1. Since the NRC staff will be providing more detailed feedback in the future concerning the BWROG test plans to evaluate potential chemical effects, the staff is interested in obtaining a summary of BWR plant materials showing the quantities of various materials in each plant and whether the plant would inject sodium pentaborate from the standby liquid control system following a LOCA. It would be acceptable to the staff if this information is provided with individual plants designated by letter or number rather than by name.

   A table that summarizes the preliminary reactive material survey data is included as Table 1. The quantities of materials are the amounts that are present within the plant, not what are present in the debris load or what are expected to contribute to the chemical effect source term.

Table 1 – Reactive Material Survey Summary (based on preliminary survey responses)

	Minimum	Maximum	Median[1]	Mean[1]
Coolant Volume	60,000 ft^3	165,000 ft^3	113,000 ft^3	106,000 ft^3
Aluminum (ft^2)	0 ft^2	40,000 ft^2	n/a	n/a
Zinc (ft^2)	3000 ft^2	193,000 ft^2	n/a	n/a
Fiberglass (lbm)	20 lbm	3600 lbm	600 lbm	900 lbm
Concrete (ft^2)	1050 ft^2		n/a	n/a
Calcium Silicate (lbm)	0 lbm	4950 lbm	n/a	n/a
Sludge (lbm)	300 lbm	3000 lbm	630	1100
Sodium Pentaborate Injected (lbm, dry equivalent)	340 lbm	7200 lbm	3200 lbm	3700 lbm
pH	4.8 [unbuffered]	8.6	-	-

[1]Not enough plants provided non-zero quantities for some debris sources, such as aluminum, lend meaning to the mean and median values, so the mean and median values are not listed for those debris sources. For instance, only three licensees indicated that calcium silicate insulation was present in their plant.

2. Overall, the NRC staff agrees with a phased testing approach since it is important that results from initial testing help inform the direction and extent of subsequent tests. The staff also agrees that it is prudent to use smaller scale, relatively inexpensive testing to explore the range of potential environments and understand the sensitivities of various environmental parameters before performing larger scale experiments.

3. Based on the strategy plan, it is not clear to the staff how the BWROG is considering international test experience that may be applicable to the BWROG post-LOCA environment. For example, testing performed in Germany (ADAMS Accession No. ML083510156) has indicated that water falling over galvanized steel grating produced zinc-based corrosion products that resulted in significant head loss across a fibrous debris bed. In

addition, some of the Japan Nuclear Safety Organization's corrosion testing results available on the following web page: http://www.nrc.gov/reactors/operating/ops-experience/pwr-sump-performance/tech-references.html may be applicable. The NRC staff suggests the BWROG include a discussion of potentially relevant international test experience that either demonstrates that the results are considered in the strategy test plan or justifies why some results are not applicable to the BWROG post-accident environment.

Domestic and international test experience will be evaluated in the survey of existing information, and will be considered in the test plan and overall resolution approach. The Material Dissolution Test Plan will clarify how international test data will be considered, and the test plan will be provided to the Staff for review and comment prior to the start of testing.

4. As discussed in Section 1.2, "PWR [pressurized water reactor] Experience" (page 6 of the strategy plan) integrated chemical effects testing, along with bench testing, formed part of the technical basis for understanding and evaluating potential chemical effects in PWRs. While the BWROG test strategy document indicates that mixed material tests will be conducted to measure possible interactions between materials, it is not clear to the staff that the dissolution testing includes fully integrated testing. Previous integrated testing was an important supplement to single effects testing since it provided confidence that an unanticipated interaction of materials was not overlooked. The staff is interested in understanding the extent of integrated testing proposed by the BWROG.

   The BWROG plans to run mixed material tests to investigate the interaction of different materials in the context of material dissolution/corrosion and precipitation, and based on the results may pursue integrated testing to confirm results and ensure no possible significant interactions between test materials are overlooked. The BWROG considers "integrated testing" to be ICET style tests, and "mixed material tests" to be material dissolution tests in continuously stirred vessels where different types of simulated plant debris are added to the same vessel. The details of the mixed material dissolution testing will be described in the Material Dissolution Test Plan, which will be provided to the NRC staff for review and comment prior to the start of testing.

5. Phase 1 of the proposed BWROG test strategy involves material corrosion, dissolution, and precipitation. According to Sections 3.1(b)(ii) and 3.1(b)(iii) of the strategy plan, "*the fluid at the end of each test will be added to a settling cone, and allowed to cool, and any precipitate will be collected via filtration. Quantitative, qualitative and elemental evaluation of precipitates will be used to characterize precipitates and gather additional insight into the materials' dissolution behavior and reactivity*." One of the lessons learned from the PWR chemical effects testing was the difficulty in accurately characterizing precipitates and subsequently generating surrogate precipitates with equivalent behavior in head loss testing. Therefore, the BWROG should consider as part of the Phase I dissolution and precipitation test methods some type of head loss screening. Even a smaller-scale, semi-

quantitative method capable of reliably differentiating head loss behavior differences between crystalline type precipitates and small amounts of amorphous, hydrated precipitates would provide valuable information to inform future decisions that could involve larger scale testing.

The BWROG plans to ensure that the lessons learned from the PWR chemical effects resolution efforts are comprehensively considered, especially with regard to the characterization of precipitation morphology in the context of its impact on head loss. The behavior of precipitates with a representative morphology will be quantified. The surrogates that will be developed in Phase 3, for both fuel testing and large-scale strainer testing with chemical effects (if required), and will conservatively represent the head loss impacts of predicted precipitates and their associated morphology.

