu) and weld flux Linde 1092 (high Cu) were inserted in the reactor prior to initial start-up [46, 47].

Current Program

Half of the surveillance capsules (T, X, Y and U) have been removed and tested, Table 6-18 [46]. DC Cook Unit 1 received a 60-year (48 EFPY) license renewal in 2005. The projected 60-year (48 EFPY) peak RPV fluence is $2.831x10^{19}$ n/cm^2 [46].

Capsules W and S changed locations in 1995 after 13.72 EFPY [46]. At this time, capsule W changed its designation to capsule S and capsule S changed its designation to capsule W. The fluence of capsule S at 32 EFPY was estimated to be 4.7×10^{19} n/cm^2 by using the cumulative lead factor at 32 EFPY (2.6) and the projected peak RPV fluence at 32 EFPY (1.802×10^{19} n/cm^2) [46]. Assuming a 0.95 capacity factor starting in 1995, capsule S should reach 32 EFPY in about 2013.

Table 6-18
DC Cook Unit 1 Current Withdrawal Schedule [46]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
T	40°	3.51	1 (1977)	1.27	2.67×10^{18}
X	40°	3.51	4	3.48	8.31×10^{18}
Y	40°	3.51	6 (1983)	4.95	1.195×10^{19}
U	40°	3.50	10 (1989)	9.17	1.837×10^{19}(a)
V	4°	1.23	Standby	---	
S	4°/40°	1.23/3.51	Planned	32	4.7×10^{19}(b)
Z	4°	1.23	Standby	---	
W	184°/4°	1.23	Standby	---	

(a) Approximate 40-year (32 EFPY) peak RPV fluence.
(b) Approximate 80-year (67 EFPY) peak RPV fluence.

Recommended Program

The following changes to the current capsule withdrawal plan, test schedule, or related commitments are recommended:

- Capsule S should be removed during the last outage before the capsule would receive a neutron fluence equal to two times the peak RPV neutron fluence at the end of the period of extended operation. Capsule S should then be tested.

Discussion

For the purpose of developing the CRVSP, the projected capsule fluence and year of withdrawal were estimated as follows: The estimated removal fluence value of 5.66×10^{19} n/cm^2 is twice the 60-year (48 EFPY) RPV peak fluence of 2.83×10^{19} n/cm^2. The EFPY of capsule S at 5.66×10^{19} n/cm^2 was estimated to be about 36 by using the cumulative lead factor at 36 EFPY (2.7) and the projected peak RPV fluence at 36 EFPY (2.06×10^{19} n/cm^2) [46]. Assuming a 0.95 capacity factor starting in 1995, capsule S should reach 36 EFPY in about 2018. The projections resulting from these estimations are shown in the table below.

Table 6-19
DC Cook Unit 1 Estimated Results of Recommended Changes to Withdrawal Schedule

Capsule	Location	Lead Factor	Estimated Removal Year	Removal (EFPY)	Estimated Fluence (n/cm^2)
S	4°/40°	1.23/3.51	2018	~36	$5.66x10^{19}$(a)

(a) Twice projected 60-year (48 EFPY) peak RPV fluence.

DC Cook Unit 2

Material Description

Eight surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (high Cu) and weld flux Linde 0124 (low Cu) were inserted in the reactor prior to initial start-up [47,48].

Current Program

Half of the surveillance capsules (T, Y, X and U) have been removed and tested, Table 6-20 [48]. DC Cook Unit 2 received a 60-year (48 EFPY) license renewal in 2005. The projected 60-year (48 EFPY) peak RPV fluence is $2.46x10^{19}$ n/cm^2 [48].

Assuming a 0.95 capacity factor starting in 1992 and the projected removal EFPY of 48.0, capsule S should reach the specified fluence in about 2034.

Table 6-20
DC Cook Unit 2 Current Withdrawal Schedule [48]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
T	40°	3.48	1	1.08	$2.384x10^{18}$
Y	320°	3.47	3	3.22	$6.64x10^{18}$
X	220°	3.46	5 (1987)	5.25	$1.019x10^{19}$
U	140°	3.44	8 (1992)	8.65	$1.583x10^{19}$(a)
S	4°	1.22	Planned	48.0	$2.99x10^{19}$(b)
Z	356°	1.22	Standby	---	---
W	184°	1.22	Standby	---	---
V	176°	1.22	Standby	---	---

(a) Approximate 40-year (32 EFPY) peak RPV fluence.
(b) Between once and twice the projected 60-year (48 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Diablo Canyon Unit 1

Material Description

Eight surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) were inserted in the reactor prior to initial start-up. Three capsules (S, V and Y) also contain Linde 1092 flux (high Cu) in addition to the ASME SA-533 Grade B Class 1 (low Cu) [49].

Replacement capsules (A, B, C and D) were inserted after cycle five [50] and contain ASME SA-533 Grade B Class 1 (high Cu) and Linde 1092 flux (high Cu) Charpy specimens. In addition, Capsules B, C and D contain Charpy specimens supplied by EPRI including Linde 124, Linde 0091 and Linde 80 flux. Capsules B and D also CVN weld specimens that had been irradiated in Capsule S.

Current Program

Three of the twelve surveillance capsules (S, Y and V) have been removed and tested, Table 6-21 [51]. Capsules A, B, C and D were inserted at the end of cycle five after 5.86 EFPY of plant operation. Capsules T, Z, C and D have been removed and placed in storage [51]. Diablo Canyon Unit 1 submitted a 60-year license renewal application in November 2009.

Capsule B is currently scheduled to be removed in 2012 at 23.2 EFPY [51]. Using the capsule lead factor and linear relationship between the reported peak RPV fluences and their corresponding EFPY values, capsule B should reach 3.23×10^{19} n/cm^2 at 23.2 EFPY. The linear relationship was based on the projected peak RPV fluence of 1.55×10^{19} n/cm^2 at 40 EFPY, 1.84×10^{19} n/cm^2 at 48 EFPY and 2.06×10^{19} n/cm^2 at 54 EFPY [49].

Table 6-21
Diablo Canyon Unit 1 Current Withdrawal Schedule [49,51]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
S	320°	3.46	1 (1987)	1.25	$2.84x10^{18}$
Y	40°	3.44	5 (1993)	5.86	$1.05x10^{19}$
T	140°	3.44	Storage	5.86	$1.05x10^{19}$
Z	220°	3.44	Storage	5.86	$1.05x10^{19}$
V	320°	2.26	11 (2002)	14.27	$1.37x10^{19}$(a)
C	140°	3.46	Storage	15.9	$2.31x10^{19}$(b)
D	220°	3.46	Storage	15.9	$2.31x10^{19}$
B	40°	3.46	17 (2012)	Planned	$3.23x10^{19}$
A	184°	1.31	Standby	---	---
U	356°	1.28	Standby	---	---
X	176°	1.28	Standby	---	---
W	4°	1.28	Standby	---	---

(a) Approximate 40-year (32 EFPY) peak RPV fluence.
(b) Approximate 60-year (54 EFPY) peak RPV fluence.

Recommended Program

The following changes to the current capsule withdrawal plan, test schedule, or related commitments are recommended:

- Capsule B should be removed at the last outage before the capsule is estimated to receive a neutron fluence equal to two times the peak RPV neutron fluence at the end of the period of extended operation. Capsule B should then be tested.

Discussion

For the purpose of developing the CRVSP, the projected 2x60-year peak RPV fluence and year of withdrawal were estimated as follows: The removal fluence value of $4.12x10^{19}$ n/cm^2 is twice the 60-year (54 EFPY) RPV peak fluence of $2.06x10^{19}$ n/cm^2 [49]. Using the capsule lead factor and linear relationship between the reported peak RPV fluences and their corresponding EFPY values, the EFPY required for capsule B to go from $3.23x10^{19}$ n/cm^2 to $4.12x10^{19}$ n/cm^2 was calculated to be 7 EFPY. Assuming a 0.95 capacity factor starting in 2002 and the projected removal EFPY of 30.2, the capsule will reach the specified fluence in about 2018. The projections resulting from these estimations are shown in the table below. The plant is responsible for formal determination of the planned withdrawal year, based on the latest RPV fluence data.

Table 6-22
Diablo Canyon Unit 1 Estimated Results of Recommended Changes to Withdrawal Schedule

Capsule	Location	Lead Factor	Estimated Removal Year	Removal (EFPY)	Estimated Fluence (n/cm^2)
B	40°	3.46	2018	30.2	4.12×10^{19}(a)

(a) Twice the projected 60-year (54 EFPY) peak RPV fluence.

Diablo Canyon Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (high Cu) and Linde 1092 flux (high Cu) were inserted in the reactor prior to initial start-up [52].

Current Program

Four of the six surveillance capsules (U, X, Y and V) have been removed and tested, Table 6-23 [51]. The remaining two capsules were removed and placed in storage [51]. Diablo Canyon Unit 2 submitted a 60-year license renewal application in November 2009.

Table 6-23
Diablo Canyon Unit 2 Current Withdrawal Schedule [51, 52]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	56.0°	5.15	1 (1988)	1.02	3.38×10^{18}
X	236.0°	5.40	3 (1990)	3.16	9.19×10^{18}
Y	238.5°	4.58	6 (1995)	7.08	1.55×10^{19}(a)
V	58.5°	4.58	9 (2000)	11.49	2.41×10^{19}(b)
W	124.0°	5.26	Storage	11.49	---
Z	304.0°	5.26	Storage	11.49	---

(a) Approximate 40-year (32 EFPY) peak RPV fluence.
(b) Approximate 60-year (54 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

Testing of capsules W and Z was not recommended based on the discussion in Section 4.

Farley Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (high Cu) and Linde 91 flux (high Cu) were inserted in the reactor prior to initial start-up [53].

Current Program

All of the six surveillance capsules have been removed and tested, Table 6-24 [53]. Farley Unit 1 received approval for a 60-year (54 EFPY) license renewal in May 2005.

Table 6-24
Farley Unit 1 Current Withdrawal Schedule [53]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
Y	343°	3.24	1 (1980)	1.15	6.12×10^{18}
U	107°	3.34	4 (1984)	3.08	1.73×10^{19}
X	287°	3.35	7 (1987)	6.11	3.06×10^{19}
W	110°	3.01	12 (1995)	12.43	4.75×10^{19}(a)
V	290°	3.04	18 (2004)	20.16	7.14×10^{19}(b)
Z	340°	3.04	21 (2008)	24.26	8.47×10^{19}

(a) Approximate 40-year (34 EFPY) peak RPV fluence.

(b) Approximate 60-year (54 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Farley Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (high Cu) and BOLA weld metal were inserted in the reactor prior to initial start-up [54].

Current Program

All six surveillance capsules have been removed and tested, Table 6-25 [54]. Farley Unit 2 received approval for a 60-year (54 EFPY) license renewal in May 2005.

Table 6-25
Farley Unit 2 Current Withdrawal Schedule [54]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	343°	3.26	1 (1983)	1.11	$6.05x10^{18}$
W	110°	2.84	4 (1987)	3.96	$1.73x10^{19}$
X	287°	3.38	6 (1989)	6.43	$2.98x10^{19}$
Z	340°	2.98	12 (1998)	13.85	$4.92x10^{19}$(a)
Y	290°	3.12	16 (2004)	19.01	$6.79x10^{19}$(b)
V	107°	3.58	18 (2008)	21.82	$8.73x10^{19}$(c)

(a) Approximate 40-year (36 EFPY) peak RPV fluence.
(b) Approximate 60-year (54 EFPY) peak RPV fluence.
(c) Approximate 80-year (73 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Fort Calhoun Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and weld flux Linde 1092 (high Cu) were inserted in the reactor prior to initial start-up [55].

Three supplemental capsules (W-225S, W-265S and W-275S) containing materials fabricated from weld flux Linde 1092 (high Cu) were inserted at a later date. Capsules W-225S and W-265S contain Linde 1092 weld heat 305414 while W-275S (installed in 1993) contains weld heats 27204 and 12008/13253 [56].

Current Program

Three of the original six surveillance capsules (W-225, W-265 and W-275) have been removed and tested, Table 6-26 [57]. Capsule W-275S was inserted at the end of cycle 14 [56]. Fort Calhoun received approval for a 60-year (48 EFPY) license renewal in November 2003. The projected 60-year (48 EFPY) peak RPV fluence is $3.5x10^{19}$ n/cm^2 [58]. Fort Calhoun takes credit for surveillance data irradiated in Mihama Unit 1, Diablo Canyon Unit 1 and Palisades [57].

The capsule lead factors were provided per correspondence with the utility.

Per utility input, there are plans to change withdrawal and test of capsule W-275S (which is currently scheduled to be removed and tested at 33.6 EFPY) to 47.2 EFPY (2028) with a fluence of $3.0x10^{19}$ n/cm^2.

Capsule W-95 will be removed and tested after 48 EFPY [57]. Using the capsule lead factor and the linear relationship between the peak RPV fluence and the corresponding EFPY values, the capsule fluence at 48 EFPY was calculated to be $3.92x10^{19}$ n/cm^2. Assuming a capacity factor of 0.95 starting in 1993, capsule W-95 should reach $3.92x10^{19}$ n/cm^2 in about 2029.

Table 6-26
Fort Calhoun Current Withdrawal Schedule [55, 57]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
W-225	225°	1.53	---	2.5	$5.1x10^{18}$
W-265	265°	1.07	---	5.9	$9.0x10^{18}$
W-275	275°	1.05	14 (1993)	13.6	$1.38x10^{19}$
W-45	45°	1.51	Standby	---	---
W-85	85°	1.17	Standby	---	---
W-95	95°	1.17	Planned	48.0	$3.92x10^{19}$(a)
W-225S	225°	1.12	Standby	---	---
W-265S	265°	0.97	Standby	---	---
W-275S	275°	---	Planned	33.6	$1.719x10^{19}$(b)

(a) Greater than projected 60-year (48 EFPY) peak RPV fluence.
(b) Contains corresponding RPV weld material.

