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U.S. Nuclear Regulatory Commission
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Subject: PWR Owners Group
Pressurized Water Reactor Owners Group Final Report on Filterability Testing (PA-SEE-0275)

Reference:

1. PWR Owners Group letter OG-07-0408, "Pressurized Water Reactor Owners Group Responses to NRC Questions for Clarification Regarding WCAP-16530, 'Evaluation of Chemical Effects in Containment Sump Fluids to Support GSI-191' (PA-SEE-0275)," September 12, 2007.

Westinghouse has conducted a laboratory test program to support the acceptance of WCAP-16530-NP by the NRC. This program produced chemical reaction products in integrated chemical effects tests and compared these reaction products to surrogates produced by recipes developed in WCAP-16530-NP. This was done to judge whether the surrogates adequately represented post-LOCA chemical reaction products and could be used in replacement sump screen testing. The results of this program are summarized in Enclosure 1: Report on Filterability of Precipitates Generated in a Simulated Post LOCA Environment.

This letter summarizes and formalizes the information previously transmitted to the NRC as Enclosures 4, 5, and 6 to Reference 1, and is submitted in response to the NRC's request for such formal submittal to support its review of the information transmitted therein.

If you have any questions, please contact John Maruschak at 412-374-3512.

Very truly yours,

for

Frederick P. "Ted" Schiffley, II
Chairman, PWR Owners Group

FPS:RRD:mjl

Enclosure

D048
NRR

cc: PWROG PMO
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Attachment 1

Report on Filterability of Precipitates Generated in a Simulated Post-LOCA Environment

Final Report, October 30, 2007

BACKGROUND

The NRC (Nuclear Regulatory Commission) expressed concern about filtration tests done to support the methods and guidance developed in WCAP-16530-NP following RAI (Request for Additional Information) discussions on Thursday, May 17, 2007. A key assertion in the WCAP was that surrogate materials developed by Westinghouse and described in the WCAP could be used in sump screen testing and that they would adequately represent chemical precipitates that might form in the containment sump after a LOCA (Loss of Coolant Accident). Another assertion of WCAP-16530-NP was that sump screen testing using the surrogates could be performed in tap water or in a boric acid solution, and that the choice of tap water or boric acid would not cause a significant difference in the results. Filtration testing using a "stepped-flow" apparatus had been performed in the WCAP to support the surrogate production technique and the recommendation regarding tap water use. The NRC was concerned that the filtration testing presented in the WCAP was not reliable enough to support the WCAP conclusions. A visit was made to the Westinghouse Science and Technology Department in Churchill to assess the reliability and applicability of the stepped-flow filtration testing.

The NRC representatives looked at the filtration equipment used at Westinghouse, examined filtration data collected during 2006, and observed new testing defined by Richard Reid's "White Paper Tests", which were transmitted to the NRC on May 25, 2007. The White Paper test plan has been included as Appendix B. The White Paper Tests were not completed at the time of the NRC's departure on May 30, 2007.

The NRC representatives gave the following comments after their visit to Westinghouse STD on May 30:

1. Overall, the NRC was not ready to accept that the WCAP surrogates can be used as recommended in WCAP 16530 for sump screen testing. They would make their final judgment after the white paper test plan was completed and discussions with Ed Lahoda took place.
2. The filtration tests are valid over only a limited mass range
3. Westinghouse could improve the stepped flow testing by:
    - Revising the criterion for changing flow rates to one based on pressure stability
    - Avoiding bed disruption by more slowly adjusting flows
    - Instituting more procedural controls for accepting data or repeating test. The procedure is currently too dependent on the skill of the operator.

Following the NRC visit, Westinghouse improved the filtration test rig and procedure and the White Paper Test tests were completed. A transmission of the preliminary results of the White Paper Tests was made to the NRC on June 24, 2007. Additional raw data from the White Paper Tests was sent to the NRC during the week of July 9, 2007. The raw data included records of temperature, pressure drop and flows measured during the filtration tests.

Several "real" corrosion product solutions were produced during the White Paper Tests and it was observed that the filterability of the corrosion product solutions were highly dependent on the time-temperature profile used during the production of the corrosion products. Precipitates that were formed by rapid cooling of sodium hydroxide solutions used to corrode aluminum coupons were difficult to filter, while corrosion products that were formed after long reaction times at high temperatures, followed by slow cooling were more easily filtered. Since the precipitates that would form after a LOCA would fit primarily into the slow-cooling category, it was concluded that this information would be useful in demonstrating that surrogates made by the recipes in WCAP-16530-NP were conservative.

The data on "real" corrosion products produced during the White Paper Tests was quite limited. Only one batch of slowly cooled corrosion product and one batch of the rapidly cooled corrosion product were tested for filterability. After discussions with the PWROG (Pressurized Water Reactor Owners Group) via Mo Dingler on June 6, Westinghouse decided to run a series of autoclave tests to produce additional "real" corrosion product material for filtration testing. The NRC was informed of the test program on June 11, 2007.

A test plan was produced which called for modeling the Palisades plant during the autoclave tests. The test plan is included as Appendix A. The test plan was modified as described in this report and executed during June and July of 2007. The results obtained are included and compared to previous filterability tests. This report includes results only on the filterability of precipitates that were produced, and does not attempt to address coupon corrosion rates and amounts of precipitates and dissolved species.

The results of the Palisades tests were presented to the USNRC in tabular form on 14, August, 2007. This letter presents a final assessment of the filterability testing. Data from both the "White Paper Tests" and the "Palisades Autoclave Tests" have been included.

The measure of filterability used to compare the surrogates and the Palisades Autoclave Test suspended solids is filter solids constant Kfx. Large values of Kfx indicate a material that does not readily clog a filter, while small values suggest a material that can easily clog a filter medium such as a fiber bed.

PALISADES AUTOCLAVE TESTS

Deviation from the Test Plan

Several changes were made to the test plan based on feed back from Palisades and internal Westinghouse review. Five autoclave tests simulating LOCA events at Palisades were run as opposed to the original four tests. Three of the tests were run in 2500B boric acid adjusted to pH 10 to represent a worst-case situation for precipitate formation and one was run with a pH 7 NaTB coolant to represent a best case scenario. Finally, a pH 7.8 NaTB coolant was used to simulate the best-estimate LOCA conditions at Palisades, after TSP change-out. The TSP buffered coolant test was not run; since Palisades reported that the likelihood of TSP change-out was high. The five tests are listed in Table 1. The first and second tests were terminated after 7 days, but a thirty day target was set for the other tests. The 5 day sampling time was extended to 7 days.

Table 1. List of Tests

Test	Autoclave	Coolant	Run Time	Status
PalisadesICET1	23	NaOH + 2500 ppm B, pH10	7	Complete
PalisadesICET2	25	NaTB + 2500 ppm B, pH 7.0	7	Complete
PalisadesICET3	21	NaOH + 2500 ppm B, pH10	33	Complete
PalisadesICET4	23	NaOH + 2500 ppm B, pH10	33	Complete
PalisadesICET5	14	NaTB + 2500 ppm B, pH 7.8	33	Complete

A "cold finger" was added to each autoclave to simulate cold surfaces within the ECCS such as the RHR. The surface area of the cold finger was scaled to have a surface area to sump volume ratio that was considered typical for a PWR. Cold tap water was circulated through the cold finger throughout each test.

The sampling procedure was changed from the plan due to low concentration of suspended precipitate in even the pH 10 coolant. The original procedure called for a sample of several milliliters to be transferred from a heated sampling bomb to the heated filtration system. The small samples did not cause sufficient pressure drop for calculation of Kfx values. The apparatus was modified so that the sampling bomb was plumbed into the filtration apparatus, and the entire solution volume of the sampling bomb (75 ml) was introduced into the filtration apparatus.

Additional filtration testing was added to the plan, since it appeared that most of the precipitates, if present, had settled quickly and were not measured by the hot sampling. The additional filtration testing steps were added.

Post-Test Filterability Testing:

1. Slowly cool the autoclave to room temperature (over-night)
2. Remove the entire contents of the autoclave into a 5-gallon bucket
3. Retrieve the metal coupons
4. Strain the remaining solution and solid material through a 20-mesh screen to remove undissolved fiberglass and fibrous CalSil (for the 30 day tests, the pressure drop across the screen should be measured as a function of flow)
5. Transfer the solution and solids passing through the 20-mesh screen into a 3-inch settling tube and allow solids to settle- record the settling photographically
6. Perform filterability test(s) on the settled solids. If it appears that there are distinct materials present, perform a filterability test on each fraction.

The test plan called for comparison of the WCAP 16530-NP chemical effects model predictions with the results of the tests. This was not done.

Results, PalisadesICET1 (pH 10 NaOH in Autoclave 23)

This test was started on 6-21-2007 and ended after a 1 week simulation. High temperature filtration procedures were used for the first time on this test. Bomb samples were taken after 1 day (2 samples), 5 days (1 sample), 6 days (1 sample) and 7 days (1 sample). None of the stepped flow filtration runs were successful due to various experimental problems associated with the hot transfer of autoclave samples to the hot filtration rig. This test run was used to refine the sampling procedure from the original test plan as noted above.

The autoclave was cooled and the contents were transferred to a 5-gallon bucket. Most of the fiberglass material was lightly attached to the walls of the autoclave. It was removed by hand and returned to the solution. The metal coupons were retrieved and separated from the solution.

