MONTHLY LETTER STATUS REPORT

Reporting Period Start Date **February 21, 2015**		**Reporting Period End Date** **March 27, 2015**	
NRC Agreement Number **NRC-HQ-60-14-D-0014**	**Task Order Number (if applicable)** **N/A**		**Common Cost Center Code**
Project Title **Crack Initiation Testing for Primary Water Stress Corrosion Cracking**			
Period of Performance Start Date **August 18, 2014**		**Period of Performance End Date** **October 31, 2015**	
COR **Eric Focht**	**Telephone** **(301) 251-7649**		**E-mail** **eric.focht@nrc.gov**
DOE Laboratory **Pacific Northwest National Laboratory (PNNL)**			
DOE Site Address **Pacific Northwest Site Office, PO Box 350/MS K9-42, Richland, WA 99352**			
Principal Investigator **Stephen Bruemmer**	**Telephone** **(509) 371-7361**		**E-mail** **stephen.bruemmer@pnnl.gov**

Financial Status Section

A. Overall Funding

Current Monthly Costs:	$64,842
Total Ceiling Amount:	$985,000
Total Amount of Funds Obligated to Date:	$850,638
Total Amount of Funds Expended to Date:	$552,304
Percentage of Funds Expended to Date:	65%
Balance of Obligated Funds Remaining:	$298,334
Total Estimated Encumbered Costs:	$141,512
Balance Available Less Estimated Encumbered Costs:	$156,822

B. DOE Laboratory Acquired Property

No single item costing more than $5,000 was received this month. The autoclave and the remaining portion of the load train are the two most expensive items and are not expected to arrive until the end of April or early May.

Description*	Quan.	Manufacturer	Model Number	Serial Nums.	Tot. Acq. Cost ($)	Receipt Date	Property Identification Number

* Asterisk is to be added to item description to indicate sensitive software.

C. NRC-Funded Software Developed

Nothing in this area.

Name*	Function	Development Cost ($)	Computer Language Used	Operating System	Location of System	Date Software Completed	Date of Scheduled Replacement/Useful Life
N/A							

*Asterisk is to be used to indicate sensitive software.

Technical Status Section

A. Deliverables/Milestones Schedule

Deliverable	Description	Planned Completion Date	Revised Completion Date (if applicable)	Actual Completion Date
1	Test plan will be completed and submitted to the NRC for review.	Within 3 months of the contract award	not applicable	11/19/2014
2	Two SCC initiation test systems will be designed and assembled, and test viability demonstrated.	Within 12 months of the contract award	on track	
3	A technical letter report will be submitted to the NRC detailing the test equipment and capabilities for SCC initiation experimentation.	Within one 1 month of completion of Deliverable 2	on track	

B. Progress During Reporting Period

Task 1 - Identification and Acquisition of Materials for the Test Matrix

Overview of Material Requirements

For the current draft test plan, one autoclave is expected to be dedicated to alloy 600/182 tests and the other for alloy 690/152/52(x) tests. Each autoclave can hold 36 specimens. The tentative loading plan for these autoclave systems is as follows:

Alloy 600/182 autoclave

- First loading: Four different alloy 182 welds. For each weld, there will be 6 specimens in the 15% CF condition and 3 in the as-welded condition.
- Second loading: Stress effects will be considered with specimens loaded to a fraction of the yield stress. Current plan is the same four alloy 182 welds, all in a 15% CF condition. Exact number of specimens for each weld is to-be-determined.
- Third loading: Four heats of alloy 600. Each heat will have 9 specimens in the 15% CF condition.

Alloy 690/152/52(x) autoclave

- First and only loading: Four heats of alloy 690 with 3 specimens per heat and four heats of alloy 152/52(x) with six specimens per heat. All specimens will be in the 15% CF condition.

Acquisition of Materials and Forging Progress

The candidate four heats/welds for each class of material are shown in Table 1. Items in bold red are still being acquired. The ENSA alloy 52M material is expected by May, while the EPRI alloy 152M V-groove is expected in July.

Table 1. Candidate heats/welds for each class of material.

Alloy 182	
NRC/PNNL Phase 2B DMW Mockup	NRC/PNNL Flawtech DMW Mockup
Studsvik Buildup	KAPL U-Groove
Alloy 600	
Spec. Met. NX6106XK-11 MA Plate	ATI 522068 MA Bar
G.O. Carlson 33375-2B MA Plate	WNP5 CRDM Tube
Alloy 152/52	
MHI Alloy 152 U-Groove Mockup	MHI Alloy 52 U-Groove Mockup
ENSA DPM Alloy 52M Butter	**EPRI Alloy 152M V-Groove**
Alloy 690	
Valinox RE243 TT CRDM Tube	Valinox WP142 TT CRDM Tube
TK-VDM 114092 TT Plate	Allvac B25K-2 MA Bar

Roughly 50 blocks need to be prepared and forged for this program. Rather than preparing and forged all the blocks at once, the work is being broken down in to smaller overlapping groups. It is anticipated that three rounds of preparation and forging will be required to obtain sufficient material for all the specimens that are needed. The first round of forging has been completed, and the second set of materials is out for forging. This second set is expected back in early May. The goal is to have all the materials needed by the end of July for the first SCC initiation loadings (alloy 182 and alloy 690/152/52 materials).

A summary of all materials acquisitions and forging activities is listed in the attached table at the end of the document.

Material Characterizations

As part of materials characterization activities, SCC CGR tests have been or will be performed on the materials to determine the range of SCC crack growth susceptibility. While SCC initiation is not expected for the alloy 690/152/52 materials, SCC crack growth susceptibility is important to know to help understand whether the materials being tested are representative. Among the alloy 690/152/52 materials that have been selected for this study, all but the ENSA DPM alloy 52M butter and the EPRI alloy 152M V-groove have been SCC tested in their as-made condition. These remaining materials will be tested if requested.

All of the alloy 600/182 materials are expected to be SCC crack growth rate tested in their as-made condition. The alloy 600 NX6106XK-11, the Flawtech alloy 182, and the Studsvik alloy 182 are all currently being SCC CGR tested and are showing average or high SCC susceptibility. Testing of the Phase 2B alloy 182 and the KAPL alloy 182 is expected to be

begin in May. Since the alloy 600 materials will not undergo SCC initiation until later in the program, their susceptibility will be assessed after starting the initiation tests on the alloy 690/152/52 and alloy 182 materials.

Other materials characterization activities are determining the hardness and yield strength of the cold-forged materials and surveying the microstructures of all the materials. For the welds, the microstructure survey will include determination of the flaw concentration, if any. This activity is now underway with the initial effort focused on optical metallography.

Task 2 - Develop Experimental Test Plan

A suggested test plan was completed and submitted on time. Comments have been received back from an expert panel that has reviewed the proposal. Responses to these comments were prepared and provided to the NRC in February. After discussions with the NRC and EPRI in March, the test plan document is now being updated to address the reviewer questions in the document itself. The revised document is expected to be given to the review panel in late April or early May.

Task 3 - Design, Construction, and Validation of SCC Initiation Test Systems

Overview

These test systems will be closely based on a 36 tensile specimen test system designed and constructed for the DOE-NE LWRS program. The DOE-NE LWRS system can monitor 12 specimens for in-situ SCC initiation. The key design change underway for the new systems is increasing the number of specimens that can be instrumented for in-situ detection of SCC initiation or for in-situ detection of failure. A larger diameter autoclave with more ports for wiring feedthroughs is being designed and constructed to enable this. Changes are also being made to the load line and the wiring feedthroughs to make the task of instrumenting all 36 specimens potentially manageable.

The test systems are built in-house at PNNL using a combination of off-the-shelf and custom-made parts. Each test system is constructed of ~140 unique parts from ~30 different vendors. A spreadsheet showing the status of all items needed to build the test system is attached at the end of this document.

Laboratory expansion is needed to make room for these two new test systems along with two more test systems for another NRC program. A lab adjacent to the current SCC lab has been made available for this. New electrical drops, specialty gas drops, pressure relief lines, and chilled water lines be installed, and an increase in room ventilation is also needed to accommodate the waste heat released by the test systems. Since this new lab space has a low ceiling that cannot accommodate the large multi-specimen initiation test systems, several existing SCC CGR test systems, which are not as tall, will be moved into the new lab space, and the new multi-specimen SCC initiation systems will be installed in the existing SCC lab.

The first phase of the test system assembly involves fabricating major components such as the heater controllers and load frames. This work is all being done in-house by PNNL crafts.

The second phase of test system assembly will include having the pipefitters install the stainless steel tubing, filtration equipment, and glass columns on to each water board. This will be

followed by installation of the high pressure pumps. Research staff, with assistance from crafts support, will install the autoclaves and servo electric load frame in the test frames. Research staff will also finish installing the electronics into each electronics rack. The goal for completing the second phase is late March.

In order to begin the second phase of test system assembly, two of the existing SCC CGR test systems in the current lab space will have to be moved into the new lab space being constructed adjacent to the existing one. If completion of the new lab space gets delayed, it may be necessary to either delay assembly of the new SCC initiation test systems, or move the existing SCC CGR test systems into temporary storage while the new lab space is being completed. Discussion with NRC project managers may be needed to determine the appropriate action.

The final stages of assembly will include installation of the load train, installation of the DCPD wiring, and making all the connections from the electronics rack to either the test frame or waterboard. Each system will then be ready to shakedown testing. Activities were will include leak-checking of all stainless steel connections, programming the heater and chilled water controllers, loading autoclave with dummy specimens, heating autoclave and preheater up to operating temperatures, and checking the servo-electric load frame and DCPD system for proper operation. These steps to completion of assembly are summarized in Table 1.

Updates

All of the test system components have been ordered, and roughly 90% of those components have been delivered to PNNL. The most expensive item that has yet to be received is the autoclave. Receipt is expected in April, and is one of the last items needed for assembly.

Assembly of the test systems is underway with the work orders provided to crafts services. Building modifications for the new laboratory space will be completed by mid-April. Table 1 shows the timeline for all the activities needed to complete the test systems.

Table 1. Timeline for assembly of the SCC initiation test systems.

Activity	Planned Start	Actual Start	Planned Completion	Actual Completion	Comments
Order Parts Components	9/1/14	9/1/14	12/31/14	3/27/15	Completed
Phase 1 System Assembly	12/1/14	12/1/14	1/31/15	3/13/15	Completed
Lab Mods	2/1/15	2/23/15	3/1/15	est. 4/10/15	
Phase 2 System Assembly	1/31/15-3/1/15	est. 4/13/15	4/1/15	est. 5/15/15	
Final System Assembly	4/1/15	est. 5/15/15	5/1/15	est. 7/15/15	
Shakedown Testing	5/1/15	est. 7/15/15	6/10/15	est. 8/15/15	
First Project Test Setup	6/10/15	est. 9/1/15	7/1/15	est. 9/15/15	
First SCC Initiation Tests	7/1/15	est. 9/30/15	1/1/16	est. 4/1/16	

C. Travel

None.

D. Description of Estimated Encumbered Costs

Encumbered costs for this month represent items that have been ordered but not yet received. Expected receipt dates are on schedule.

Type	PO No.	Vendor	Description	Burdened Commitment
B2B	251240	Pacific Office Solutions	Misc Parts	$90
BNW Procurements	247396	Laboratory Testing	Pre-heater part	$6,386
BNW Procurements	247979	High Pressure Equip	Autoclave	$98,797
BNW Procurements	251585	Glas-Col, LLC	Autoclave heating mantle	$11,256
BNW Procurements	252254	Advanced Industrial	Bushings for Specimens ends	$13,069
Subcontracts	251544	General Electric Global	Cold Forging of Materials for Initiation test specimens	$11,913
		Commitments as of 3-27-15		$141,512

E. Anticipated and Encountered Problem Areas

None.

F. Plans for the Next Reporting Period

Task 1 - Materials acquisitions and forging will continue with the majority of the effort directed at having additional materials forged. Work will continue for characterizing SCC response of alloy 182 and alloy 600 to aid in material selection.

Task 2 - Original scope complete, however there are ongoing discussions on responding to the Expert Panel review of the test plan. These discussions are expected to last several more months.

Task 3 - Design, acquisition, test system construction, and laboratory modification activities will continue.

Travel and Meetings - None planned.

Spending Plan

Month/Year	13-Oct	13-Nov	13-Dec	14-Jan	14-Feb	14-Mar	14-Apr	14-May	14-Jun	14-Jul	14-Aug	14-Sep
Planned ($)											100,000	580,638
Revised ($)											0	21,936
Actual ($)											0	21,936
Variance (%)											0.00%	0.00%
Month/Year	14-Oct	14-Nov	14-Dec	15-Jan	15-Feb	15-Mar	15-Apr	15-May	15-Jun	15-Jul	15-Aug	15-Sep
Planned ($)	0	0	0	60,000	60,000	50,000	40,000	30,000	20,000	15,000	15,000	14,362
Revised ($)	71,694	55,422	143,260	140,515	54,635	64,843	65,000	65,000	65,000	70,000	65,000	55,000
Actual ($)	71,694	55,422	143,260	140,515	54,635	64,843						
Variance (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%						
Month/Year	15-Oct											
Planned ($)	0											
Revised ($)	47,696											
Actual ($)												
Variance (%)	-100.00%											
TOTAL												
Planned ($)	985,000											
Revised ($)	985,000											
Actual ($)	552,304											

Variance Narrative - None.

NRC/EPRI SCC Initiation Program Materials Matrix as of 3/27/2015.