Recommended Program

The following changes to the current capsule withdrawal plan, test schedule, or related commitments are recommended:

- Capsule W-45 should be removed during the first scheduled outage which follows estimated capsule exposure to the projected 80-year peak RPV fluence. Capsule W-45 should then be tested.
- Capsule W-95 should remain in the reactor on standby until needed to fulfill future 10 CFR 50 Appendix H [3] or license renewal requirements.
- Capsule W-275S should be removed at 47.2 EFPY (rather than at 33.6 EFPY) to obtain higher fluence data for the limiting RV welds. [See note in Discussion.]

Discussion

For the purpose of developing the CRVSP, the projected 80-year peak RPV fluence and year of withdrawal were estimated as follows: The 80-year (67 EFPY) fluence of $4.72x10^{19}$ n/cm^2 was extrapolated from the linear relationship between the peak RPV fluence and the corresponding EFPY values. The 67 EFPY value was determined by assuming a 0.95 capacity factor starting after 60 years of operation. Using the capsule lead factor and the linear relationship between the reported peak RPV fluences and their corresponding EFPY values, capsule W-45 should reach the specified fluence at 42 EFPY, which will occur in about 2022. The projections resulting from these estimations are shown in the

table below. The plant is responsible for formal determination of the planned year of withdrawal, based on latest vessel fluence data.

Note: The change in withdrawal schedule for W-275S from 33.6 EFPY to 47.2 EFPY is not a recommendation from the CRVSP and is not required to obtain the objectives of the CRVSP; it was added to the list of recommended changes at the request of the plant.

Table 6-27
Fort Calhoun Estimated Results of Recommended Changes and Plant's Changes to Withdrawal Schedule

Capsule	Location	Lead Factor	Estimated Removal Year	Removal (EFPY)	Estimated Fluence (n/cm^2)
W-45	45°	1.51	2022	42.0	4.72×10^{19}(a)
W-95	95°	1.17	Standby	--	--
W-275S	275°	--	2028	47.2	3.0×10^{19}(b, c)

(a) Projected 80-year (67 EFPY) peak RPV fluence.

(b) Contains corresponding RPV weld material.

(c) Not a change required for the CRVSP but added to list at plant's request.

R. E. Ginna Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-508 Class 2 (low Cu) and Linde 80 weld flux (high Cu) were inserted in the reactor prior to initial start-up [59].

Current Program

Five of the six surveillance capsules (V, R, T, S and N) have been removed and tested, Table 6-28 [59]. R. E. Ginna Unit 1 received approval for a 60-year (54 EFPY) license renewal in May 2004. The 60-year (54 EFPY) peak RPV fluence is projected to be 5.66×10^{19} n/cm^2 [59].

Table 6-28
R.E. Ginna Current Withdrawal Schedule [59]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
V	77°	2.96	1 (1973)	1.4	$5.87x10^{18}$
R	257°	2.97	3 (1974)	2.6	$1.02x10^{19}$
T	67°	1.82	9 (1982)	6.9	$1.69x10^{19}$
S	57°	1.79	22 (1993)	17.0	$3.64x10^{19}$(a)
N	237°	1.82	33 (2009)	30.5	$5.80x10^{19}$(b)
P	247°	1.90	Standby	--	(c)

(a) Approximate 40-year (32 EFPY) peak RPV fluence.
(b) Approximate 60-year (54 EFPY) peak RPV fluence.
(c) Per utility input, will be removed and put in storage between 33.9 to 39.9 EFPY per Amendment 97 (LR SER).

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

Capsule P was not selected for testing based on the discussion in Section 4.

Indian Point Unit 2

Material Description

Eight surveillance capsules containing beltline materials fabricated from ASME SA-302 Grade B Modified (high Cu) and Linde 1092 flux (high Cu) were inserted in the reactor prior to initial start-up. [60, 61]. Capsule S is the only remaining capsule that contains Charpy V-notch welds specimens [61].

Current Program

Half of the surveillance capsules (T, Y, Z and V) have been removed and tested, Table 6-29 [61]. Per utility input, capsule S was not retrievable during the 2010 attempt and another attempt will be made with modified tooling in 2012. The current plan calls for capsule S to be tested upon removal. This is dependent on whether relief is obtained from the 2x60-year peak RPV fluence limit. Indian Point Unit 2 applied for a 60-year (48 EFPY) license renewal in April 2007. The projected 60-year (48 EFPY) peak RPV fluence is $1.906x10^{19}$ n/cm^2 [62].

Table 6-29
Indian Point Unit 2 Current Withdrawal Schedule [61, 63]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
T	320°	3.42	1	1.42	$2.53x10^{18}$
Y	220°	3.48	2	2.34	$4.55x10^{18}$
Z	40°	3.53	5	5.17	$1.02x10^{19}$(a)
V	4°	1.18	8 (1987)	8.6	$4.92x10^{18}$
S	140°	3.50	(2012)	Planned	(b)
U	176°	1.20	Standby	---	---
W	184°	1.20	Standby	---	---
X	356°	1.20	Standby	---	---

(a) Approximate 40-year (32 EFPY) peak RPV fluence.
(b) Approximately twice projected 60-year (48 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Indian Point Unit 3

Material Description

Eight surveillance capsules containing beltline materials fabricated from ASME SA-302 Grade B Modified (high Cu) and weld flux Linde 1092 (high Cu) were inserted in the reactor prior to initial start-up. [64].

Current Program

Half of the surveillance capsules (T, Y, Z and X) have been removed and tested, Table 6-30 [64]. Per utility input, capsule S is currently not retrievable, but another attempt will be made with modified tooling during the 2015 outage. The current plan calls for capsule S to be tested upon removal. This is dependent on whether relief is obtained from the 2x60-year peak RPV fluence limit. Indian Point Unit 3 applied for a 60-year (48 EFPY) license renewal in 2007. The projected 60-year (48 EFPY) peak RPV fluence is $1.56x10^{19}$ n/cm^2 [62].

Table 6-30
Indian Point Unit 3 Current Withdrawal Schedule [64]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
T	140°	3.43	1	1.4	$2.63x10^{18}$
Y	40°	3.49	3	3.2	$6.92x10^{18}$
Z	220°	3.48	5	5.5	$1.04x10^{19}$
S	320°	3.74	(2015)	Planned	(a)
X	176°	1.49	12 (2004)	15.5	$8.74x10^{18}$
V	184°	1.52	Standby	---	---
W	4°	1.52	Standby	---	---
U	356°	1.52	Standby	---	---

(a) Approximately twice projected 60-year (48 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Kewaunee Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 1092 flux (high Cu) were inserted in the reactor prior to initial start-up [65].

Current Program

Five of the six surveillance capsules (V, R, P, S and T) have been removed and tested, Table 6-31 [65]. Per utility input, capsule N is on standby until a decision is made whether to test capsule N or a potential supplemental capsule. Kewaunee received approval for a 60-year (52.1 EFPY) license renewal in 2011.

Table 6-31
Kewaunee Current Withdrawal Schedule [65]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
V	77°	3.03	1	1.3	$5.86x10^{18}$
R	257°	3.03	5	4.6	$1.76x10^{19}$
P	247°	2.00	13	11.1	$2.61x10^{19}$
S	57°	2.08	19	16.2	$3.67x10^{19}$(a)
T	67°	2.17	26 (2004)	24.6	$5.62x10^{19}$(b)
N	237°	2.12	---	Standby	---

(a) Approximate 40-year (33 EFPY) peak RPV fluence.
(b) Approximate 60-year (52.1 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Per utility input, Dominion intends to test an additional capsule that will be at a high fluence, but it has not been determined whether to test Capsule N or a potential new supplemental capsule.

McGuire Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (high Cu) and weld flux Linde 1092 (high Cu) were inserted in the reactor prior to initial start-up [66,67].

Current Program

Five of the six surveillance capsules (U, X, V, Y and W) have been removed and tested, Table 6-32 [67]. Only the weld specimens from capsule W have been tested [67]. Capsule Z was removed and disassembled to analyze the dosimeters with the specimens (not analyzed) being put in storage in 1993 [68]. McGuire Unit 1 received approval for a 60-year (54 EFPY) license renewal in December 2003. The projected 60-year (54 EFPY) peak RPV fluence is 3.07×10^{19} n/cm^2 [68].

Table 6-32
McGuire Unit 1 Current Withdrawal Schedule [67, 68]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	56°	4.91	1 (1984)	1.09	3.78×10^{18}
X	236°	5.10	5 (1988)	4.30	1.40×10^{19}
V	58.5°	4.47	8 (1993)	7.24	1.93×10^{19}
Y	238.5°	4.49	11 (1997)	10.21	2.64×10^{19}(a)
Z	304°	5.11	Storage	7.24	2.20×10^{19}(b)
W	124°	5.14	18	19.22	5.10×10^{19}

(a) Approximate 60-year (54 EFPY) peak RPV fluence.
(b) Approximate 40-year (32 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

Capsules W and Z have been disassembled and are not available for re-insertion.

McGuire Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-508 Class 2 (high Cu) and weld flux Grau Lo LW320 were inserted in the reactor prior to initial start-up [69].

Current Program

Four of the six surveillance capsules (V, X, U and W) have been removed and tested, Table 6-33 [69]. Per utility input, capsules Z and Y were removed in 1993 and disassembled with the dosimeters being analyzed and the specimens (not analyzed) being put in storage. McGuire Unit 2 received approval for a 60-year (54 EFPY) license renewal in December 2003. The projected 60-year (54 EFPY) peak RPV fluence is 2.88×10^{19} n/cm^2 [68].

Table 6-33
McGuire Unit 2 Current Withdrawal Schedule [68, 69]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
V	58.5°	4.40	1 (1985)	1.03	3.23×10^{18}
X	236.0°	5.12	5 (1989)	4.16	1.47×10^{19}
U	56.0°	5.16	7 (1992)	6.05	2.04×10^{19}(a)
W	124.0°	5.17	10 (1996)	9.44	3.07×10^{19}(b)
Z	304.0°	5.17	Storage	7.18	2.41×10^{19}
Y	238.5°	4.52	Storage	7.18	2.08×10^{19}

(a) Approximate 40-year (34 EFPY) peak RPV fluence.
(b) Approximate 60-year (54 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

Capsules Z and Y have been disassembled and are not available for re-insertion.

Millstone Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (high Cu) and weld flux Linde 91 (high Cu) were inserted in the reactor prior to initial start-up [70].

Current Program

Four of the seven surveillance capsules (W-97, W-104, W-83 and W-97S) have been removed and tested, Table 6-34 [70]. Per utility input, capsule W-97S was for flux monitoring and did not contain any vessel test specimens. Millstone Unit 2 received approval for a 60-year (54 EFPY) license renewal in November 2005. The projected 60-year (54 EFPY) peak RPV fluence is 3.83×10^{19} n/cm^2 [70]. The supplemental capsule was irradiated for cycles 7-10.

Using the capsule lead factor and the linear relationship between the reported peak RPV fluences and their corresponding EFPY values, the EFPY required for capsule W-277 to reach the projected 60-year (54 EFPY) peak RPV fluence of 3.83×10^{19} n/cm^2 was calculated to be 40.1. This linear relationship was based on 2.4×10^{19} n/cm^2 at 32 EFPY, 3.44×10^{19} n/cm^2 at 48 EFPY and 3.83×10^{19} n/cm^2 at 54 EFPY [70]. Assuming a 0.95 capacity factor starting in 2002 and the projected removal EFPY of 40.1, capsule W-277 should reach the specified fluence in about 2028.

Table 6-34
Millstone Unit 2 Withdrawal Schedule [70, 71]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
W-97	97°	1.40	3	3.0	3.24×10^{18}
W-104	104°	0.95	10	10.0	9.49×10^{18}
W-263	263°	1.31	Standby	---	---
W-83	83°	1.31	14 (2002)	15.3	1.74×10^{19}
W-277	277°	1.31	Planned	40.1	3.83×10^{19}(a)
W-284	284°	0.97	Standby	---	---
W-97S(b)	97°	1.28	6-10	10.0	7.62×10^{18}

(a) Projected 60-year (54 EFPY) peak RPV fluence and between once and twice the projected 40-year (32 EFPY) peak RPV fluence.
(b) Flux monitoring.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Millstone Unit 3

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 91 flux (low Cu) were inserted in the reactor prior to initial start-up [72].

Current Program

Three of the six surveillance capsules (U, X and W) have been removed and tested, Table 6-35 [73]. Millstone Unit 3 received approval for a 60-year (54 EFPY) license renewal in November 2005.

Table 6-35
Millstone Unit 3 Withdrawal Schedule [73]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	58.5°	4.06	1	1.34	4.00×10^{18}
X	238.5°	4.35	6	8.0	1.98×10^{19}(a)
W	121.5°	4.22	10 (2005)	13.8	3.16×10^{19}(b)
Y	241.0°	3.98	Storage	13.8	2.98×10^{19}(b)
V	61.0°	3.98	Storage	13.8	2.98×10^{19}(b)
Z	301.5°	4.22	Standby	---	---

(a) Approximate 40-year (32 EFPY) peak RPV fluence.

(b) Between once and twice the projected 60-year (54 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

The basis for not selecting capsule Z for testing is addressed in Section 4.

North Anna Unit 1

Material Description

Eight surveillance capsules containing beltline materials fabricated from ASME SA-508 Class 2 (high Cu) and weld flux SMIT 89 were inserted in the reactor prior to initial start-up [74].

Current Program

Three of the eight surveillance capsules (V, U and W) have been removed and tested, Table 6-36 [75]. Capsules Z and T were moved to higher lead factor locations in the year 2000 after 16.1 EFPY. Capsule Z has a planned removal date of 2030. North Anna Unit 1 received approval for a 60-year (50.3 EFPY) license renewal in 2003.