The solution containing the reacted fiberglass, CalSil and precipitants was filtered through a 20 mesh screen. The material remaining on the screen is shown below in Figure 1. Undissolved CalSil and fiberglass were clearly visible.

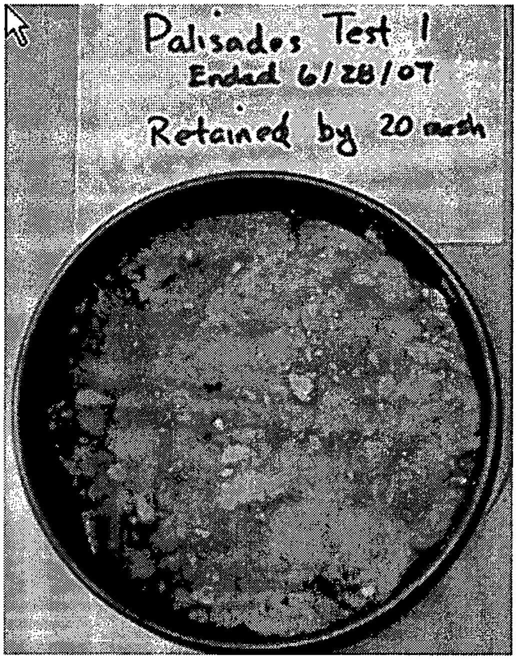
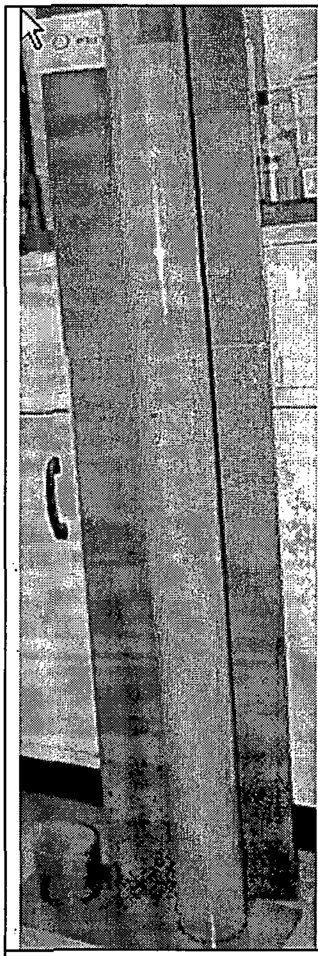
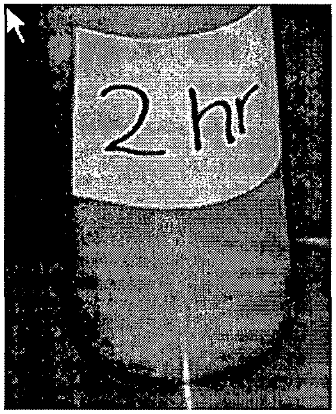


Figure 1. 20-Mesh Fraction of PalisadesICET1 Product

The solution passing through the screen was transferred to a settling tube and observed over 2.5 hours. The settling tube is shown in Figure 2 just after addition of the solutions. Several inches of fast-settling precipitate had collected at the bottom of the tube after 2 hours as shown in Figure 3. It took 24 hours to complete the settling. The settled material was transferred to centrifuge tubes to produce a sharper separation between the different layers that were observed. The settled material after centrifuging is shown in Figure 4. It was clear that there were three distinct layers: a white top layer, a tan middle layer, and a dark bottom layer.





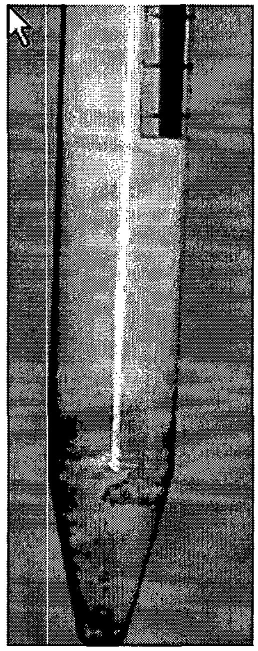


Figure 2. PalisadesICET1 Settling Test at 0 hours.	Figure 3. PalisadesICET1 Settling Test at 2 hours.	Figure 4. PalisadesICET1 Settling Test. Solids Removed after 24 Hours Settling after Centrifuging

Filtration testing was performed on the middle and bottom layers. The top layer was inadvertently dried before filtration testing so no filtration testing was possible. Testing was done in deionized water at room temperature. The results are given in Table 4.

Table 4. Kfx Values for Settled Material from PalisadesICET1 (NaOH, pH 10)

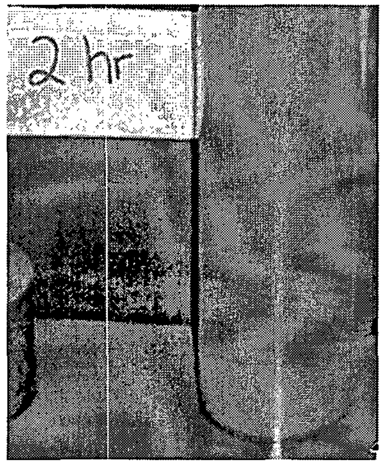
Sample	Temperature of Filtration (°F)	Kfx (gpm lbm cP ft^{-4} psi^{-1})
Middle fraction, 7 days	77	1.34 E-03
Middle fraction, 7 days	76	1.53 E-03
Middle fraction, 7 days	76	1.51 E-03
Middle fraction, 7 days	79	2.42 E-03
Bottom fraction, 7 days	76	2.01 E-03
Bottom fraction, 7 days	77	2.39 E-03
Bottom fraction, 7 days	79	4.24 E-03
Bottom fraction, 7 days	78	2.71 E-03

Results, PalisadesICET2 (pH 7 NaTB in Autoclave 25)

This test was started on July 2, 2007 and ended after a 1 week simulation. High temperature filtration was performed successfully after 1 and 7 days.

The autoclave was cooled and the contents were transferred to a 5-gallon bucket. Most of the fiberglass material was lightly attached to the walls of autoclave as in the case of the first Palisades ICET test. It was removed by hand and returned to the solution. The metal coupons were retrieved.

The solution was passed through a screen and was transferred to a settling tube and observed over 2 hours. The settling behavior is shown in Figure 5 through Figure 7. Most all of the precipitates had settled within 2 hours. The settled material did not have distinct boundaries between different types of material, even after centrifuging. The top 1 mm of the settled material was the lightest in color, and it gave way to a darker tan material. The sample was divided into two fractions. The "middle fraction" included the white particles that covered the top of the settled material.

		
Figure 5. PalisadesICET2 Settling Test at 0.5 hours.	Figure 6. PalisadesICET2 Settling Test at 1 hour.	Figure 7. PalisadesICET2 Settling Test after 2 hours

Filtration tests were performed on the two settled fractions. The Kfx values for the post-test settled fractions and the hot filtration runs are given in Table 5.

Table 5 . Filterability of Settled Solids and Suspended Material from PalisadesICET2 (pH 7 NaTB)

Sampling	**Temperature of Filtration (°F)**	**Kfx (gpm lbm cP ft^{-4} psi^{-1})**
Hot Filtration 1 day	166	2.24E-04
Hot Filtration 7 days	149	2.67E-04
Middle fraction, 7 days	78	2.47E-02
Middle fraction, 7 days	78	5.41E-03
Middle fraction, 7 days	78	3.77E-03
Middle fraction, 7 days	79	5.09E-03
Middle fraction, 7 days	79	4.49E-03
Bottom fraction, 7 days	78	6.80E-03
Bottom fraction, 7 days	78	5.56E-03
Bottom fraction, 7 days	78	7.76E-03
Bottom fraction, 7 days	78	5.28E-03

Results, PalisadesICET3 (pH 10 NaOH)

This test was started on June 28, 2007 in Autoclave 21 and was ended after a 33 day simulation. High temperature filtration was performed successfully after 1, 7, and 33 days.

The autoclave was cooled and the contents were transferred to a 5-gallon bucket. Most of the fiberglass material was lightly attached to the walls of autoclave as in the case of the first two Palisades ICET tests. It was removed by hand and returned to the solution. The metal coupons were removed from solution.

The solution was passed through a screen and was transferred to a settling tube and observed over 18 hours. The settling behavior is shown in Figure 8 and Figure 9. Most all of the precipitates had settled within 2 hours but some of the particles took overnight to settle. The settled material showed a distinct boundary between a white top fraction and underlying brown material, both in the settling tube and after centrifuging (Figure 10). The sample was divided into three fractions. The top fraction included only the white material. The middle fraction contained the bulk of the settled material and the bottom fraction included the lighter brown particles at the bottom of the centrifuge tubes. Approximate locations for separation of fractions are shown by a horizontal line.

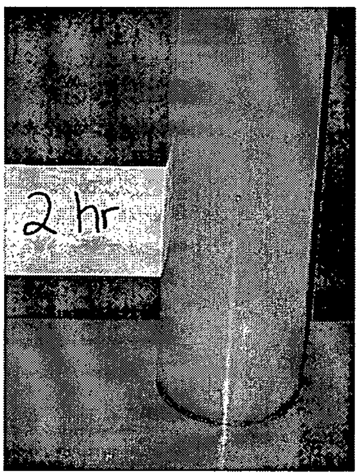


Figure 8. PalisadesICET3 Settling Test at 2 hours.