Alloy Class and Material Name	Top 4 Candidate?	Reason	Description/Form	Dimensions	Alloy Vendor	Heat Number	CMTR?	Weld Fabricator	WPS	At PNNL?	Number of Possible Specimens	Microstructure Characterized?	Have SCC CGR Data?	# CF Initiation Specimens Needed	# CF CT Specimens Needed	# CF Initiation Specimens Per Block	# CF Blocks Needed	CF Slice removed for Met, EBSD, HV?	Number of Blocks Forged	Additional Forged Blocks Needed
Alloy 182																				
PNNL/NRC Phase 2B Mockup	yes	**well-documented mockup**	LAS-SS DMW with alloy 182 butter and fill	circumferential pipe buttweld, 15" OD x 1.5" wall	TBD	TBD	TBD	EWI	yes	yes	50	no	preparing to machine AW CTs	18	1	3	7	in-progress	2	**5**
PNNL/Flawtech/NRC Mockup	yes	**well-documented mockup**	LAS-SS DMW with alloy 182 butter and fill	circumferential pipe buttweld, 14" OD x 1.5" wall	Spec. Met.	844305	yes	Flawtech	yes	yes	90	no	AW CTs machined	18	1	3	7	in-progress	1	**6**
Studsvik	yes	**well-documented mockup**	alloy 182 buildup	3"tall x 2.75" x 5"long	TBD	TBD	TBD	ENSA	yes	yes	64	no	AW CTs machined	18	1	10	2	in-progress	2	**0**
KAPL	yes	**well-documented mockup**	alloy 182 U-groove	1.5"wide x 1.5"tall x 8"long	Techalloy	823030	yes	KAPL	yes	yes	25	no	preparing to machine AW CTs	18	1	6	4	planned	0	**4**
EPRI weld		?	alloy 182 groove	TBD	TBD	TBD	yes	TBD	yes	no	TBD	no	no	TBD						
CRDM J-groove	no	too challenging to forge and extract initiation specimens	alloy 182 J-groove from dismantled partially built PWR	≈15" ID x 0.XX" thick x XX" tall	unknown	unknown	no	unknown	no	yes	none	no	no							
Alloy 600																				
PNNL Plate #1 (MA)	yes	**prior SCCI data from LWRS**	2" thick plate	9.6x15x2" thick	Spec. Met.	NX6016XK-11	yes	N/A	N/A	yes	300	Met, SEM, TEM	in-progress	12	1	6	3	in-progress	3	**0**
PNNL Plate #3 (MA)	yes	**using for NRC Peening program**	3" thick plate	3x18x3" thick	ATI	522068	yes	N/A	N/A	yes	50	Met	preparing to machine AW CTs	12	1	6	3	planned	0	**3**
KAPL Plate (MA)	yes	**vintage material**	vintage 2" thick plate	4x12x2" thick	G.O. Carlson	33375-2B	yes	N/A	N/A	yes	50	no	planned	12	1	6	3	in-progress	0	**3**
CRDM Tube	yes	**service material**	From dismantled partially built PWR	4.15"OD x 0.70" wall x 8" long	unknown	unknown	no	N/A	N/A	yes	50	Met	preparing to machine AW CTs	12	1	5	3	planned	0	**3**
Foroni Bar	no	under consideration	6" dia. bar	6"OD x 12" long	Foroni	31907	yes	N/A	N/A	expected 05/2015	100	no	no					planned		
PNNL Plate #2 (MA)	no	other better candidates	2" thick plate	6x24x2" thick	ATI	521616	yes	N/A	N/A	yes	300	Met	no						3	
Alloy 152/52																				
MHI alloy 152 U-groove	yes	**have SCC CGR data**	U-groove weld joining SS	1.8"tall x 2"wide x 2.5" long	TK-VDM?	307380	yes	MHI	yes	yes	15	Met, SEM	yes	9	2	6	2	planned	0	**2**
MHI alloy 52 U-groove	yes	**have SCC CGR data**	U-groove weld joining SS	1.8"tall x 2"wide x 2.5" long	Spec. Met.	NX2686JK	yes	MHI	yes	yes	15	Met, SEM	yes	9	2	6	2	planned	0	**2**
ENSA DPM alloy 52M butter	yes	**sufficient material available**	Double bevel 690-LAS DMW, alloy 52M butter	0.75"tall x 2.7"wide x 4" long	unknown	unknown	no	ENSA	yes	yes	20	Met, SEM	no	9	2	3	4	planned	0	**4**
EPRI alloy 152M	yes	**favorable geometry, sufficient material**	TBD	TBD	TBD	TBD	yes	TBD	yes	expected 07/2015	TBD	no	no	9	2	3	4	planned	0	**4**
KAPL alloy 52M NG	no	too narrow	narrow gap weld joining alloy 690	1.6"tall x 0.5"wide x 1.1" long	Spec. Met.	NX5285TK	yes	KAPL	yes	yes	6	no	yes							
EPRI alloy 52i	no	not enough material	V-groove weld	1.6"tall x 0.75-1.75"wide x 1.5" long	TK-VDM	187775	yes	unknown		yes	9	no	no						1	
ENSA DPM alloy 52 fill	no	alloy 52 with prior SCC experience already identified	Double bevel 690-LAS DMW, alloy 52 fill	1.3"tall x 0.5-1.6"wide x 4" long	Spec. Met.	NX4196JK	yes	ENSA	yes	yes	20	Met, SEM	in-progress						1	
NRC alloy 52MSS NG	no	too narrow	narrow gap weld joining alloy 690	2"tall x 0.4-0.6" wide x 2.8" long	Spec. Met.	NX77W3UK	yes	REI	yes	yes	16	no	yes							
Alloy 690																				
Valinox Alloy 690 CRDM RE243 (TT)	yes	**significant SCC CGR data**	CRDM	4.4"OD x 1.35"wall x 6" long	Valinox	RE243	no	N/A	N/A	yes	>20	Met, SEM, TEM, APT	yes	9	1	6	2	in-progress	2	**0**
Valinox Alloy 690 CRDM WP142 (TT)	yes	**have SCC CGR data, and substantial material**	CRDM	4.56"OD x 1.20"wall x 4" long	Valinox	WP142	no	N/A	N/A	yes	>20	Met, SEM, TEM	yes	9	1	6	2	in-progress	2	**0**
TK-VDM 114092 plate (TT)	yes	**have SCC CGR data**	plate	2"tall x 4"wide x 2.5" long	TK-VDM	114092	yes	N/A	N/A	EPRI	>20	Met, SEM, TEM	yes	9	1	6	2	planned	0	**2**
ATI/Allvac B25K-2 (MA)	yes	**have SCC CGR data**	plate	3"thick x 5.5"wide x 2.2" long	ATI/Allvac	B25K-2	yes	N/A	N/A	yes	>20	Met, SEM, TEM	yes	9	1	6	2	in-progress	2	**0**
Doosan CRDM bar (TT)	no	insufficient material for additional tests	CRDM	[illegible] x 2.5" long	TK-VDM	133454	yes	N/A	N/A	yes	30	Met, SEM, TEM	yes						1	
EPRI NX8625HG21 (TT)	no	no SCC data, other better candidates	plate	12x12x1.3" thick	Spec. Met.	NX8625HG21		N/A	N/A	yes	>20	no	no							

MONTHLY LETTER STATUS REPORT

<table>
<tr><td colspan="2">Reporting Period Start Date
April 25, 2015</td><td colspan="2">Reporting Period End Date
May 22, 2015</td></tr>
<tr><td>NRC Agreement Number
NRC-HQ-60-14-D-0014</td><td colspan="2">Task Order Number (if applicable)
N/A</td><td>Common Cost Center Code</td></tr>
<tr><td colspan="4">Project Title
Crack Initiation Testing for Primary Water Stress Corrosion Cracking</td></tr>
<tr><td colspan="2">Period of Performance Start Date
August 18, 2014</td><td colspan="2">Period of Performance End Date
October 31, 2015</td></tr>
<tr><td>COR
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</table>

Financial Status Section

A. Overall Funding

Current Monthly Costs:	$51,403
Total Ceiling Amount:	$985,000
Total Amount of Funds Obligated to Date:	$984,638
Total Amount of Funds Expended to Date:	$661,578
Percentage of Funds Expended to Date:	67%
Balance of Obligated Funds Remaining:	$323,060
Total Estimated Encumbered Costs:	$133,771
Balance Available Less Estimated Encumbered Costs:	$189,289

B. DOE Laboratory Acquired Property

No single item costing more than $5,000 was received this month. The autoclave and the remaining portion of the load train are the two most expensive items and are not expected to arrive until the end of April or early May.

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* Asterisk is to be added to item description to indicate sensitive software.

C. NRC-Funded Software Developed

Nothing in this area.

Name*	Function	Development Cost ($)	Computer Language Used	Operating System	Location of System	Date Software Completed	Date of Scheduled Replacement/Useful Life
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Technical Status Section

A. Deliverables/Milestones Schedule

Deliverable	Description	Planned Completion Date	Revised Completion Date (if applicable)	Actual Completion Date
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2	Two SCC initiation test systems will be designed and assembled, and test viability demonstrated.	Within 12 months of the contract award	on track	
3	A technical letter report will be submitted to the NRC detailing the test equipment and capabilities for SCC initiation experimentation.	Within one 1 month of completion of Deliverable 2	on track	

B. Progress During Reporting Period

Task 1 - Identification and Acquisition of Materials for the Test Matrix

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For the current draft test plan, one autoclave is expected to be dedicated to alloy 600/182 tests and the other for alloy 690/152/52(x) tests. Each autoclave can hold 36 specimens. The tentative loading plan for these autoclave systems is as follows:

Alloy 600/182 autoclave

- First loading: Four different alloy 182 welds. For each weld, there will be 6 specimens in the 15% CF condition and 3 in the as-welded condition.
- Second loading: Stress effects will be considered with specimens loaded to a fraction of the yield stress. Current plan is the same four alloy 182 welds, all in a 15% CF condition. Exact number of specimens for each weld is to-be-determined.
- Third loading: Four heats of alloy 600. Each heat will have 9 specimens in the 15% CF condition.

Alloy 690/152/52(x) autoclave

- First and only loading: Four heats of alloy 690 with 3 specimens per heat and four heats of alloy 152/52(x) with six specimens per heat. All specimens will be in the 15% CF condition.

Progress on Acquisition of Materials and Forging

The candidate four heats/welds for each class of material are shown in Table 1. The only material yet to be delivered is the EPRI alloy 152M V-groove that is expected in July.

Table 1. Candidate heats/welds for each class of material.

Alloy 182	
NRC/PNNL Phase 2B DMW Mockup	NRC/PNNL Flawtech DMW Mockup
Studsvik Buildup	KAPL U-Groove
Alloy 600	
Spec. Met. NX6106XK-11 MA Plate	ATI 522068 MA Bar
G.O. Carlson 33375-2B MA Plate	WNP5 CRDM Tube
Alloy 152/52	
MHI Alloy 152 U-Groove Mockup	MHI Alloy 52 U-Groove Mockup
ENSA DPM Alloy 52M Butter	**EPRI Alloy 152M V-Groove**
Alloy 690	
Valinox RE243 TT CRDM Tube	Valinox WP142 TT CRDM Tube
TK-VDM 114092 TT Plate	Allvac B25K-2 MA Bar

Roughly 50 blocks need to be prepared and forged for this program. Rather than preparing and forged all the blocks at once, the work is being broken down into smaller overlapping groups. Forging status for each of the materials is tracked in Table 2. A summary of all materials acquisitions and forging activities is listed in the attached table at the end of the document.

Table 2. Status of forging for each of the materials.

Alloy 182	
NRC/PNNL Phase 2B DMW Mockup*	**NRC/PNNL Flawtech DMW Mockup**
Studsvik Buildup	**KAPL U-Groove****
Alloy 600	
Spec. Met. NX6106XK-11 MA Plate	**ATI 522068 MA Bar**
G.O. Carlson 33375-2B MA Plate	**WNP5 CRDM Tube**
Alloy 152/52	
MHI Alloy 152 U-Groove Mockup	**MHI Alloy 52 U-Groove Mockup**
ENSA DPM Alloy 52M Butter	**EPRI Alloy 152M V-Groove*****
Alloy 690	
Valinox RE243 TT CRDM Tube	**Valinox WP142 TT CRDM Tube**
TK-VDM 114092 TT Plate	**Allvac B25K-2 MA Bar**

* Green = complete
** Blue = in-progress
*** Red = waiting on material

Material Characterizations

As part of materials characterization activities, SCC CGR tests have been or will be performed on the materials to determine the range of SCC crack growth susceptibility. While SCC initiation is not expected for the alloy 690/152/52 materials, SCC crack growth susceptibility is important to assess to help understand whether the materials being tested are representative. Among the alloy 690/152/52 materials that have been selected for this study, all but the ENSA DPM alloy 52M butter and the EPRI alloy 152M V-groove have been SCC tested in their as-made condition.

All of the alloy 600/182 materials are expected to be SCC crack growth rate tested in their as-made condition. The alloy 600 NX6106XK-11, the Flawtech alloy 182, and the Studsvik alloy 182 are all currently being SCC CGR tested and are showing average or high SCC susceptibility. Testing of the Phase 2B alloy 182 and the KAPL alloy 182 is expected to be begin in early June. Since the alloy 600 materials will not undergo SCC initiation testing until later in the program, their SCC crack growth rate susceptibility will be assessed after starting the initiation tests on the alloy 690/152/52 and alloy 182 materials.

Other characterization activities include determining the hardness and yield strength of the cold-forged materials and surveying the microstructures of all the materials. For the welds, the microstructure survey will include determination of the flaw concentration, if any. Optical metallography, SEM examinations, hardness measurements, and YS measurements are all underway. Yield strength, hardness, and SCC CGR measurements are being populated in Table 3.

Task 2 - Development of Experimental Test Plan

A suggested test plan was completed and submitted on time. Comments have been received back from an expert panel that has reviewed the proposal. Responses to these comments were prepared and provided to the NRC and EPRI in February. After discussions with the NRC and EPRI in March, the test plan document was revised and submitted to the NRC for a second round of review. After receiving any final comments from the NRC, the test plan will be provided to EPRI for comment, and then presumably it will go back to the Expert Panel for any final comment.

Table 3. Hardness, 360°C yield strength, and SCC CGR results for the candidate materials.

Material	ID	Condition	Hardness (kg/mm^2)	YS@360°C (MPa)	SCC CGR (mm/s)†
Alloy 182 Buildup	Studsvik	AW	*		~1e-07**
		15%CF	240-345	*	
Alloy 182 Nozzle DMW	Flawtech 844305	AW	*		~3e-08**
		15%CF	225-345	*	
Alloy 182 Nozzle DMW	Phase 2B	AW	*		*
		15%CF	225-330	*	
Alloy 182 V-Groove	KAPL 823030	AW	*		*
		15%CF	*		
Alloy 600 Plate	NX6016XK-11	MA	*	310	~2e-08**
		15%CF	265	*	*
Alloy 600 Plate	522068	MA			
		15%CF	*	*	
Alloy 600 Plate	33375-2B	MA			
		15%CF			
Alloy 600 CRDM	WNP5	MA			
		15%CF	*	*	
Alloy 152 U-groove	MHI 307380	AW			<1e-09
		15%CF	*	*	
Alloy 52 U-Groove	MHI NX2686JK	AW			<1e-09
		15%CF	*	*	
Alloy 52M Butter	ENSA DPM Butter	AW			
		15%CF	*	*	
Alloy 152M V-Groove	EPRI	AW			
		15%CF			
Alloy 690 CRDM	RE243	TT	155		<1e-09
		15%CF	240	*	
Alloy 690 CRDM	WP142	TT	163		<1e-09
		15%CF	247	*	
Alloy 690 Plate	114092	TT	165		<1e-09
		15%CF	*	*	
Alloy 690 Plate	B25K-2	MA	173		1.1e-09
		15%CF	270	*	

† 25-30 MPa√m
* Specimens being prepared
** Ongoing test

Task 3 - Design, Construction, and Validation of SCC Initiation Test Systems

Overview

These test systems will be closely based on a 36 tensile specimen test system designed and constructed for the DOE-NE LWRS program. The DOE-NE LWRS system can monitor 12 specimens for in-situ SCC initiation. The key design change underway for the new systems is increasing the number of specimens that can be instrumented for in-situ detection of SCC initiation or for in-situ detection of failure. A larger diameter autoclave with more ports for wiring feedthroughs is being designed and constructed to enable this. Changes are also being made to the load line and the wiring feedthroughs to make the task of instrumenting all 36 specimens potentially manageable.

The test systems are built in-house at PNNL using a combination of off-the-shelf and custom-made parts. Each test system is constructed of ~140 unique parts from ~30 different vendors. A spreadsheet showing the status of all items needed to build the test system is attached at the end of this document.

Laboratory expansion is needed to make room for these two new test systems along with two more test systems for another NRC program. A lab adjacent to the current SCC lab has been made available for this. New electrical drops, specialty gas drops, pressure relief lines, and chilled water lines be installed, and an increase in room ventilation is also needed to accommodate the waste heat released by the test systems. Since this new lab space has a low ceiling that cannot accommodate the large multi-specimen initiation test systems, several existing SCC CGR test systems, which are not as tall, will be moved into the new lab space, and the new multi-specimen SCC initiation systems will be installed in the existing SCC lab. This activity was completed on 4/13/2015.

The first phase of the test system assembly involves fabricating major components such as the heater controllers and load frames. This work was done in-house by PNNL crafts and is complete.

The second phase of test system assembly includes having the pipefitters install the stainless steel tubing, filtration equipment, and glass columns on to each water board. This will be followed by installation of the high pressure pumps. Research staff, with assistance from crafts support, will install the autoclaves and servo electric load frame in the test frames. Research staff will also finish installing the electronics into each electronics rack.

The final stages of assembly will include installation of the load train, installation of the DCPD wiring, and making all the connections from the electronics rack to either the test frame or waterboard. Each system will then be ready to shakedown testing. Activities were will include leak-checking of all stainless steel connections, programming the heater and chilled water controllers, loading autoclave with dummy specimens, heating autoclave and preheater up to operating temperatures, and checking the servo-electric load frame and DCPD system for proper operation. These steps to completion of assembly are summarized in Table 4.

Updates

The only major items that have yet to be delivered are the autoclaves and the internal support for the load train. These were expected in May, but current information from the vendors is that the autoclaves will arrive in June and the load train support in early July. Phase 2 activities continue, but at a pace slower than planned due to inavailability of crafts personnel despite making requests several months in advance. At the current rate of prorgress, the start of the first tests may be delayed to early October. Table 4 shows the timeline for all the activities needed to complete the test systems.

Table 4. Timeline for assembly of the SCC initiation test systems.