Table 6-36
North Anna Unit 1 Current Withdrawal Schedule [75]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
V	165°	1.6	(1979)	1.1	$2.63x10^{18}$
U	65°	1.0	6 (1987)	5.9	$8.72x10^{18}$
X	285°	1.6	Standby	---	---
W	245°	1.03	13 (1998)	14.8	$2.052x10^{19}$
Y	295°	1.03	Standby	---	---
Z(a)	305°/165°	0.69/1.6	Planned	44.5	$6.49x10^{19}$(b)
S	45°	0.55	Standby	---	---
T(a)	55°/245°	0.69/1.03	Standby	---	---

(a) Capsules Z and T were moved in the year 2000 after 16.1 EFPY.

(b) Greater than 60-year (50.3 EFPY) peak RPV fluence.

Recommended Program

The following changes to the current capsule withdrawal plan, test schedule, or related commitments are recommended:

- Capsule X should be removed after exposure to a fluence between $8.0x10^{19}$ n/cm^2 and $9.0x10^{19}$ n/cm^2. Capsule X should then be tested.
- Capsule Z should remain in the reactor on standby until needed to fulfill future 10 CFR 50 Appendix H [3] or license renewal requirements.

Discussion

For the purpose of developing the CRVSP, the projected withdrawal year was estimated as follows: Assuming a capacity factor of 0.95 starting in 2000, the EFPY in 2025 was calculated to be 40.7. Using the capsule lead factor and the linear relationship between the peak RPV fluence and the corresponding EFPY

values, the fluence of capsule X at 40.7 EFPY was calculated to be $8.2x10^{19}$ n/cm^2.This linear relationship was based on $1.99x10^{19}$ n/cm^2 at 14.76 EFPY, $2.15x10^{19}$ n/cm^2 at 16.1 EFPY and $4.108x10^{19}$ n/cm^2 at 32.2 EFPY [74, 75]. The projections resulting from these estimations are shown in the table below.

Table 6-37
North Anna Unit 1 Estimated Results of Recommended Changes to Withdrawal Schedule

Capsule	Location	Lead Factor	Estimated Removal Year	Removal (EFPY)	Estimated Fluence (n/cm^2)
X	285°	1.6	2025	40.7	$8.2x10^{19}$(a)
Z	305°/165°	0.69/1.6	Standby		

(a) Between once and twice the projected 60-year (50.3 EFPY) peak RPV fluence.

North Anna Unit 2

Material Description

Eight surveillance capsules containing beltline materials fabricated from ASME SA-508 Class 2 (high Cu) and Grau Lo LW320 were inserted in the reactor prior to initial start-up [76].

Current Program

Three of the eight surveillance capsules (V, U and W) have been removed and tested, Table 6-38 [75]. Capsule T and Z were moved to higher lead factor locations in 1999 after 15.3 EFPY. Per utility input, the current plan calls for testing either capsule X or Z at 42.8 EFPY (2029), which will be at a fluence between once and twice the projected 60-year (52.3 EFPY) peak RPV fluence of $5.91x10^{19}$ n/cm^2. North Anna Unit 2 received approval for a 60-year license renewal in 2003.

Using the capsule lead factor and the linear relationship between the reported peak RPV fluences and their corresponding EFPY values, the fluence of capsule X at 42.8 EFPY was calculated to be $8.33x10^{19}$ n/cm^2. This linear relationship was based on $1.76x10^{19}$ n/cm^2 at 15.3 EFPY and $5.91x10^{19}$ n/cm^2 at 52.3 EFPY [75].

Table 6-38
North Anna Unit 2 Withdrawal Schedule [75]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
V	165°	1.66	(1982)	1.0	$2.46x10^{18}$
U	65°	1.19	(1989)	6.3	$9.80x10^{18}$
W	245°	1.19	(1999)	15.3	$2.092x10^{19}$
X	285°	1.72	Planned	42.8	$8.33x10^{19}$(a)
Y	295°	1.19	Standby	---	---
T	55°/65°	0.81/1.19	Standby	---	---
Z	305°/165°	0.81/1.66	Planned	42.8	$6.50x10^{19}$(a)
S	45°	0.65	Standby	---	---

(a) Capsule X or Z will be tested at 42.8 EFPY in 2029.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Table 6-39
Not used.

Palisades Unit 1

Material Description

Eight surveillance capsules containing beltline materials fabricated from ASME SA-302 Grade B Modified (high Cu) and weld flux Linde 1092 (high Cu) were inserted in the reactor prior to initial start-up [77].

Current Program

Four of the eight original surveillance capsules (A-240, W-110, W-100 and W-290) have been removed and tested, Table 6-40 [78]. Supplemental capsules SA-60-1 and SA-240-1 were inserted at the end of cycle 11 and then removed and tested. Palisades received a 60-year license renewal in 2007. Per utility input, the projected 60-year (42.1 EFPY) peak RPV fluence is $3.42x10^{19}$ n/cm^2. The utility plans to update the plant specific RVSP to account for the projected 60-year fluence.

Table 6-40
Palisades Current Withdrawal Schedule [79, 80, 78]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
A60	60°	---	---	---	---
A-240	240°	---	2	2.26	4.01×10^{19}
W-110	110°	---	10 (1993)	9.95	1.66×10^{19}
W-100	100°	---	16	16.93	2.10×10^{19}(a)
W-80	80°	---	27 (2019)	Planned	3.06×10^{19}
W-260	260°	---	Standby	---	---
W-280	280°	---	Standby	---	---
W-290	290°	---	5 (1983)	5.21	9.26×10^{18}
SA-60-1	60°	---	11-13	---	---
SA-240-1	240°	---	11-14	---	---

(a) Approximate projected 40-year (24.17 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Palo Verde Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 91 flux (low Cu) were inserted in the reactor prior to initial start-up [81, 82].

Current Program

Half of the six surveillance capsules (137°, 38° and 230°) have been removed and tested, Table 6-41 [81, 83]. Palo Verde Unit 1 received approval for a 60-year (54 EFPY) license renewal in 2011.

Capsule 310° has a planned removal at the projected 60-year (54 EFPY) peak RPV fluence of 2.56×10^{19} n/cm^2 [81, 83]. Assuming a 0.95 capacity factor starting in 2004 and the projected removal EFPY of 40, capsule 310° should reach the specified fluence in about 2031.

Table 6-41
Palo Verde Unit 1 Current Withdrawal Schedule [81, 83]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
137°	137°	1.34	4	4.57	$3.65x10^{18}$
38°	38°	1.33	8	9.76	$6.28x10^{18}$
230°	230°	1.35	11 (2004)	13.83	$8.76x10^{18}$
310°	310°	1.35	(2031)	Planned	$2.56x10^{19}$(a)
43°	43°	1.35	Standby	---	(b)
142°	142°	1.33	Standby	---	(b)

(a) Projected 60-year (54 EFPY) peak RPV fluence.
(b) Removal fluence between the 60-year (54 EFPY) and 80 year (72 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Palo Verde Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 124 flux (low Cu) were inserted in the reactor prior to initial start-up [82, 84].

Current Program

Two of the six surveillance capsules (137° and 230°) have been removed and tested, Table 6-42 [84]. Palo Verde Unit 2 received approval for a 60-year (54 EFPY) license renewal in 2011.

Capsule 310° has a planned removal at the projected 60-year (54 EFPY) peak RPV fluence of $2.83x10^{19}$ n/cm^2 [84]. Assuming a 0.95 capacity factor starting in 2005 and the projected removal EFPY of 39.3, capsule 310° should reach the specified fluence in about 2031.

Table 6-42
Palo Verde Unit 2 Current Withdrawal Schedule [84]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
137°	137°	1.38	4	4.54	$3.87x10^{18}$
230°	230°	1.39	12 (2005)	14.35	$9.92x10^{18}$
310°	310°	1.39	(2031)	Planned	$2.83x10^{19}$(a)
38°	38°	1.37	Standby	---	(b)
43°	43°	1.38	Standby	---	(b)
142°	142°	1.37	Standby	---	(b)

(a) Projected 60-year (54 EFPY) peak RPV fluence.
(b) Removal fluence between the 60-year (54 EFPY) and 80 year (72 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Palo Verde Unit 3

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 124 flux (low Cu) were inserted in the reactor prior to initial start-up [82, 85].

Current Program

Two of the six surveillance capsules (137° and 230°) have been removed and tested, Table 6-43 [83, 85]. Palo Verde Unit 3 received approval for a 60-year (54 EFPY) license renewal in 2011.

Capsule 310° has a planned removal at the projected 60-year (54 EFPY) peak RPV fluence of $2.99x10^{19}$ n/cm^2 [83, 85]. Assuming a 0.95 capacity factor starting in 2005 and the projected removal EFPY of 42, capsule 310° should reach the specified fluence in about 2034.

Table 6-43
Palo Verde Unit 3 Current Withdrawal Schedule [83, 85]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
142°	137°	1.28	4	4.44	$3.48x10^{18}$
230°	230°	1.31	11 (2004)	13.75	$9.07x10^{18}$
310°	310°	1.31	(2034)	Planned	$2.99x10^{19}$(a)
43°	43°	1.30	Standby	---	(b)
137°	142°	1.28	Standby	---	(b)
38°	38°	1.28	Standby	---	(b)

(a) Projected 60-year (54 EFPY) peak RPV fluence.
(b) Removal fluence between the 60-year (54 EFPY) and 80 year (72 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Point Beach Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-302 Grade B (high Cu) and weld flux Linde 80 (high Cu) were inserted in the reactor prior to initial start-up [15, 86].

Current Program

Point Beach Unit 1 is a participant in the B&W MIRVP. Four of the six surveillance capsules (V, S, R and T) have been removed and tested, Table 6-44 [16]. Capsule P was removed and placed in storage after cycle 21. Per utility input, capsule N has a lead factor of 1.93. Point Beach Unit 1 received approval for a 60-year (53 EFPY) license renewal in 2005. Per utility input, the projected 60-year (53 EFPY) peak RPV fluence is $5.09x10^{19}$ n/cm^2. Per B&W MIRVP, Point Beach Unit 1 is not required to test capsules P or N to meet the requirements of their 60-year (53 EFPY) license [16].

Table 6-44
Point Beach Unit 1 Current Withdrawal Schedule [16, 87]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
V	13°	---	1	---	---
S	33°	---	3	---	---
R	13°	---	5	---	---
T	23°	---	11	---	---
P	23°	---	Storage	---	---
N	33°	1.93	Standby	---	(a)

(a) Remove and put in storage at EOL.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

Capsule N was not selected for testing based on the discussion in Section 4.

Point Beach Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-508 Class 2 (low Cu) and Linde 80 flux (high Cu) were inserted in the reactor prior to initial start-up [15, 88].

A supplemental capsule was inserted at EOC 25 containing Linde 80 flux (high Cu) [16].

Current Program

Point Beach Unit 2 is a participant in the B&W MIRVP. Four of the six surveillance capsules (V, T, R and S) have been removed and tested, Table 6-45 [16]. Capsule P was removed and placed in storage at the end of cycle 22 in 1997. Per utility input, capsule N has a lead factor of 1.97. Point Beach Unit 2 received approval for a 60-year (53 EFPY) license renewal in 2005. Per utility input, the projected 60-year (53 EFPY) peak RPV fluence is 5.07×10^{19} n/cm^2. Per B&W MIRVP, Point Beach Unit 2 is only required to test the supplemental capsule to meet the requirements of their 60-year (53 EFPY) license.

The supplemental capsule was inserted at the end of cycle 25, which (per utility input) occurred in 2002 and is planned to be removed and tested at the end of cycle 33 at a capsule fluence of 5.0×10^{19} n/cm^2 [16]. The supplemental capsule has a planned removal at 38 EFPY in 2022 [89].

Table 6-45
Point Beach Unit 2 Current Withdrawal Schedule [16,87,89,90]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
V	13°	---	1 (1974)	---	---
T	23°	---	3 (1977)	---	---
R	13°	---	5 (1979)	---	---
S	33°	---	16 (1990)	14.8	3.47×10^{19}(a)
P	23°	---	Storage	---	---
N	33°	1.97	Standby	---	---
Suppl.	13°	---	Planned	38	5.0×10^{19}(b)

(a) Approximate 40-year (32 EFPY) peak RPV fluence.
(b) Approximate 60-year (53 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

Point Beach Unit 2 already plans to test the supplemental capsule in 2022, which will meet the requirements of their 60-year (53 EFPY) license. Capsule N will remain in the reactor to monitor vessel fluence.

Capsule N was not selected for testing based on the discussion in section 4.

Prairie Island Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-508 Class 3 (low Cu) and UM 89 flux were inserted in the reactor prior to initial start-up [91].

Current Program

Four of the six surveillance capsules (V, P, R and S) have been removed and tested, Table 6-46 [91, 92]. Prairie Island Unit 1 received approval for a 60-year (54 EFPY) license renewal in 2011. To account for license renewal, one of the two remaining capsules will be withdrawn and tested after the capsule has received a neutron fluence equivalent to the 60-year fluence [92]. The projected 60-year (54 EFPY) peak RPV fluence is 5.162×10^{19} n/cm^2 [93]. The utility is aware of the recommendations of the CRVSP and has delayed removal of capsules T and N.

Table 6-46
Prairie Island Unit 1 Current Withdrawal Schedule [91, 92]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
V	77°	2.94	1 (1976)	1.34	$5.63x10^{18}$
P	247°	1.72	5 (1980)	4.60	$1.318x10^{19}$
R	257°	2.99	9 (1985)	8.56	$4.478x10^{19}$
S	57°	1.77	17 (1996)	18.12	$4.017x10^{19}$
T(a)	67°	1.89	27 (2011)	Planned	$6.292x10^{19}$(b)
N(a)	237°	1.77	27 (2011)	Planned	$5.893x10^{19}$(b)

(a) One of these two capsules will be removed and tested. The other will remain inserted.