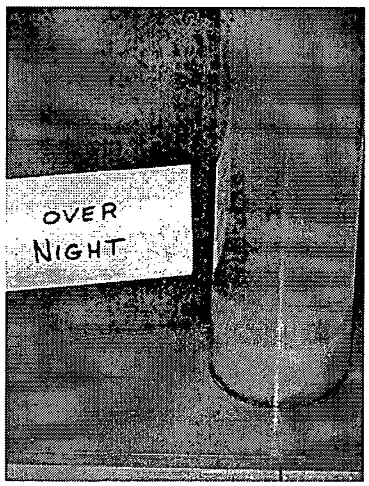


Figure 9. PalisadesICET3 Settling Test after 18 hours.

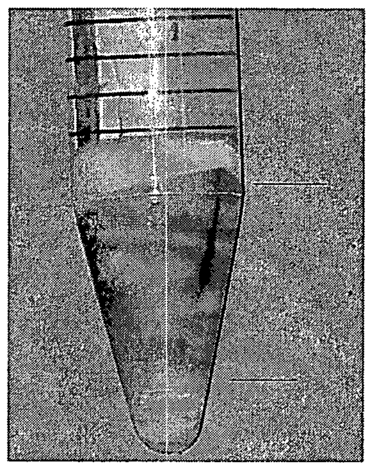


Figure 10. PalisadesICET3 Settling Test. Solids Removed and Centrifuged

Filtration tests were performed on the three settled fractions which are shown with the hot filtration Kfx values.

Table 6 . Filterability of Settled Solids and Suspended Material from PalisadesICET3 (pH 10 NaOH)

Sampling	**Temperature of Filtration (°F)**	**Kfx (gpm lbm cP ft^{-4} psi^{-1})**
Hot Filtration 1 day	183	3.52E-04
Hot Filtration 7 days	141	1.65E-04
Hot Filtration 33 days	157	5.84E-04
Top Fraction, 33 days	78	3.91E-04
Top Fraction, 33 days	78	4.31E-04
Middle Fraction, 33 days	77	4.20E-03
Middle Fraction, 33 days	61	5.31E-03
Middle Fraction, 33 days	62	9.48E-04
Middle Fraction, 33 days	59	2.26E-03
Bottom Fraction, 33 days	78	1.77E-02
Bottom Fraction, 33 days	60	6.30E-03
Bottom Fraction, 33 days	63	3.40E-03
Bottom Fraction, 33 days	69	2.98E-03

Results, PalisadesICET4 (pH 10, NaOH)

This test was started on June 28, 2007 in Autoclave 23 and was ended after a 33 day simulation. High temperature filtration was performed successfully after 7 and 33 days.

The autoclave was cooled and the contents were transferred to a 5-gallon bucket. Most of the fiberglass material was lightly attached to the walls of autoclave. It was removed by hand and returned to the solution. The metal coupons were removed from solution.

The solution was passed through a 20-mesh screen to remove the fibrous material. The collected material is shown in Figure 11. The solution passing through the screen and water from a rinse of the collected material was added to a settling tube. Not all of the precipitate material was washed out of the fibers with the first rinse, so a second rinse was performed and the solution from the second rinse was added to the top of the settling tube. When solution from the second rinse was added to the settling tube, even more solids appeared to precipitate. This is shown in Figure 11. Apparently the drop in pH from addition of the rinse water was enough to induce the additional precipitation.

Figure 11. 20-Mesh Fraction of PalisadesICET4 Product

The precipitate was mostly settled after 2 hours (Figure 12). The remaining fine material was allowed to settle overnight and the solids were removed and centrifuged. There was a clear separation between a white top layer and a middle layer that was tan in color. The tan particles at the bottom of the centrifuge tube were more coarse. The sample was divided into three fractions. The top fraction included only the white material. The middle fraction contained the fine tan settled material and the bottom fraction included the coarser particles in the conical section of the centrifuge tubes.

Figure 12. PalisadesICET4 Settling Test 4 after addition of the second rinse.

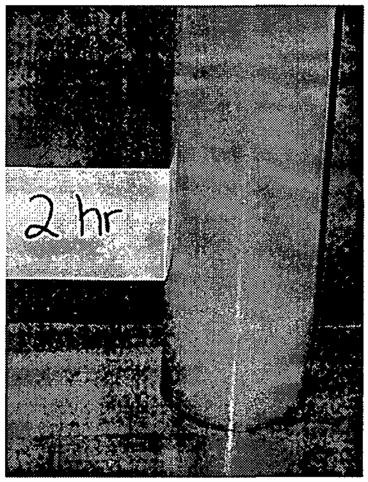


Figure 13. PalisadesICET4 Settling Test after 2 hours.

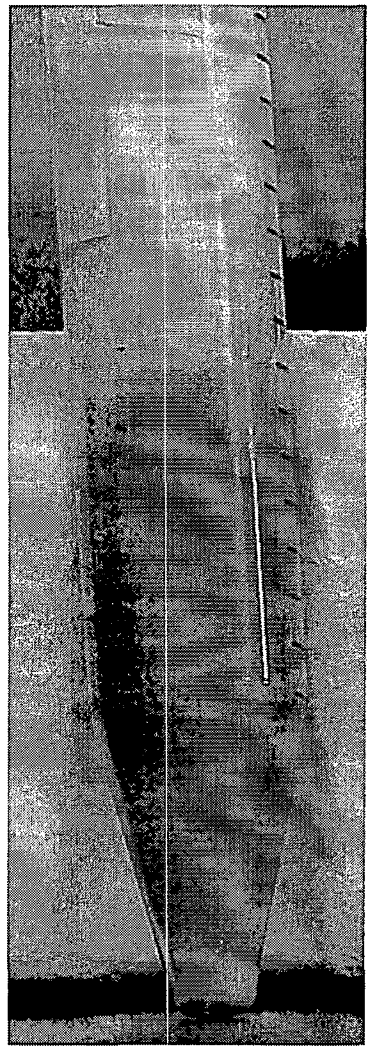


Figure 14. PalisadesICET4 Settling Test. Solids Removed and Centrifuged

Filtration tests were performed on the three settled fractions. The results are shown in Table 7 along with the hot filtration Kfx values.

Table 7 . Filterability of Settled Solids and Suspended Material from PalisadesICET4 (pH 10 NaOH)

Sampling	**Temperature of Filtration (°F)**	**Kfx (gpm lbm cP ft^{-4} psi^{-1})**
Hot Filtration 7 days	146	1.28E-04
Hot Filtration 33 days	154	9.23E-04
Top Fraction, 33 days	77	3.96E-04
Middle Fraction, 33 days	77	6.72E-04
Bottom Fraction, 33 days	76	1.10E-03

Results, PalisadesICET5 (pH 7.8 NaTB)

This test was started on June 28, 2007 in Autoclave 14 and was ended after a 33 day simulation. High temperature filtration was performed successfully after 1, 7, and 33 days.

The autoclave was cooled and the contents were transferred to a 5-gallon bucket. Most of the fiberglass material was lightly attached to the walls of autoclave. It was removed by hand and returned to the solution. The metal coupons were removed from solution.

The solution was passed through a screen and was transferred to a settling tube and observed over 18 hours. The settling behavior is shown in Figure 15 and Figure 16. Most all of the precipitates had settled within 2 hours but some of the particles took overnight to settle. The settled material did not show a distinct boundary between a light gray top fraction and underlying material of similar color. The sample was divided into two fractions. The top fraction composed the upper three-fourths of the centrifuged samples and the remaining one-fourth of the material was defined as the bottom fraction.

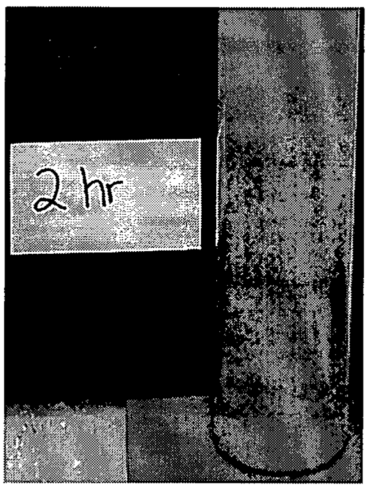
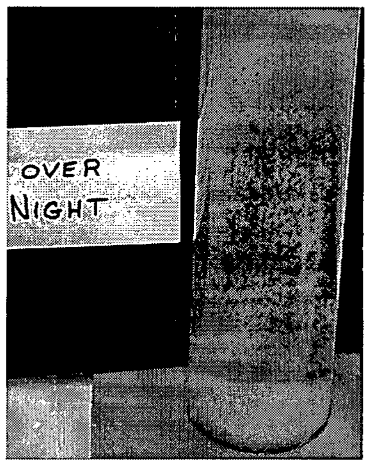
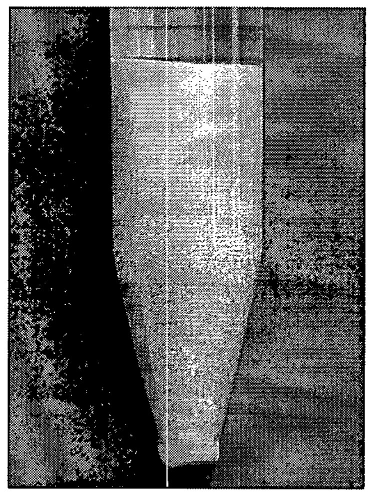
		

Figure 15. PalisadesICET5 Settling Test at 2 hours.	Figure 16. PalisadesICET5 Settling Test after 18 hours.	Figure 17. PalisadesICET5 Settling Test. Solids Removed and Centrifuged

Filtration tests were performed on the two settled fractions which are shown with the hot filtration Kfx values in Table 8.

