STP Post-meeting Notes for January 26-27, 2012 Public Meeting

STP Team Participants: (in alphabetical order)

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    - Manager, Risk Management Projects, South Texas Project Nuclear Operating Company
    - STP/Industry/NRC Coordinator for STP Risk-informed GSI-191 project
    - 25 years of experience in risk management at a commercial nuclear power plant

- *Kerry Howe, PE, Ph.D., BCEE.*
    - Associate Professor at the University of New Mexico
    - Corrosion/Head Loss Experimental (CHLE) lead for STP Risk-informed GSI-191 project
    - 5 years of experience in GSI-191

- *Ernie Kee, Mechanical Eng.*
    - Supervisor, Risk-Informed Applications, at the South Texas Project Nuclear Operating Company
    - STP Technical Leader for STP Risk-informed GSI-191 project
    - 14 years of experience in Probabilistic Risk Assessment (PRA) at a commercial nuclear power plant

- *Janet Leavitt, Ph.D. in Environmental Eng.*
    - Post-doc in the Civil Eng. Department at the University of New Mexico
    - Corrosion/Head Loss Experimental (CHLE) team member of STP Risk-informed GSI-191
    - 5 years of experience in GSI-191

- *Bruce Letellier, Ph.D. in Nuclear Eng.*
    - Nuclear Reactor Safety and Risk Analysis at Los Alamos National Lab
    - CASA lead for STP Risk-informed GSI-191 project
    - 10 years of experience in GSI-191

- *Zahra Mohaghegh, Ph.D. in Reliability Eng.*
    - Principal Research Scientist at Soteria Consultants
    - Oversight lead for STP Risk-informed GSI-191 project
    - 8 years of experience in Probabilistic Risk Assessment (PRA)

- *Seyed Reihani, Ph.D. in Mechanical Eng.* {teleconference participant}
    - Research Scientist at Soteria Consultants
    - Oversight team member for STP Risk-informed GSI-191 project
    - 10 years of experience in catalytic combustion

- *Tim Sande, M.S. in Petroleum Eng.*
    - Engineering Supervisor at Alion Science & Technology
    - Separate Chemical Effects Tests (SCET) lead for STP Risk-informed GSI-191 project
    - 8 years of experience in GSI-191

Resolutions & Comments

1. The interface of CASA Grande and PRA:

Figure (1), on the next page, shows the schematic interrelationship of PRA and CASA Grande in the STP Risk-informed GSI-191 project. The figure does not attempt to cover all PRA scenarios (to avoid complexity with the figure). The main purpose is to present and to clarify the relationship between PRA and CASA Grande.

In the integrated model, developed in this project, PRA is located at the top level of system analysis. This plant-specific PRA has the typical Power Plant Fault Trees and Event Trees covering hardware failures and operators' actions and so, has the typical PRA **cut set**s.

One important aspect of this project is that CASA Grande provides estimates for the likelihood of three basic events of Fault Trees in PRA:

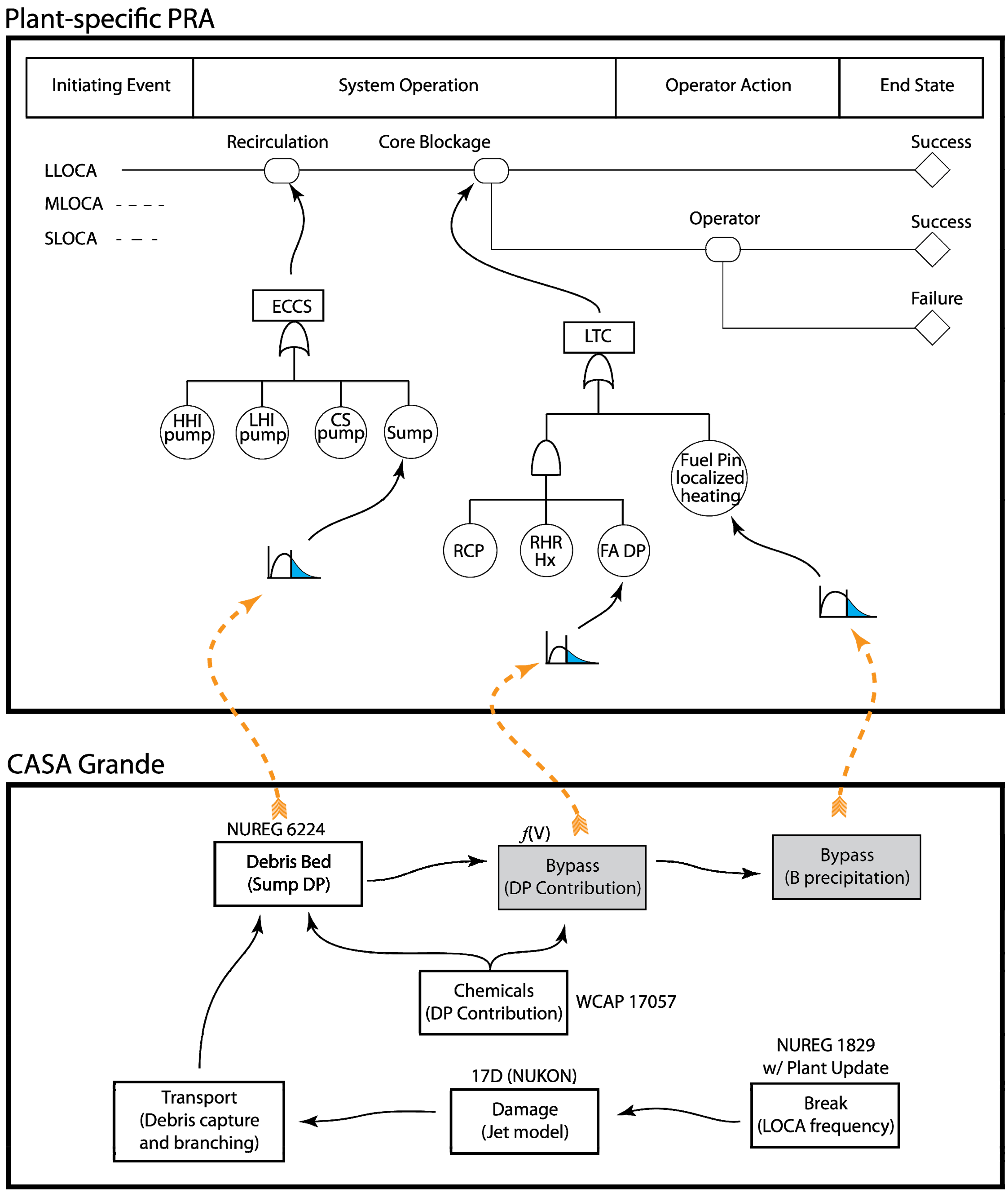
(1) the sump strainer failure (which leads to emergency core cooling system failure and, ultimately "recirculation" in the risk scenarios),
(2) fuel assembly differential pressure (which might lead to long-term cooling and ultimately "core blockage" in the risk scenarios),
(3) fuel pin localized heating (which leads to long-term cooling and ultimately "core blockage" in the risk scenarios).

In other words, rather than relying solely on historical failure data for these three basic events (something that a typical PRA does), the STP risk-informed project develops the models (in CASA Grande) for the underlying chemical and mechanical phenomena which lead to the three basic events. The output of CASA Grande will give a more accurate estimate of the likelihood of these three basic events and can then be imported to Fault Trees of the plant-specific PRA in order to calculate CDF.

In view of this, the response to the question/comment about the cut sets in this project would be "we have the typical cut sets of Power Plant PRA"

And the response to the comment on CASA Grande being a black box is that "CASA Grande is **not** a black box but is, in fact, instrumental in opening the black boxes of two important events in the scenarios of a Power Plant PRA (i.e. recirculation and core blockage) by model-based estimations of the likelihood of their underlying basic events".

CASA Grande, in the Risk-Informed GSI-191 project, provides models for the underlying physical phenomena (i.e. mechanical and chemical phenomena) of three basic events in the PRA of power plants. This means that the Risk-Informed GSI-191 project not only contributes toward the closure of the GSI-191 issues, but can also make a contribution toward PRA research and applications. It can improve the scientific incorporation of underlying physical failure mechanisms into PRA, an important topic of interest in the PRA field.



Acronyms

- CS -Containment spray (pump)
- ECCS -Emergency core cooling system
- FA DP - Fuel assembly differential pressure
- HHI -High head injection (pump)
- LHI -Low head injection (pump)
- LLOCA - Large LOCA
- LOCA - Loss of coolant accident
- LTC - Long term cooling
- MLOCA - Medium LOCA
- RHR Hx - Residual heat removal heat exchanger
- SLOCA - Small LOCA
- B precipitation - Boron precipitation in areas of debris in the core

Fig1. The schematic representation of PRA & CASA Grande in the STP Risk-Informed GSI-191 project

2. *Chemical Effects PIRT Issues*

The NRC Phenomena Identification and Ranking Table (PIRT) was reviewed and general agreement was obtained regarding the items that need to be addressed in the realistic chemical effects testing. Some items requiring further study are summarized in the following paragraphs:

1. Item 2.5 (Root issue 2, "Radionuclides trapped in the debris bed may cause the bed to break down"):
   Paul Klein noted that there is a knowledge base of fiberglass debris beds, but questioned whether there are other materials (such as paint or other non-fibrous insulation materials) that could break down in a debris bed. This needs to be further investigated to verify that there is no effect from these contributors.