Activity	Planned Start	Actual Start	Planned Completion	Actual Completion	Comments
Order Parts Components	9/1/14	9/1/14	12/31/14	3/27/15	Completed
Phase 1 System Assembly	12/1/14	12/1/14	1/31/15	3/13/15	Completed
Lab Mods	2/1/15	2/23/15	3/1/15	4/10/15	Completed
Phase 2 System Assembly	1/31/15-3/1/15	est. 4/13/15	4/1/15	est. 7/15/15	
Final System Assembly	4/1/15	est. 7/15/15	5/1/15	est. 8/7/15	
Shakedown Testing	5/1/15	est. 8/7/15	6/10/15	est. 8/21/15	
First Project Test Setup	6/10/15	est. 9/1/15	7/1/15	est. 9/15/15	
First SCC Initiation Tests	7/1/15	est. 9/30/15	1/1/16	est. 4/1/16	

C. Travel

None.

D. Description of Estimated Encumbered Costs

Encumbered costs for this month represent items that have been ordered but not yet received. We are in communication with the vendors on the delivery dates for these items.

Type	PO No.	Vendor	Description	Burdened Commitment
BNW Procurements	247979	High Pressure Equip Co	Autoclave	$98,797
BNW Procurements	255719	Applied Test Systems	Misc parts such as: End link, Threaded Ball, Socket Bushing, Post Bolt, Socket Plate, Rod Support, Top support plate, Tri-arm etc.	$31,268
Subcontracts	251544	General Electric Global	Cold Forging of Materials for initiation test specimens	$3,706
		Commitments as of 5-22-15		$133,771

E. Anticipated and Encountered Problem Areas

None.

F. Plans for the Next Reporting Period

Task 1 - Materials acquisitions and forging will continue with the majority of the effort directed at having additional materials forged. Work will continue for characterizing SCC response, yield strength measurement, and hardness measurement to aid in material selection.

Task 2 - Original scope complete and test plan revisions have been made. Revised draft currently at NRC for comment and then will go to EPRI and Expert Panel.

Task 3 - Parts acquisition and test system construction will continue.

Travel and Meetings - None planned.

Spending Plan

Month/Year	13-Oct	13-Nov	13-Dec	14-Jan	14-Feb	14-Mar	14-Apr	14-May	14-Jun	14-Jul	14-Aug	14-Sep
Planned ($)											100,000	580,638
Revised ($)											0	21,936
Actual ($)											0	21,936
Variance (%)											0.00%	0.00%
Month/Year	**14-Oct**	**14-Nov**	**14-Dec**	**15-Jan**	**15-Feb**	**15-Mar**	**15-Apr**	**15-May**	**15-Jun**	**15-Jul**	**15-Aug**	**15-Sep**
Planned ($)	0	0	0	60,000	60,000	50,000	40,000	30,000	20,000	15,000	15,000	14,362
Revised ($)	71,694	55,422	143,260	140,515	54,635	64,843	65,000	65,000	65,000	70,000	65,000	55,000
Actual ($)	71,694	55,422	143,260	140,515	54,635	64,843	57,871	51,403				
Variance (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-10.97%	-20.92%				
Month/Year	**15-Oct**											
Planned ($)	0											
Revised ($)	47,696											
Actual ($)												
Variance (%)	-100.00%											
TOTAL												
Planned ($)	**985,000**											
Revised ($)	**985,000**											
Actual ($)	**661,578**											

Variance Narrative - None.

NRC/EPRI SCC Initiation Program Materials Matrix as of 5/22/2015.

Alloy Class and Material Name	Top 4 Candidate?	Reason	Description/Form	Dimensions	Alloy Vendor	Heat Number	CMTR?	Weld Fabricator	WPS	At PNNL?	Number of Possible Specimens	Microstructure Characterized?	Have SCC CGR Data?	# CF Initiation Specimens Needed	# CF CT Specimens Needed	# CF Initiation Specimens Per Block	# CF Blocks Needed	Number of Blocks Forged	Additional Forged Blocks Needed	CF Slice removed for Met, EBSD, HV?
Alloy 182																				
PNNL/NRC Phase 2B Mockup	**yes**	**well-documented mockup**	LAS-SS DMW with alloy 182 butter and fill	circumferential pipe buttweld, 15" OD x 1.5" wall	TBD	TBD	TBD	EWI	yes	yes	50	no	machining AW CTs	18	1	3	7	7	**0**	complete
PNNL/Flawtech/NRC Mockup	**yes**	**well-documented mockup**	LAS-SS DMW with alloy 182 butter and fill	circumferential pipe buttweld, 14" OD x 1.5" wall	Spec. Met.	844305	yes	Flawtech	yes	yes	90	no	in-progress	18	1	3	7	7	**0**	complete
Studsvik	**yes**	**well-documented mockup**	alloy 182 buildup	3"tall x 2.75" x 5"long	TBD	TBD	TBD	ENSA	yes	yes	64	no	in-progress	18	1	10	2	2	**0**	complete
KAPL	**yes**	**well-documented mockup**	alloy 182 U-groove	1.5"wide x 1.5"tall x 8"long	Techalloy	823030	yes	KAPL	yes	yes	25	no	machining AW CTs	18	1	6	4	0	**4**	planned
EPRI weld		under consideration	alloy 182 J-groove	TBD	TBD	TBD	yes	TBD	yes	no	TBD	no	no	TBD						
CRDM J-groove	no	too challenging to forge and extract initiation specimens	alloy 182 J-groove from dismantled partially built PWR	4.15" ID x 0.XX" thick x XX" tall	unknown	unknown	no	unknown	no	yes	none	no	no							
Alloy 600																				
PNNL Plate #1 (MA)	**yes**	**prior SCCI data from LWRS**	2" thick plate	9.6x15x2" thick	Spec. Met.	NX6016XK-11	yes	N/A	N/A	yes	300	Met, SEM, TEM	in-progress	12	1	6	3	3	**0**	complete
PNNL Plate #3 (MA)	**yes**	**using for NRC Peening program**	3" thick plate	3x18x3" thick	ATI	522068	yes	N/A	N/A	yes	50	Met	preparing to machine AW CTs	12	1	6	3	3	**0**	in-progress
KAPL Plate (MA)	**yes**	**vintage material**	vintage 2" thick plate	4x12x2" thick	G.O. Carlson	33375-2B	yes	N/A	N/A	yes	50	no	planned	12	1	6	3	0	**3**	planned
CRDM Tube	**yes**	**service material**	From dismantled partially built PWR	4.15"OD x 0.70" wall x 8" long	unknown	unknown	no	N/A	N/A	yes	50	Met	preparing to machine AW CTs	12	1	5	2	2	**0**	in-progress
Foroni Bar	no	under consideration	6" dia. bar	6"OD x 12" long	Foroni	31907	yes	N/A	N/A	yes	100	No	no							planned
PNNL Plate #2 (MA)	no	other better candidates	2" thick plate	6x24x2" thick	ATI	531616	yes	N/A	N/A	yes	200	[illegible]	no					3		
Alloy 152/52																				
MHI alloy 152 U-groove	**yes**	**have SCC CGR data**	U-groove weld joining SS	1.8"tall x 2"wide x 2.5" long	TK-VDM?	307380	yes	MHI	yes	yes	15	Met, SEM	yes	9	2	6	2	2	**0**	in-progress
MHI alloy 52 U-groove	**yes**	**have SCC CGR data**	U-groove weld joining SS	1.8"tall x 2"wide x 2.5" long	Spec. Met.	NX2686JK	yes	MHI	yes	yes	15	Met, SEM	yes	9	2	6	2	2	**0**	in-progress
ENSA DPM alloy 52M butter	**yes**	**sufficient material available**	Double bevel 690-LAS DMW, alloy 52M butter	0.75"tall x 2.7"wide x 4" long	unknown	unknown	no	ENSA	yes	yes	20	Met, SEM	no	9	2	3	4	2	**2**	in-progress
EPRI alloy 152M	**yes**	**favorable geometry, sufficient material**	TBD	TBD	TBD	TBD	yes	TBD	yes	expected 07/2015	TBD	no	no	9	2	3	4	0	**4**	planned
KAPL alloy 52M NG	no	too narrow	narrow gap weld joining alloy 690	1.8"tall x 0.5"wide x 1.4" long	Spec. Met.	NX5285TK	yes	KAPL	yes	yes	6	no	yes							
EPRI alloy 52i	no	not enough material	V-groove weld	1.8"tall x 0.75 1.75"wide x 1.5" long	TK-VDM	107775	yes	unknown		yes	9	no	no					1		
ENSA DPM alloy 52 fill	no	alloy 52 with prior SCC experience already identified	Double bevel 690-LAS DMW, alloy 52 fill	1.5"tall x 0.5-1.5"wide x 4" long	Spec. Met.	NX4196IK	yes	ENSA	yes	yes	20	Met, SEM	in-progress					1		
NRC alloy 52MSS NG	no	too narrow	narrow gap weld joining alloy 690	2"tall x 0.4-0.6"wide x 2.8" long	Spec. Met.	NX77W3UK	yes	PCI	yes	yes	15	no	yes							
Alloy 690																				
Valinox Alloy 690 CRDM RE243 (TT)	**yes**	**significant SCC CGR data**	CRDM	4.4"OD x 1.35"wall x 6" long	Valinox	RE243	no	N/A	N/A	yes	>20	Met, SEM, TEM, APT	yes	9	1	6	2	2	**0**	complete
Valinox Alloy 690 CRDM WP142 (TT)	**yes**	**have SCC CGR data, and substantial material**	CRDM	4.56"OD x 1.20"wall x 4" long	Valinox	WP142	no	N/A	N/A	yes	>20	Met, SEM, TEM	yes	9	1	6	2	2	**0**	complete
TK-VDM 114092 plate (TT)	**yes**	**have SCC CGR data**	plate	2"tall x 4"wide x 2.5" long	TK-VDM	114092	yes	N/A	N/A	yes	>20	Met, SEM, TEM	yes	9	1	6	2	2	**0**	in-progress
ATI/Allvac B25K-2 (MA)	**yes**	**have SCC CGR data**	plate	3"thick x 5.5"wide x 2.2" long	ATI/Allvac	B25K-2	yes	N/A	N/A	yes	>20	Met, SEM, TEM	yes	9	1	6	2	2	**0**	complete
Doosan CRDM bar (TT)	no	insufficient material for additional tests	CRDM	6"OD x 2.5" long	TK-VDM	133454	yes	N/A	N/A	yes	13	Met, SEM, TEM	yes					1		
EPRI NX8625HG21 (TT)	no	no SCC data, other better candidates	plate	12x12x1.34" thick	Spec. Met.	NX8625HG21		N/A	N/A	yes	>20	no	no							

MONTHLY LETTER STATUS REPORT

Reporting Period Start Date October 1, 2014		Reporting Period End Date October 24, 2014
NRC Agreement Number NRC-HQ-60-14-D-0014	Task Order Number (if applicable) N/A	Common Cost Center Code
Project Title Crack Initiation Testing for Primary Water Stress Corrosion Cracking		
Period of Performance Start Date August 18, 2014		Period of Performance End Date October 31, 2015
COR Eric Focht	Telephone (301) 251-7649	E-mail eric.focht@nrc.gov
DOE Laboratory Pacific Northwest National Laboratory (PNNL)		
DOE Site Address Pacific Northwest Site Office, PO Box 350/MS K9-42, Richland, WA 99352		
Principal Investigator Stephen Bruemmer	Telephone (509) 371-7361	E-mail stephen.bruemmer@pnnl.gov

Financial Status Section

A. Overall Funding

Current Monthly Costs:	$71,694
Total Ceiling Amount:	$985,000
Total Amount of Funds Obligated to Date:	$649,000
Total Amount of Funds Expended to Date:	$93,630
Percentage of Funds Expended to Date:	14%
Balance of Obligated Funds Remaining:	$555,370
Total Estimated Encumbered Costs:	$112,677
Balance Available Less Estimated Encumbered Costs:	$442,693

B. DOE Laboratory Acquired Property

No items costing more than $5000 were received this month.

Description*	Quantity	Manufacturer	Model Number	Serial Number(s)	Acquisition Cost ($)	Receipt Date	Property Identification Number

* Asterisk is to be used to indicate sensitive software.

C. NRC-Funded Software Developed

Nothing in this area.

Name*	Function	Development Cost ($)	Computer Language Used	Operating System	Location of System	Date Software Completed	Date of Scheduled Replacement/Useful Life
N/A							

*Asterisk is to be used to indicate sensitive software.

Technical Status Section

A. Deliverables/Milestones Schedule

Deliverable	Description	Planned Completion Date	Revised Completion Date (if applicable)	Actual Completion Date
1	Test plan will be completed and submitted to the NRC for review.	Within 3 months of the contract award	on track	
2	Two SCC initiation test systems will be designed and assembled, and test viability demonstrated.	Within 12 months of the contract award	on track	
3	A technical letter report will be submitted to the NRC detailing the test equipment and capabilities for SCC initiation experimentation.	Within one 1 month of completion of Deliverable 2	on track	

B. Progress During Reporting Period

Task 1 - Identification and Acquisition of Materials for the Test Matrix

Efforts to obtain sufficient amounts of all the necessary types of materials are underway. Desired heats of materials or weldments have already been identified with some materials already obtained. Brief notes are as follows.

Alloy 182: Goal is to obtain 4 separate alloy 182 welds, possibly obtain and assess additional welds to select "best" set of 4.

(1) PNNL/NRC Phase 2B Mockup Weld - LAS-SS DMW with alloy 182 butter and fill. Can extract 3.3 specimens/inch of arc length. >15" available = ~50 specimens. *In possession.*

(2) PNNL/Flawtech/NRC Pipe Weld Mockup - LAS-SS DMW with alloy 182 butter and fill. Can extract 0.36 specimens/deg of arc length. ~270 degrees available = ~97 specimens. *In possession.*

(3) Studsvik Weld from EPRI - 3x2.75x5" long linear weld. Can obtain 8 specimens/0.6" = 64 specimens. *In possession.*

(4) KAPL Mockup Weld for PNNL - Alloy 182 joining alloy 2" tall 600 plate. Can extract 2 specimens/0.6" of length. ~8 inches available = ~25 specimens. *Available in Feb. 2015.*

(5) EPRI Alloy 182 Weld - Being fabricated by WRTC (Greg Fredrick). Completion date unknown. *Determining availability.*

Alloy 600: Goal is for 4 separate alloy heats, one of which should be a CRDM heat.

(1) PNNL Plate #1 - Special Metals Heat NX6106XK-11 (9.6x15x2" thick). Have SCC initiation data. Preparing to obtain SCC CGR data. ~300 specimens possible. *In possession. Possible material for multi-lab round robin.*

(2) PNNL Plate #2 - ATI Heat 521616 (6x24x2" thick). ~300 specimens possible. *In possession. Possible material for multi-lab round robin.*

(3) KAPL Plate - 1995 Vintage. Heat 33375-2B (4x24x2" thick). ~200 specimens possible. *Will ship as part of KAPL alloy 182 weld, so available in Feb. 2015.*

(4) Additional Plate Heats - *Can be purchased as needed. KAPL may have additional vintage material available.*

(5) Thick-Wall CRDM Tube - Several available at PNNL from unused service components. *Determining availability.*

Alloy 52M/152/52: Goal is to obtain 4 separate welds, possibly obtain and assess additional welds to select "best" set of 4.

(1) Alloy 152 MHI Weld Mockup (307380) for Kewanee. Enough at PNNL for 6 specimens in transverse orientation and 15 specimens in longitudinal orientation. Has been SCC CGR tested in as-welded and 20% CF condition. ***None at EPRI. Possibly more material at GE. Investigating.***

(2) KAPL Alloy 152M V-groove dissimilar metal weld (WC83F8). Can extract 3 specimens per 0.6" of weld length. Has been SCC CGR tested. ***None at PNNL or EPRI. Investigating whether any available at KAPL.***

(3) KAPL Alloy 52M narrow gap weld (NX5285TK). Has been SCC CGR tested. ***Enough at PNNL for 6 specimens. Investigating whether any available at KAPL.***

(4) Alloy 52i heat 87775 V-groove weldment received from EPRI (1 piece 1.75" long). Not previously tested. ***Enough at PNNL for 9 specimens.***

(5) ENSA Divider Plate Mockup Alloy 52 DM Weld from EPRI DB. Alloy 52M butter and alloy 52 fill. SCC CGR testing of alloy 52 fill is underway. Enough for at least 20 specimens each from alloy 52M butter and alloy 52 fill.