Table 8 . Filterability of Settled Solids and Suspended Material from PalisadesICET5 (pH 7.8 NaTB)

Sampling	Temperature of Filtration (°F)	Kfx (gpm lbm cP ft^{-4} psi^{-1})
Hot Filtration 1 day	173	3.06E-04
Hot Filtration 7 days	136	1.35E-04
Hot Filtration 33 days	136	1.13E-04
Top Fraction, 33 days	69	3.24E-03
Top Fraction, 33 days	69	2.13E-03
Top Fraction, 33 days	60	6.90E-03
Top Fraction, 33 days	59	7.61E-03
Bottom Fraction, 33 days	68	4.08E-03
Bottom Fraction, 33 days	55	1.64E-02
Bottom Fraction, 33 days	53	1.47E-02
Bottom Fraction, 33 days	55	1.61E-02

DISCUSSION

The integrated chemical effects tests reported here were performed under conditions that represented a range of possible post-LOCA environments at Palisades. The temperatures conformed to those expected from a large-break LOCA. The simulated coolant pH values of 7, 7.8 and 10 spanned the range that will bound buffers being considered at the plant. Containment materials were representative of those at Palisades and they were mixed and allowed to interact. Thus, the reaction products that formed and the suspended solids that were sampled should have been representative of what might be found in solution after a LOCA at Palisades.

Since Palisades has a bounding aluminum metal surface area for the industry, and since precipitates formed from aluminum corrosion are known to be difficult to filter from the WCAP-16530-NP bench tests, the suspended solids produced in these tests should bound the industy. It is not expected that the precipitates formed at any other plant would be more difficult to filter. If surrogates produced for sump screen testing are similar to the Palisades suspended solids in terms of filterability, or if they are more difficult to filter, then they should be acceptable for replacement sump screen testing.

The filterabilities of various WCAP-16530-NP surrogates are included here for comparison. The filterabilities of surrogates produced in the 'White Paper Tests' are given in Table 9. The filterabilities of surrogates produced in 2006 are included in Table 10. Average Kfx values and 95% confidence intervals for the different types of precipitates are shown Figure 18.

All but one of the surrogates (AlOOHTapOld) had a lower Kfx value than any of the autoclave generated material. The AlOOHTapOld surrogate filterability was well within the range of the autoclave materials that were measured. Thus it can be concluded that surrogates made by the WCAP-16530-NP receipe are suitable for use in sump screen qualification tests.

Table 9. Results from 'White Paper Tests'

Sample Name	Kfx (gpm lbm cP ft^{-4} psi^{-1})
AlOOH Surrogate at 2.2 g/L in tap water made 5/24/07	5.50E-05
AlOOH Surrogate at 2.2 g/L in tap water made 5/24/07	8.20E-05
AlOOH Surrogate at 2.2 g/L in tap water made 5/24/07	6.77E-05
AlOOH Surrogate at 2.2 g/L in tap water made 5/24/07	5.73E-05
AlOOH Surrogate at 2.2 g/L in tap water made 5/24/07	4.00E-05
AlOOH Surrogate at 2.2 g/L in tap water made 5/24/07	5.07E-05
AlOOH Surrogate at 2.2 g/L in tap water made 5/24/07	5.95E-05
AlOOH Surrogate at 2.2 g/L in tap water made 5/24/07	5.63E-05
AlOOH Surrogate at 2.2 g/L in tap water made 5/24/07	3.92E-05
AlOOH Surrogate at 2.2 g/L in 4400 ppm B made 5/24/07	1.34E-04
AlOOH Surrogate at 2.2 g/L in 4400 ppm B made 5/24/07	1.70E-04
AlOOH Surrogate at 2.2 g/L in 4400 ppm B made 5/24/07	4.74E-05
AlOOH Surrogate at 2.2 g/L in 4400 ppm B made 5/24/07	2.62E-04
Sodium Aluminum Silicate made in Tap Water 9.7 g/L 5/26/13	3.55E-05
Sodium Aluminum Silicate made in Tap Water 9.7 g/L 5/26/14	3.81E-05
Sodium Aluminum Silicate made in Tap Water 9.7 g/L 5/26/16	2.81E-05
Sodium Aluminum Silicate made in Tap Water 9.7 g/L 5/26/17	5.39E-04
Sodium Aluminum Silicate made in Tap Water 9.7 g/L 5/26/18	2.58E-05

Table 10. Results from Surrogate Filtration Tests in 2006

Sample Name	Kfx (gpm lbm cP ft^{-4} psi^{-1})
AlOOHBoricOld	0.0001
AlOOHBoricOld	0.0001
AlOOHTapOld	0.0005
AlOOHTapOld	0.0019
AlOOHTapOld	0.0020
AlOOHTapOld	0.0022
AlOOHTapOld	0.0004

AlOOHBoric = AlOOH surrogate precipitated in 4400 ppm boric acid solution and run with 4400 ppm boric acid solution in the filtration test apparatus
AlOOHTapOld = AlOOH surrogate precipitated in tap water and run with 4400 ppm boric acid solution in the filtration test apparatus

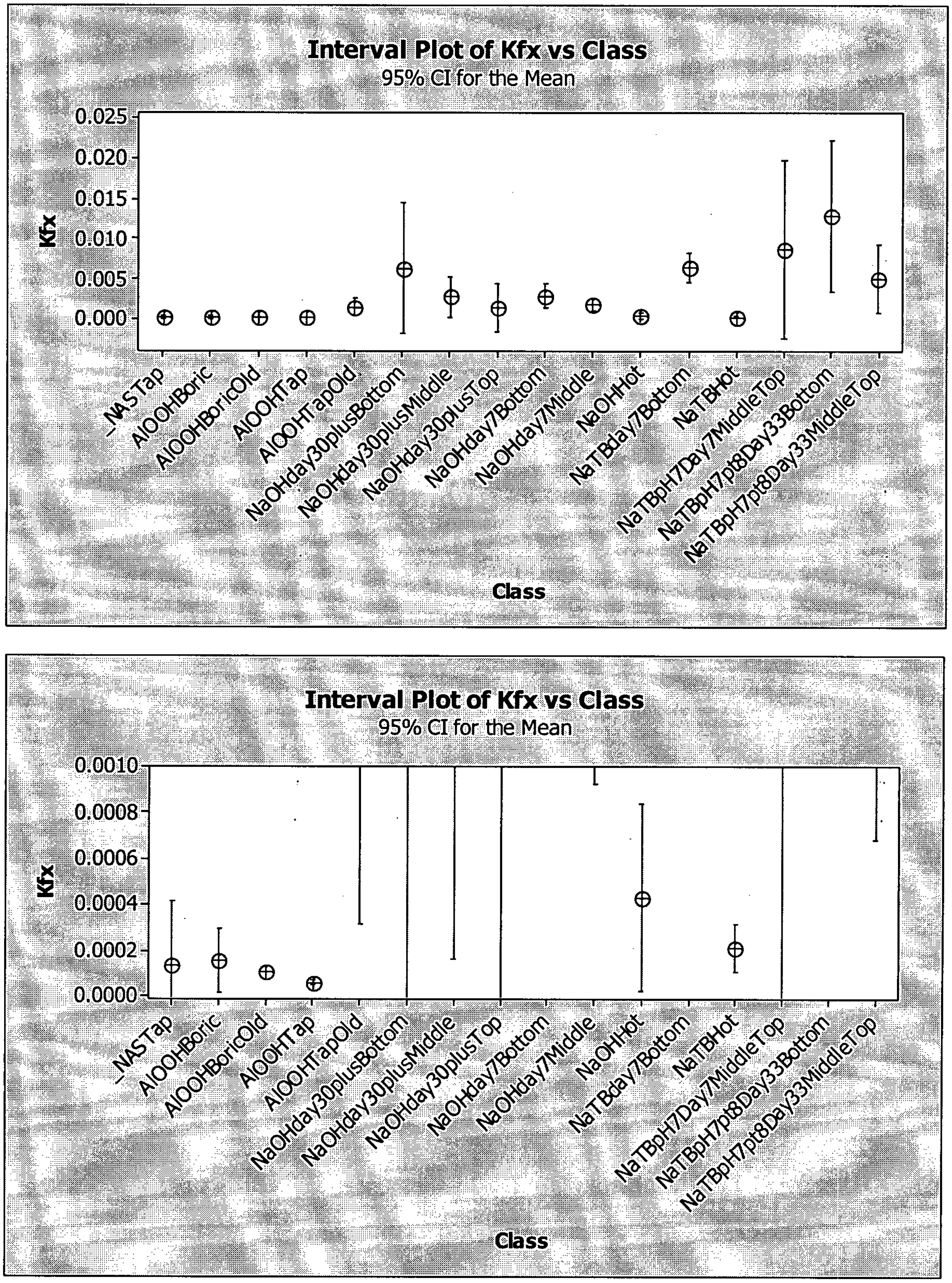


Figure 18. Comparison of Palisades Test Results to WCAP-16530 Surrogates (bottom plot is an expansion of top)