(b) Between one and twice the projected 60 year (54 EFPY) peak RPV fluence.

Recommended Program

The following changes to the current capsule withdrawal plan, test schedule, or related commitments are recommended:

- Either capsule T or N should be removed at a scheduled outage which follows estimated capsule exposure to the projected 80-year peak RPV fluence, but no later than the year 2024. The capsule should then be tested.
- The remaining capsule should remain in the reactor on standby until needed to fulfill future 10 CFR 50 Appendix H [3] or license renewal requirements.

Discussion

For the purpose of developing the CRVSP, the projected 80-year peak RPV fluence and withdrawal year were estimated as follows: The projected EFPY for the 80-year license was determined using a conservative capacity factor of 0.95. Based on the 32 EFPY fluence of $3.37x10^{19}$ n/cm^2 and the 60-year (54 EFPY) fluence of $5.162x10^{19}$ n/cm^2 [93], the 80-year (73 EFPY) peak RPV fluence was determined by extrapolation to be $6.7x10^{19}$ n/cm^2. For the purpose of this discussion, it is assumed that Capsule T will be withdrawn, although the plant may choose to withdraw Capsule N. Using the capsule lead factor and the linear relationship between the reported peak RPV fluences and their corresponding EFPY values, the EFPY required for capsule T to reach $6.7x10^{19}$ n/cm^2 was calculated to be 34.1. Assuming a 0.95 capacity factor starting in 1996 and the projected removal EFPY of 34.1, capsule T should reach the specified fluence in about 2013. The projections resulting from these estimations are shown in the table below. The plant is responsible for formal determination of the planned year of capsule withdrawal, based on the latest RPV fluence data.

Table 6-47
Prairie Island Unit 1 Estimated Results of Recommended Change to Withdrawal Schedule

Capsule	Location	Lead Factor	Estimated Removal Year	Removal (EFPY)	Estimated Fluence (n/cm^2)
T(a)	67°	1.89	2013(b)	34.1	$6.7x10^{19}$(c)
N	237°	1.77	Standby	---	---

(a) Per the recommendation above, either capsule T or N can be tested. Capsule T was assessed in this table as an example only.
(b) For the purpose of this table, the earliest removal date was assumed. However, the plant may withdraw the chosen capsule at any time after the target fluence is achieved, up to 2024.
(c) Projected 80-year (73 EFPY) peak RPV fluence.

Prairie Island Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-508 Class 3 (low Cu) and UM 89 flux were inserted in the reactor prior to initial start-up [94].

Current Program

Four of the six surveillance capsules (V, T, R and P) have been removed and tested, Table 6-48 [92, 94]. Prairie Island Unit 2 received approval for a 60-year (54 EFPY) license renewal in 2011. The projected 60-year (54 EFPY) peak RPV fluence is $5.196x10^{19}$ n/cm^2 [93]. One of the two remaining capsules will be withdrawn and tested after the capsule has received a neutron fluence equivalent to the 60-year fluence to account for license renewal [92].

Table 6-48
Prairie Island Unit 2 Current Withdrawal Schedule [92, 94]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
V	77°	2.95	1	1.39	$6.206x10^{18}$
T	67°	1.75	4	4.0	$1.199x10^{19}$
R	257°	2.99	9	8.81	$4.376x10^{19}$
P	247°	1.84	16 (1995)	17.24	$4.165x10^{19}$
N(a)	237°	1.72	(2012)	Planned	$5.74x10^{19}$(b)
S(a)	57°	1.72	(2012)	Planned	$5.74x10^{19}$(b)

(a) One of these two capsules will be removed and tested. The other will remain inserted.
(b) Between once and twice the projected 60 year (54 EFPY) peak RPV fluence.

Recommended Program

The following changes to the current capsule withdrawal plan, test schedule, or related commitments are recommended:

- Capsule N should be removed during a scheduled outage that follows estimated capsule exposure to the projected 80-year peak RPV fluence, but no later than 2025. Capsule N should then be tested.
- Capsule S should remain in the reactor on standby until needed to fulfill future 10 CFR 50 Appendix H or license renewal requirements.

Discussion

For the purpose of developing the CRVSP, the projected 80-year peak RPV fluence and removal year were estimated as follows: The projected EFPY for the 80-year license was determined using a conservative capacity factor of 0.95. Based on the 32 EFPY fluence of 3.32×10^{19} n/cm^2 and the 60-year (54 EFPY) fluence of 5.196×10^{19} n/cm^2 [93], the 80-year (73 EFPY) peak RPV fluence was determined by extrapolation to be 6.82×10^{19} n/cm^2. Using the capsule lead factor and the linear relationship between the reported peak RPV fluences and their corresponding EFPY values, the EFPY required for capsule N to reach 6.82×10^{19} n/cm^2 was calculated to be 39.5. Assuming a 0.95 capacity factor starting in 1997 and the projected removal EFPY of 39.5, capsule N should reach the specified fluence in about 2020. The projections resulting from these estimations are shown in the table below. The plant is responsible for formal determination of the capsule withdrawal year, based on the latest RPV fluence data.

Table 6-49
Prairie Island Unit 2 Estimated Results of Recommended Changes to Withdrawal Schedule

Capsule	Location	Lead Factor	Estimated Removal Year	Removal (EFPY)	Estimated Fluence (n/cm^2)
N	237°	1.72	2020 (a)	39.5	6.82×10^{19}(b)
S	57°	1.72	Standby	---	---

(a) For the purpose of this table, the estimated removal year was assumed to be the year the capsule is estimated to attain the projected 80-year RPV fluence. However, per the bulleted recommendation, the plant may choose any removal year beyond after that, up to 2025.

(b) Projected 80-year (73 EFPY) peak RPV fluence.

Robinson Unit 2

Material Description

Eight surveillance capsules containing beltline materials were inserted in the reactor prior to initial start-up [95]. Capsules X, V and T contained specimens fabricated from ASME SA-302 Grade B (high Cu) and Linde 1092 flux (high Cu) [96]. The remaining capsules contain only base metal specimens.

Current Program

Half of the eight surveillance capsules (S, V, T and X) have been removed and tested, Table 6-50 [95]. Capsule U was moved to the 280° location at the end of cycle 8. Per utility input, the current plan calls for removal and testing of capsule U in 2012. Robinson Unit 2 received approval for a 60-year (50 EFPY) license renewal in 2004. The projected 60-year (50 EFPY) peak RPV fluence is 6.00×10^{19} n/cm^2 [95].

Table 6-50
Robinson Unit 2 Current Withdrawal Schedule [95]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
S	280°	1.90	1	1.28	4.79×10^{18}
V	290°	0.91	3	3.18	5.30×10^{18}
T	270°	2.80	8	7.27	3.87×10^{19}
X	50°	1.63	20 (2001)	20.39	4.49×10^{19}
U	30°/280°	1.41 (2.02)	Planned	29.8	6.00×10^{19}(a)
Y	150°	0.92 (1.04)	Standby	---	---
W	40°	0.59 (0.61)	Standby	---	---
Z	230°	0.59 (0.61)	Standby	---	---

(a) Projected 60-year (50 EFPY) peak RPV fluence.
(b) The lead factors in parentheses are for future cycles [95].

Recommended Program

The following changes to the current capsule withdrawal plan, test schedule, or related commitments are recommended:

- Capsule U should be removed during the first scheduled outage that follows estimated capsule exposure to the projected 80-year RPV peak fluence. Capsule U should then be tested.

Discussion

For the purpose of developing the CRVSP, the projected 80-year peak RPV fluence and year of withdrawal were estimated as follows: Per utility input, Capsule U is estimated to reach the projected 80-year (66 EFPY) RPV peak fluence of $7.84x10^{19}$ n/cm^2 at 38.0 EFPY. Assuming a 0.95 capacity factor starting in 2001 and the projected removal EFPY of 38.0, capsule U should reach the specified fluence in about 2019. The projections resulting from these estimations are shown in the table below. The plant is responsible for determination of the actual removal year, based on the latest RPV fluence data.

Table 6-51
Robinson Unit 2 Estimated Results of Recommended Changes to Withdrawal Schedule

Capsule	Location	Lead Factor	Estimated Removal Year	Removal (EFPY)	Estimated Fluence (n/cm^2)
U	30°/280°	1.41 (2.02)	2019	38.0	$7.84x10^{19}$(a)

(a) Projected 80-year (66 EFPY) peak RPV fluence.

Salem Unit 1

Material Description

Eight surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (high Cu) and Linde 1092 flux (high Cu) were inserted in the reactor prior to initial start-up [97]. Remaining capsules U, W, and X contain only Charpy V-notch base metal specimens and capsule V contains base metal, weld metal and 8 HAZ Charpy V-notch specimens [98].

Current Program

Half of the eight surveillance capsules (T, Y, Z and S) have been removed and tested, Table 6-52 [99]. Salem Unit 1 received approval for a 60-year (50 EFPY) license renewal in 2011.

Based on a 32 EFPY peak RPV fluence of $1.53x10^{19}$ n/cm^2 [97], a 50 EFPY peak RPV fluence of $1.84x10^{19}$ n/cm^2 [99] and a lead factor of 1.28, the capsule fluence at 40.0 EFPY is projected to be $2.13x10^{19}$ n/cm^2. Assuming a capacity factor of 0.95 starting in 1995 and an EFPY of 40.0, the capsules should reach the specified fluence in about 2025.

Table 6-52
Salem Unit 1 Current Withdrawal Schedule [97, 99]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
T	140°	3.47	1 (1979)	1.1	$2.59x10^{18}$
Y	40°	3.47	5 (1984)	3.6	$8.70x10^{18}$
Z	220°	3.47	7 (1987)	6.0	$1.26x10^{19}$
S	320°	3.46	12 (1995)	10.9	$1.99x10^{19}$(a)
V	184°	1.28	Planned	40.0	$2.13x10^{19}$(b)
U	356°	1.28	Planned	40.0	$2.13x10^{19}$(b)
X	176°	1.28	Planned	40.0	$2.13x10^{19}$(b)
W	4°	1.28	Planned	40.0	$2.13x10^{19}$(b)

(a) Approximate 60-year (50 EFPY) peak RPV fluence.

(b) Remove between once and twice the projected 60-year (50 EFPY) peak fluence of $1.84x10^{19}$ n/cm^2. Test one capsule and put the remaining three in storage.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

The maximum potential capsule fluence (2x60-year peak RPV fluence) barely meets the high fluence requirements of this program (>$3.0x10^{19}$ n/cm^2) and this peak fluence will not be reached in the planning horizon of this program (2025).

Salem Unit 2

Material Description

Eight surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (high Cu) and Linde 1092 flux (high Cu) were inserted in the reactor prior to initial start-up [100].

Current Program

Half of the eight surveillance capsules (T, U, X and Y) have been removed and tested, Table 6-53 [101]. Salem Unit 2 received approval for a 60-year (50 EFPY) license renewal in 2011.

Based on the 32 EFPY peak RPV fluence of $1.34x10^{19}$ n/cm^2 [100], a 50 EFPY peak RPV fluence of $1.96x10^{19}$ n/cm^2 [101] and a lead factor of 1.38, the capsule fluence at 40 EFPY is projected to be $2.23x10^{19}$ n/cm^2. Assuming a capacity factor of 0.95, the specified fluence should be reached in about 2030.

Table 6-53
Salem Unit 2 Current Withdrawal Schedule [100, 101]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
T	40°	3.41	1	1.19	$2.75x10^{18}$
U	140°	3.45	3	2.7	$5.82x10^{18}$
X	220°	3.48	6	6.19	$1.12x10^{19}$
Y	320°	3.47	11 (2000)	10.8	$1.82x10^{19}$
S	4°	1.38	Planned	40.0	$2.23x10^{19}$(a)
V	176°	1.38	Planned	40.0	$2.23x10^{19}$(a)
W	184°	1.38	Planned	40.0	$2.23x10^{19}$(a)
Z	356°	1.38	Planned	40.0	$2.23x10^{19}$(a)

(a) Remove between once and twice the projected 60-year (50 EFPY) peak fluence of $1.96x10^{19}$ n/cm^2. Test one capsule and put the remaining three in storage.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

The maximum potential capsule fluence (2x60-year peak RPV fluence) barely meets the high fluence requirements of this program (>$3.0x10^{19}$ n/cm^2) and this peak fluence will not be reached in the planning horizon of this program (2025).

San Onofre Nuclear Generating Station (SONGS) Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 91 weld flux (low Cu) were inserted in the reactor prior to initial start-up [102, 103].

Current Program

Two of the six surveillance capsules (97° and 263°) have been removed and tested, Table 6-54 [102]. SONGS Unit 2 has not submitted a 60-year license renewal application.

Per utility input, the current plan calls for the removal and testing of capsule 83° at 24.0 EFPY in 2013.

Table 6-54
SONGS Unit 2 Current Withdrawal Schedule [102, 103, 104]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
97°	97°	1.21	3	2.85	$5.07x10^{18}$
263°	263°	1.21	10 (2000)	13.28	$2.2x10^{19}$
83°	83°	1.21	2013	24.0	$3.80x10^{19}$(a)
104°	104°	0.86	Standby	---	---
277°	277°	1.21	Standby	---	---
284°	284°	0.86	Standby	---	---

(a) Less than projected 40-year (32 EFPY) peak RPV fluence.

Recommended Program

The following changes to the current capsule withdrawal plan, test schedule, or related commitments are recommended:

- Capsule 83° should be removed during the first scheduled outage which follows estimated capsule exposure to the projected 40-year peak RPV fluence. Capsule 83° should then be tested.