2. Item 3.1 (Root Issues 1 and 2, "The crud may influence the localized radiolytic environment" and "A significant quantity of crud could be released as another source of particulate debris):
   The first root issue is directly related to PIRT Item 2.5. The second root issue is a question of the quantity of crud particulate that would be released by the LOCA shock, and how much of it would transport to the strainer. Steve Smith noted that crud is an "immediate" source term, with no delay for crud appearance. Rob Tregoning noted that if the amount of particulate is reduced, then crud becomes more of a consideration (it may need to be included for cases with lower particulate concentrations). It was also noted that considerations of transport based on the break location are important. The quantity of crud that could be generated and transported to the strainers should be evaluated to determine whether this is a significant factor that needs to be considered in a realistic analysis.

3. Item 3.8 (Root Issues 2 and 3, "Dissolved copper can enhance the corrosion rate of other metals by forming local galvanic cells" and "Copper can inhibit corrosion of other metals by depositing and creating a passivation layer"):
   Root Issue 2 is the only thing to be concerned with in the CHLE experiments. The third root issue (passivation of aluminum by copper) is not considered to be a realistic phenomenon. Zinc was not included in the PIRT, but needs to be considered in a similar way as with lead and copper. Paul Klein noted that lead and copper would be plant specific issues. They could likely be addressed in bench top experiments. It was noted that the STP Units 3 & 4 team had several discussions with NRC on Zinc issues.

4. Item 3.9 (Root Issue 1, "Aged concrete may release a larger quantity of calcium"):
   Paul Klein stated that aging of concrete does not need to be considered. There was general agreement that this issue does not need further consideration.

5. Item 3.12 (Root Issue 1, "Biological growth in the post-LOCA environment may contribute to clogging issues"):
   The NRC (and some industry representatives) did not necessarily agree that biological growth is negligible in the post-LOCA containment pool. This issue needs additional evaluation to determine whether it is significant.

6. Items 5.1/6.2 (Root Issue 1, "Agglomeration of chemical precipitates, insulation particulate, and/or latent particulate may form larger particles that would be more easily captured in a debris bed" and "Organic agglomeration may form larger particles which would be more easily captured in a debris bed"):
   NRC agreed that this is probably not an issue, but may be important if chemical precipitates are amorphous. More thought needs to be put into this issue to determine whether it is significant or not.

7. Item 6.1 (Root Issues 1 and 2, "Certain breaks may result in a significant quantity of oil being released into the containment pool" and "Other organic materials may be present due to failure of coatings and the organic binders in insulation debris"):

   Previous integrated chemical effects head loss testing where oil was added did not show any effect from the oil. Rob Tregoning felt that the results of the tests with oil were not clear because there was no differential test to compare against. The oil was poured in after the bed was formed, and particulates were still in solution. Additional plant-specific analysis may be required to address this issue. Matt Edwards indicated that AECL may have test data that could be used for this.

   There was additional discussion on the chemical effects due to leaching from coatings. Matt Yoder stated that qualified coatings in general don't leach, but unqualified coatings could leach various materials. However, qualified coating debris (generated inside the ZOI) may be an important factor for leaching due to the significantly higher surface area for failed coatings. There was general agreement that intact qualified coatings or failed epoxy paint chips do not need to be considered for leaching.

   Additional analysis is required to address organic materials. The issue of RCP motor oil does not appear to be a significant concern, but for that, more thought will need to be given prior to testing. Also coating leach rates need to be addressed based on previous tests and/or new bench top tests.

8. Item 7.2 (Root Issue 1, "Precipitation within the heat exchanger may affect the heat exchanger performance"):
   There was general agreement that the clogging of the heat exchanger is not likely to be a significant issue. However, Rob Tregoning indicated that a post-test inspection of the heat exchanger (to see if there is any significant precipitation) would be a good idea.

3. The Status of LOCA Frequency

LOCA frequencies should be derived based on a "top down" rather than the "bottom up" process used in the initial quantification. The document "Partitioning of the NUREG-1829 LOCA frequencies for the STP GSI-191 resolution" by Alexander Galenko and Elmira Popova provides a description of the "top down" methodology we propose to use in CASA Grande. We are currently arranging a public meeting/teleconference to discuss the methodology with the NRC staff during the week of 27 February.