Key for Figure 18 :

Designation	Sample Type
_NASTap	WCAP 16530 sodium aluminum silicate surrogate produced in tap water and run in tap water, 2007 (white paper tests)
AlOOHBoric	WCAP 16530 aluminum oxide hydroxide surrogate produced in boric acid and run in boric acid, 2007 (white paper tests)
AlOOHBoricOld	surrogate produced in boric acid and run in boric acid, 2006
AlOOHTap	WCAP 16530 aluminum oxide hydroxide surrogate produced in tap water and run in tap water, 2007 (white paper tests)
AlOOHTapOld	WCAP 16530 surrogate produced in tap water and run in boric acid, 2006
NaOHday30plusBottom	Settled bottom fraction from PalisadesICET3 and PalisadesICET4
NaOHday30plusMiddle	Settled middle fraction from PalisadesICET3 and PalisadesICET4
NaOHday30plusTop	Settled top fraction from PalisadesICET3 and PalisadesICET4
NaOHday7Bottom	Settled bottom fraction from PalisadesICET1
NaOHday7Middle	Settled middle fraction from PalisadesICET1
NaOHHot	Hot sample from PalisadesICET1, PalisadesICET3, Palisades ICET4
NaTBday7Bottom	Settled bottom fraction from PalisadesICET3 and PalisadesICET2
NaTBHot	Hot sample from PalisadesICET2 and Palisades ICET5
NaTBpH7Day7MiddleTop	Settled material from PalisadesICET2, top and middle layers
NaTBpH7pt8Day33Bottom	Settled material from Palisades ICET5, bottom layer
NaTBpH7.8Day33MiddleTop	Settled material from Palisades ICET5, middle and top layers

It should be noted that the samples were not analyzed chemically. Since the reactants and the products were all mixed in one vessel, it is not known what fraction the suspended solids that were sampled during the elevated temperature filtrations were unreacted starting material and what fraction was precipitate formed during the test. The post-test visual examination of the solids suggested that some of the fine particles were actually unreacted CalSil, even in the 33 day samplings. The low-density material that made up the top fraction of the settled materials was unlike any of the reactants, and probabally formed during the test.

Appendix A

Test Plan for High Temperature LOCA Precipitate Filterability Tests

To: **John Maruschak**
Rick Reid
Mike Peck
Josh McKinley
Kristin Ruth
Mike Burke

Date: June 20, 2007

Table of Contents

Introduction

Westinghouse has developed chemical materials to be used in testing sump screen performance. These materials are intended to represent hard to filter precipitates and corrosion products that might form after a LOCA by reaction of coolant with containment materials. The recipe for the production of the surrogate chemical materials and instructions for their use was published in WCAP-16530-NP in 2006.[1]

The NRC questioned whether the testing done by Westinghouse to qualify the precipitates was adequate in a May 17, 2007 teleconference. WCAP-16530-NP stated that sump screen testing using the surrogates could be performed in tap water or in a boric acid solution, and that the choice of tap water or boric acid would not cause a significant difference in the results. Filtration testing using a "stepped-flow" apparatus had been

[1] WCAP-16530-NP, Revision 0, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191," February 2006.

performed in the WCAP to support the surrogate production technique and the recommendation regarding tap water use. The NRC challenged the filtration technique and the data it had produced.

Subsequent to the May 17 teleconference with the NRC, Westinghouse conducted additional filterability tests that showed that the stepped flow filtration technique gave reliable results. A number of the tests were observed by the NRC. The new testing, along with the original WCAP-16530-NP testing, examined six different batches of surrogate material. In five of six cases, the Westinghouse surrogates were more difficult to filter than the precipitates produced from reaction of containment materials in the WCAP-16530 bench testing. However, one of the Westinghouse AlOOH surrogates produced in 2006 (AlOOHTapOld) had roughly the same filterability as the containment material precipitates, using the average Kfx value as the basis of comparison.[2] This is shown below in Figure 19. The surrogates are usually more difficult to filter than the containment material reaction products, but occasionally, due to factors that are not well understood, a surrogate is produced that is still difficult to filter, but not any more so than the containment materials from the WCAP 16530 bench tests.

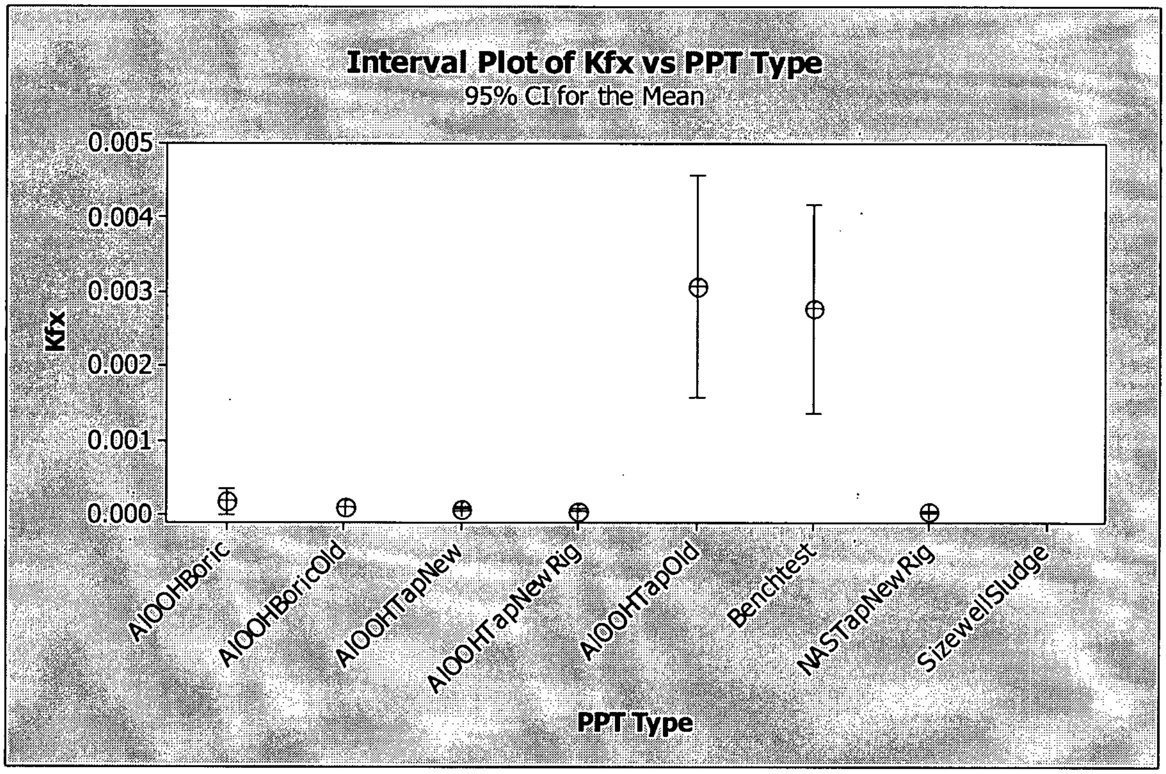


Figure 19. Filterability of surrogates compared to reaction products produced from containment materials in the WCAP 16530 bench tests. Higher Kfx values indicate a more easily filtered material.

A logical approach to solving the problem of variable surrogate filterability would be to tighten the controls on the surrogate production process, or to tighten the acceptance criteria for surrogates produced for sump screen testing. This path is unacceptable because some plants have already completed sump screen testing using material produced by the WCAP 16530 recipe.

Another approach to achieving acceptance of the WCAP-16530 precipitates is to show that real precipitates formed after an accident would be easier to filter than the bench test reaction products. The possibility of this approach became apparent while trying to produce a new batch of corrosion products to test the filtration

[2] Kfx is a measure of filterability and lower Kfx values indicate a material is more difficult to filter

apparatus[3]. It was observed that the filtration characteristics of corrosion products were strongly influenced by the temperature history of the reaction. Corrosion products that were formed in beakers from corrosion of aluminum at approximately 200°F settled quickly in some circumstances. These corrosion products were easy to filter when they were formed at temperature, or were formed by slowly cooling the solution after some initial precipitation. The exact cooling rate was not measured, but the solution was cooled from 200°F to room temperature in approximately 1 hour. Similar results were observed when corrosion products produced in a pressure vessel were cooled from 265°F to room temperature in 20 minutes. A solution produced by aluminum corrosion that was cooled rapidly by dumping it into a second solution of 4400 ppm boric acid at room temperature produced a precipitate that settled slowly and was difficult to filter. Thus, it appears that rapidly cooled post-LOCA chemical reaction products are difficult to filter, while products that form at temperature or during slow cooling are easy to filter.

The rate of cooling of coolant in the containment sump after a LOCA will be slow, and more easily filtered chemical reaction products are to be expected. If this can be proven in more careful laboratory testing, then the surrogates can be shown to be clearly conservative in all cases. This situation is shown graphically in Figure 20, where the data anticipated from the tests proposed here has been labeled "Realistic PPT".