Discussion

For the purpose of developing the CRVSP, the projected 40-year peak RPV fluence and year of withdrawal were estimated as follows: The projected 40-year (32 EFPY) peak RPV fluence is $4.37x10^{19}$ n/cm^2 [103]. Using the capsule lead factor and the linear relationship between the reported peak RPV fluences and their corresponding EFPY values, the EFPY required for capsule 83° to reach $4.37x10^{19}$ n/cm^2 was extrapolated to be 26.5. Assuming a 0.95 capacity factor starting in 2001 and the projected removal EFPY of 26.5, capsule 83° should reach the specified fluence in about 2015. The projections resulting from these estimations are shown in the table below. The plant is responsible for determination of the actual removal year, based on the latest RPV fluence data.

Table 6-55
SONGS Unit 2 Estimated Results of Recommended Changes to Withdrawal Schedule

Capsule	Location	Lead Factor	Estimated Removal Year	Removal (EFPY)	Estimated Fluence (n/cm^2)
83°	83°	1.21	2015	26.5	$4.37x10^{19}$(a)

(a) Projected 40-year (32 EFPY) peak RPV fluence.

SONGS Unit 3

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 0124 flux (low Cu) were inserted in the reactor prior to initial start-up [104].

Current Program

Two of the six surveillance capsules (97° and 263°) have been removed and tested, Table 6-56 [105]. Per utility input, the planned removal EFPY of 83° is 24.0. SONGS Unit 3 has not submitted a 60-year license renewal application.

Assuming a capacity factor of 0.95 starting in 2003, capsule 83° should reach 24.0 EFPY in about 2012.

Table 6-56
SONGS Unit 3 Current Withdrawal Schedule [104, 105]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
97°	97°	1.21	4 (1990)	4.33	8.0×10^{18}
263°	263°	1.21	11 (2003)	14.92	2.471×10^{19}
83°	83°	1.21	Planned	24.0	3.79×10^{19}(a)
277°	277°	1.21	Standby	--	--
104°	104°	0.86	Standby	--	--
284°	284°	0.86	Standby	--	--

(a) Less than projected 40-year (32 EFPY) peak RPV fluence.

Recommended Program

The following changes to the current capsule withdrawal plan, test schedule, or related commitments are recommended:

- Capsule 83° should be removed during the first scheduled outage which follows estimated capsule exposure to the projected 40-year peak RPV fluence. Capsule 83° should then be tested.

Discussion

For the purpose of developing the CRVSP, the projected 40-year peak RPV fluence and year of withdrawal were estimated as follows: The projected 40-year (32 EFPY) peak RPV fluence is $4.19x10^{19}$ n/cm^2 [106]. Using the capsule lead factor and the linear relationship between the reported peak RPV fluences and their corresponding EFPY values, the EFPY required for capsule 83° to reach $4.19x10^{19}$ n/cm^2 was extrapolated to be 26.5 EFPY. This linear relationship is based on $2.01x10^{19}$ n/cm^2 at 14.93 EFPY and $4.19x10^{19}$ n/cm^2 at 32 EFPY [106]. Assuming a 0.95 capacity factor starting in 2003 and the projected removal EFPY of 26.5, capsule 83° should reach the specified fluence in about 2016. The projections resulting from these estimations are shown in the table below. The plant is responsible for determination of the actual removal year, based on the latest RPV fluence data.

Table 6-57
SONGS Unit 3 Estimated Results of Recommended Changes to Withdrawal Schedule

Capsule	Location	Lead Factor	Removal Year	Removal (EFPY)	Fluence (n/cm^2)
83°	83°	1.21	2016	26.5	$4.19x10^{19}$(a)

(a) Projected 40-year (32 EFPY) peak RPV fluence.

Seabrook Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 91 flux (low Cu) were inserted in the reactor prior to initial start-up [107].

Current Program

Half of the six surveillance capsules (U, Y and V) have been removed and tested, Table 6-58 [107]. Seabrook submitted a 60-year (55 EFPY) license renewal application in June 2010. Based on the peak RPV fluence of $1.72x10^{19}$ n/cm^2 at 32 EFPY, $2.86x10^{19}$ n/cm^2 at 54 EFPY and $3.17x10^{19}$ n/cm^2 at 60 EFPY [107], the peak RPV fluence at 55 EFPY was interpolated to be $2.91x10^{19}$ n/cm^2. Per utility input, capsule X is planned to be removed and tested at the end of cycle 16 (21 EFPY) at a projected fluence of $4.74x10^{19}$ n/cm^2. Assuming a capacity factor of 0.95 starting in 2005, this is projected to occur in 2014.

Table 6-58
Seabrook Current Withdrawal Schedule [107]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	58.5°	3.96	1 (1991)	0.91	$3.142x10^{18}$
Y	241°	3.74	5 (1997)	5.57	$1.292x10^{19}$
V	61°	3.78	10 (2005)	12.39	$2.669x10^{19}$(a)
X	238.5°	4.11	16 (2014)	Planned	$4.74x10^{19}$(b)
W	121.5°	4.10	Standby	---	(c)
Z	301.5°	4.10	Standby	---	(c)

(a) Approximate 40-year (32 EFPY) peak RPV fluence.

(b) Estimated removal at 21 EFPY; between once and twice 60-year (55 EFPY) peak RPV fluence.

(c) Remove and place in storage within one cycle after capsule X removal.

Recommended Program

The following changes to the current capsule withdrawal plan, test schedule, or related commitments are recommended:

- Capsule X should be removed during the last scheduled outage before the capsule would receive a neutron fluence equal to two times the peak RPV neutron fluence at the end of the period of extended operation. Capsule X should then be tested.

Discussion

For the purpose of developing the CRVSP, the projected 2x60-year peak RPV fluence and year of withdrawal were estimated as follows: The projected 2x60-year peak RPV fluence is $5.82x10^{19}$ n/cm^2, which is twice the projected 60-year (55 EFPY) peak RPV fluence of $2.91x10^{19}$ n/cm^2. Using the capsule lead factor and the linear relationship between the reported peak RPV fluences and their corresponding EFPY values, the EFPY required for capsule X to reach $5.82x10^{19}$ n/cm^2 was calculated to be 26.13. Assuming a 0.95 capacity factor starting in 2005 and the projected removal EFPY of 26.13, capsule X should reach the specified fluence in about 2019. The projections resulting from these estimations are shown in the table below. The plant is responsible for determination of the actual removal year, based on the latest RPV fluence data.

Table 6-59
Seabrook Estimated Results of Recommended Changes to Withdrawal Schedule

Capsule	Location	Lead Factor	Estimated Removal Year	Removal (EFPY)	Estimated Fluence (n/cm^2)
X	238.5°	4.11	2019	26.13	5.82×10^{19}(a)

(a) Twice projected 60-year (55 EFPY) peak RPV fluence.

Sequoyah Unit 1

Material Description

Eight surveillance capsules containing beltline materials fabricated from ASME SA-508 Class 2 (high Cu) and SMIT 89 weld flux were inserted in the reactor prior to initial start-up [108, 109].

Current Program

Half of the eight surveillance capsules (T, U, X and Y) have been removed and tested, Table 6-60 [109, 110]. Sequoyah Unit 1 has not submitted a 60-year license renewal application.

Table 6-60
Sequoyah Unit 1 Current Withdrawal Schedule [108, 109]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
T	40°	3.39	1	1.03	2.61×10^{18}
U	140°	3.47	---	3.0	7.96×10^{18}
X	220°	3.47	5 (1992)	5.27	1.32×10^{19}
Y	320°	3.43	(1999)	10.03	2.19×10^{19}(a)
S	4°	1.08	Standby	---	---
V	176°	1.08	Standby	---	---
W	184°	1.08	Standby	---	---
Z	356°	1.08	Standby	---	---

(a) Approximate 40-year (32 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

The value of relocating Capsule S to a higher lead factor location was assessed, but that action is not recommended because the RPV fluence is relatively low and the achievable fluence would be of limited benefit to the PWR fleet.

Sequoyah Unit 2

Material Description

Eight surveillance capsules containing beltline materials fabricated from ASME SA-508 Class 2 (high Cu) and SMIT 89 weld flux were inserted in the reactor prior to initial start-up [111].

Current Program

Half of the eight surveillance capsules (T, U, X and Y) have been removed and tested, Table 6-61 [111]. Sequoyah Unit 2 has not submitted a 60-year license renewal application.

Table 6-61
Sequoyah Unit 2 Current Withdrawal Schedule [111]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
T	40°	3.33	1	1.04	2.61×10^{18}
U	140°	3.40	3	2.93	6.92×10^{18}
X	220°	3.39	5	5.36	1.22×10^{19}
Y	320°	3.35	9 (1999)	10.54	2.14×10^{19}(a)
S	4°	1.09	Standby	---	---
V	176°	1.09	Standby	---	---
W	184°	1.09	Standby	---	---
Z	356°	1.09	Standby	---	---

(a) Approximate 40-year (32 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

The value of relocating Capsule S to a higher lead factor location to obtain high fluence data more quickly was assessed, but that action is not recommended because the benefit to the PWR surveillance database is low. The remaining capsules contain high copper SA-508 base metal and SMIT 89 weld metal. High fluence data is well represented in both these categories at the projected 80-year peak RPV fluence of 4.09×10^{19} n/cm^2.

Shearon Harris Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 124 weld flux (low Cu) were inserted in the reactor prior to initial start-up [112].

Current Program

Half of the six surveillance capsules (U, V and X) have been removed and tested, Table 6-62 [112]. The lead factors for the remaining capsules increased from 2.38 to 2.68 after cycle 10. Per utility input, capsule W was removed in 2010 and placed in storage. Shearon Harris received a 60-year (55 EFPY) license renewal in 2008.

Based on a 0.95 capacity factor starting in 1999 and the removal in 2010, capsule W should have an EFPY of about 20, at which time the capsule W fluence will be about 6.80×10^{19} n/cm^2 [113].

Table 6-62
Shearon Harris Current Withdrawal Schedule [112, 113, 114]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	343°	2.9	1 (1989)	1.09	5.52×10^{18}
V	107°	3.3	3 (1992)	3.05	1.32×10^{19}
X	287°	2.68	9 (1999)	9.4	3.25×10^{19}
W	110°	2.38/2.68	Storage	~20	~6.8×10^{19}(a)
Y	290°	2.38/2.68	Standby	---	---
Z	340°	2.38/2.68	Standby	---	---

(a) Approximate 60-year (55 EFPY) peak fluence.

Recommended Program

The following changes to the current capsule withdrawal plan, test schedule, or related commitments are recommended:

- Capsule Y or Z should be removed during the first scheduled outage which follows estimated capsule exposure to the projected 80-year peak RPV fluence. The removed capsule should then be tested.

Discussion

For the purpose of developing the CRVSP, the projected 80-year peak RPV fluence and year of withdrawal were estimated as follows: Per utility input, the projected 80-year, 73 Effective Full Power Years (EFPY), peak RPV fluence is approximately 9.15 $\times 10^{19}$ n/cm^2. At the end of Cycle 21, both Capsule Y and Capsule Z are estimated to receive an estimated fluence of 9.39 $\times 10^{19}$ n/cm^2. Because Capsule Y, at the 290° location, and Capsule Z, at the 340° location,

have identical capsule contents, receive approximately equal fluence, and have the same lead factor, either of the two may be withdrawn during RFO-21. The remaining capsule will serve as a standby capsule. The projections resulting from these estimations are shown in the table below.

The value of relocating Capsule S to a higher lead factor location was assessed, but that action is not recommended because the benefit to the PWR surveillance database is low.

Table 6-63
Shearon Harris Estimated Results of Recommended Changes to Withdrawal Schedule

Capsule	Location	Lead Factor	Estimated Removal Year	Removal (EFPY)	Estimated Fluence (n/cm^2)
Y	290°	2.38/2.68	2018	27.2	$9.15x10^{19}$(a)

(a) Projected 80-year (73 EFPY) peak RPV fluence.

South Texas Project Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) Linde 124 weld flux (low Cu) were inserted in the reactor prior to initial start-up [115].

Current Program

Half of the six surveillance capsules (U, Y and V) have been removed and tested, Table 6-64 [116]. The current plan calls for capsule W to be removed and tested in 2011 instead of capsule X [116]. South Texas Project Unit 1 submitted a 60-year license renewal application in 2010. The 60-year (54 EFPY) peak RPV fluence is projected to be $3.86x10^{19}$ n/cm^2 [116].

Table 6-64
South Texas Project Unit 1 Current Withdrawal Schedule [115, 116]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	58.5°	3.59	1 (1989)	0.78	$2.58x10^{18}$
Y	241°	3.28	6	4.90	$1.29x10^{19}$
V	61°	3.04	11 (2003)	11.13	$2.62x10^{19}$(a)
X	238.5°	3.28	Standby	---	---
W	121.5°	3.24	16 (2011)	Planned	$4.33x10^{19}$(b)
Z	301.5°	3.24	Standby	---	---

(a) Approximate 40-year (34 EFPY) peak RPV fluence.

(b) Between once and twice the projected 60-year (54 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

Capsules X and Z were not selected for testing based on the discussion in Section 4.

South Texas Project Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 124 weld flux (low Cu) were inserted in the reactor prior to initial start-up [117].

Current Program

Half of the six surveillance capsules (V, Y and U) have been removed and tested, Table 6-65 [116]. The current plan calls for capsule W to be removed and tested in 2011 instead of capsule X [116]. South Texas Project Unit 2 submitted a 60-year license renewal application in 2010. The 60-year (54 EFPY) peak RPV fluence is projected to be 3.73×10^{19} n/cm^2 [116].

Table 6-65
South Texas Project Unit 2 Current Withdrawal Schedule [116, 117]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
V	61°	3.09	1	0.87	3.4×10^{18}
Y	241°	3.11	5	5.13	1.21×10^{19}
U	58.5°	3.20	9 (2003)	10.31	2.40×10^{19}(a)
X	238.5°	3.22	Standby	---	---
W	121.5°	3.19	15 (2011)	Planned	4.14×10^{19}(b)
Z	301.5°	3.19	Standby	---	---

(a) Approximate 40-year (34 EFPY) peak RPV fluence.
(b) Greater than projected 60-year (54 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

The basis for not recommending additional testing beyond the 60-year capsule is provided in Section 4.