(6) Alloy 52MSS. Obtained from NRC. Has been SCC tested. Enough at PNNL for 18 specimens.

(7) EPRI Alloy 52/152 weld. *Determining availability.* ***EPRI is still pursuing this. ETA not yet provided.***

Alloy 690: Goal is for at least 4 separate alloy 690 heats including CRDM tubing and plate heats.

(1) Valinox Alloy 690TT CRDM Tube Heat RE243 at PNNL. Has been SCC CGR tested in as-received and several different CW conditions. *Enough for >20 specimens.*

(2) Valinox Alloy 690TT CRDM Tube. Other heats at PNNL. Has been tested in as-received condition. *Enough for >20 specimens.*

(3) TK-VDM (Doosan) Alloy 690TT CRDM Bar Heat 133454. Has been SCC CGR tested in as-received and CW conditions. *Enough for 12 specimens.*

(4) Sumitomo Alloy 690TT CRDM Tube Heat E67074C. Has been SCC CGR tested in as-received and CW conditions. *Determining availability from EPRI.* ***Likely unavailable.***

(5) TK-VDM 114092 Plate Material - Has been SCC CGR tested in as-received and CW conditions. *Enough for >20 specimens.*

(6) ATI/Allvac B25K-2 Plate Material. Has been SCC CGR tested in as-received and CW conditions. Obtaining enough material from GE to make >20 specimens.

(7) Additional Plate Material - EPRI NX8625HG21 Alloy 690TT (12"x12"x1.34" thick). *In possession. Has not been SCC tested at PNNL.*

Dissimilar Metal Welds: Of possible interest to the NRC

(1) PNNL/NRC Phase 2B Mockup Weld - LAS-SS DMW with alloy 182 butter and fill. Can extract 3.3 specimens/inch of arc length. 5.5" available for DMW dilution zone studies = 18 specimens. *In possession.*

(2) ENSA Divider Plate Alloy 52 DMW Mockup - LAS-690 DMW with alloy 52M butter and fill. *Determining availability.*

Task 2 - Develop Experimental Test Plan

A draft test plan was completed and sent to the NRC for comment. Comments have been received back, and the final report is expected to be submitted on time.

Task 3 - Design, Construction, and Validation of SCC Initiation Test Systems

These test systems will be closely based on a 36 tensile specimen test system designed and constructed for the DOE-NE LWRS program. The DOE-NE LWRS system can monitor 12 specimens for in-situ SCC initiation. The key design change underway is increasing the number of specimens that can be instrumented for in-situ detection of SCC initiation or for in-situ detection of failure. A larger diameter autoclave with more ports for wiring feedthroughs is being designed and constructed to enable this. Changes are also being made to the load line and the wiring feedthroughs to make the task of instrumenting all 36 specimens potentially manageable.

The test systems are built in-house at PNNL using a combination of off-the-shelf and custom-made parts. Each test system is constructed of ~140 unique parts from ~30 different vendors. A spreadsheet showing the status of all items needed to build the test system is attached at the end of this document. Ordering of the parts continued this month with the longest lead time items being ordered first. Items began arriving this month.

Laboratory expansion for the new test systems is underway. A lab adjacent to the current SCC lab has been made available and is being prepared for installation of test systems. New electrical drops, specialty gas drops, pressure relief lines, and chilled water lines will need to be installed. An increase in room ventilation may also be needed to accommodate the waste heat released by the test systems. Since this new lab space is somewhat small, rather than install the large initiation test systems in it, two existing SCC CGR test systems, which are not as tall, will be moved into the lab, and the two new systems will be installed in the existing SCC lab that has more room.

C. Travel

None.

D. Description of Estimated Encumbered Costs

Encumbered costs for this month represent items that have been ordered but not yet received. Expected receipt dates are on schedule.

E. Anticipated and Encountered Problem Areas

None.

F. Plans for the Next Reporting Period

Task 1 - Materials acquisitions will continue. The majority of the effort will be directed at obtaining useful amounts of alloy 152/52/52M welds. Inquiries will be made with KAPL for archival alloy 600 material and possibly remnant alloy 182 material. In order to assess the SCC susceptibility of the alloy 182 materials that are expected to be more resistant to SCC initiation than alloy 600, compact tension specimens will be cut from the available welds and SCC tested in two NRC owned SCC CGR test systems. The beginning steps of fabricating these specimens will take place next month.

Task 2 - The test plan letter report will be completed and submitted.

Task 3 - Design, acquisition, and laboratory modification activities will continue. Construction of test systems is not expected to start until after January 1, 2015.

Travel and Meetings - None expected.

Spending Plan

Spending Plan:

Month/Year	13-Oct	13-Nov	13-Dec	14-Jan	14-Feb	14-Mar	14-Apr	14-May	14-Jun	14-Jul	14-Aug	14-Sep
Planned ($)											100,000	580,638
Revised ($)											0	21,936
Actual ($)											0	21,936
Variance (%)											0.00%	0.00%
Month/Year	14-Oct	14-Nov	14-Dec	15-Jan	15-Feb	15-Mar	15-Apr	15-May	15-Jun	15-Jul	15-Aug	15-Sep
Planned ($)	0	0	0	60,000	60,000	50,000	40,000	30,000	20,000	15,000	15,000	14,362
Revised ($)	71,694	0	0	60,000	60,000	50,000	40,000	30,000	20,000	15,000	15,000	14,362
Actual ($)	71,694											
Variance (%)	0.00%											
TOTAL												
Planned ($)	985,000											
Revised ($)	397,992											
Actual ($)	93,630											

Variance Narrative - None.

PNNL 36 Specimen SCC Initiation Test System Purchases For the NRC Initiation Program

System/Item	Unit Cost	min # needed	extras	Total Cost	Delivery (incl	Notes
AC Internal Stucture (Supports)	$25,000.00	1		$25,000.00	12 weeks	
Counterweight system	$5,000.00	1		$5,000.00	5 weeks	
autoclave head support plate	$800.00	1		$800.00	6 weeks	
Skala support plate	$800.00	1		$800.00	6 weeks	
Load Frame	$5,000.00	1		$5,000.00	3 weeks	
glass column end plate	$250.00	2		$500.00	6 weeks	
Band Heater for preheater	$62.15	2		$124.30	3 weeks	
Watlow temperature controller for preheater	$322.00	1		$322.00	3 weeks	
Watlow temperature controller for AC blanket	$402.00	3		$1,206.00	3 weeks	
Process HX temp controller for LWRSP	$312.00	1		$312.00	3 weeks	SD8C-HFAE-AARG Discontinued
Online UPS	$1,982.53	1		$1,982.53	3 weeks	
End Link	$433.00	6		$2,598.00	10 weeks	$40,898 per system
Wide Link Specimen Holder	$589.00	18		$10,602.00	10 weeks	
Wide Link Specimen Holder	$516.00	18		$9,288.00	10 weeks	
Narrow Link Specimen Holder	$339.00	15		$5,085.00	10 weeks	
Button Head Pin with Safety Wire Hole	$110.00	90		$9,900.00	10 weeks	
Button Head Short	$125.00	18		$2,250.00	10 weeks	
loading box	$800.00	1		$800.00	10 weeks	
retainer for 3/4" Omniseal	$375.00	1		$375.00	10 weeks	
bushing pairs	$60.00	72	11	$4,980.00	4 weeks	11 extra is price of material.
Part 2 Ceramic Socket Ball					4 weeks	
Micropump (brand) micropump service kit	$254.70	3		$764.10	2 weeks	
Control Valve Spring	$4.73	5		$23.65	2 weeks	
Control Valve Poppet	$16.52	5		$82.60	2 weeks	
Control Valve Guide	$6.83	5		$34.15	2 weeks	
micropump head	$577.80	1		$577.80		
Micropump (brand) micropump	$1,043.10	1		$1,043.10	2 weeks	
demineralizer holder	$374.33	1		$374.33	2 weeks	B28 or Clarkson Laboratory
demineralizer cartridge	$88.13	1		$88.13	2 weeks	
submicron filter	$81.25	2		$162.50	2 weeks	
Tescom back pressure regulator (5-50 psi)	$975.00	1		$975.00	3 weeks	Need replacement-Possible Swagelok
Conax feedthrough - 4 hole	$116.00	1	1	$232.00	2 weeks	
Conax feedthrough - 8 hole	$173.00	3	1	$693.00	2 weeks	
Conax feedthrough - 8 hole repl. Packing	$37.00	1		$37.00	2 weeks	
Conax feedthrough - 4 hole repl. packing	$21.00	1		$21.00	2 weeks	
Ceramic (TTZ) wire sheath (4 ft)	$36.12	120		$4,334.40		28654 88.24 pf for 17ft
Brooks Sho-Rate water flow meter	$444.00	1		$444.00	3 weeks	New Vendor Redmond, Wa
rectangle carboy with spigot	$258.75	1		$258.75	1 week	
fluid injection pump motor	$731.00	1		$731.00	6 weeks	
fluid injection pump adapter kit	$32.00	1		$32.00	2 weeks	
fluid injection pump head	$515.00	1		$515.00	2 weeks	
fluid injection pump head replacement lip seal	$3.80	5		$19.00	2 weeks	
fluid injection pump head replacement gland washer	$3.80	5		$19.00	2 weeks	
DB9 to DB9 ribbon cable (Skala to PC)	$1.00	1	1	$2.00	1 week	House Electricians
custom parallel port cable	$1.00	1	1	$2.00	1 week	House Electricians
custom MUX <-> DVM interconnect	$1.00	1	1	$2.00	1 week	House Electricians
gas bubbler for mixing column	$50.00	1		$50.00	6 weeks	
solid state polarity switching modules	$1.00	1		$1.00	2 weeks	House Electricians
autoclave heating mantle	$1,420.00	3		$4,260.00	8-10 weeks	
autoclave insulating cap	$512.00	1		$512.00	8-10 weeks	
PID Coolant Temperature Controller	$1,552.00	1		$1,552.00	2 weeks	
safety head for rupture disk	$124.00	1		$124.00	2 weeks	
12 liter autoclave	$41,620.00	1		$41,620.00	12 weeks	
autoclave spare gasket kit	$215.00	4		$860.00	6 weeks	
1-1/4 Cap Screw	$99.00	8		$792.00	6 weeks	
ASME pressure qualification for autoclaves	$1,800.00	1		$1,800.00	6 weeks	only 1 cert needed
3" Swivel Stem Casters for Pulsafeeder	$5.12	4		$20.48	1 week	Ordered non-braking casters
Skala servo-electric testing system	$29,600.00	1		$29,600.00	2 weeks	
preheater body for high pressure water	$2,585.00	1		$2,585.00	5 weeks	
CW System: Grade 8 Alloy Steel Hex Head Cap Screw Zinc Yellow Pltd, 3/4"-10 Thrd, 2-1/2" L, Fully Thrd	$1.65	10		$16.50	1 week	
CW System: 3/4" - 10 SS Nut	$0.70	10		$7.00	1 week	
CW System: 300 Series SS MS35338 Split Lock Washer 3/4" Screw Size, Dash #146, 1.27" OD	$0.39	10		$3.90	1 week	
CW System: Ultra-Coated Grade 8 Steel SAE Flat Washer 3/4" Screw Size, 1-15/32" OD, .12"-.18" Thick	$0.18	20		$3.60	1 week	
CW System: Grade 8 Alloy Steel Hex Head Cap Screw Zinc Yellow- Plated, 1/4"-20 Thread, 1-1/4" Length	$0.12	25		$3.00	1 week	
CW System: Grade 8 Steel Nylon-Insert Hex Locknut Znc- Yellow Pltd, 1/4"-20 Thrd Sz, 7/16" W, 5/16" H	$0.05	25		$1.25	1 week	
CW System: Zinc & Yellow Grade 8 Steel Flat Washer SAE, 1/4" Screw Size, 5/8" OD, .05"-.08" Thick	$0.03	25		$0.75	1 week	
CW System: Type 316 Stainless Steel Heavy Hex Nut 1"-8 Thread Size, 1-5/8" Width, 63/64" Height	$7.80	1		$7.80	1 week	
CW System: Grade 8 Alloy Steel Hex Head Cap Screw Zinc Yellow- Plated, 1"-8 Thread, 8" Length	$10.50	1		$10.50	1 week	
CW System: 300 Series SS MIL Spec Flat Washer 1" Size, 2" OD, .06"-.10" Thk, NASM/MS15795-826	$0.95	4		$3.80	1 week	
3/4-10 x 1 1/2 hex bolt grade 8	$1.05	8		$8.40	1 week	
3/4-10 x 2 1/2 hex bolt stainless steel	$2.90	4		$11.60	1 week	
3/4-10 x 2 1/4 hex bolt stainless steel	$2.54	4		$10.16	1 week	
1/2"-13 x 1 1/4" SS bolts: autoclave to plate	$0.48	4		$1.92	1 week	
1/2"-13 x 2 1/4" SS bolts: Skala to plate	$0.94	3		$2.82	1 week	
3/4 flat washer f436	$0.16	16		$2.56	1 week	ASTM F436
1/2" SS washers: betw autoclave and plate	$0.26	7		$1.82	1 week	
3/4-10 hex nut stainless steel	$0.70	16		$11.20	1 week	
1/2" malleable bevel washers	$0.60	16		$9.60	2 week	
LCD monitor for PC	$192.00	1		$192.00	2 weeks	
PCI-GPIB board + one 2 meter 488 cable	$625.00	1		$625.00	2 weeks	
1 meter IEEE488 cable	$80.00	2		$160.00	5 weeks	
Crydom solid state relays for solid state switch	$75.18	4	4	$601.44	1 week	Crydom D1D40
Crydom solid state relays for power to heaters	$44.05	2	2	$176.20	1 week	SSR D2440
external power switch for Watlow controllers	$0.69	4	1	$3.45	1 week	RA911-VB-B-1-V
light socket for blanket/preheat power indicator	$8.76	4	1	$43.80	1 week	081-1310-01-303
panel mount fuse holders	$2.08	2	1	$6.24	1 week	342828
0.5 A fast acting fuses	$0.15	2	2	$0.60	1 week	312.500
12 AWG power cords for heaters (25 ft)	$47.04	5		$235.20	1 week	
18 AWG power cord for Watlows (xx ft)	$7.14	1		$7.14	1 week	17513
DCPD MUX Card replacment channel	$2.19	3		$6.57	1 week	
DCPD MUX Card replacment bank relay	$2.12	3		$6.36	1 week	
RG-174/U cable 50 ft	$92.22	1		$92.22	1 week	9239-100-10
BNC female RG-174 panel plug isolated pomona	$3.85	20		$77.00	1 week	31-318
BNC male RG-174 plug amphenol	$2.88	20		$57.60	1 week	31-315
Electronics Racks	$1,270.50	1		$1,270.50	12 weeks	
Type J TC female round panel jacks	$2.40	3	1	$9.60	1 week	
Type J 20 AWG twisted shielded TC wire 50 ft	$75.00	1		$75.00	1 week	
Type J standard size male plug w/label	$2.50	6	1	$17.50	1 week	
Type J standard size female plug w/label	$3.60	3	1	$14.40	1 week	We have plenty
Type J Inconel sheathed TCs with 18" probe	$34.00	3	1	$136.00	1 week	
low pressure gauge (60 psi)	$160.00	3		$480.00	2 weeks	
low pressure gauge (60 psi)	$145.00	1		$145.00	2 weeks	
high pressure gauge (3000 psi)	$200.00	2		$400.00	9 weeks	
Heinemann 20A breaker/switch for preheater	$34.07	2		$68.14	2 weeks	
clear lens for power indicator light	$4.70	20		$94.00	1 week	135-3237-003F
red cluster based LED indicator light	$6.56	4	1	$32.80	10 weeks	
Blacoh Sentry pulsation dampner	$1,926.00	1		$1,926.00	3 weeks	
Replacement bladder for Blacoh	$567.00	1		$567.00	1 week	
Blacoh inlet stabilizer	$573.00	1		$573.00	5 weeks	
SS tubing (oxygen service)	$3,059.75	1		$3,059.75	1 week	
custom SS switch power cable	$1.00	1	1	$2.00	1 week	House Electricians
strain relief bushings for large power cord	$1.00	5		$5.00	1 week	
strain relief bushing for small power cord	$1.00	2		$2.00	1 week	
15 or 20 terminal barrier strips	$1.00	2		$2.00	1 week	House Electricians
hookup wire	$1.00	1		$1.00	1 week	House Electricians
wire connectors	$1.00	1		$1.00	1 week	House Electricians
wire straps and holders	$1.00	1		$1.00	1 week	House Electricians
Heinemann 30A breaker/switch for blanket	$24.05	0		$0.00	2 weeks	
3/4" Omniseal	$75.67	1		$75.67	6 weeks	
glass column	$975.00	2		$1,950.00	2 weeks	
glass column gaskets	$18.00	1.5		$27.00	2 weeks	
glass column flange/coupling	$70.00	0.5		$35.00	2 weeks	
platinum wire - 0.020" (24 awg)	$82.10	60		$4,926.00	3 week	May 2014
platinum wire - 0.032" (20 awg)	$204.80	40		$8,192.00	3 week	May 2014
all Swagelok fittings (oxygen service)	$10,827.07	1		$10,827.07	3 weeks	Victoria Patterson Contact
Swagelok BPR	$551.84	1		$551.84	5 weeks	
Agilent current source	$2,293.56	1		$2,293.56	3 weeks	$8,393.16
Agilent voltmeter	$4,008.44	1		$4,008.44	2 weeks	
Agilent MUX	$1,608.16	1		$1,608.16	2 weeks	
Agilent MUX card	$483.00	1		$483.00	2 weeks	
Thornton conductivity sensor flow chamber	$268.00	5		$1,340.00	3 weeks	
Thornton conductivity sensor	$431.00	2		$862.00	3 weeks	
M300 Thornton Multiparameter	$1,678.00	1		$1,678.00	3 weeks	
M300 Multiparameter panel mount kit	$63.00	1		$63.00	3 weeks	
M300 parameter 5' patch cord	$92.00	2		$184.00	3 weeks	
Pulsafeeder pump	$6,153.90	1		$6,153.90	5 weeks	
Pulsafeeder service kit	$775.00	1		$775.00	5 weeks	
Pulsafeeder input shaft cover plate shim set	$14.00	2		$28.00	5 weeks	
Pulsalube oil #1, 1GAL (for servicing)	$53.00	2		$106.00	5 weeks	
Direct I/O to control serial port	$22.00	1		$22.00	1 week	price reduced for 4 copies
PTFE wire sheath - 24 awg - 4 ft	$13.55	9		$121.95	1 week	