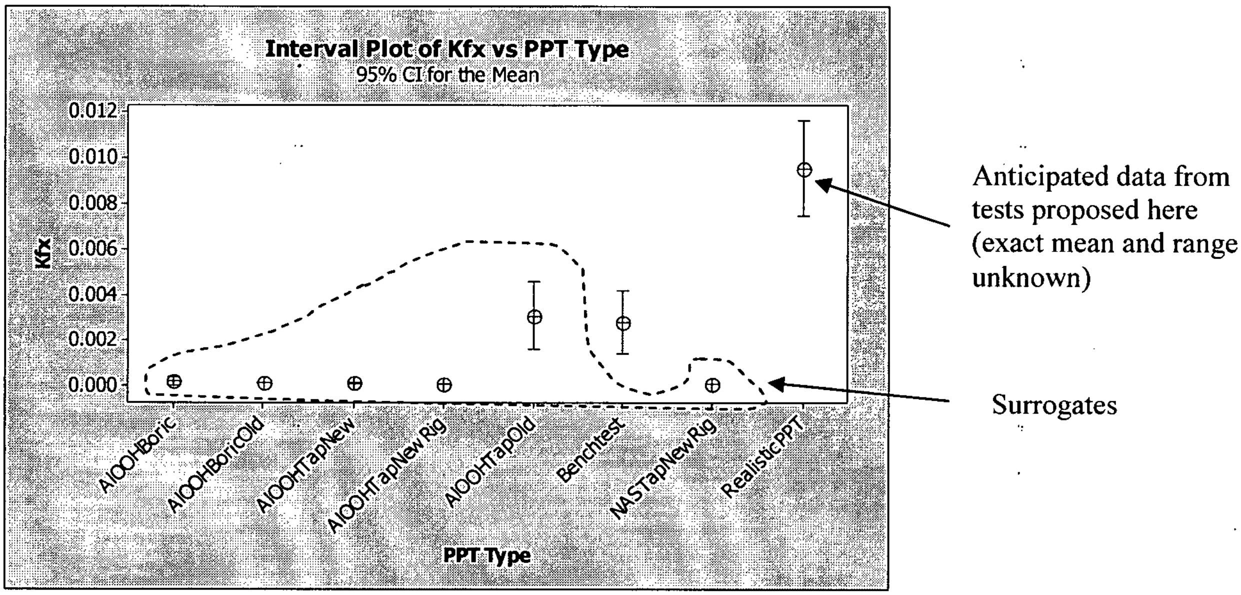


Figure 20. The testing proposed here will demonstrate that more realistic post-LOCA precipitates clearly bound all surrogate materials.

It should be noted that all of the containment material reaction products formed in the WCAP 16530 bench tests were rapidly cooled. They went from the reaction temperature to 70°F in a matter of seconds, as the simulated coolant was passed through a heat exchanger.

Goal of Testing

To produce more realistic post-LOCA chemical reaction products by limiting the amount and rate of cooling, and then show that the more realistic post-LOCA chemical reaction products are in all cases more easily filtered than the Westinghouse surrogates produced by WCAP-16530 method.

[3] Tests recorded in lab notebook 212926,p103-106, May 25

Requirements

The NRC has issued several requests for additional information (RAIs) in reviewing WCAP-16530-NP. These RAIs give some measure of where the NRC believes that additional work needs to be done, and as such, they are a useful guide for setting requirements for testing.

The requests for additional information from the NRC were reviewed and a subset of the RAIs has been paraphrased below in Table 1. The RAIs were subjectively ranked in importance to the NRC. Addressing the first RAI is the main requirement of this test plan. Other RAIs will be considered if doing so will enhance the acceptability of the results or doing so will not add significant cost to the testing.

Table 1. Selected Issues/Question from NCR Concerning Acceptance of WCAP-16530-NP

Issue/Question	Importance to NRC (0-10)	Addressed in Requirement
Can the WCAP surrogates be used in screen testing to produce conservative results?	9	1, 4, 5, 6
Are the quantities of chemical products predicted with the model conservative?	10	1, 2, 3, 5
Should iron oxides from crud be included in the surrogate mixture?	3	5
Can galvanized steel corrosion be ignored?	2	5
Can steel corrosion be ignored?	2	5
Could chloride accelerate corrosion significantly?	2	5
Can copper accelerate corrosion significantly?	2	5
Can deposition in the core accelerate additional dissolution/release?	4	none
Can TSP stimulate additional Ca release?	2	2
Were insulation materials prepared in a representative way?	3	none
High scatter in the measured dissolution rates decreases confidence in quantities predicted.	7	2
Does the presence of CO_2 in containment create more precipitates	4	7
In general, why should single effects tests be considered to be conservative?	8	5
Filterability of precipitate mixtures may be different from single precipitates.	4	5
Scatter in repeat "stepped flow" filtration tests is too high.	3	3
Have not demonstrated that surrogate behavior in tap water is "conservative" relative to real corrosion products.	6	1, 4, 5, 6
Is having the right percentages of surrogate species critical for testing.	2	2
Is filterability is non-linear or linear with concentration	2	none
Does the presence of CO_2 in containment make precipitates that are harder to filter than bench test precipitates?	2	7
Behavior of surrogates may change with time	3	3
May have batch-to-batch variation in surrogate make-up	3	1, 4, 5, 6

A requirement list was generated from the testing goal and the RAI review. The list is given below.

Requirement List

R1. Containment materials chemical reaction products are to be produced using a limiting but realistic time temperature profile for recirculating coolant in a PWR post-LOCA.
R2. Enough tests will be done to quantify the variability in reaction product formation due to changes in pH/buffer variation.
R3. A sufficient number of samples will be taken to quantify variability in sampling and analysis
R4. The filtration will be performed at a typical sump screen temperature.
R5. The test will include a mix of containment materials
R6. The mix of containment materials should produce reaction products that are though to be most limiting in terms of filtration.
R7. The test solution should be exposed to air

Reference Plant- Palisades

A simulation of the Palisades Plant post-accident environment in the laboratory should meet the test requirements. The Palisades plant is a good choice because it has large quantities of CalSil and fiberglass insulation as well as a large surface area of aluminum. It has one of the highest predicted sump temperatures and the cooling rate for the sump is high during the first day of the accident. Palisades is also required to operate containment spray for a period of 30 days after the accident, so this plant should be limiting in terms of containment post-accident chemical reactions By using a variety of buffer solutions with the Palisades materials and temperature profile, a range of chemical reaction products will be produced, meeting requirement R2.

The sump pH and temperature profiles have been provided by Palisades and are listed in Table 2. The materials that are susceptible to post-LOCA chemical reactions are listed in Table 3. These values were taken from the chemical effects model spreadsheet provided by the plant. It should be noted that the plant is exploring different buffer options, so the pH profile is not set at the current time. Other materials not listed in the chemical effects spreadsheet were described in the Palisades response to the PWROG industry survey of containment materials. These have been listed in Table 4. It should be noted that some of the material estimates in Table 3 have been revised since the original survey, and Table 3 values should be used when there is a difference between Table 3 and Table 4.

Table 2 Sump Temperature and pH Profile for Palisades from Chemical Effects Spreadsheet

Time (sec)	min	hr	days	Sump pH	Sump Temp. (°F)	Sump Mixed 1=Yes	Steam or Spray pH	Containment Temp. (°F)
10	0	0.00	0.000	9.32	228.0	0	5.1	280.0
20	0.3	0.01	0.000	9.32	250.0	0	5.1	281.0
30	0.5	0.01	0.000	9.32	260.0	0	5.1	279.0
60	1	0.02	0.001	9.32	268.0	0	5.1	276.0
90	2	0.03	0.001	9.32	272.0	0	5.1	272.0
300	5	0.08	0.003	9.32	277.0	0	5.1	265.0
600	10	0.17	0.007	9.32	275.0	0	5.1	255.0
900	15	0.25	0.010	9.32	271.0	0	5.1	245.0
1200	20	0.33	0.014	8	268.0	0	8	240.0
1500	25	0.42	0.017	8	261.0	0	8	220.0
1800	30	0.50	0.021	8	255.0	0	8	215.0
2700	45	0.75	0.031	8	243.0	0	8	198.0
3600	60	1.00	0.042	8	239.0	0	8	216.0
5400	90	1.50	0.063	8	238.0	0	8	221.0
7200	120	2.00	0.083	8	236.0	0	8	222.0
14400	240	4.00	0.167	8	231.0	0	8	220.0
21600	360	6.00	0.250	8	225.0	0	8	220.0
28800	480	8.00	0.333	8	216.0	0	8	218.0
36000	600	10.00	0.417	8	210.0	0	8	212.0
43200	720	12.00	0.500	8	206.0	1	8	205.0
50400	840	14.00	0.583	8	200.0	1	8	201.0
57600	960	16.00	0.667	8	196.0	1	8	195.0
72000	1200	20.00	0.833	8	190.0	1	8	190.0
86400	1440	24.00	1.000	8	185.0	1	8	185.0
129600	2160	36.00	1.500	8	175.0	1	8	175.0
172800	2880	48.00	2.000	8	166.0	1	8	165.0
259200	4320	72.00	3.000	8	158.0	1	8	155.0
432000	7200	120.00	5.000	8	158.0	1	8	150.0
626400	10440	174.00	7.250	8	148.0	1	8	137.0
864000	14400	240.00	10.000	8	139.7	1	8	126.0
1296000	21600	360.00	15.000	8	134.0	1	8	116.7
1728000	28800	480.00	20.000	8	130.3	1	8	111.8
2160000	36000	600.00	25.000	8	122.2	1	8	102.2
2592000	43200	720.00	30.000	8	120.0	1	8	101.0