St. Lucie Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (high Cu) and Linde 91 (high Cu) were inserted in the reactor prior to initial start-up [118].

Current Program

Half of the six surveillance capsules (97°, 104° and 284°) have been removed and tested, Table 6-66 [119]. St. Lucie Unit 1 received approval for a 60-year (52 EFPY) license renewal in 2003. The projected 60-year (52 EFPY) peak RPV fluence is 4.24×10^{19} n/cm^2 [120].

Table 6-66
St. Lucie Unit 1 Current Withdrawal Schedule [119, 121]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
97°	97°	---	5	4.67	5.91×10^{18}
104°	104°	---	9	9.515	9.18×10^{18}
284°	284°	---	15 (1999)	17.23	1.45×10^{19}
263°	263°	1.36	(2022)	Planned	4.24×10^{19}(a)
83°	83°	1.36	(2030)	Planned	4.98×10^{19}(b)
277°	277°	1.36	Standby	---	---

(a) Remove at 38 EFPY, which is the 60-year (52 EFPY) peak RPV fluence.

(b) Remove at 45 EFPY.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

Altering the current withdrawal schedule will not yield high fluence data in the planning horizon of this program.

St. Lucie Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (high Cu) and Linde 0124 flux (low Cu) were inserted in the reactor prior to initial start-up [122].

Current Program

Two of the six surveillance capsules (83° and 263°) have been removed and tested, Table 6-67 [122]. St. Lucie Unit 2 received approval for a 60-year (55 EFPY) license renewal in 2003. The projected 60-year (55 EFPY) peak RPV fluence is 4.48×10^{19} n/cm^2 [120].

Based on a 0.95 capacity factor starting in 1998 and an EFPY of 26, capsules 97° should reach the specified fluence in about 2013. Using this same method for capsule 277°, an EFPY of 44 gives a removal year of about 2032.

Table 6-67
St. Lucie Unit 2 Current Withdrawal Schedule [122, 123]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
83°	83°	---	1 (1984)	1.11	1.78×10^{18}
97°	97°	1.27	(2013)	Planned	2.70×10^{19}
104°	104°	0.98	Standby	---	---
263°	263°	---	(1998)	11	1.244×10^{19}
277°	277°	1.27	(2032)	Planned	4.56×10^{19}(a)
284°	284°	0.98	Standby	---	---

(a) Approximate 60-year (54 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

Altering the current withdrawal schedule will not yield high fluence data in the planning horizon of this program.

Surry Unit 1

Material Description

Eight surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (high Cu) and Linde 80 flux (high Cu) were inserted in the reactor prior to initial start-up [15, 124]. Capsule Z is the only remaining capsule that contains both base metals and weld metal Charpy V-notch specimens.

Current Program

Surry Unit 1 is a participant in the B&W MIRVP. Half of the eight surveillance capsules (T, W, V and X) have been removed and tested, Table 6-68 [125]. Capsules X, Z and U were moved to higher lead factor locations in 1994. Capsule Y was moved in 1997 [126]. Per utility input, the current plan calls for the removal and testing of capsule Z in 2025 at a fluence of 6.31×10^{19} n/cm^2. Surry Unit 1 received approval for a 60-year (48 EFPY) license renewal in 2003. The projected 60-year (48 EFPY) peak RPV fluence is 5.66×10^{19} n/cm^2 [125].

Table 6-68
Surry Unit 1 Current Withdrawal Schedule [125, 126]

Capsule	Location	Lead Factor	Year Removed	Removal (EFPY)	Fluence (n/cm^2)
T	285°	---	1974	1.1	2.89×10^{18}
W	55°	---	1978	3.5	4.31×10^{18}
V	165°	---	1986	8.2	1.94×10^{19}
X	65°/165°	---	1997	13.3/16.3	1.60×10^{19}
Z	245°/285°	---	Planned	43.2	6.31×10^{19}(a)
S	295°	---	Standby	---	---
Y	305°/165°	---	Standby	---	---
U	45°/65°	---	Standby	---	---

(a) Between once and twice projected 60-year (48 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

Altering the current withdrawal schedule will not yield high fluence data more expeditiously.

Surry Unit 2

Material Description

Eight surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (high Cu) and Grau Lo LW320 were inserted in the reactor prior to initial start-up [127].

Current Program

Surry Unit 2 is a participant in the B&W MIRVP. Four of the eight surveillance capsules (X, W, V and Y) have been removed and tested, Table 6-69 [16]. Capsule S was evaluated for dosimetry and placed in storage. Capsule Y was moved to the 165° location and capsule Z was moved to the 245° location at the beginning of cycle 13. Capsule T was moved to the 165° location at the beginning of cycle 18 [127]. Capsule U was moved to the 285° location in the fall of 2009 [126]. The current plan calls for capsule U to be removed and tested in 2027 at $5.95x10^{19}$ n/cm^2 [125]. Surry Unit 2 received approval for a 60-year (48 EFPY) license renewal in 2003. The projected 60-year (48 EFPY) peak RPV fluence is $5.38x10^{19}$ n/cm^2 [125].

Table 6-69
Surry Unit 2 Current Withdrawal Schedule [125, 126, 127, 128]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
X	285°	1.60	1 (1975)	1.2	$2.97x10^{18}$
W	245°	1.08	4 (1979)	3.8	$6.36x10^{18}$
V	165°	1.61	8 (1986)	8.7	$1.89x10^{19}$
S(a)	45°	0.61	13 (1996)	15.0	$1.07x10^{19}$
Y	295°/165°	1.27/1.61	17 (2002)	20.8	$2.73x10^{19}$
U	65°/285°	1.15/1.60	Planned	45.0	$5.95x10^{19}$(b)
T	55°/165°	0.80/1.61	Standby	---	---
Z	305°/245°	0.89/1.08	Standby	---	---

(a) Capsule was evaluated for dosimetry and placed in storage.
(b) Between once and twice projected 60-year (48 EFPY) peak RPV fluence.

Recommended Program

The following changes to the current capsule withdrawal plan, test schedule, or related commitments are recommended:

- Capsule U should be removed during the first scheduled outage which follows estimated capsule exposure to the projected 60-year peak RPV fluence. Capsule U should then be tested.

Discussion

For the purpose of developing the CRVSP, the projected 60-year peak RPV fluence and year of withdrawal were estimated as follows: The projected 60-year (48 EFPY) peak RPV fluence is $5.38x10^{19}$ n/cm^2 [125]. Based on the current withdrawal schedule, capsule U will reach $5.95x10^{19}$ n/cm^2 at 45.0 EFPY. Using this information, the EFPY at $5.38x10^{19}$ n/cm^2 was interpolated to be 40.7. Given the current projection of 45.0 EFPY in 2027 and assuming a capacity factor of 0.95, 40.7 EFPY should occur in 2022. The projections resulting from these estimations are shown in the table below. The plant is responsible to formally determine the year of capsule withdrawal based on latest RPV fluence data.

Table 6-70
Surry Unit 2 Estimated Results of Recommended Changes to Withdrawal Schedule

Capsule	Location	Lead Factor	Estimated Removal Year	Removal (EFPY)	Estimated Fluence (n/cm^2)
U	65°/285°	1.15/1.60	2022	40.7	$5.38x10^{19}$(a)

(a) Projected 60-year (48 EFPY) peak RPV fluence.

Turkey Point Unit 3 and Unit 4

Material Description

Eight surveillance capsules containing beltline materials fabricated from ASME SA-508 Class 2 (low Cu) and Linde 80 flux (high Cu) were inserted in each reactor prior to initial start-up [129, 130, 131]. For each plant, capsules S, U, W, Y and Z contain only base metal Charpy V-notch specimens.

Current Program

Turkey Point Units 3 and 4 participate in the B&W MIRVP. Half of the eight Turkey Point Unit 3 surveillance capsules (T, S, V and X) have been removed and tested [129]. Two of the eight surveillance Turkey Point Unit 4 (TP4) capsules (T and S) have been removed and tested, Table 6-71[129]. Both plants received approval for a 60-year (48 EFPY) license renewal in 2002.

Per utility input, the current plan calls for the removal of TP4 capsule X (lead factor 2.09) at a fluence between once and twice the 60-year (48 EFPY) limiting intermediate to lower shell weld fluence of $5.739x10^{19}$ n/cm^2, which will occur at 33.2 EFPY. The 60-year (48 EFPY) peak RPV fluence is $6.38x10^{19}$ n/cm^2. Assuming a capacity factor of 0.95 starting in 2002, 33.2 EFPY should be reached in 2017.

Table 6-71
Turkey Point Unit 3 and 4 Current Withdrawal Schedule [16, 132]

Capsule	Location	Lead Factor (d)	Removed EOC	Removal (EFPY)	Fluence (n/cm^2) (d)
T3	270°	2.74	1	1.15	$5.99x10^{18}$
T4	270°	2.74	1	1.17	$6.49x10^{18}$
S3	280°	2.00	4	3.46	$1.27x10^{19}$
S4	280°	2.03	3 (1979)	3.41	$1.29x10^{19}$
V3	290°	0.89	9	8.06	$1.223x10^{19}$
V4	290°	1.02	Standby	---	---
X3 (a)	50°/270°	1.13 (b)	18(2002)	19.85	$2.897x10^{19}$
X4 (a)	50°/270°	2.09 (b)	29 (2017)	Planned	$5.89x10^{19}$(c)
Y3	150°	0.77	Standby	---	---
Y4	150°	0.77	Standby	---	---
U3	30°	0.77	Standby	---	---
U4	30°	0.77	Standby	---	---
W3	40°	0.52	Standby	---	---
W4	40°	0.52	Standby	---	---
Z3	230°	0.52	Standby	---	---
Z4	230°	0.52	Standby	---	---

(a) Capsules X3 and X4 were moved to the 270° location in 1990.
(b) Lead factor takes into account the movement of the capsules in 1990. Lead factor for X4 is based on 60–year (48 EFPY) projection.
(c) Between once and twice projected 60-year (48 EFPY) fluence of the limiting RPV material as listed in the current FSAR.
(d) Capsule lead factors and fluences updated by [132]

Recommended Program

The following changes to the current capsule withdrawal plan, test schedule, or related commitments are recommended:

- Capsule X4 should be removed during the first scheduled outage which follows estimated capsule exposure to the 80-year peak RPV fluence. Capsule X4 should then be tested.

Discussion

For the purpose of developing the CRVSP, the projected 80-year peak RPV fluence and year of withdrawal were estimated as follows: Per utility input, capsule X4 will reach the projected 80-year (67 EFPY) peak RPV fluence of $9.30x10^{19}$ n/cm^2 at 38.1 EFPY. Assuming a capacity factor of 0.95 starting in 2002, capsule X4 should reach the projected fluence in about 2021.

Table 6-72
Turkey Point Units 3 and 4 Estimated Results of Recommended Changes to Withdrawal Schedule

Capsule	Location	Lead Factor	Estimated Removal Year	Removal (EFPY)	Estimated Fluence (n/cm^2)
X4	50°/270°	2.09	2021	38.1 (b)	9.30×10^{19}(a)

(a) Projected 80-year (67 EFPY) peak RPV fluence [132].
(b) Removal may be performed at the first refueling outage after the Removal (EFPY) is achieved.

V. C. Summer Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 124 flux (low Cu) were inserted in the reactor prior to initial start-up [133].

Current Program

Five of the six surveillance capsules (U, V, X, W and Z) have been removed and tested and the sixth capsule (Y) was removed and placed in storage, Table 6-73 [134]. V. C. Summer received approval for a 60-year (54 EFPY) license renewal in 2004. The projected 60-year (54 EFPY) peak RPV fluence is 6.56×10^{19} n/cm^2 [133].

Table 6-73
V. C. Summer Current Withdrawal Schedule [133, 134]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	343°	3.14	1	1.13	6.77×10^{18}
V	107°	3.46	3	2.93	1.56×10^{19}
X	287°	3.66	5	5.04	2.53×10^{19}
W	110°	3.30	10	11.21	4.63×10^{19}(a)
Z	340°	3.19	14 (2003)	16.36	6.54×10^{19}(b)
Y	290°	3.17	Storage	17.28	--

(a) Approximate 40-year (36 EFPY) peak RPV fluence.
(b) Approximate 60-year (54 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

Capsule Y was not selected for testing based on the discussion in Section 4.

Vogtle Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 91 flux (low Cu) were inserted in the reactor prior to initial start-up [135].

Current Program

Five of the six surveillance capsules (U, Y, V, X and W) have been removed and tested, Table 6-74 [135]. Capsule Z was removed after cycle 14 and placed in storage. Vogtle Unit 1 received a 60-year (56 EFPY) license renewal in June 2009.

Table 6-74
Vogtle Unit 1 Current Withdrawal Schedule [135]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	58.5°	4.14	1	1.14	3.32×10^{18}
Y	24.0°	3.97	4	4.85	1.14×10^{19}
V	61.0°	3.97	7	8.78	1.93×10^{19}
X	238.5°	4.19	11	14.33	3.47×10^{19}(a)
W	121.5°	4.16	14 (2008)	18.41	4.36×10^{19}(b)
Z	301.5°	4.16	Storage	18.41	–

(a) Approximate 60-year (56 EFPY) peak RPV fluence.
(b) Approximate 80-year (75 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

Based on the reasoning provided in Section 4, the CRVSP does not recommend testing capsule Z.

Vogtle Unit 2

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 124 flux (low Cu) were inserted in the reactor prior to initial start-up [136].

Current Program

Five of the six surveillance capsules (U, Y, X, W and Z) have been removed and tested, Table 6-75 [136, Utility Input]. Vogtle Unit 2 received a 60-year (56 EFPY) license renewal in June 2009. The projected 60-year (56 EFPY) peak RPV fluence is 3.02×10^{19} n/cm^2 [137].