COLOR CODING

Items that need configuring	Grand Tot.	$239,713.10	(price est)
Items in Process of ordering			
Quote Request Sent			
Order Place with Donna	Orders as of 11/18	$174,312.67	
Item Arrived			
Items Manufactured On Site/or GE			

MONTHLY LETTER STATUS REPORT

Reporting Period Start Date **August 23, 2014**		**Reporting Period End Date** **September 30, 2014**	
NRC Agreement Number **NRC-HQ-60-14-D-0014**	**Task Order Number (if applicable)** **N/A**		**Common Cost Center Code**
Project Title **Crack Initiation Testing for Primary Water Stress Corrosion Cracking**			
Period of Performance Start Date **August 18, 2014**		**Period of Performance End Date** October 31, 2015	
COR **Matthew Rossi**	**Telephone** **(301) 251-7646**		**E-mail** **matthew.rossi@nrc.gov**
DOE Laboratory **Pacific Northwest National Laboratory (PNNL)**			
DOE Site Address **Pacific Northwest Site Office, PO Box 350/MS K9-42, Richland, WA 99352**			
Principal Investigator **Stephen Bruemmer**	**Telephone** **(509) 371-7361**		**E-mail** **Stephen.Bruemmer@pnnl.gov**

Financial Status Section

A. Overall Funding

Current Month Cost: $21,936
Total Ceiling Amount: $ 985,000
Total Amount of Funds Obligated to Date: $649,000
Total Amount of Funds Expended to Date: $ 21,936
Percentage of Funds Expended to Date: 3%
Balance of Obligated Funds Remaining: $627,064
Total Estimated Encumbered Costs: $2,869
Balance Available Less Estimated Encumbered Costs: $624,195

B. DOE Laboratory Acquired Property

Several orders have been placed, but nothing has arrived yet.

Item*	Description	Manufacturer	Model Number	Serial Number	Acquisition Cost ($)	Receipt Date	Property Identification Number
N/A							

* Asterisk is to be used to indicate sensitive software.

C. NRC-Funded Software Developed

Nothing in this area.

Name*	Function	Development Cost ($)	Computer Language Used	Operating System	Location of System	Date Software Completed	Date of Scheduled Replacement/Useful Life
N/A							

*Asterisk is to be used to indicate sensitive software.

Technical Status Section

A. Deliverables/Milestones Schedule

Deliverable	Description	Planned Completion Date	Revised Completion Date (if applicable)	Actual Completion Date
1	Test plan will be completed and submitted to the NRC for review.	Within 3 months of the contract award	on track	
2	Two SCC initiation test systems will be designed and assembled, and test viability demonstrated.	Within 12 months of the contract award	on track	
3	A technical letter report will be submitted to the NRC detailing the test equipment and capabilities for SCC initiation experimentation.	Within one 1 month of completion of Deliverable 2	on track	

B. Progress During Reporting Period

Task 1 - Identification and Acquisition of Materials for the Test Matrix

Efforts to obtain sufficient amounts of all the necessary types of materials are underway. Desired heats of materials or weldments have already been identified with some materials already obtained. Brief notes are as follows.

Alloy 182: Goal is to obtain 4 separate alloy 182 welds, possibly obtain and assess additional welds to select "best" set of 4.

(1) PNNL/NRC Phase 2B Mockup Weld - LAS-SS DMW with alloy 182 butter and fill. Can extract 3.3 specimens/inch of arc length. 4.5" definitely available = 15 specimens. Another 5.5" potentially available. *In possession.*

(2) PNNL/Flawtech/NRC Pipe Weld Mockup - LAS-SS DMW with alloy 182 butter and fill. Can extract 0.36 specimens/deg of arc length. ~270 degrees available = ~97 specimens. *In possession.*

(3) Studsvik Weld from EPRI - 3x3x5" long linear weld. Determining specimen availability. *In possession.*

(4) KAPL Mockup Weld for PNNL - Alloy 182 joining alloy 2" tall 600 plate. Can extract 2 specimens/0.6" of length. ~8 inches available = ~25 specimens. *Available in Feb. 2015.*

(5) EPRI Mockup Weld - *Determining availability.*

Alloy 600: Goal is for 4 separate alloy heats, one of which should be a CRDM heat.

(1) PNNL Plate #1 - Special Metals Heat NX6106XK-11 (9.6x15x2" thick). Have SCC initiation data. Preparing to obtain SCC CGR data. ~300 specimens possible. *In possession.*

(2) PNNL Plate #2 - ATI Heat 521616 (6x24x2" thick). ~300 specimens possible. *In possession.*

(3) KAPL Plate - 1995 Vintage. Heat 33375-2B (4x24x2" thick). ~200 specimens possible. *Will ship as part of KAPL alloy 182 weld, so available in Feb. 2015.*

(4) Additional Plate Heats - *Can be purchased as needed. KAPL may have additional vintage material available.*

(5) Thick-Wall CRDM Tube - Several available at PNNL from unused service components. *Determining availability.*

Alloy 52M/152/52: Goal is to obtain 4 separate welds, possibly obtain and assess additional welds to select "best" set of 4.

(1) Alloy 52M Weld, 250CS at EPRI. (5x4x0.5", two pieces) - *Determining availability.*

(2) Alloy 52 Weld, Heat NX6523JK at EPRI (2x10x2", additional pieces available) - *Determining availability.*

(3) Alloy 152 MHI Weld Mockup (307380) for Kewanee. Enough at PNNL for 6 specimens in transverse orientation and 15 specimens in longitudinal orientation. *Possibly more material at GE or EPRI.*

(4) KAPL Alloy 152M V-groove dissimilar metal weld (WC83F8). Can extract 3 specimens per 0.6" of weld length. *Determining availability.*

(5) CIEMAT alloy 152 weld M864M2 from EPRI DB. (1.5x4.25x5.25") Can extract 2 initiation specimens per 0.6" of weld length. *Determining Availability.*

Alloy 690: Goal is for at least 4 separate alloy 690 heats including CRDM tubing and plate heats.

(1) Valinox Alloy 690TT CRDM Tube - Heat RE243 at PNNL. Has been SCC CGR tested. *In possession.*

(2) TK-VDM (Doosan) Alloy 690TT CRDM Bar - Heat 133454. Has been SCC CGR tested. *Determining availability.*

(3) Sumitomo Alloy 690TT CRDM Tube - Heat E67074C. Has been SCC CGR tested. *Determining availability.*

(4) Plate Materials - ATI B25K-2 and TK-VDM 114092. Have been SCC CGR tested. *Determining availability.*

(5) Additional Plate Material - EPRI NX8625HG21 Alloy 690TT (12"x12"x1.34" thick). *In possession.*

Task 2 - Develop Experimental Test Plan

Early phases of planning are underway at PNNL, and discussions are being held with NRC and EPRI staff. A key aspect of this plan will be agreeing upon a realistic number of materials, material conditions, number of test specimens, and number of test conditions for both alloy 182/600 and alloy 690/152/52 needs.

Task 3 - Design, Construction, and Validation of SCC Initiation Test Systems

These test systems will be closely based on a 36 specimen test system designed and constructed for the DOE LWRS program. This system can monitor 12 specimens for in-situ SCC initiation. The key design change underway is increasing the number of specimens that can be instrumented for in-situ detection of SCC initiation or for in-situ detection of failure. A larger diameter autoclave with more ports for wiring feedthroughs is being designed and constructed to enable this. Changes are also being made to the load line and the wiring feedthroughs to make the task of instrumenting all 36 specimens manageable.

The test systems are built in-house at PNNL using a combination of off-the-shelf and custom made parts. Each test system is constructed of over 200 unique parts from ~30 different vendors. Ordering of the parts has commenced with the longest lead time items being ordered first. While several items were ordered during this reporting period, nothing has arrived. The first items are expected to arrive next month.

Laboratory expansion for the new test systems is underway. A lab adjacent to the current SCC lab has been made available and is being prepared for installation of test systems. New electrical drops, specialty gas drops, pressure relief lines, and chilled water lines will need to be installed. An increase in room ventilation may also be needed to accommodate the waste heat released by the test systems. Since this new lab space is somewhat small, rather than install the large initiation test systems in it, four existing SCC CGR test systems, which are much smaller, will be moved into this lab, and the four new systems will be installed in the existing SCC lab that has more room.

C. Travel

None.

D. Description of Estimated Encumbered Costs

Two items that were ordered for construction of the electronics rack systems are on backorder. However, the delay is not significant and will not affect the test system construction schedule.

E. Anticipated and Encountered Problem Areas

None.

F. Plans for the Next Reporting Period

Task 1 - Materials acquisitions will continue. Several alloy 152 and alloy 52M welds are expected to be received. Analysis will be completed on determining the number of specimens that can be obtained from the Phase 2B and Studsvik alloy 182 welds. Availability of CRDM materials at PNNL will be determined. Inquiries will be made with KAPL for archival alloy 600 material and possibly remnant alloy 182 material. Requests will be made from EPRI for alloy 690/152/52 materials.

Task 2 - Discussions will continue with the NRC and EPRI with the goal of creating a first draft test plan.

Task 3 - Design, acquisition, and laboratory modification activities will continue. Construction of test systems is not expected to start until after January 1, 2015.

Travel and Meetings - None expected.

Spending Plan

Spending Plan:

Month/Year	13-Oct	13-Nov	13-Dec	14-Jan	14-Feb	14-Mar	14-Apr	14-May	14-Jun	14-Jul	14-Aug	14-Sep
Planned ($)											100,000	580,638
Revised ($)											0	
Actual ($)											0	21,936
Variance (%)											100%	96%
Month/Year	14-Oct	14-Nov	14-Dec	15-Jan	15-Feb	15-Mar	15-Apr	15-May	15-Jun	15-Jul	15-Aug	15-Sep
Planned ($)	0	0	0	60,000	60,000	50,000	40,000	30,000	20,000	15,000	15,000	14,362
Revised ($)												
Actual ($)												
Variance (%)												
TOTAL												
Planned ($)	985,000											
Revised ($)												
Actual ($)	21,936											

Variance Narrative - First funding was received on August 19. As discussed previously, to proceed with ordering parts to construct the SCC initiation test systems, the full dollar amount for any item being purchased must be available in the project. The money however, is not accrued until an item is received thus creating a time lag and the appearance of being underspent. Accrued spending is expected to catch up with the spend plan by January 2015.

Experimental Plan for the Joint NRC/EPRI Project on Crack Initiation Testing for Primary Water Stress Corrosion Cracking

S. M. Bruemmer and M. B. Toloczko
Pacific Northwest National Laboratory

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References

1. D. S. Morton, et. al., "SCC Initiation Testing of Nickel-Base Alloys in High Temperature Water," *Proc. 14th International Conference on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors*, American Nuclear Society, 2009.

2. M. B. Toloczko, M. J. Olszta, D. K. Schreiber and S. M. Bruemmer, *Stress Corrosion Crack Initiation of Alloy 600 in PWR Primary Water Environments*, Technical Milestone Report M3LW-13OR0403032, Light Water Reactor Sustainability Program, DOE Office of Nuclear Energy, March 2013.

3. M. B. Toloczko, M. J. Olszta, D. K. Schreiber and S. M. Bruemmer, *Corrosion and Stress Corrosion Crack Initiation of Cold-Worked Alloy 690 in PWR Primary Water Environments*, Technical Milestone Report M2LW-13OR0402035, Light Water Reactor Sustainability Program, DOE Office of Nuclear Energy, September 2013.

4. S. M. Bruemmer, M. J. Olszta, D. K. Schreiber and M. B. Toloczko, *Corrosion and Stress Corrosion Crack Initiation of Cold-Worked Alloy 600 and Alloy 690 in PWR Primary Water Environments*, Technical Milestone Report M2LW-13OR0402035, Light Water Reactor Sustainability Program, DOE Office of Nuclear Energy, September 2014.

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MONTHLY LETTER STATUS REPORT

Reporting Period Start Date October 25, 2014		Reporting Period End Date November 21, 2014
NRC Agreement Number NRC-HQ-60-14-D-0014	Task Order Number (if applicable) N/A	Common Cost Center Code
Project Title Crack Initiation Testing for Primary Water Stress Corrosion Cracking		
Period of Performance Start Date August 18, 2014		Period of Performance End Date October 31, 2015
COR Eric Focht	Telephone (301) 251-7649	E-mail eric.focht@nrc.gov
DOE Laboratory Pacific Northwest National Laboratory (PNNL)		
DOE Site Address Pacific Northwest Site Office, PO Box 350/MS K9-42, Richland, WA 99352		
Principal Investigator Stephen Bruemmer	Telephone (509) 371-7361	E-mail stephen.bruemmer@pnnl.gov

Financial Status Section

A. Overall Funding

Current Monthly Costs:	$55,422
Total Ceiling Amount:	$985,000
Total Amount of Funds Obligated to Date:	$850,638
Total Amount of Funds Expended to Date:	$149,052
Percentage of Funds Expended to Date:	18%
Balance of Obligated Funds Remaining:	$701,586
Total Estimated Encumbered Costs:	$189,746
Balance Available Less Estimated Encumbered Costs:	$511,840

B. DOE Laboratory Acquired Property

Only one item was received this month that was more than $5,000 as listed below. The smaller items with shorter lead times have been arriving. Many of the more expensive items will arrive in January and are expected to be costed in February. The autoclave and the load train are the two most expensive items and are not expected to arrive until the end of February.