Table 3 Containment Materials at Palisades from Chemical Effects Spreadsheet

Class	Material	Amount
Coolant	Sump Pool Volume (ft3)	52714.8
Metallic Aluminum	Aluminum Submerged (sq ft)	31951.7
	Aluminum Submerged (lbm)	1633.9
	Aluminum Not-Submerged (sq ft)	108745
	Aluminum Not-Submerged (lbm)	5756
Calcium Silicate	CalSil Insulation(ft3)	153.3
	Asbestos Insulation (ft3)	0
	Kaylo Insulation (ft3)	0
	Unibestos Insulation (ft3)	0
E-glass	Fiberglass Insulation (ft3)	50.1
	NUKON (ft3)	1139
	Temp-Mat (ft3)	0
	Thermal Wrap (ft3)	0
Silica Powder	Microtherm (ft3)	0
	Min-K (ft3)	0
Mineral Wool	Min-Wool (ft3)	0
	Rock Wool (ft3)	0
Aluminum Silicate	Cerablanket (ft3)	0
	FiberFrax Durablanket (ft3)	0
	Kaowool (ft3)	0
	Mat-Ceramic (ft3)	0
	Mineral Fiber (ft3)	0
	PAROC Mineral Wool (ft3)	0
Concrete	Concrete (ft2)	7730000
Trisodium Phosphate	Trisodium Phosphate Hydrate (lbm)	0
Interam	Interam (ft3)	0

Table 4 Initial Palisades PWROG Survey Entries

Material	Amount	Percent Submerged	Ratio
Galvanized Steel	73600 ft^2	1	2.53 ft^2/ft^3
Zinc Coating (Untopcoated)	63000 ft^2	2	2.17 ft^2/ft^3
Aluminum	157500 ft^2	1	5.42 ft^2/ft^3
Copper	280000 ft^2	25	9.64 ft^2/ft^3
Fiberglass Insulation	1180 ft^3	100	0.04 ft^3/ft^3
Cal Sil Insulation	97 ft^3	100	0.003 ft^3/ft^3
Insulation Transported to Sump	1277 ft^3	100	0.04 ft^3/ft^3
Total Insul. in Containment	1277 ft^3	100	0.04 ft^3/ft^3
Carbon Steel	217900 ft^2	5	7.50 ft^2/ft^3
Exposed Concrete Surface	457880 ft^2	0	1.58 ft^2/ft^3
Max Total Recir Vol	55169 ft^3		
Min Total Recir Vol	29050 ft^3		
Min Sump Approach Velocity (ft/s)	0.13 ft/s		
Max Sump Screen Approach Velocity (ft/s)	0.37 ft/s		
Max Sump pH	8		
Min Sump pH	7		
Buffering Agent	TSP		

Note- The "Ratio" column is the ratio of a material to the sump solution volume.

Equipment List

1. Four two gallon stainless steel autoclaves with the configuration shown in Figure 21.
2. Filtration set-up as shown in Figure 22.
3. Containment Materials- See tables below

Table 5 Coupons to be added to each Autoclave

Coupon Material	Value at Palisades (ft^2)	Amount per Autoclave (ft^2)	Number Coupons	Coupon Width (in)	Coupon Length (in)
Galvanized Steel or other Zn Coating	517000	2.12	8	3.18	6
Copper Sheet	280000	1.15	3	4	7
Aluminum 1 mil thick	126007	0.52	2	3	6.20
Aluminum 63 mils thick	14689	0.06	1	2	2.17

Table 6 Powders / Fibers to be added to each Autoclave

Insulation Material	Value at Palisades	units	Amount per Autoclave	units
CalSil	1008.3	kg	4.13	g
Nukon	2066.6	kg	8.47	g
Other Fiberglass	90.9	kg	0.37	g
Concrete	77.7	kg	0.32	g
Sodium Chloride	100	ppm	1	g
Magnetite	36	kg	0.15	g

Table 7 Simulated Coolants

Coolant	pH	Amount
2500 ppm B Boric Acid + Trisodium Phosphate (TSP)	7.0	6114 ml
2500 ppm B Boric Acid + Sodium Tetraborate (NaTB)	7.0	6114 ml
2500 ppm B Boric Acid + Sodium Tetraborate (NaTB)	7.8	6114 ml
2500 ppm B Boric Acid + Sodium Hydroxide	10.0	6114 ml

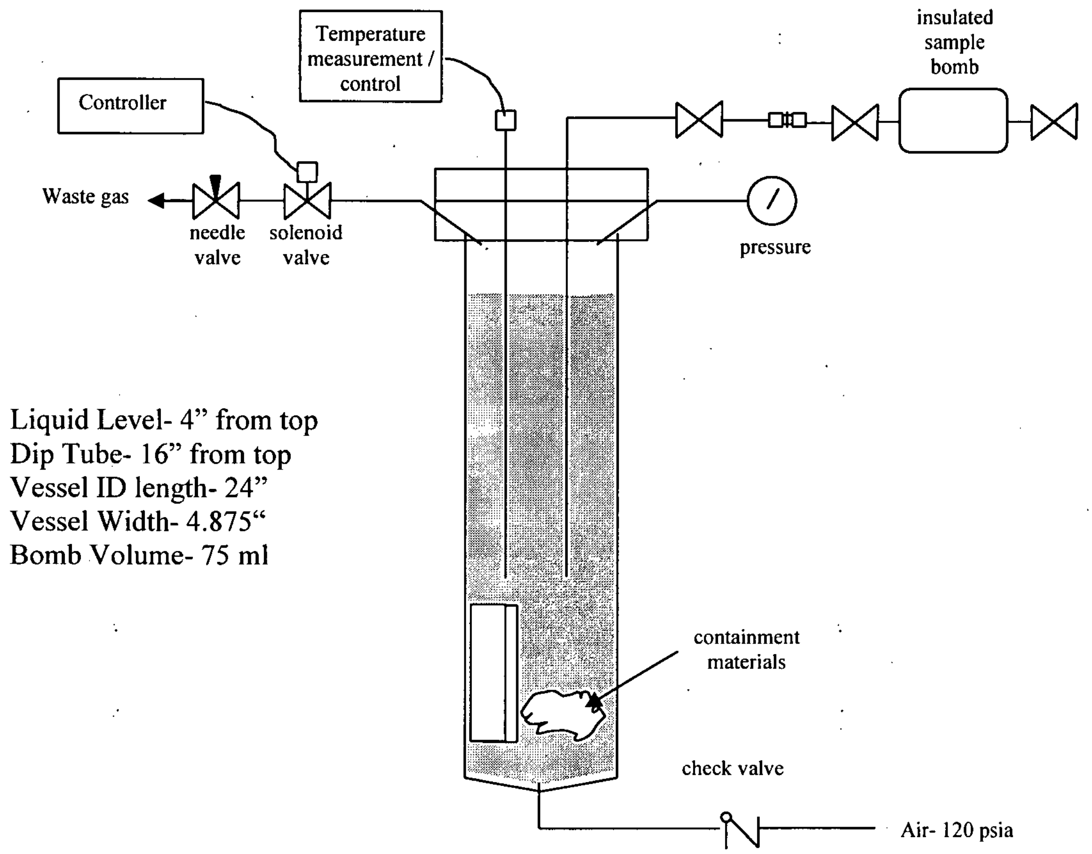


Figure 21 Autoclave set-up

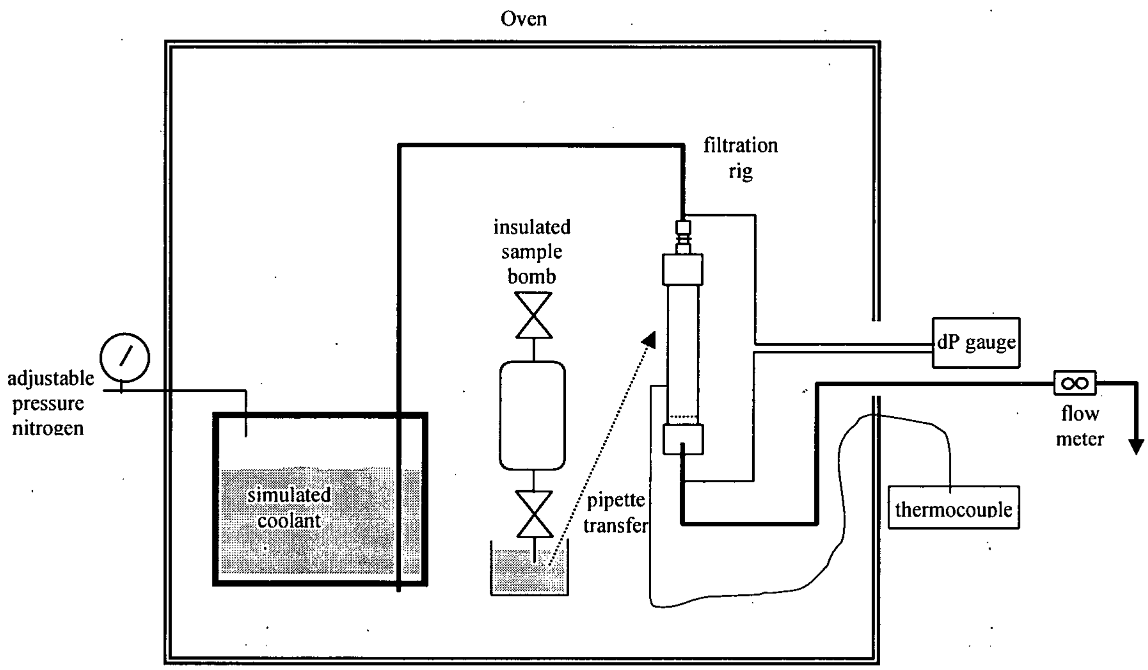


Figure 22 Filtration rig set-up

Test Procedure

For each of the four tests:

