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U.S. Nuclear Regulatory Commission
Attn: Mr. Mike Scott
Document Control Desk
Washington, DC 20555-0001

SUBJECT: GSI-191 Chemical Effects – CCI chemical testing position paper

Dear Mr. Scott

As you are aware from the Nuclear Regulatory Commission (NRC) staff presentation during the October 24, 2007, public meeting on Generic Safety Issue 191, the staff has noted there may be an uncertainty in the chemical precipitate properties and in the repeatability of the CCI testing procedure. During the chemical effects testing the type, amount, and properties of precipitates that are formed in the test loop should be understood and it has to be verified that the precipitation process has occurred as expected, with precipitates exhibiting representative properties. CCI has to provide therefore further information that shows repeatability between laboratory conditions (Bench Top Test) and test loop conditions (MFT Chemical Test) and reasonable similarity of precipitant properties.

The CCI work included additional MFT chemical tests without debris to evaluate chemical precipitate properties that are used in certain industry head loss qualification tests. The CCI position paper is intended to provide the NRC staff with additional information to support reviews of licensee supplements to Generic Letter 2004-02. Licensees may be interested in reviewing the results since this information adds to the chemical effects testing verification base.

The purpose of this letter is to provide you a copy of the CCI position paper. The attachment contains the CCI position paper entitled, " Evaluation of Chemical Effects; Precipitates formed by adding Chemicals to Borated Test Loop Water"

If you would like to discuss this letter further, please contact me.

With best regards

CCI Switzerland, Nuclear Service

Martin Spörri

Manager Site Services (Engineering and Test)

Attachment:
CCI Position Paper on Evaluation of Chemical Effects; Precipitates formed by adding Chemicals to Borated Test Loop Water

CCI AG Switzerland
Martin Spörri
April 29, 2008

Position Paper on
Evaluation of Chemical Effects; Precipitates formed by adding Chemicals to Borated Test Loop Water

April 29, 2008
Revision 2

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Executive Summary

Argonne National Laboratory (ANL) performed additional NRC sponsored testing related to GSI-191 chemical effects as part of technical support provided to the U.S. Nuclear Regulatory Commission. The purpose of these tests was to evaluate the properties of chemical precipitates that are used in sump strainer head loss testing by certain nuclear industry test vendors.

The NRC sponsored ANL testing was discussed at the Public Meeting on GSI-191 on October 24, 2007. The NRC addressed CCI with questions regarding the CCI chemical testing procedure based on the ANL test results.

The main NRC questions were found in the NRC staff conclusions on page 13 of 14 of the Public Meeting on GSI-191 presentation:

1. Preliminary results from bench tests and vertical loop head loss tests indicate that precipitate formation and properties are sensitive to concentration effects and chemical addition rates
2. Head loss test procedures available to the staff are not specific with respect to chemical addition rates and there appears to be no performance based test for the mixing procedure
3. Therefore, the NRC staff has questions about the uncertainty in the chemical precipitate properties and the repeatability of the process
4. Licensees are expected to understand the type, amount, and properties of precipitates that are expected to form during head loss testing and then verify that the precipitation process occurred as expected, with precipitates exhibiting representative properties

It is CCI's goal to do bench tests in order to understand the type, amount, and properties of precipitates that are expected to form during head loss testing and to verify that the precipitation process occurred as expected, with precipitates exhibiting representative properties according to WCAP-16530-NP criteria.

A generic test was done in order to verify the accuracy of bench testing in comparison to the MFT test loop. The generic test was performed using the information for a TSP plant in which aluminum, silicate and phosphate precipitates are expected to form. The hydrodynamic conditions for the generic test were the same as for the MFT tests. The test followed the procedure of a specific MFT chemical test and was analyzed for all variables like in bench testing, because the generic chemical test in the test loop was performed without debris. This generic test was done from November 21 until 23, 2007 in the 200 L test loop with a scale factor calculated in the way that the chemical concentration was equal to the chemical concentration in the previous MFT chemical tests (chemical test with debris in the1700 L water filled test loop).

The results of the precipitate settling rate, precipitate 1-h settled volume, particle size, particle filterability, pH of the solution, temperature of the solution, total suspended solids (TSS) and dissolved elements of the generic test were compared to the results found in the previous MFT chemical tests. The results of the generic test show consistency with the previous bench testing and with the MFT chemical tests done in the past. Also all values are in accordance with the WCAP criteria.