Description*	Quantity	Manufacturer	Model Number	Serial Number(s)	Acquisition Cost ($)	Receipt Date	Property Identification Number
5K Servo Load Frame and Controller	1	Interactive Instruments	5K Servo	224	$14,500	11/10/2014	This load frame will be installed into a rack system that will have a property identification number associated with all the components in the rack. That property number will be assigned after assembly.

* Asterisk is to be used to indicate sensitive software.

C. NRC-Funded Software Developed

Nothing in this area.

Name*	Function	Development Cost ($)	Computer Language Used	Operating System	Location of System	Date Software Completed	Date of Scheduled Replacement/Useful Life
N/A							

*Asterisk is to be used to indicate sensitive software.

Technical Status Section

A. Deliverables/Milestones Schedule

Deliverable	Description	Planned Completion Date	Revised Completion Date (if applicable)	Actual Completion Date
1	Test plan will be completed and submitted to the NRC for review.	Within 3 months of the contract award	not applicable	11/19/2014
2	Two SCC initiation test systems will be designed and assembled, and test viability demonstrated.	Within 12 months of the contract award	on track	
3	A technical letter report will be submitted to the NRC detailing the test equipment and capabilities for SCC initiation experimentation.	Within one 1 month of completion of Deliverable 2	on track	

B. Progress During Reporting Period

Task 1 - Identification and Acquisition of Materials for the Test Matrix

Overview of Material Requirements

One autoclave is expected to be dedicated to alloy 600/182 tests and the other for alloy 690/152/52(x) tests. Each autoclave can hold 36 specimens. The tentative loading plan for these autoclave systems is as follows:

Alloy 600/182 autoclave

- First loading: Four heats of alloy 182. Each heat will have 6 specimens in the 15% CF condition and 3 in the as-welded condition.
- Second loading: Same four heats of alloy 182. Stress effects will be considered. Exact number of specimens for each heat of material is to-be-determined.
- Third loading: Four heats of alloy 600. Each heat will have 9 specimens in the 15% CF condition.

Alloy 690/152/52(x) autoclave

- First and only loading: Four heats of alloy 690 with 3 specimens per heat and three heats of alloy 152/52(x) with six specimens per heat. All specimens will be in the 15% CF condition.

Acquisition of Materials

Efforts to obtain sufficient amounts of all the necessary types of materials are underway. Desired heats of materials or weldments have already been identified with some materials already obtained. Brief notes are as follows.

Alloy 182 Material Acquisition: Goal is to obtain 4 separate alloy 182 welds, possibly obtain and assess additional welds to select "best" set of 4.

(1) PNNL/NRC Phase 2B Mockup Weld - LAS-SS DMW with alloy 182 butter and fill. Can extract 3.3 specimens/inch of arc length. >15" available = ~50 specimens. *In possession.*

(2) PNNL/Flawtech/NRC Pipe Weld Mockup - LAS-SS DMW with alloy 182 butter and fill. Can extract 0.36 specimens/deg of arc length. ~270 degrees available = ~97 specimens. *In possession.*

(3) Studsvik Weld from EPRI - 3x2.75x5" long linear weld. Can obtain 8 specimens/0.6" = 64 specimens. *In possession.*

(4) KAPL Mockup Weld for PNNL - Alloy 182 joining alloy 2" tall 600 plate. Can extract 2 specimens/0.6" of length. ~8 inches available = ~25 specimens. *Available in Feb. 2015.*

(5) PNNL CRDM J-Groove weld - Taken from an uncommissioned PWR. *Determining the feasibility of extracting weld material for initiation specimens.*

(6) EPRI Alloy 182 Weld - Being fabricated by WRTC (Greg Fredrick). Completion date unknown. *Determining availability.*

Alloy 600 Material Acquisition: Goal is for 4 separate alloy heats, one of which should be a CRDM heat.

(1) PNNL Plate #1 - Special Metals Heat NX6106XK-11 (9.6x15x2" thick). Have SCC initiation data. Preparing to obtain SCC CGR data. ~300 specimens possible. *In possession. Possible material for multi-lab round robin.*

(2) PNNL Plate #2 - ATI Heat 521616 (6x24x2" thick). ~300 specimens possible. *In possession. Possible material for multi-lab round robin.*

(3) PNNL Plate #3 - ATI Heat 522068 (3x18x3" thick). ~50 specimens possible

(4) KAPL Plate - 1995 Vintage. Heat 33375-2B (4x24x2" thick). ~200 specimens possible. *Will ship as part of KAPL alloy 182 weld, so it will be available in Feb. 2015.*

(5) Additional Plate Heats - *KAPL may have additional vintage material available.*

(6) CRDM Tube - A 10" long piece of a 4.15" OD x 0.70" wall CRDM tube from an uncommissioned PWR has been obtained. This is sufficient material to make 90 initiation specimens.

Alloy 52M/152/52 Material Acquisition: Goal is to obtain 4 separate welds, possibly obtain and assess additional welds to select "best" set of 4.

(1) Alloy 152 MHI Weld Mockup (307380) for Kewanee. Enough at PNNL for 6 specimens in transverse orientation and 15 specimens in longitudinal orientation. Has been SCC CGR tested in as-welded and 20% CF condition. ***None at EPRI. Possibly more material at GE. Investigating.***

(2) KAPL Alloy 152M V-groove dissimilar metal weld (WC83F8). Can extract 3 specimens per 0.6" of weld length. Has been SCC CGR tested. ***No longer available.***

(3) KAPL Alloy 52M narrow gap weld (NX5285TK). Has been SCC CGR tested. ***Enough at PNNL for 6 specimens. No other additional material available.***

(4) Alloy 52i heat 187775 V-groove weldment received from EPRI (1 piece 1.75" long). Not previously tested. Enough at PNNL for 9 specimens.

(5) ENSA Divider Plate Mockup Alloy 52 DM Weld from EPRI DB. Alloy 52M butter and alloy 52 fill. SCC CGR testing of alloy 52 fill is underway. Enough for at least 20 specimens each from alloy 52M butter and alloy 52 fill.

(6) Alloy 52MSS. Obtained from NRC. Has been SCC tested. Enough at PNNL for 18 specimens.

(7) EPRI Alloy 52/152 weld. *Determining availability.* ***EPRI is still pursuing this. ETA not yet provided.***

Alloy 690 Material Acquisition: Goal is for at least 4 separate alloy 690 heats including CRDM tubing and plate heats.

(1) Valinox Alloy 690TT CRDM Tube Heat RE243 at PNNL. Has been SCC CGR tested in as-received and several different CW conditions. *Enough for >20 specimens.*

(2) Valinox Alloy 690TT CRDM Tube. Other heats at PNNL. Has been tested in as-received condition. *Enough for >20 specimens.*

(3) TK-VDM (Doosan) Alloy 690TT CRDM Bar Heat 133454. Has been SCC CGR tested in as-received and CW conditions. *Enough for 12 specimens.*

(4) Sumitomo Alloy 690TT CRDM Tube Heat E67074C. Has been SCC CGR tested in as-received and CW conditions. *Determining availability from EPRI.* ***Likely unavailable.***

(5) TK-VDM 114092 Plate Material - Has been SCC CGR tested in as-received and CW conditions. *Enough for >20 specimens.*

(6) ATI/Allvac B25K-2 Plate Material. Has been SCC CGR tested in as-received and CW conditions. Have obtained enough from GE to make >20 specimens.

(7) Additional Plate Material - EPRI NX8625HG21 Alloy 690TT (12"x12"x1.34" thick). *In possession. Has not been SCC tested at PNNL.*

Dissimilar Metal Welds: Of possible interest to the NRC

(1) PNNL/NRC Phase 2B Mockup Weld - LAS-SS DMW with alloy 182 butter and fill. Can extract 3.3 specimens/inch of arc length. 5.5" available for DMW dilution zone studies = 18 specimens. *In possession.*

(2) ENSA Divider Plate Alloy 52 DMW Mockup - LAS-690 DMW with alloy 52M butter and fill. *Determining availability.*

<u>Forging of Materials</u>

Roughly 45 blocks need to be prepared and forged for this program. Rather than preparing all the blocks and then having them all forged at once, the work is being broken down in to smaller overlapping groups. It is anticipated that three rounds of preparation and forging will be required to obtain sufficient material for all the specimens that are needed. Preparation for the first round of forging is underway. The following materials are being cut into blocks that will then forged to 15% reduction:

Alloy 182 Specimen Preparation

(1) PNNL/NRC Phase 2B Mockup Weld - 6 cold-forged specimens are needed for first round of initiation testing and 2-3 needed to determine yield strength. Two blocks are being prepared. This is sufficient material.

(2) PNNL/Flawtech/NRC Pipe Weld Mockup - 6 cold-forged specimens are needed for first round of initiation testing and 2-3 needed to determine yield strength. Two blocks are being prepared. This is sufficient material.

(3) Studsvik Weld from EPRI - 6 cold-forged specimens are needed for first round of initiation testing and 2-3 needed to determine yield strength. Two blocks are being prepared. This is sufficient material.

(4) KAPL Mockup Weld for PNNL - *Available in Feb. 2015. Forging preparations not yet started.*

(5) PNNL CRDM J-Groove weld - *Determining the feasibility of extracting weld material for initiation specimens.*

(6) EPRI Alloy 182 Weld - *Determining availability of this weldment.*

Alloy 600 Specimen Preparation

(1) PNNL Plate #1 (Special Metals Heat NX6106XK-11) - 9 cold-forged specimens are needed for initiation testing, 2-3 are needed to determine yield strength, and one CT specimen is needed for SCC CGR characterization. Three blocks are being prepared. This is sufficient material for all these specimens.

(2) PNNL Plate #2 (ATI Heat 521616) - 9 cold-forged specimens are needed for initiation testing, 2-3 are needed to determine yield strength, and one CT specimen is needed for SCC CGR characterization. Three blocks are being prepared. This is sufficient material for all these specimens.

(3) PNNL Plate #3 (ATI Heat 522068) - *No action taken yet.*

(4) KAPL Plate (Heat 33375-2B, 1995 vintage) - *Will be available in Feb. 2015. No action taken yet.*

(5) Additional Plate Heats - *No action taken yet.*

(6) PNNL CRDM Tube - *No action taken yet.*

Alloy 52M/152/52 Specimen Preparation

(1) Alloy 152 MHI Weld Mockup (307380) for Kewanee - *No action taken yet.*

(2) KAPL Alloy 152M V-groove dissimilar metal weld (WC83F8). ***No longer available.***

(3) KAPL Alloy 52M narrow gap weld (NX5285TK) - *No action taken yet.*

(4) Alloy 52i heat 187775 V-groove weldment received from EPRI - 6 cold-forged specimens are needed for the first round of initiation testing, 2-3 are needed to determine yield strength. One block is being prepared. Another block is needed.

(5) ENSA Divider Plate Mockup Alloy 52 DM Weld from EPRI DB - 6 cold-forged specimens are needed for the first round of initiation testing, 2-3 are needed to determine yield strength. One block is being prepared. Another block is needed.

(6) Alloy 52MSS obtained from the NRC - *No action taken yet.*

(7) EPRI Alloy 52/152 weld - *Determining availability. No action taken yet.*

Alloy 690 Specimen Preparation

(1) Valinox Alloy 690TT CRDM Tube Heat RE243 at PNNL - 3 cold-forged specimens are needed for initiation testing, 2-3 are needed to determine yield strength. Two blocks are being prepared. This is sufficient for all the required specimens.

(2) Valinox Alloy 690TT CRDM Tube - 3 cold-forged specimens are needed for initiation testing, 2-3 are needed to determine yield strength. Two blocks are being prepared. This is sufficient for all the required specimens.

(3) TK-VDM (Doosan) Alloy 690TT CRDM Bar Heat 133454 - 3 cold-forged specimens are needed for initiation testing, 2-3 are needed to determine yield strength. One block is being prepared and another is needed.

(4) Sumitomo Alloy 690TT CRDM Tube Heat E67074C - *Likely unavailable. No action taken yet.*

(5) TK-VDM 114092 Plate Material - *No action taken yet.*

(6) ATI/Allvac B25K-2 Plate Material - 3 cold-forged specimens are needed for initiation testing, 2-3 are needed to determine yield strength. Two blocks are being prepared. This is sufficient for all the required specimens.

(7) Additional Plate Material - *No action taken yet.*

Material Characterizations

0.5T compact tension specimens are currently being machined from as-welded Phase 2B, Flawtech, and Studsvik alloy 182 material. The expectation is that these CT specimens will received back from the machine shop by the end of December and that SCC testing will begin by mid-January. The plan is to test two specimens in tandem and one specimen by itself.

SCC CGR tests may also be performed on the cold-forged alloy 182 material to gauge the increase in SCC initiation susceptibility.

Task 2 - Develop Experimental Test Plan

A suggested test plan was completed and submitted on time.

Task 3 - Design, Construction, and Validation of SCC Initiation Test Systems

These test systems will be closely based on a 36 tensile specimen test system designed and constructed for the DOE-NE LWRS program. The DOE-NE LWRS system can monitor 12 specimens for in-situ SCC initiation. The key design change underway is increasing the number of specimens that can be instrumented for in-situ detection of SCC initiation or for in-situ detection of failure. A larger diameter autoclave with more ports for wiring feedthroughs is being designed and constructed to enable this. Changes are also being made to the load line and the wiring feedthroughs to make the task of instrumenting all 36 specimens potentially manageable.

The test systems are built in-house at PNNL using a combination of off-the-shelf and custom-made parts. Each test system is constructed of ~140 unique parts from ~30 different vendors. A spreadsheet showing the status of all items needed to build the test system is attached at the end of this document. Ordering of the parts continued this month with the longest lead time items being ordered first.

Laboratory expansion for the new test systems is underway. A lab adjacent to the current SCC lab has been made available and is being prepared for installation of test systems. New electrical drops, specialty gas drops, pressure relief lines, and chilled water lines will need to be installed. An increase in room ventilation may also be needed to accommodate the waste heat released by the test systems. Since this new lab space is somewhat small, rather than install the large initiation test systems in it, two existing SCC CGR test systems, which are not as tall, will be moved into the lab, and the two new systems will be installed in the existing SCC lab that has more room.

As of 11/21/2014, approximately 95% of test system components have been ordered and roughly 70% of those components have been procured. Several large orders have arrived in the past month. These include hardware for the counterweight system, load frame materials, stainless steel tubing, glass columns for the mixing loop, the high pressure Pulsafeeder pumps, and 1 of the 2 servo electric load frames.

Assembly of the test systems is in the early stages with the initial work orders into crafts services for fabrication of several items. Fabrication of heater controllers for the electronics rack (to control heating and cooling of the preheater, autoclave, and building chilled water) is already underway. The carpenters and millwrights have work orders to construct the waterboards and the unistrut stands. These are the support for the glass column, filtration, and mixing loop. Millwrights and welders will also handle the load frame fabrication and painting. These three work orders are expected to be completed by the end of January.

In order to begin the second phase of test system assembly, three of the existing SCC test systems in the current lab space will have to be moved out of the way and ideally into the new lab space being constructed adjacent to the existing one. If the new space is not complete, it may be necessary to either delay assembly of the new SCC initiation test systems, or move the existing SCC test systems into temporary storage while the new lab space is being constructed. Discussion with NRC project managers may be needed to determine the appropriate action.

The second phase of test system assembly will include having the pipefitters install the stainless steel tubing, filtration equipment, and glass columns on to each water board. This will be followed by installation of the Pulsafeeder pumps. Research staff, with assistance from crafts support, will install the autoclaves and servo electric load frame in the test frames. Research staff will also finish installing the electronics into each electronics rack. The goal for completing the second phase is late March.

The final stages of assembly will include installation of the load train, installation of the DCPD wiring, and making all the connections from the electronics rack to either the test frame or waterboard. Each system will then be ready to shakedown testing. Activities were will include leak-checking of all stainless steel connections, programming the heater and chilled water controllers, loading autoclave with dummy specimens, heating autoclave and preheater up to operating temperatures, and checking the servo-electric load frame and DCPD system for proper operation. These steps to completion of assembly are summarized in Table 1.

Table 1. Timeline for assembly of the SCC initiation test systems.