Per utility input, capsule Z was removed and tested in 2010 and capsule V was removed and placed in storage. The capsule report is not yet available.

Table 6-75
Vogtle Unit 2 Current Withdrawal Schedule [136]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	58.5°	4.10	1 (1991)	1.20	3.56×10^{18}
Y	241°	3.95	4 (1996)	4.98	1.12×10^{19}
X	238.5°	4.25	6	7.78	1.78×10^{19}
W	121.5°	4.14	10 (2004)	13.29	2.98×10^{19}(a)
Z	301.5°	4.15	14 (2010)	18.48	4.16×10^{19}(b)
V	61°	3.84	Storage	18.48	--

(a) Approximate 60-year (56 EFPY) peak RPV fluence.
(b) Approximate 80-year (75 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

Based on the reasoning provided in Section 4, the CRVSP does not recommend testing capsule V.

Waterford Unit 3

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 91 flux (low Cu) were inserted in the reactor prior to initial start-up [138].

Current Program

Two of the six surveillance capsules (97° and 263°) have been removed and tested, Table 6-76 [138]. Waterford Unit 3 plans to submit a 60-year (54 EFPY) license renewal application in 2013.

Based on a 0.95 capacity factor starting in 2002 and the projected removal EFPY of 26.0, capsule 83° should reach the specified fluence in about 2014.

Table 6-76
Waterford Unit 3 Current Withdrawal Schedule [138]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
97°	97°	1.18	4	4.44	6.47×10^{18}
263°	263°	1.18	11 (2002)	13.83	1.45×10^{19}
83°	83°	1.18	Planned	26.0	2.47×10^{19}(a)
277°	277°	1.18	Standby	---	---
104°	104°	0.83	Standby	---	---
284°	284°	0.83	Standby	---	---

(a) Approximate 40-year (32 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

Altering the current withdrawal schedule will not yield high fluence data in less time.

Watts Bar Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-508 Class 2 (high Cu) and Grau Lo LW320 flux were inserted in the reactor prior to initial start-up [139].

Current Program

Four of the six surveillance capsules (U, W, X and Z) have been removed and tested, Table 6-77 [139]. Watts Barr has not submitted a 60-year license renewal application.

Capsules V and Y have a planned removal at 15 EFPY [139], at which time capsule V will be tested and capsule Y will be placed in storage. Using the capsule lead factor and the linear relationship between the reported peak RPV fluences and their corresponding EFPY values, the capsule fluence at 15 EFPY was calculated to be 3.36×10^{19} n/cm^2. This linear relationship was based on 1.75×10^{19} n/cm^2 at 32 EFPY, 2.66×10^{19} n/cm^2 at 48 EFPY and 3.01×10^{19} n/cm^2 at 54 EFPY [139]. Assuming a 0.95 capacity factor starting in 2006 and the projected removal EFPY of 15, capsules V and Y should reach the specified fluence in about 2012.

Table 6-77
Watts Bar Current Withdrawal Schedule [139]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	56°	5.00	1 (1997)	1.20	4.47×10^{18}
W	124°	5.05	3 (2000)	3.88	1.08×10^{19}
X	236°	5.03	5 (2003)	6.63	1.71×10^{19}(a)
Z	304°	5.06	7 (2006)	9.37	2.40×10^{19}
V	58.5°	4.31	(2012)	Planned	3.36×10^{19}(b)
Y	238.5°	4.31	(2012)	Planned	3.36×10^{19}(b)

(a) Approximate 40-year (32 EFPY) peak RPV fluence.
(b) Approximate 60-year (54 EFPY) peak RPV fluence. Test capsule V or Y and place the other in storage.

Recommended Program

The following changes to the current capsule withdrawal plan, test schedule, or related commitments are recommended:

- Capsule V or Y should be removed during the last scheduled outage before estimated capsule exposure to a neutron fluence equal to two times the peak RPV neutron fluence at the end of the period of extended operation. The removed capsule should then be tested.
- The remaining capsule should remain inserted on standby until needed to fulfill future 10 CFR 50 Appendix H or license renewal requirements.

Discussion

For the purpose of developing the CRVSP, the projected 2x60-year peak RPV fluence and year of withdrawal were estimated as follows: The projected EFPY for the 60-year license was determined using a conservative capacity factor of 0.95. Based on the 60-year (54 EFPY) fluence of $3.01x10^{19}$ n/cm^2, twice the 60-year (54 EFPY) peak RPV fluence was determined to be $6.02x10^{19}$ n/cm^2. Using the capsule lead factor and the linear relationship between the reported peak RPV fluences and their corresponding EFPY values, the EFPY required for capsule V to reach $6.02x10^{19}$ n/cm^2 was calculated to be 25.7. Assuming a 0.95 capacity factor starting in 2006 and the projected removal EFPY of 25.7, capsule V should reach the specified fluence in about 2023. The projections resulting from these estimations are shown in the table below. The plant is responsible for determination of the actual removal year, based on the latest RPV fluence data.

Table 6-78
Watts Bar Estimated Results of Recommended Changes to Withdrawal Schedule

Capsule	Location	Lead Factor	Estimated Removal Year	Removal (EFPY)	Estimated Fluence (n/cm^2)
V	58.5°	4.31	2023	25.7	$6.02x10^{19}$(a)

(a) Twice projected 60-year (54 EFPY) peak RPV fluence.

Wolf Creek Unit 1

Material Description

Six surveillance capsules containing beltline materials fabricated from ASME SA-533 Grade B Class 1 (low Cu) and Linde 124 flux (low Cu) were inserted in the reactor prior to initial start-up [140].

Current Program

Four of the six surveillance capsules (U, Y, V and X) have been removed and tested, Table 6-79 [140]. Wolf Creek received a 60-year (54 EFPY) license renewal in 2008.

Per utility input, capsules W and Z were removed and placed in storage in 2005. Assuming a 0.95 capacity factor starting in 2002, capsules W and Z had an EFPY of 16.7 at removal. Using the capsule lead factor and the linear relationship between the EFPY and the peak RPV fluence, the capsule fluence at the time of removal was estimated to be $4.11x10^{19}$ n/cm^2. This linear relationship was based on $2.03x10^{19}$ n/cm^2 at 32 EFPY, $3.11x10^{19}$ n/cm^2 at 48 EFPY and $3.51x10^{19}$ n/cm^2 at 54 EFPY [140].

Table 6-79
Wolf Creek Current Withdrawal Schedule [140]

Capsule	Location	Lead Factor	Removed EOC	Removal (EFPY)	Fluence (n/cm^2)
U	58.5°	4.25	1	1.07	$3.16x10^{18}$
Y	241°	3.93	5	4.79	$1.19x10^{19}$
V	60.1°	4.02	9	9.78	$2.22x10^{19}$(a)
X	238.5°	4.30	12 (2002)	13.83	$3.49x10^{19}$(b)
W	121.5°	4.11	14 (2005)	Storage	$4.11x10^{19}$
Z	301.5°	4.11	14 (2005)	Storage	$4.11x10^{19}$

(a) Approximate 40-year (32 EFPY) peak RPV fluence.

(b) Approximate 60-year (54 EFPY) peak RPV fluence.

Recommended Program

No changes are recommended to the current capsule withdrawal plan, test schedule, or related commitments.

Discussion

Additional testing was not recommended based on the discussion in Section 4.

Section 7: Implementation Requirements

The purpose of this section is to summarize the implementation requirements of the CRVSP. The CRVSP does not reduce, alter, or otherwise affect each plant's responsibility to comply with 10 CFR 50 Appendix H[3] and relevant licensing commitments, but it may require a plant to submit a request to the NRC to modify the details (e.g., schedule) of how the plant will comply with Appendix H and applicable license commitments.

NEI 03-08 Implementation Protocol

This program is a 'work product' of the EPRI MRP, an 'Issue Program (IP)' as defined in NEI 03-08 [5]. Addendum D to NEI 03-08, Implementation Protocol, defines the processes and expectations for implementing industry guidance issued under the Materials Initiative, and requires that IPs identify the specific implementation category for 'requirements' identified guideline-type work products.

The three implementation categories described in NEI 03-08 are as follows:

- Mandatory – to be implemented at all plants where applicable;
- Needed – to be implemented wherever possible, but alternative approaches are acceptable; and
- Good Practice – implementation is expected to provide significant operational and reliability benefits, but the extent of use is at the discretion of the individual utility.

The CRVSP recommended changes detailed in Section 6 of this report have been designated as "Needed" requirements, as explained below. A failure to meet a Needed requirement is a deviation from the guidelines and a written justification for the deviation must be prepared and approved as described in Appendix B to NEI 03-08 [5]. A copy of the deviation is sent to the MRP so that improvements to the guidelines can be developed.

Implementation of this guidance as a Needed requirement is justified because the ability of the CRVSP to achieve the objectives of obtaining higher fluence PWR surveillance data is dependent on all plants with recommended changes implementing those recommendations. It was discussed earlier in this report that the paucity of high fluence PWR data without the CRVSP is likely to result in an embrittlement trend correlation based in large part on test reactor data at

fluences above $3x10^{19}$ n/cm^2; such an ETC could result in significantly increased RPV embrittlement predictions because test reactor data typically exhibits higher rates of embrittlement. This in turn could have significant financial impact on the industry, ranging from increased startup/shutdown times and costs (and regulatory action) to the possible need for some plants to mitigate RPV embrittlement resulting from application of embrittlement correlations that are not representative of power reactor trends. The Yankee Rowe experience clearly demonstrated the ability of RPV embrittlement issues to shorten the useful financial life of a unit. Thus, the issue fulfills either of the following conditions for implementation under the "Needed" category:

- "Element addresses a material degradation mechanism [neutron embrittlement] that has significant financial impact on the entire industry, especially where failure at one plant could affect many other plants.
- *A consensus of the responsible materials IP believes the element should be designated as "Needed".*"

Coordinated Surveillance Program Requirement

Needed: Following issuance of MRP-326, Rev. 0, each commercial U.S. PWR unit for which a change to its reactor vessel surveillance program has been recommended in Section 6 shall

- *Submit a request to the NRC to revise the plant's surveillance capsule program and/or schedule as required to implement the recommendation(s). The changes covered by this requirement are presented as bulleted items in the "Recommended Program" section for each plant in Section 6; plants with no bulleted recommendations require no action. When submission of program change request is required, the submission shall be made per the following schedule:*
  - *If the change affects a capsule withdrawal/test which is scheduled before January 1, 2014, the request should be submitted to the NRC no later than ten months following the issuance of MRP-326, Rev. 0.*
  - *If the change affects a capsule withdrawal/test which is scheduled after January 1, 2014, the request should be submitted to the NRC no earlier than ten months nor later than 18 months after issuance of MRP-326, Rev. 0.*

The phased submission of RVSP change requests to the NRC will make the flow of requests arrive in general order of calendar urgency and will permit plants with near-term needs to receive priority review.

An optional template for use in generating the letter request to the NRC is provided in Appendix B of this document. The template provides a format that will demonstrate the plant's continued compliance with 10 CFR 50, Appendix H, after implementation of the recommended changes.

Section 8: References

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140. WCAP-16028, "Analysis of Capsule X from the Wolf Creek Nuclear Operating Corporation, Wolf Creek Reactor Vessel Radiation Surveillance Program," March 2003.

Appendix A: Surveillance Capsule Data Summary

Tested Surveillance Capsules

Of the 69 PWR plants considered, 35 surveillance capsules with a fluence of 3.0x1019 n/cm2 or greater have been removed and tested to date, Table A-1.

For the purposes of these tables, low copper is defined as equal to or less than 0.10 wt%.

Table A-1
Tested Surveillance Capsules

Plant-Capsule	Fluence E+19	Base Material	Cu	Weld Flux	Cu
Beaver Val2-W	3.6	SA-533	Low	Linde 0091	Low
Beaver Val2-X	5.6	SA-533	Low	Linde 0091	Low
Callaway1-X	3.3	SA-533	Low	Linde 0124	Low
Calvert1-284	3.1	SA-533	High	Linde 0091	High
Comanche1-X	3.2	SA-533	Low	Linde 0091	Low
Comanche2-W	3.0	SA-533	Low	Linde 0124	Low
Farley1-V	7.1	SA-533	High	Linde 0091	High
Farley1-W	4.8	SA-533	High	Linde 0091	High
Farley1-X	3.1	SA-533	High	Linde 0091	High
Farley1-Z	8.5	SA-533	High	Linde 0091	High
Farley2-V	8.7	SA-533	High	BOLA	---
Farley2-Y	6.8	SA-533	High	BOLA	---
Farley2-Z	4.9	SA-533	High	BOLA	---
Ginna1-N	5.8	SA-508	Low	Linde 80	High
Ginna1-S	3.6	SA-508	Low	Linde 80	High
Kewaunee-S	3.7	SA-533	Low	Linde 1092	High
Kewaunee-T	5.6	SA-533	Low	Linde 1092	High
McGuire1-W	5.1	N/A	N/A	Linde 1092	High

Table A-1 (continued)
Tested Surveillance Capsules

Plant-Capsule	Fluence E+19	Base Material	Cu	Weld Flux	Cu
McGuire2-W	3.1	SA-508	High	Grau Lo LW320	---
Millstone3-W	3.2	SA-533	Low	Linde 0091	Low
Palisades-A240	4.0	SA-302M	High	Linde 1092	High
Prairie Is1-R	4.5	SA-508	Low	UM 89	---
Prairie Is1-S	4.0	SA-508	Low	UM 89	---
Prairie Is2-P	4.2	SA-508	Low	UM 89	---
Prairie Is2-R	4.4	SA-508	Low	UM 89	---
Pt Beach2-S	3.5	SA-508	Low	Linde 80	High
Robinson2-T	3.9	SA-302	High	Linde 1092	High
Robinson2-X	4.5	SA-302	High	Linde 1092	High
Sh Harris-X	3.3	SA-533	Low	Linde 0124	Low
VC Summer-W	4.6	SA-533	Low	Linde 0124	Low
VC Summer-Z	6.5	SA-533	Low	Linde 0124	Low
Vogtle1-W	4.4	SA-533	Low	Linde 0091	Low
Vogtle1-X	3.5	SA-533	Low	Linde 0091	Low
Vogtle2-Z	4.2	SA-533	Low	Linde 0124	Low
Wolf Creek-X	3.5	SA-533	Low	Linde 0124	Low

Planned Surveillance Capsules

By the year 2025, 26 of the remaining surveillance capsules will be removed and tested at a fluence of 3.0×10^{19} n/cm^2 or greater according to the current withdrawal schedule of each plant, Table A-2.