CCI Answer Summary to NRC staff conclusions on page 13 of 14 of the Public Meeting on GSI-191 presentation:

1. CCI knows that precipitate formation and properties are sensitive to concentration effects and can lead to different results. CCI's procedure is to use the same chemical concentrations both for bench as well as for the MFT chemical test.
   The addition rate of the chemicals to the test loop follows the addition rate used during the bench top tests.
2. The CCI test procedure states to add the chemicals carefully to the test loop water. This is in line with the WCAP mixing tank addition rate were it states "slowly add the reactants" individually. The mixing of the chemicals at CCI tests is done by the hydrodynamics of the loop itself. The time between two individual chemical additions is based on 5 test loop water turnovers. Each chemical batch of the three individual chemicals is mixed at least 15 turnovers of the test loop water and has to fulfill the stabilization criteria. CCI keeps the final chemical batch running over the weekend to let the chemicals react and the head loss to stabilize for additional 2 days.
3. Possible uncertainty in the precipitate properties and repeatability of the process are visible in the results of the chemical analysis from the bench and the MFT tests. The precipitate amount derives from the balance between the added and dissolved elements (see data table).
   The test results show precipitate properties within the WCAP criteria. An additional chemical test without debris, the so called generic test, confirms the repeatability.
4. The analysis of the bench tests, chemical tests as well as the generic test show similar results within reasonable accuracy, although the physical circumstances of the three test types were different.
   a) Quantity of precipitates:
      The amount of the dissolved elements is a measure for the quantity of precipitates. The analyzed dissolved elements show similar concentrations with reasonable accuracy in bench, MFT and generic test.
      ⇒ The quantity of the precipitates formed is as expected for all 5 Tests.

b) Quality of precipitates:
A comparison of the particle size distribution can be done between the lab bench tests and the generic test. (Determination of particle sizes from MFT tests is not possible; precipitates are mixed with debris in layer on strainer screen.) Taking into account the additional splitting effect of the fast rotating magnetic stirrer in the bench tests, the results of the generic test represent a reliable particle size distribution of the precipitates.
⇒ The quality of the precipitates formed is consistent.

c) WCAP criteria:
⇒ All test results fulfill the WCAP-16530-NP criteria and all its RAI's and guidance documentation.

Test Results

CCI Precipitate Formation

In order to represent the actual precipitates formed in the post-LOCA environment the bench testing as well as the generic test were performed with a stepwise addition of surrogate chemicals, which form all precipitates mixed together in the final solution. This differs from the WCAP method in which each precipitate is formed separately outside of the loop. All data provided in the following sections is based on a mixture of precipitates formed in the same containment. However, even though the precipitates are mixed, the solution yields acceptable solids concentration (TSS) per the WOG standards.

For the generic test the pH was adjusted to a range (+/- 0.2 pH units) according to the plant conditions, also the water temperature was considered to be close (+/- 1°C) to the bench testing and MFT chemical testing. The addition rate of the chemicals was in the same manner as for the MFT chemical testing (1 kg chemical solution in 10 min) in order to be comparable to both bench testing and MFT chemical testing. The addition of the chemicals was done in steps to get 40, 70 and 100 % of the nominal chemical amounts. Only the final solution was analyzed.

Interpretation of the Data

The interpretation of the data is done step by step following the sequence in the Data Table in order to facilitate its comprehension. The results to be compared derive from a single data set (as obtained from the generic test) which includes the uncertainty of the analysis as well as the uncertainty of a representative sample taking. However, the sometimes deviating figures seem to be in an acceptable range and are in line with the WCAP criteria.

Only the results of the dissolved elements of the previous two MFT chemical tests can be compared to all other tests. All other results are comparable between the bench tests and the generic test:

- The pH was adjusted according to the range given for the plant conditions. The values are within an acceptable range of 0.1.
- The viscosities were measured after filtration and the values were within a range of 0.03 mPa*s.
- All temperatures showed acceptable values within 1°C.
- The content of dissolved B in the generic test solution is 13% higher than in the MFT chemical test 2, but still within an acceptable range, since the measurement had an uncertainty of 10%.

- The dissolved Na content was within an acceptable range.

- There is more dissolved Al in the generic solution and in the MFT tests than in the bench test solutions. The biggest difference in the Al concentrations was between MFT chemical tests 2 and generic test: 9%.

- The dissolved Ca content was within an acceptable range. The biggest difference in the Ca concentrations was between bench tests in tap water and MFT chemical test 2: 7%.

- The dissolved SiO_2 content was within an acceptable range. The biggest difference in the SiO_2 concentrations was between bench tests in tap water and generic test: 14%.