6. Additional information is needed to help the staff evaluate and provide feedback on the Phase I dissolution tests that will be provided to the NRC as stated in Section 5.1.5 of the Strategy Plan. In particular, the NRC staff is interested in how the materials and environment will be determined for the Phase 1 tests. Defining the chemical environment may not be straightforward due to: (1) variability in whether sodium pentaborate is injected, (2) pH transients resulting from the types and quantities of insulation materials that may dissolve, (3) differences in environment or flow conditions in locations where debris could collect, and (4) the potential for formation of acids following a LOCA. Therefore, the staff is interested in understanding the assumptions and other supporting information that will be used to determine the dissolution test matrix.

    1. *Both types of chemical environments will be considered: with and without NaPB injection.*
    2. *pH transients that occur due to insulation dissolution will be evaluated in mixed materials testing and single material insulation dissolution testing, and observed effects will be measured and accounted for in the Chemical Effects Screening Tool.*
    3. *The details and potential impacts of the active and inactive volumes on chemical effects for the three BWR containment designs will be evaluated and documented in the BWR Material Dissolution Test Plan.*
    4. *The potential for post-LOCA acid formation and the consequent pH variation will be considered in the test plan.*

7. It is not clear to the NRC staff how the small scale dissolution tests would screen for precipitates that may form at higher temperatures due to retrograde solubility. For example, Pressurized Water Reactor Owners' Group sponsored testing supporting WCAP-16530-NP included tests at 265 ^{o}F to evaluate higher temperature phenomena. The staff is

interested in how the BWROG will evaluate the high temperature range of post accident conditions.

Most of the BWR suppression pools do not experience temperatures above 212°F, which will allow for most testing to be at atmospheric conditions. BWR drywells can experience temperatures above 212°F for less than 20 minutes during the LOCA event. The effect of this short time above 212°F on dissolution will be considered, but due to the very limited duration that the drywell can experience temperatures above 212°F (0.04% of the event duration), the test program will focus on temperatures below 212°F. Should the test program need to test at >212°F to address dissolution and retrograde solubility in the drywell, separate tests will be developed in an autoclave.

8. Following the Phase 1 dissolution testing, vertical loop head loss tests are proposed to facilitate development of a time dependent chemical effects factor calculated by a ratio of head loss from a test with dissolved materials to head loss from a baseline test that does not have a chemical contribution representing dissolved plant materials. The chemical effects factor for each category of plants is intended to be applied to the design basis head loss as a function of time. The NRC staff questions the feasibility of applying a chemical effects multiplier since for cases other than when the chemical effects factor equals one, the magnitude of the chemical effects factor will be influenced by the debris bed characteristics and composition. This approach is conceptually similar to one that was pursued by some PWR licensees for a time before being dropped due to difficulty responding to technical issues raised by the NRC staff. Furthermore, the staff has questions concerning the test procedures and empirical correlations that were used to determine existing design basis head loss values. The staff also notes that previous vertical head loss tests that provided part of the chemical effects evaluation technical basis in PWRs supported short-term solubility credit for aluminum based precipitates.

   The head loss due to BWR chemical effects is expected to be less than that measured using PWR surrogates in head loss testing (based on the high head loss that often resulted from using amorphous surrogate precipitates), which will ease the application of a head loss adjustment factor to the design basis head loss. Preliminary testing has shown that material dissolution rates of reactive materials in a BWR environment (even with SLC) are orders of magnitude less than the rates predicted using the material release correlations developed for PWRs, so the quantities of dissolved materials that can contribute to chemical effects will be much less than in PWRs. Additionally, BWR strainers are generally sized using a correlation that applies a "flat plate" head loss to a complex strainer, so the application of a head loss adjustment factor would be consistent with the existing design bases.

   The BWROG is aware that resolving this issue is paramount to successfully address the NRC staff's concerns regarding the BWR fleet ECCS strainers, and plans to work closely with the NRC staff to drive this issue to a mutually agreeable resolution.

9. If initial testing indicates that significant head loss could occur due to chemical effects in the post-LOCA BWROG environment, the BWROG should consider resolving interconnected issues (e.g., break zone of influence, debris transport) either prior to or concurrently with the resolution of chemical effects since other issues may influence the test approach used to evaluate the overall head loss.

   Agreed.

10. The staff is interested in the details concerning the BWR chemical effects resolution screening tool since items such as determining how the plant groups will be established, the criteria for evaluating whether a plant fits into any group, and how release rates for different groups are determined are important steps in the resolution process.

    The approach and criteria for grouping plants for the screening tool depends on the similitude of the various BWR chemical parameters. This approach is proposed in the case of a reasonable degree of similitude, to help optimize the approach with regard to number of tests, duration and scope of the test program, and the amount of staff review that will ultimately be required. The screening tool is not expected to be useful for all plants, but will be used where appropriate. Prior to implementation of the screening tool, it will be submitted to the NRC for review and comment.

11. The NRC staff has a number of questions related to the issue of high temperature water pooling. For example, the staff questions how the potential for differences in species concentrations and/or pH between the water in the drywell pools and the suppression pool will be addressed in the chemical evaluations. The staff notes that the BWROG letter dated January 5, 2011 (ADAMS Accession No. ML110070025) states that the details and potential impacts of the active and inactive volumes on chemical effects will be evaluated and documented in the BWR Material Dissolution Test Plan.

    The BWROG will consider the chemical and thermal parameters of reactor coolant in both the suppression pool and in the drywell for the full range of BWR post-LOCA conditions, including transient volumes within the drywell that may have different chemical and thermal parameters than are characteristic of the coolant in the wetwell.

12. The NRC staff has additional comments that are more detail oriented compared to the more general methodology comments provided in this letter. The NRC staff suggests a telephone call with the BWROG to help clarify any questions the BWROG may have based on these staff comments and to discuss the staff's lower priority comments.

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