1. Weigh containment material portions and place in autoclave (See Table 5and Table 6 for amounts and coupon sizes). Bend the coupons so that they cannot lay flat against each other.
2. Add one of the four simulated coolants (a separate coolant is used for each test) per Table 7.
3. Bolt head to the autoclave and heat to 277°F at the maximum heat rate without overshoot.
4. As soon as the 277°F temperature is achieved, cool the autoclave at the rate shown for sump cooling in Table 2.
5. Every 30 minutes, admit air for three seconds to stir solution
6. Preheat analysis oven to 185°F.
7. After 1 day, take a 75 ml sample for solution chemical analysis
    a. Begin taking sample 20 minutes after stirring so that any easily filterable material will have settled.
8. Take a 75 ml sample for analysis of filterability 30 minutes after the sample for solution chemical analysis (20 min after the next air burst for stirring)
9. Transfer the filterability sample to the analysis oven as quickly as possible
10. Perform filterability test on sample at 185°F
11. Continue to cool the sample per the Table 2 sump temperature profile.
12. For one of the autoclaves, three additional filterability samples should be taken in sequence to test for reproducibility.
13. After 5 days when the autoclave temperature is 158°F, repeat the sampling sequence and the filterability test, with filtration being performed at 158°F.
14. Continue test for up to 30 days if endorsement is obtained from Entergy or PWROG.
15. After the termination of the testing, weigh coupons before and after de-scaling.
16. Analyze chemistry samples for Si, Ca, and Al

Calculations

1. Calculate Kfx per the corrected WCAP-16530-NP procedure (corrected).
2. Compare Kfx values for each test to the WCAP-16530-NP surrogate Kfx values
3. Compare chemical analyses to chemical effects spreadsheet output to determine the amount of conservatism in the chemical effects spreadsheet.

Reporting

A letter report will be written which describes the tests, the results, and the implication of the testing.

W. A. Byers
Fellow Engineer
Westinghouse Materials Center of Excellence

Appendix B

'Reid White Paper Test Plan »

Test Outline for WCAP 16530 Surrogate Filtration Testing

Preparation of Precipitate Slurries

Prepare 1 liter each of WCAP 16530 aluminum oxyhydroxide (AlOOH) surrogate in tap water and in tap water with 4400 ppm boron (added as boric acid), with a nominal concentration of 2.2 g/l aluminum.

Prepare 1 liter of WCAP 16530 sodium aluminum silicate (NAS) surrogate in tap water, with a nominal concentration of 9.7 g/l aluminum.

Prepare 1 liter of aluminum oxyhydroxide precipitate slurry by dissolution of aluminum metal (at ~95°C) in 4400 ppm boron solution that has been pH adjusted with sodium hydroxide. This slurry will simulate the precipitate expected to be generated under prototypical post-accident conditions.

For each precipitate, determine the one-hour settling rate using a 10 ml sample, in accordance with WCAP 16530.

For each precipitate, filter a 2 ml sample through a tared 1 μm filter paper. Dry the collected precipitate and determine dry mass in accordance with procedure MCT-156, Revision 0.

Testing

Determine the filterability of each of the above surrogates in accordance with MCT-156. Perform a minimum of four test runs on each precipitate.

For precipitates prepared in boric acid solutions, the simulated coolant should be 4400 ppm boric acid with pH adjusted to 8.0. For precipitates prepared in tap water only, the simulated coolant should be tap water.

Table 1: Test Matrix for WCAP 16530 Surrogate Filtration Testing

Precipitate Type	Simulated Coolant
AlOOH from Al Coupon Corrosion in 4400 ppm B, pH adjusted	4400 ppm B; pH 8.0 with NaOH
WCAP 16530 AlOOH Surrogate	Tap Water
WCAP 16530 AlOOH Surrogate	4400 ppm B; pH 8.0 with NaOH
WCAP 16530 NAS Surrogate	Tap Water
$NiFe_2O_4$ or Fe_3O_4 Powder	4400 ppm B; pH 8.0 with NaOH

Attachment 2

RECORD OF SELF REVIEW AND INDEPENDENT VERIFICATION[4]

STD-MCE-07-57 Document Number and Revision	Final Summary of Filterability Testing for the USNRC Document Title
W. A. Byers Author(s)	G. R. Marshall Verifier(s)

Part 1: Author:

No.	Self Review Topic	Yes	No	N/A
1	Is the subject and/or purpose of the report clearly stated?	x	☐	
2	Are the required inputs and their sources provided and determined to be appropriate for the current analysis? Do the references contain sufficient information to clearly identify the source and facilitate its retrieval, including documents not maintained as quality records by Westinghouse?	x	☐	☐
3	Does the report contain test data?	x	☐	
4	Has a Test data Report Verification Checklist per STD 0403 been completed and attached?	x	☐	☐
5	Are the assumptions clearly identified and justified?	x	☐	☐
6	Are the methods clearly identified?	x	☐	☐
7	Is a Design Analysis documented in the report?		x	
8	Are the units of measurement clearly identified?	x	☐	☐
9	Have the limits of applicability been identified?	x	☐	☐
10	Are the results of literature searches, if conducted or other background data provided?	x	☐	☐
11	Are all the pages sequentially numbered and revision number listed on each page? Is a Table of Contents included in the report?	x	☐	
12	Were the computer codes(s) used applicable for modeling the physical and/or computational problem(s) contained in this report?	☐	☐	x
13	If the computer code(s) used for the analysis are not described in the references (including source code and equations), are the source code(s) included in the report?	☐	☐	x
14	Has the required computer calculation information been provided? Are all computer calculation input and outputs necessary to demonstrate that the objective of the analysis was accomplished, identified and included in the report?	☐	☐	x
15	Are the results and conclusions clearly stated?	☐	☐	x
16	Are open items properly identified?	☐	☐	x

[4] This template is only applicable to STD Technical Reports and shall not be used to document Design Analyses.

No.	Self Review Topic	Yes	No	N/A
17	Are all references clearly identified in the analysis and in any attachment?	x	☐	
18	Is the appropriate proprietary classification of the report determined?	x		
If 'NO' to any of the above, except 7, provide cross-reference to justification or additional explanation here or on subsequent pages:				

Part 2: Verifier:

Verification Methodology Checklist **Verification Method (One or more must be completed by each verifier)**		**Check If Performed**
1.	Independent Design Review of document.	☐
2.	Verification performed by alternative method(s) as indicated below.[5]	
	a. Comparison to a sufficient number of simplified calculations which give persuasive support to the original analysis.	☐
	b. Comparison to an analysis by an alternate method.	☐
	c. Comparison to a similar verified report.	☐
	d. Comparison to test results.	☐
	e. Comparison to published data and correlation confirmed by experience in the industry.	☐
3.	Other (Describe under Additional Details of Verifier's Review below).	x

Complete by checking the appropriate box		Yes	No	N/A
1.	Does the Verifier concur with the author's entries in Part 1, including "N/A" entries and the justification for any "No" responses?	x	☐	
2.	Are all comments identified during the review, all required actions and actions taken recorded on the comment sheet below?	x		

Additional Details of Verifier's Review (If no additional details, indicate "None")

I examined this work in detail as I adapted it subsequent ANO test. Calculations were replicated.

[5] For independent verification accomplished by comparisons with results of one or more alternate calculations or processes, the comparison should be referenced, shown herein, or attached to the checklist.

Part 3: Verifier's Comments, Author's Response and Actions Taken:

Use this page to document verifier's comments during the course of the review, author's response and actions taken. Note: Verifier should indicate if, "No response required."

No.	Verifier's Comments (If no comments, indicate "None")	Author's Response and Action Taken	Verifier Concurs? (Yes/No)
1	Editorial changes as marked	Corrected	Yes

Verification: The verifier's approval indicates that all comments or necessary corrections identified during the review of this document have been incorporated as required. This document has been verified using the method(s) described above. For multiple verifiers, indicate appropriate methods(s) by initials.

Review of Final Test Reports

Westinghouse

STD Final Report Verification Checklist

Note: If completing form electronically, highlight the checkbox and type an "x" to fill in the checkbox.

Document Title				
STD Letter Number STD-MCE-07-57	**10-22-2007**			
Test Prospectus Verifier G. R. Marshall	**Revision**			
Checklist		**Yes**	**No**	**N/A**
1.0	Is an approved test prospectus or statement of work, etc. provided?	☒	☐	☐
2.0	Are the STD procedures identified?	☒	☐	☐
3.0	Were the calculations correctly performed?	☒	☐	☐
4.0	Were data properly transcribed?	☒	☐	☐
5.0	Were test samples correctly identified or prepared, for example, with respect to lot number, fabrication history, etc.?	☒	☐	☐
6.0	Were test deviations identified?	☒	☐	☐
7.0	If yes to 6.0, were there any possible effects to the test results? If so, please list	☐	☒	☐
Verifier Statement – List steps and techniques used in verification				
Reviewed lab book and also looked at calculations performed to target input mass and area values				