- It seems that in the generic test more calcium phosphate was being generated than in the bench and chemical tests. However the dissolved PO_4 content was within an acceptable range. The biggest difference in the PO_4 concentrations was between bench tests in tap water and generic test: 20%.

- The total suspended solids of the generic test were within an acceptable range, comparable to the other obtained values and to the WOG.

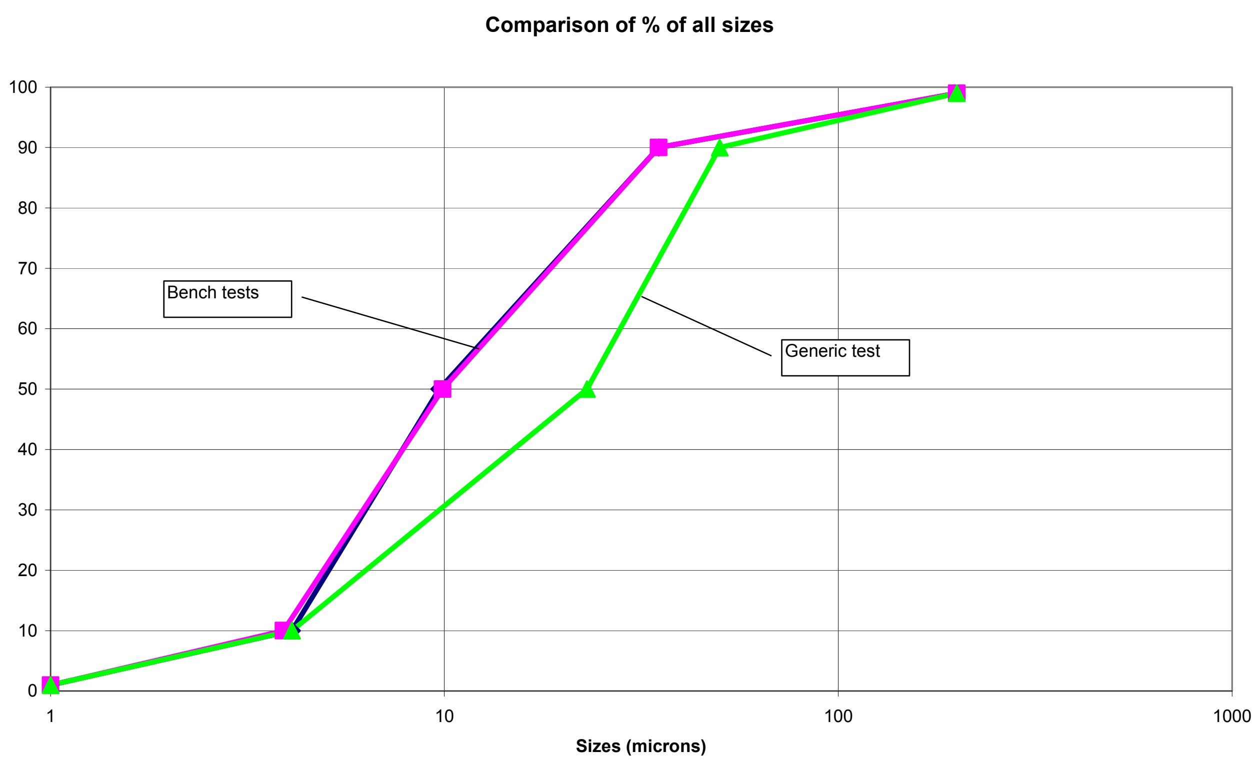
- For the generic test the precipitate settling rate and 1h settled volume in a 100 ml graduated cylinder a value of <1 mm/h was determined. The settled volume remains at 99.5%. There was practically no settling for freshly prepared surrogate. The difference in the settling rates between bench tests and generic test was checked once more by new bench test settling rate measurements. The precipitate settling in the old and new bench tests occurred mainly in two phases: a heavy phase (larger particles) with a high settling rate and a milky light phase with practically no settling. This milky light phase in the bench tests shows the same behavior as in the generic test: 1-h settled volume is 99.5 %, respectively 100 %.
  This is in line with a recent test (with precipitate generation outside the loop) where the light phase only was considered by Westinghouse representatives.
  Practically no settling is conservative because all of the chemical precipitates remain in solution and will finally reach the strainer.

- The precipitate filterability values shown in the table are within an acceptable range by the WCAP and its guidance document OG-06-387.