The current STP PRA (Revision 6) uses LOCA frequencies defined in NUREG/CR 5750; however, the model under review for release in 2012 uses NUREG 1829 frequencies as a basis. We intend to use the updated (NUREG 1829) frequencies as the branch LOCA frequencies in the final quantification.

4. *Chemical Effects Experimental Issues*

The following items were discussed or need follow-up:

1. What is basis for test duration? Would we have an acceptance criterion for the duration of tests (for example, stable head loss or other criteria?)
2. Will the recirculation time be simulated? Recirculation time is a secondary effect. We will be primarily concerned with the velocity through test sections.
3. We plan to simulate the nominal temperature histories for three different representative scenarios (nominally, Small, Medium, Large LOCA).
4. Will the filter surface area to tank volume be a scaling parameter? Will the strainer area be matched to the volume in the plant?
5. In the event differential pressure begins to increase on the debris beds, we will continue to record the pressure. However, the bed will remain in the test section until the end of the test.
6. We need to ensure that no fines in the tank get transported to the debris beds. In post test analysis, we need to check any debris left in the tank for preferential deposition.
7. The water to be used in the CHLE experiments will have the as-operated plant chemistry.
8. We will use a reservoir in the CHLE experiments to make sure the residence times between the heat exchanger and the debris bed are similar to that in the plant.
9. Retrograde solubility will be addressed in separate tests (to account for boron precipitation and core deposition).
10. The most critical parameter for the heat exchangers is the temperature change. A secondary consideration is the residence time.
11. The coupons will be carefully placed to ensure they are wet during the spray-down phase.
12. We do not plan to use WCAP precipitate to evaluate debris bed performance.
13. We need to ensure PH effects are incorporated in the experiment design.
14. Zinc will be considered. Inventories of materials either excluded or "under consideration" will be listed for consideration in testing.
15. We will prepare the fiber in accordance with the new NEI debris preparation protocol.
16. We will evaluate the use of coupon weight loss in CASA Grande correlations. We will investigate different protocols (such as ASTM) for removal of the oxide layer.
17. The purpose for the long-term and short-term tests will be provided.

5. *Boron* **Precipitation**

Boron precipitation, separate from Chemical Effects, will now need to be directly addressed in GSI-191 analyses. It does not appear that boron precipitation will be a concern for a hot leg break with hot leg injection. For a cold leg break with hot leg injection, or a hot leg break with cold leg injection, it does not appear that boron precipitation will be a concern as long as the flow through the core exceeds the boil-off rate by at least 10%. For a cold leg break with cold leg injection it does not

appear that boron precipitation will be a concern as long as there is less than 15 g of fiber per fuel assembly present in the core.

6. *Bypass*

The two critical parameters to evaluate the impact of by-pass fiber on the core are the quantity of fibers that by-pass the ECCS sump screen and the characteristics, i.e. the size distribution, of the bypass fibers. Both parameters are highly dependent on the assumptions of the quantity and characteristics of the fiber reaching the strainer. The fiber characteristics used in all fuel testing performed to date by the PWROG have been based on fiber size distribution presented at the 9/23/2008 ACRS. The average fiber by-pass size distribution presented at the ACRS meeting was:

< 500 µm	500 – 1000 µm	> 1000 µm
76.5%	17.9%	5.6%

There is evidence from other recently performed by-pass tests that the by-pass fiber characteristics tend to the longer fibers. Longer fibers will more readily bridge gaps than shorter fibers. These recent tests were performed with debris preparation methods in conformance with the NRC March 2008 guidance. Recently the NEI has issued a debris preparation method that is undergoing review by the NRC. Discussions with NEI indicate that the NRC will shortly issue a note endorsing the use of the NEI debris preparation method. Any new fuel testing should be done with fibers characteristics based on by-pass testing performed with the NEI fiber debris preparation methodology.

7. *Schedule of the Project*

The current milestones of the project are:

- 9 February: Public Meeting to discuss CHLE experimental design.
- Month of February: Procure basic materials for experimental apparatus and begin construction of CHLE loop as described at the 01/26-01/27 Public Meeting (NEI Chemical Effects).
- Week of 27 February: Revised LOCA frequency methodology.
- 5 March: Public meeting on bypass and head loss experimental design.
- Month of March: Procurement and construction.
- Month of April: Shakedown of facility.
- Month of May: Conduct baseline 30-day CHLE experiment.
- Month of July: Conduct first CHLE 30-day experiment for LOCA simulation.