Activity	Planned Start	Actual Start	Planned Completion	Actual Completion	Comments
Order Parts Components	9/1/14	9/1/14	12/31/14		On schedule
Phase 1 System Assembly	12/1/14	12/1/14	1/31/15		Just started
Lab Mods	2/1/15		3/1/15		
Phase 2 System Assembly	1/31/15-3/1/15		4/1/15		
Final System Assembly	4/1/15		5/1/15		
Shakedown Testing	5/1/15		6/10/15		
First Project Test Setup	6/10/15		7/1/15		
First SCC Initiation Tests	7/1/15		1/1/16		

C. Travel

None.

D. Description of Estimated Encumbered Costs

Encumbered costs for this month represent items that have been ordered but not yet received. Expected receipt dates are on schedule.

E. Anticipated and Encountered Problem Areas

None.

F. Plans for the Next Reporting Period

Task 1 - Materials acquisitions and forging will continue. The majority of the acquisition activities will be directed at obtaining useful amounts of alloy 152/52/52M welds. Inquiries will be made with GEG and EPRI about additional materials. The first round of blocks are expected to be sent to GEG for forging.

Task 2 - Complete.

Task 3 - Design, acquisition, and laboratory modification activities will continue. Construction of test systems is not expected to start until after January 1, 2015.

Travel and Meetings - Mychailo Toloczko will attend the EPRI PWSCC Collaboration Meeting in Tampa, FL to present and discuss the NRC/EPRI SCC Initiation test plan.

Spending Plan

Please note the below spend plan has been revised to better reflect anticipated spending.

Spending Plan:

Month/Year	13-Oct	13-Nov	13-Dec	14-Jan	14-Feb	14-Mar	14-Apr	14-May	14-Jun	14-Jul	14-Aug	14-Sep
Planned ($)											100,000	580,638
Revised ($)											0	21,936
Actual ($)											0	21,936
Variance (%)											0.00%	0.00%
Month/Year	14-Oct	14-Nov	14-Dec	15-Jan	15-Feb	15-Mar	15-Apr	15-May	15-Jun	15-Jul	15-Aug	15-Sep
Planned ($)	0	0	0	60,000	60,000	50,000	40,000	30,000	20,000	15,000	15,000	14,362
Revised ($)	71,694	55,422	130,000	100,000	120,000	120,000	100,000	80,000	60,000	50,000	40,000	35,948
Actual ($)	71,694	55,422										
Variance (%)	0.00%	0.00%										
TOTAL												
Planned ($)	985,000											
Revised ($)	985,000											
Actual ($)	149,052											

Variance Narrative - None.

PNNL 36 Specimen Initiation Test System Purchaces for the NRC Initiation Program

System/Item	Unit Cost	min # needed	extras	Total Cost	Delivery (incl shipping)
AC Internal Stucture (Supports)	$25,000.00	1		$25,000.00	12 weeks
Counterweight system	$5,000.00	1		$5,000.00	5 weeks
autoclave head support plate	$800.00	1		$800.00	6 weeks
Skala support plate	$800.00	1		$800.00	8 weeks
Load Frame	$5,000.00	1		$5,000.00	3 weeks
glass column end plate	$250.00	2		$500.00	6 weeks
Band Heater for preheater	$62.15	2		$124.30	3 weeks
Watlow temperature controller for preheater	$322.00	1		$322.00	3 weeks
Watlow temperature controller for AC blanket	$402.00	3		$1,206.00	3 weeks
Process HX temp controller for LWRSP	$312.00	1		$312.00	3 weeks
Online UPS	$865.99	1		$865.99	2 weeks
Online UPS	$194.25	1		$194.25	2 weeks
End Link	$433.00	6		$2,598.00	10 weeks
Wide Link Specimen Holder	$589.00	18		$10,602.00	10 weeks
Wide Link Specimen Holder	$516.00	18		$9,288.00	10 weeks
Narrow Link Specimen Holder	$339.00	15		$5,085.00	10 weeks
Button Head Pin with Safety Wire Hole	$110.00	90		$9,900.00	10 weeks
Button Head Shim	$125.00	18		$2,250.00	10 weeks
loading box	$800.00	1		$800.00	10 weeks
retainer for 3/4" Omniseal	$375.00	1		$375.00	10 weeks
bushing pairs	$60.00	72	11	$4,980.00	4 weeks
Part 2 Ceramic Socket Ball	$800.00	6		$4,800.00	4 weeks
Micropump (brand) micropump service kit	$254.70	3		$764.10	2 weeks
Control Valve Spring	$4.73	5		$23.65	2 weeks
Control Valve Poppet	$16.52	5		$82.60	2 weeks
Control Valve Guide	$6.83	5		$34.15	2 weeks
micropump head	$577.80	1		$577.80	2 weeks
Micropump (brand) micropump	$1,043.10	1		$1,043.10	2 weeks
demineralizer holder	$374.33	1		$374.33	2 weeks
demineralizer cartridge	$88.13	1		$88.13	2 weeks
submicron filter	$81.25	2		$162.50	2 weeks
Tescom back pressure regulator (5-50 psi)	$975.00	1		$975.00	3 weeks
Conax feedthrough - 4 hole	$116.00	1	1	$232.00	2 weeks
Conax feedthrough - 8 hole	$173.00	3	1	$692.00	2 weeks
Conax feedthrough - 8 hole repl. Packing	$37.00	1		$37.00	2 weeks
Conax feedthrough - 4 hole repl. packing	$21.00	1		$21.00	2 weeks
Ceramic (TTZ) wire sheath (4 ft)	$36.12	120		$4,334.40	8 weeks
Brooks Sho-Rate water flow meter	$444.00	1		$444.00	3 weeks
rectangle carboy with spigot	$258.75	1		$258.75	1 week
fluid injection pump motor	$731.00	1		$731.00	6 weeks
fluid injection pump adapter kit	$32.00	1		$32.00	2 weeks
fluid injection pump head	$515.00	1		$515.00	2 weeks
fluid injection pump head replacement lip seal	$3.80	5		$19.00	2 weeks
fluid injection pump head replacement gland washer	$3.80	5		$19.00	2 weeks
DB9 to DB9 ribbon cable (Skala to PC)	$1.00	1	1	$2.00	1 week
custom parallel port cable	$1.00	1	1	$2.00	1 week
custom MUX <-> DVM interconnect	$1.00	1	1	$2.00	1 week
gas bubbler for mixing column	$50.00	1		$50.00	6 weeks
solid state polarity switching modules	$1.00	1		$1.00	2 weeks
autoclave heating mantle	$1,420.00	3		$4,260.00	8-10 weeks
autoclave insulating cap	$512.00	1		$512.00	8-10 weeks
PID Coolant Temperature Controller	$1,552.00	1		$1,552.00	2 weeks
safety head for rupture disk	$124.00	1		$124.00	2 weeks
12 liter autoclave	$41,620.00	1		$41,570.00	12 weeks
autoclave spare gasket kit	$215.00	4		$860.00	6 weeks
1-1/4 Cap Screw	$99.00	8		$792.00	6 weeks
ASME pressure qualification for autoclaves	$1,800.00	1		$1,800.00	6 weeks
3" Swivel Stem Casters for Pulsafeeder	$5.12	4		$20.48	1 week
Skala servo-electric testing system	$29,600.00	1		$29,600.00	2 weeks
preheater body for high pressure water	$2,585.00	1		$2,585.00	5 weeks
CW System: Grade 8 Alloy Steel Hex Head Cap Screw Zinc Yellow Pltd, 3/4"-10 Thrd, 2-1/2" L, Fully Thrd	$1.65	10		$16.50	1 week
CW System: 3/4" - 10 SS Nut	$0.70	10		$7.00	1 week
CW System: 300 Series SS MS35338 Split Lock Washer 3/4" Screw Size, Dash #146, 1.27" OD	$0.39	10		$3.90	1 week
CW System: Ultra-Coated Grade 8 Steel SAE Flat Washer 3/4" Screw Size, 1-15/32" OD, .12"-.18" Thick	$0.18	20		$3.60	1 week
CW System: Grade 8 Alloy Steel Hex Head Cap Screw Zinc Yellow- Plated, 1/4"-20 Thread, 1-1/4" Length	$0.12	25		$3.00	1 week
CW System: Grade 8 Steel Nylon-Insert Hex Locknut Znc- Yellow Pltd, 1/4"-20 Thrd Sz, 7/16" W, 5/16" H	$0.05	25		$1.25	1 week
CW System: Zinc & Yellow Grade 8 Steel Flat Washer SAE, 1/4" Screw Size, 5/8" OD, .05"-.08" Thick	$0.03	25		$0.75	1 week
CW System: Type 316 Stainless Steel Heavy Hex Nut 1"-8 Thread Size, 1-5/8" Width, 63/64" Height	$7.80	1		$7.80	1 week
CW System: Grade 8 Alloy Steel Hex Head Cap Screw Zinc Yellow- Plated, 1"-8 Thread, 8" Length	$10.50	1		$10.50	1 week
CW System: 300 Series SS MIL Spec Flat Washer 1" Size, 2" OD, .06"-.10" Thk, NASM/MS15795-826	$0.95	4		$3.80	1 week
3/4-10 x 1 1/2 hex bolt grade 8	$1.05	8		$8.40	1 week
3/4-10 x 2 1/2 hex bolt stainless steel	$2.90	4		$11.60	1 week
3/4-10 x 2 1/4 hex bolt stainless steel	$2.54	4		$10.16	1 week
1/2"-13 x 1 1/4" SS bolts: autoclave to plate	$0.48	4		$1.92	1 week
1/2"-13 x 2 1/4" SS bolts: Skala to plate	$0.94	3		$2.82	1 week
3/4 flat washer f436	$0.16	16		$2.56	1 week
1/2" SS washers: betw autoclave and plate	$0.26	7		$1.82	1 week
3/4-10 hex nut stainless steel	$0.70	16		$11.20	1 week
1/2" malleable bevel washers	$0.60	16		$9.60	2 week
LCD monitor for PC	$192.00	1		$192.00	2 weeks
PCI-GPIB board + one 2 meter 488 cable	$625.00	1		$625.00	2 weeks
1 meter IEEE488 cable	$80.00	2		$160.00	5 weeks
Crydom solid state relays for solid state switch	$75.18	4	4	$601.44	1 week
Crydom solid state relays for power to heaters	$44.05	2	2	$176.20	1 week
external power switch for Watlow controllers	$0.69	4	1	$3.45	1 week
light socket for blanket/preheat power indicator	$8.76	4	1	$43.80	1 week
panel mount fuse holders	$2.08	2	1	$6.24	1 week
0.5 A fast acting fuses	$0.15	2	2	$0.60	1 week
12 AWG power cords for heaters (25 ft)	$47.04	5		$235.20	1 week
18 AWG power cord for Watlows (xx ft)	$7.14	1		$7.14	1 week
DCPD MUX Card replacment channel	$2.19	3		$6.57	1 week
DCPD MUX Card replacment bank relay	$2.12	3		$6.36	1 week
RG-174/U cable 50 ft	$92.22	1		$92.22	1 week
BNC female RG-174 panel plug isolated pomena	$3.85	20		$77.00	1 week
BNC male RG-174 plug amphenol	$2.88	20		$57.60	1 week
Electronics Racks	$1,270.50	1		$1,270.50	12 weeks
Type J TC female round panel jacks	$2.40	3	1	$9.60	1 week
Type J 20 AWG twisted shielded TC wire 50 ft	$75.00	1		$75.00	1 week
Type J standard size male plug w/label	$2.50	6	1	$17.50	1 week
Type J standard size female plug w/label	$3.60	3	1	$14.40	1 week
Type J Inconel sheathed TCs with 18" probe	$34.00	3	1	$136.00	1 week
low pressure gauge (60 psi)	$160.00	3		$480.00	2 weeks
low pressure gauge (60 psi)	$145.00	1		$145.00	2 weeks
high pressure gauge (3000 psi)	$200.00	2		$400.00	9 weeks
Heinemann 20A breaker/switch for preheater	$34.07	2		$68.14	2 weeks
clear lens for power indicator light	$4.70	20		$94.00	1 week
red cluster based LED indicator light	$6.56	4	1	$32.80	10 weeks
Blacoh Sentry pulsation dampner	$1,926.00	1		$1,926.00	3 weeks
Replacement bladder for Blacoh	$567.00	1		$567.00	1 week
Blacoh inlet stabilizer	$573.00	1		$573.00	5 weeks
SS tubing (oxygen service)	$3,059.75	1		$3,059.75	1 week
custom SS switch power cable	$1.00	1	1	$2.00	1 week
strain relief bushings for large power cord	$1.00	5		$5.00	1 week
strain relief bushing for small power cord	$1.00	2		$2.00	1 week
15 or 20 terminal barrier strips	$1.00	2		$2.00	1 week
hookup wire	$1.00	1		$1.00	1 week
wire connectors	$1.00	1		$1.00	1 week
wire straps and holders	$1.00	1		$1.00	1 week
Heinemann 30A breaker/switch for blanket	$24.05	0		$0.00	2 weeks
3/4" Omniseal	$75.67	1		$75.67	6 weeks
glass column	$975.00	2		$1,950.00	2 weeks
glass column gaskets	$18.00	1.5		$27.00	2 weeks
glass column flange/coupling	$70.00	0.5		$35.00	2 weeks
platinum wire - 0.020" (24 awg)	$82.10	60		$4,926.00	3 week
platinum wire - 0.032" (20 awg)	$204.80	40		$8,192.00	3 week
all Swagelok fittings (oxygen service)	$10,827.07	1		$10,827.07	3 weeks
Swagelok BPR	$551.84	1		$551.84	5 weeks
Agilent current source	$2,293.56	1		$2,293.56	3 weeks
Agilent voltmeter	$4,008.44	1		$4,008.44	2 weeks
Agilent MUX	$1,608.16	1		$1,608.16	2 weeks
Agilent MUX card	$483.00	1		$483.00	2 weeks
Thornton conductivity sensor flow chamber	$268.00	5		$1,340.00	3 weeks
Thornton conductivity sensor	$431.00	2		$862.00	3 weeks
M300 Thornton Multiparameter	$1,678.00	1		$1,678.00	3 weeks
M300 Multiparameter panel mount kit	$63.00	1		$63.00	3 weeks
M300 parameter 5' patch cord	$92.00	2		$184.00	3 weeks
Pulsafeeder pump	$6,153.90	1		$6,153.90	5 weeks
Pulsafeeder service kit	$775.00	1		$775.00	5 weeks
Pulsafeeder input shaft cover plate shim set	$14.00	2		$28.00	5 weeks
Pulsalube oil #1, 1GAL (for servicing)	$53.00	2		$106.00	5 weeks
Direct I/O to control serial port	$22.00	1		$22.00	1 week
PTFE wire sheath - 24 awg - 4 ft	$13.55	9		$121.95	1 week

COLOR CODING
Items that need configuring
Items in Process of ordering
Quote Request Sent
Order Placed
Item Arrived
Items Manufactured On Site/or GE

Grand Tot. $243,648.81 (price est)

Orders as of 12/18: $186,584.41 (~17% burden)

Statement of Work

<table>
<tr><td colspan="3">NRC Agreement Number

NRC-HQ-60-14-D-0014</td><td colspan="3">NRC Agreement Modification Number</td><td colspan="3">NRC Task Order Number (If Applicable)</td><td colspan="3">NRC Task Order Modification Number (If Applicable)</td></tr>
<tr><td colspan="12">Project Title

Crack Initiation Testing for Primary Water Stress Corrosion Cracking</td></tr>
<tr><td colspan="4">Job Code Number</td><td colspan="4">B&R Number</td><td colspan="4">DOE Laboratory

PNNL</td></tr>
<tr><td colspan="12">NRC Requisitioning Office

Office of Nuclear Regulatory Research</td></tr>
<tr><td colspan="6">NRC Form 187, Contract Security and Classification Requirements

☐ Applicable

☒ Not Applicable</td><td colspan="6">☐ Involves Proprietary Information

☐ Involves Sensitive Unclassified</td></tr>
<tr><td colspan="6">☒ Non Fee-Recoverable</td><td colspan="6">☐ Fee-Recoverable (If checked, complete all applicable sections below)</td></tr>
<tr><td colspan="6">Docket Number (If Fee-Recoverable/Applicable)</td><td colspan="6">Inspection Report Number (If Fee Recoverable/Applicable)</td></tr>
<tr><td colspan="6">Technical Assignment Control Number (If Fee-Recoverable/Applicable)</td><td colspan="6">Technical Assignment Control Number Description (If Fee-Recoverable/Applicable)</td></tr>
</table>

1. Background

The purpose of this project is to obtain crack initiation data for reactor component nickel based alloys by establishing a testing program at Pacific Northwest National Laboratory (PNNL). PNNL performs primary water stress corrosion crack (PWSCC) growth rate tests under contract to NRC and, over a number of years, has established a strong knowledge base and a high level of technical experimental and analytical capability. PNNL also conducts PWSCC initiation testing under the sponsorship of the Department of Energy's (DOE's) Light Water Reactor Sustainability Research (LWRS). This research will build upon these already established efforts.