- Per WCAP-16530-NP, Rev.0, § 5.3.2, after cooling the sump in a post-LOCA, the precipitates tend to flocculate resulting in agglomerates with sizes in a range of 10 - 100 µm.
  The values shown in the data table indicate that the size of the particles formed with the CCI method meets the given criteria. Nevertheless, the particles formed in the MFT are bigger than the ones formed in the bench test. It is important to mention that the mixing procedure has an influence on the particle size: in the bench test a magnetic stirrer generates a very fast movement of the solution which supports the possibility of splitting the particles, while the particles in the MFT have fewer opportunities to be split at the moment of passing the strainer and the pump. Additionally, this may be also

plant specific, due to the varying flow rate from plant to plant.

The particle size distribution from the measurements is shown below:



Comparison of Relevant Results with WCAP Acceptance Criteria

Parameter	Units	Experimental Results	WCAP Acceptance Criteria
pH	-	7.62 – 7.72	> 6.5
Temperature	°C	23.3 – 23.5	Room temperature
Total susp. solids (TSS)	g/l	1.37 – 1.84	$Ca_3(PO_4)_2$ < 5 $NaAlSi_3O_8$ < 11 AlOOH < 11
1-h settled volume	%	99 - 100	> 60
Particle size X10%	µm	3.9 – 4.1	10 - 100
Particle size X50%	µm	9.9 - 23	
Particle size X90%	µm	35 - 50	
Filterability K_{fx}	kg/m	8.5E-14 to 1.68E-13	4.827E-14 to 4.1E-12

Data Table

The generic test results are shown in the table below. This generic test has four sets of data to be compared with: the results of the bench test done in deionized water, the results of the bench test done in tap water and the results of the dissolved elements of the two previous two MFT chemical tests.

Name of sample		Lab bench test in de-ionized water	Lab bench test in tap water	MFT test 2 in tap water with debris	MFT test 3 in tap water with debris	MFT test generic in tap water w/o debris
Date of test		**09.03.2007**	**09.03.2007**	**16.03.2007**	**23.03.2007**	**23.11.2007**
Total test volume	l	2	2	1700	1700	200
pH	-	7.70	7.70	7.72	7.62	7.72
Viskosity 25°C, unfiltered	mPa*s	1.03	1.03	0.99	0.99	--
Viskosity 25°C, filtered	mPa*s	0.96	0.97	0.98	0.97	0.95
Temperature	°C	22.5	23.3	23.5	23.5	22.5
B added	mg/l	4400	4400	4400	4400	4400
Al added	mg/l	201	201	201	201	201
Ca added	mg/l	112	112	112	112	112
SiO2 added	mg/l	558	558	558	558	558
PO4 added	mg/l	2257	2257	2257	2257	2257
B dissolved	mg/l	4050	4030	3820	3960	4410
Na dissolved	mg/l	2'380	2'320	--	--	2'140
Al dissolved	mg/l	32	34	47	38	52
Ca dissolved	mg/l	22	18	12	13	20
SiO2 dissolved	mg/l	160	140	120	160	200
PO4 dissolved	mg/l	1830	1800	1640	1610	1340
Total susp. solids (TSS)	g/l	**1.37**	**1.84**	**--**	**--**	**1.43**
Precipitate settling in 100 ml grad. Cylinder						
1-h settled volume	%	a) 28.5 / b) -	a) 27 / b) -	--	--	a) - / b) 99.5
Precipitate settling rate 0-1h	mm/h	a) 132 / b) -	a) 128 / b) -	--	--	a) - / b) <1
Precipitate settling in 15 ml centrifuge tube						
1-h settled volume	%	--	a) 25 **/ b) 99**	--		a) 45 **/ b)100**
Precipitate settling rate (best fit)	mm/h	--	--	--	--	a) - / b) <1
Specific resistance of filtration	m/kg	4.80E+13	3.40E+13	--	--	1.30E+13
Filter coefficient $K_{fx, inst}$	kg/m	2.60E-14	3.90E-14	--	--	8.60E-14
Filter coefficient $K_{fx, av}$	kg/m	5.50E-14	8.50E-14	--	--	1.68E-13
Specific surface	m^2/cm^3	0.9	0.9	--	--	0.56
Particle size X10%	< µm	**4.1**	**3.9**	**--**	**--**	**4.1**
Particle size X50%	< µm	**9.7**	**9.9**	**--**	**--**	**23**
Particle size X90%	< µm	**35**	**35**	**--**	**--**	**50**

a) heavy phase
b) milky light phase