In these tables, low copper is defined as equal to or less than 0.10 wt%.

Table A-2
Planned Surveillance Capsules

Plant-Capsule	Removal Year	Fluence E+19	Base Material	Cu	Weld Flux	Cu
ANO2-W284	2016	5.3	SA-533	Low	Linde 0091	Low
Beaver Val1-X	2013	5.0	SA-533	High	Linde 1092	High
Beaver Val1-Z	2023	5.6	SA-533	High	Linde 1092	High
Beaver Val2-Y	2018	8.5	SA-533	Low	Linde 0091	Low
Calvert1-83	2020	5.3	SA-533	High	Linde 0091	High
Calvert2-104	2011	3.2	SA-533	High	Linde 0091	High
Calvert2-83	2025	6.2	SA-533	High	Linde 0091	High
DC Cook1-S	2013	4.7	SA-533	High	Linde 1092	High
Diablo Canyon1-B	2012	3.2	SA-533	High	Linde 1092	High
Indian Pt2-S	2012	3.9	SA-302M	High	Linde 1092	High
Indian Pt3-S	2015	3.3	SA-302M	High	Linde 1092	High
Palisades-W80	2019	3.1	SA-302M	High	Linde 1092	High
Prairie Is1-T	2011	6.3	SA-508	Low	UM 89	---
Prairie Is2-N	2012	5.7	SA-508	Low	UM 89	---
Pt Beach2-suppl	2022	5.0	N/A	N/A	Linde 80	High
Robinson2-U	2012	6.0	SA-302	High	N/A	N/A
S Texas1-W	2011	4.3	SA-533	Low	Linde 0124	Low
S Texas2-W	2011	4.1	SA-533	Low	Linde 0124	Low
San Onofre2-83	2013	3.8	SA-533	Low	Linde 0091	Low
San Onofre3-83	2012	3.8	SA-533	Low	Linde 0124	Low
Seabrook-X	2014	4.7	SA-533	Low	Linde 0091	Low
Sh Harris-W	2012	6.8	SA-533	Low	Linde 0124	Low
St Lucie1-263	2022	4.2	SA-533	High	Linde 0091	High
Surry1-Z	2025	6.3	SA-533	High	Linde 80	High
Turkey Pt4-X	2017	5.9	SA-508	Low	Linde 80	High
Watts Bar-V	2012	3.4	SA-508	High	Grau Lo LW320	---

Recommended Coordinated Surveillance Capsules

By the year 2025, 30 of the remaining surveillance capsules will be removed and tested at a fluence of 3.0×10^{19} n/cm^2 or greater according to the recommended coordinated PWR RVSP plan described in this document, Table A-3.

Note that low copper is defined as equal to or less than 0.10 wt%.

Table A-3
Recommended Coordinated RVSP Capsules

Plant-Capsule	Removal Year[1]	Fluence E+19	Base Material	Cu	Weld Flux	Cu
ANO2-W284	2016	5.3	SA-533	Low	Linde 0091	Low
Beaver Val1-X	2013	5.0	SA-533	High	Linde 1092	High
Beaver Val1-Z	2023	5.6	SA-533	High	Linde 1092	High
Beaver Val2-Y	2018	8.5	SA-533	Low	Linde 0091	Low
Beaver Val2-A	2025	9.72	N/A	N/A	Linde 1092	High
Calvert1-83	2020	5.3	SA-533	High	Linde 0091	High
Calvert2-104	2011	3.2	SA-533	High	Linde 0091	High
Calvert2-83	2025	6.2	SA-533	High	Linde 0091	High
DC Cook1-S	2017	5.7	SA-533	High	Linde 1092	High
Diablo Canyon1-B	2018	4.1	SA-533	High	Linde 1092	High
Fort Calhoun-W45	2022	4.7	SA-533	Low	Linde 1092	High
Indian Pt2-S	2012	3.9	SA-302M	High	Linde 1092	High
Indian Pt3-S	2015	3.3	SA-302M	High	Linde 1092	High
N Anna1-X	2025	8.2	SA-508	High	SMIT 89	--
Palisades-W80	2019	3.1	SA-302M	High	Linde 1092	High
Prairie Is1-T or N	<2025	6.7	SA-508	Low	UM 89	--
Prairie Is2-N	2020	6.8	SA-508	Low	UM 89	--
Pt Beach2-suppl	2022	5.0	N/A	N/A	Linde 80	High
Robinson2-U	2019	7.8	SA-302	High	NA	NA
S Texas1-W	2011	4.3	SA-533	Low	Linde 0124	Low
S Texas2-W	2011	4.1	SA-533	Low	Linde 0124	Low
San Onofre2-83	2015	4.4	SA-533	Low	Linde 0091	Low
San Onofre3-83	2016	4.2	SA-533	Low	Linde 0124	Low
Seabrook-X	2019	5.8	SA-533	Low	Linde 0091	Low
Sh Harris-Y	2018	9.2	SA-533	Low	Linde 0124	Low
St Lucie1-263	2022	4.2	SA-533	High	Linde 0091	High
Surry1-Z	2025	6.3	SA-533	High	Linde 80	High
Surry2-U	2022	5.4	SA-533	High	Grau Lo LW320	--
Turkey Pt4-X	2021	9.3	SA-508	Low	Linde 80	High
Watts Bar-V	2023	6.0	SA-508	High	Grau Lo LW320	--

[1]These dates are estimations of the year of withdrawal upon adoption of the CRVSP recommendations (which are based on fluence or EFPY targets); these dates are not the CRVSP recommendations per se, and the plant estimate of the withdrawal year that fulfills a recommendation may differ.

Appendix B: Template for Surveillance Program Change Request

This template is presented as an aid for development of a request for NRC approval of a change to a plant's RVSP if recommended in Section 6. The example provided in this appendix is largely based on a recent submission by Calvert Cliffs Nuclear Power Plant. Many other examples are readily available and can be downloaded at www.nrc.gov (key word search: reactor vessel surveillance program). In most cases, it is recommended that a plant use its previous RVSP change submittal format, updating as necessary for the current change.

Example Forwarding Letter

Date

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

[Plant name]
[Docket Number]
[License number]

Revision to Reactor Vessel Surveillance Capsule Withdrawal Schedule

Pursuant to 10 CFR 50, Appendix H, III.C.3, [Owner name] is requesting Nuclear Regulatory Commission (NRC) review and approval of the enclosed revision to the surveillance capsule removal schedule for [plant name]. The proposed reactor vessel surveillance capsule removal schedule was developed to implement recommendations for [plant name] in *MRP-326, Coordinated PWR Reactor Vessel Surveillance Program (CRVSP) Guidelines.* MRP-326 addresses the need for reactor vessel property data at fluences representative of 60 years of operation and beyond for [Plant Name] and the industry. The requested change to the Appendix H program for [Plant Name] satisfies the requirements of 10 CFR 50, Appendix H and ASTM E-185-82, "Standard Practice for Conducting Surveillance Tests for Light-Water Cooled Nuclear Power Reactor Vessels", dated July 1, 1982, and is consistent with the guidance of NUREG-1801, Rev. 2, *Generic Aging Lessons Learned.*

Approval of this proposed change is requested no later than [date].

Summary of Commitments

This letter contains no new commitments and no revisions to existing commitments. [if applicable]
(License renewal commitments and issues should be looked at and addressed, if applicable)

ENCLOSURE
REVISION TO REACTOR VESSEL SURVEILLANCE PROGRAM
[PLANT NAME]

I. Background

Appendix H to 10 CFR Part 50 describes reactor vessel material surveillance program requirements. Paragraph (III)(B)(3) of this Appendix states that a proposed material withdrawal schedule must be submitted with a technical justification per 10 CFR 50.4, and approved prior to implementation.

Industry has developed a Coordinated PWR Reactor Vessel Surveillance Program (CRVSP), which is documented in *MRP-326, Coordinated PWR Reactor Vessel Surveillance Program (CRVSP) Guidelines.* The purpose of the CRVSP is to increase the fluence levels of future surveillance capsules at withdrawal while maintaining compliant with 10 CFR 50 Appendix H and consistent with the guidance of NUREG-1801, Rev. 2, GALL Report. The CRVSP will help generate high fluence PWR surveillance data in support of extended life operations.

The proposed withdrawal schedule satisfies the requirements of American Society for Testing and Materials (ASTM) E 185-xx, the version that was current at the time the reactor vessel surveillance program was designed.

Table (1) shows the currently approved withdrawal schedule for [plant name] reactor vessel surveillance capsules (Updated Final Safety Analysis Report Table x-xx).

II. Proposed Revision

Table (2) provides the proposed revision to the reactor vessel surveillance capsule withdrawal schedule for [plant name]. The revised schedule is based on the recommendations for [plant name] in MRP-326, and reflects updated fluence information from the surveillance capsule removed in [year] with appropriate adjustment made for fuels loaded in subsequent cycles. As shown below in Section III, the proposed withdrawal schedule satisfies the requirements of ASTM E 185-xx, the version that was current at the time the reactor vessels were designed. Therefore, the withdrawal schedule satisfies the requirements of Appendix H to 10 CFR Part 50.

III. Justification

The [*plant name*] reactor vessel was designed to the [year] through [*identity of applicable addenda*] Addenda, edition of the American Society of Mechanical Engineers Code. American Society for Testing and Materials E 185-xx was the current standard when the surveillance program was designed. As stated in the [*Plant name*] Updated Final Safety Analysis Report, the reactor vessel surveillance program meets the requirements of ASTM E 185-xx.

The guidance provided in ASTM E 185-82 is consistent with, but more specific than, the guidance provided in earlier editions, including ASTM E 185-xx to which the [plant name] reactor vessel surveillance program is required to conform. Therefore, compliance with the ASTM E185-82 withdrawal schedule guidance ensures compliance with ASTM E 185-xx withdrawal schedule guidance. ASTM E

185-82 provides a withdrawal schedule in terms of years of operation but also provides the option to develop a schedule tied to target fluences accumulated in the vessel. As in the case of the currently approved withdrawal schedule, the proposed withdrawal schedule follows the guidance that ties the withdrawal schedule to vessel fluence targets.

This request proposes to revise the reactor vessel surveillance capsule withdrawal schedule to [*detail the specific change as recommended by MRP-326*]. A detailed explanation of the change for [*plant name*] is provided in MRP-326.

The [*capsule name*] capsule meets the requirements of ASTM E 185-82 to withdraw the third capsule at a time when the accumulated neutron fluence on the capsule corresponds to the approximate end of life peak fluence at the reactor vessel ¼ T location. As noted on Table (2), we would withdraw the [*capsule name*] capsule during the [*year or RFO number*] refueling outage and designate the *[capsule name*] capsule as the standby capsule [*if applicable*]. This proposed change meets the requirements of Appendix H to 10 CFR Part 50.

If applicable: [*Plant name*] received approval of license renewal in [*year*]. The [*plant name*] license renewal application (LRA) referenced GALL Revision 1, and Capsule [*capsule name*] was identified as the capsule to be tested to meet the recommendations of GALL Rev. 1. GALL Rev. 1 recommends that the plant "...withdraws one capsule at an outage in which the capsule receives a neutron fluence equivalent to the 60-year fluence...." As a result, the current capsule withdrawal schedule is based on withdrawing Capsule [*capsule name*] at Refueling Outage (RFO)-xx. NUREG-1801, Rev. 2 (GALL Report) recommends that

- "The plant-specific or integrated surveillance program shall have at least one capsule with a projected neutron fluence equal to or exceeding the 60-year peak reactor vessel wall neutron fluence prior to the end of the period of extended operation. The program withdraws one capsule at an outage in which the capsule receives a neutron fluence of between one and two times the peak reactor vessel wall neutron fluence at the end of the period of extended operation and tests the capsule in accordance with the requirements of ASTM E 185-82."
- "Plant-specific and fleet operating experience should be considered in determining the withdrawal schedule for all capsules..."

The proposed withdrawal date for Capsule [*capsule name*] meets both of these recommendations. The operating experience of both [*Plant name*] and the U.S. PWR fleet were considered in the development of the revised capsule withdrawal schedule, as discussed in MRP-326. The capsule fluence at the proposed withdrawal date will meet the guidance that the license renewal capsule should achieve a fluence between one and two times the peak reactor vessel wall neutron fluence at the end of the period of extended operation.

[*If applicable:*] GALL Rev. 2 is cited as it represents the latest guidance provided by the Staff. No request to revise the licensing basis of the [*Plant Name*] renewed operating license is implied by this citation; it is offered only as a reference and objective evidence to support the Technical Justification for the deferral.

Table B-1
Current [Plant name] Reactor Vessel Surveillance Program Capsule Removal Schedule

Capsule Name or Azimuthal Position	Target Fast Neutron Fluence (x 10^{19} n/cm^2)	Projected End-of-Cycle Date

Table B-2
Proposed [Plant name] Reactor Vessel Surveillance Program Capsule Removal Schedule

Capsule Name or Azimuthal Position	Target Fast Neutron Fluence (x 10^{19} n/cm^2)	Projected End-of-Cycle Date

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