Primary water stress corrosion cracking (PWSCC) can occur in nickel-based alloy components in pressurized water reactors (PWRs) at locations such as dissimilar metal welds that join stainless and low-alloy steel control rod drive mechanism penetrations in the reactor pressure vessel upper head, and at instrument penetrations in the lower head. In the U.S., PWSCC has led to coolant leakage at V.C. Summer (2000), Arkansas Nuclear One Unit 1 (2001), Davis Besse (2002), and Wolf Creek (2006), among others. Many plants have systematically replaced components fabricated from the nickel-based Alloy 600 and Alloy 82 or 182 weld metals with higher chromium-content alloys, which are considered to be more resistant to PWSCC, particularly Alloy 690 and variants of Alloy 52 and 152 weld metals.

The evolution of PWSCC can be divided into periods of initiation and propagation. During the initiation period, processes such as the rupture of passive oxide film and internal (grain boundary) oxidation serve as precursors to the formation of macroscopically stable cracks. During the propagation period, the crack growth is affected by the electro chemical and mechanical (stress-related) interactions. While the initiation period may be much longer than the propagation period for a plant component, most NRC research to date has focused on crack propagation because staff assumes the presence of a postulated initial flaw to evaluate relief requests and to develop regulatory technical bases for inspection frequencies. Probabilistic approaches incorporating consideration of PWSCC initiation, such as EPRI MRP-105 and MRP-113, were reviewed by the NRC staff and were not accepted. To better understand the process of crack initiation, several organizations, including the DOE, Knolls Atomic Power Laboratory (KAPL), and international groups have pursued more robust initiation testing programs, but data are still limited and have not led to well-supported analytical models that could be used to predict the time to crack initiation after a component enters service.

The development of the Extremely Low Probability of Rupture (xLPR) computational code by NRC and the Electric Power Research Institute, however, has highlighted the need for additional data to support model assumptions. Data may also support the technical bases for new inspection requirements for nickel-based alloy components. The NRC is seeking testing plans and equipment (destructive and nondestructive examination) capable of producing viable (as defined by reproducibility, and the identification and/or establishment of accuracy, precision,

and bias) data to further develop xLPR. This data may include, but is not limited to, effects of cold work; effects of the dilution zone of alloying element; and, the effects of surface morphology on crack initiation time distribution.

PNNL Response:

Primary water stress corrosion cracking (PWSCC) can occur in nickel-base alloy components in pressurized water reactors (PWRs) at locations such as dissimilar metal welds that join stainless and low-alloy steel control rod drive mechanism penetrations in the reactor pressure vessel upper head, and at instrument penetrations in the lower head. PWSCC has led to coolant leakage at V.C. Summer (2000), Arkansas Nuclear One Unit 1 (2001), Davis Besse (2002), and Wolf Creek (2006), among others in the U.S. Many plants have replaced components fabricated from the nickel-base Alloy 600 and Alloy 82/182 weld metals with higher chromium-content alloys, which are considered to be more resistant to PWSCC, particularly Alloy 690 and variants of Alloy 52/152 weld metals.

The evolution of PWSCC can be divided into periods of crack initiation and growth. During the initiation period, processes such as the rupture of the protective oxide film and grain boundary oxidation can serve as precursors to the formation of stable, propagating stress corrosion cracks. While the initiation period may be much longer than the growth period for a plant component, most NRC research to date has focused on crack propagation because a postulated initial flaw is assumed to be present to evaluate relief requests and to develop the regulatory technical basis for inspection frequencies. Probabilistic approaches incorporating consideration of PWSCC initiation, such as EPRI MRP-105 and MRP-113, were reviewed by the NRC staff and were not accepted. To better understand the process of SCC initiation, several organizations including the Knolls Atomic Power Laboratory (KAPL), Pacific Northwest National Laboratory (PNNL) and international groups have pursued more robust initiation testing programs. However, data are still limited and have not led to well-supported analytical models that could be used to effectively predict the time to SCC initiation after a component enters service.

The development of the Extremely Low Probability of Rupture (xLPR) computational code by the NRC and the Electric Power Research Institute (EPRI) has highlighted the need for SCC initiation data in addition to the better-established SCC growth response to support model assumptions. More detailed and reproducible SCC initiation data on Alloy 600/82/182 and Alloy 690/152/52 materials may also support the technical basis for new inspection requirements for nickel-base alloy components. In order to meet this testing need, the ability to establish reproducible and statistically valid SCC initiation data is required using high-temperature autoclave systems where crack nucleation in a large number of actively loaded specimens can be detected in situ. The current proposal addresses this critical first step to construct state-of-the-art, SCC initiation test systems, and the development of a detailed experimental test plan including selection of nickel-base alloys in well-controlled material conditions.

2. Relationships to Other Projects

Several projects led by the proposal principal investigators are underway at PNNL that deal directly with PWSCC mechanistic and applied issues for nickel-base alloys. To some degree, each of these projects will provide key knowledge to support the new research and support a common general objective. However, information from these projects is not required to accomplish the proposed new research. A brief summary of these related projects is given below.

Stress Corrosion Crack Initiation of Nickel-Base Alloys in LWR Environments, DOE Office of Nuclear Energy, Light Water Reactor Sustainability Program, 2009 - current

The focus of the work is to identify mechanisms controlling IGSCC nucleation in nickel-base alloys under PWR primary water conditions. Research is investigating important material (composition, processing and microstructure) and environmental (water chemistry, temperature and electrochemical potential) effects on the SCC initiation. Of particular importance to the proposed work has been the design, development and operation of state-of-the-art test systems. In addition, SCC initiation experiments have been performed or are underway on alloy 600 and alloy 690 materials of direct interest to the new research.

Primary Water Stress Corrosion Cracking of High-Chromium Nickel-Base Alloys, NRC Office of Nuclear Regulatory Research, 2010 - current

The objective of this program is to obtain crack-growth-rate data to evaluate the PWSCC susceptibility of high-chromium, nickel-base Alloy 690 and its Alloy 152/52 weld metals and determine the relationship between PWSCC susceptibility and metallurgical characteristics. As a result, a unique collection of Alloy 690/152/52 materials have been examined and PWSCC response has been established in various conditions including isolating the influence of cold work on SCC growth rates. It is expected that many of these materials will be represented in the SCC initiation test matrix for the proposed project.

Mechanisms of Environment-Assisted Degradation in Reactor Materials, Rolls Royce, 2006 - current

The focus of this research is to investigate mechanisms controlling the degradation and cracking of iron- and nickel-base alloys in high-temperature, LWR environments and help establish an improved basis for the interpretation of stress corrosion crack initiation and growth processes. Collaborative research has been performed over the last several years with the DOE and NRC projects described above, in particular high-resolution characterization of intergranular attack in Alloy 600 and electron backscatter diffraction measurements of strain evolution in cold-worked Alloy 690 materials. These results and ongoing examinations will provide important microstructural information on materials as part of the SCC initiation test matrix for the proposed project.

3. Objective of Proposed Work

The objective of this program is to obtain PWSCC initiation data for reactor component nickel-based alloys, including Alloys 600/82/182 and Alloys 690/52/152. The data will support the development of the xLPR code and the technical bases for formulating inservice inspection requirements of nickel-based alloys.

PNNL Response:

The long-term objective of this program is to obtain PWSCC initiation data for reactor component nickel-base alloys including Alloy 600/182 and Alloy 690/52/152 materials. This data will support the development of the xLPR code and the technical basis for formulating in-service inspection requirements. The first stage of the work proposed here focuses on the development of an experimental test plan and construction of two SCC initiation test systems.

4. Scope of Work

PNNL shall be responsible for submitting a plan for designing the experimental apparatus and test plan; procuring necessary materials and components, including dedicated data capture and analysis capability; assembling; and pre-testing the equipment and data acquisition and analysis (systems) for viability in carrying the test plan. Section 4 of this statement of work describes these tasks in greater detail.

The general scope is divided into the following tasks:

Task 1: Design a test plan
Deliverable(s): A letter report detailing the test plan, which demonstrates testing and data viability.

Task 2: Design and assemble testing apparatus
Deliverable(s): A letter report detailing the system specifications, assembly of the apparatus, possible testing conditions, such as temperature, pressure, chemistry of the test environment, including controls, measurement and analysis test systems, and a demonstration of the system viability.

PNNL Response:

Research activities for this project are divided into the 3 major tasks: (1) Identification of Alloy 600/690 Materials and 182/152/52 Welds for the Test Matrix; (2) Experimental Test Plan Development and (3) Design, Construction and Validation of SCC Initiation Test Systems. See Section 5 for more details.

5. Specific Tasks

PNNL must perform the following tasks:

Task 1: Test Plan Development

Data produced under the Test Plan should address the need mentioned in Section 1 above with respect to producing viable data suitable for use in xLPR. Ultimately, the data should be able to: a) correlate with Operation Experience data; b) provide a statistical basis to provide an informed description of the distribution in crack initiation times; and, c) provide a correlation between the material variables, test variables and crack initiation times.

PNNL shall develop a test plan to meet the following requirements:

- Two (2) test machines will be used, each of which has the capability to test at least thirty (30) specimens in simulated primary water (PWR conditions). One test machine will be used for Alloys 600/82/182 and the other for Alloys 690/52/152. The test plan will describe the equipment used for the test machines and criteria for evaluating its functionality. The test equipment shall include capability to simulate reactor coolant environment (coolant loop, pressure and temperature) in a highly controlled manner. The equipment shall also include an appropriate automatic data acquisition and analysis system, preferably with proven commercial software.

- The test plan will describe materials to be tested, including such information as alloy chemistry, heat treatment, level of cold work, surface finish, and other relevant parameters.

- The test plan will describe the experimental procedure, including specimen geometries, any applicable Standards or Codes, and must also include criteria for determining when a crack has initiated in a specimen. The test plan must include evaluations of experiments for viability, and a description of the means to do so. ASTM Standards may apply to the viability of the test plan, which should be documented in the test plan.

- The test plan must include details and expectations of the data collected. This includes, but is not limited to, means of data viability and collection of data from Operation Experience.

- The test plan will describe any planned pre- and post-test sample qualification and analysis, e.g. material examination and characterization necessary to interpret the testing results and will include microscopy and microstructural characterization.

- The test plan will propose a schedule for conducting the tests, based on previous PNNL experience with initiation testing of these alloys.

This test plan shall be furnished in a letter report consistent with NRC document guidelines, and must detail assumptions, expectations, potential issues and research gaps, and the justifications for each.

PNNL Response:

Task 1: Identification and Acquisition of Materials for the Test Matrix

An essential first step for the project will be to identify and acquire specific Alloy 600/690 heats and Alloy 182/152/52 welds that meet key project criteria for heat-to-heat variability in composition and microstructure with established processing histories representative of PWR service components. In addition, material sources must be adequate to obtain a sufficient quantity of specimens for a statistically relevant number of SCC initiation tests. While many Alloy 690 materials and a few Alloy 152/52 welds are available from other PNNL projects or from a materials stockpile controlled by EPRI, obtaining a proper distribution Alloy 600 materials (e.g., mill-annealed CRDM tubing and plate) and Alloy 182 welds may be more difficult. It is anticipated that extra activities will be required to section, ship and prepare several Alloy 600 materials and Alloy 182/152/52 welds to fill out the matrix. A subset of these Alloy 600 materials (minimum of 3 heats) will be used for the SCC initiation test system validation experiments in Task 3 and may require additional preparation. Obtaining a reasonable number of Alloy 182 welds is expected to be the biggest challenge, since project timing and budget limitations appear to preclude the production of new welds for the project. Alloy 182 represents the most important material to xLPR and will need to be the first set of specimens in test. Therefore, efforts will be made to acquire a minimum of 3 Alloy 182 welds capable of extracting a minimum of ~20 test specimens in an acceptable microstructural orientation for SCC initiation and growth from each weld. Additional high-chromium alloy welds will also be obtained with a goal to obtain a minimum of 3 Alloy 152 and 3 Alloy 52 welds for the materials matrix. If possible, a few special weld conditions will be considered such as dissimilar metal welds and welds with pre-existing defects.

Task 2: Experimental Test Plan Development

The test plan will address the need to produce a viable data base suitable for use in xLPR and enable a quantitative comparison between the SCC initiation response for cold-worked Alloy 600/182 and Alloy 690/152/52 materials.

The test plan will be developed and include the following aspects:

- *Two SCC initiation systems will be used that enable 30-36 specimens to be tested simultaneously in simulated PWR primary water. Initial expectations are that one system will be used for Alloy 600/182 materials and the other for Alloy 690/52/152 materials.*
- *The test plan will describe materials to be tested, including such information as alloy chemistry, heat treatment, level of cold work, surface finish and other relevant parameters.*
- *The test plan will describe the experimental procedure, specimen geometries, criteria for determining when a crack has initiated and evaluations of experimental viability.*
- *The test plan will include details and expectations of the data collected.*

- *The test plan will describe planned pre- and post-test sample qualification and analyses including characterizations necessary to interpret/quantify the testing results.*

- *The test plan will propose a schedule for conducting the tests based on previous PNNL experience with SCC initiation testing of Alloy 600 and Alloy 690 materials.*

This test plan will be submitted to the NRC as a technical letter report consistent with NRC document guidelines. Assumptions, expectations, potential issues and research gaps will be described along with the justifications for each.

Task 2: Construction and Viability of Test Machines

PNNL shall design, procure materials and components, assemble, and prove the viability of testing equipment (systems) capable of carrying out the Test Plan as described in Task 1. Two (2) systems shall be constructed for crack initiation testing, each with the capability to test at least thirty (30) concurrent specimens. PNNL shall also design and implement a program to prove as-designed efficacy. PNNL shall submit a letter report detailing the system viability, including details of, and justifications for, any major assumptions within the testing system. ASTM Standards may apply to the viability of the system, which should be documented in the letter report. Additionally, PNNL shall provide the necessary staff to service and maintain the testing systems, as needed, for the proper function of such systems.

PNNL Response:

Task 3: Design, Construction and Validation of SCC Initiation Test Systems

Two SCC initiation test systems will be designed, test frames will be fabricated, individual components will be purchased and assembled, and a demonstration experiment will be performed to document system capabilities. The 2 systems will have the capability to test 30-36 concurrent specimens in 360°C simulated PWR primary water under active constant load conditions. Test system instrumentation will allow continuous measurement of the applied load, temperature and water conductivity along with DC potential drop for the detection of crack nucleation on individual specimens. PNNL has extensive experience in the construction and operation of these SCC test systems with 8 crack-growth and 3 initiation systems being used for near-continuous testing of nickel-base alloys in 360°C simulated PWR primary water. The most recent system was assembled in 2012 and is essentially identical to those being built for this proposed project. This experience provides confidence that the component purchasing, construction and validation testing can be effectively completed within 12 months after the project is started. A technical letter report will be submitted to the NRC detailing the system characteristics and a summary of the demonstration tests to establish test viability.

6. Technical and Other Special Qualifications Required

This project requires unique knowledge of the metallurgy and PWSCC behavior of nickel-based alloys used for nuclear reactor components, including the effects of temperature, stress level,

thermo-mechanical processing, microstructure, chemical composition, and welding parameters. Prior experience with PWSCC testing is also required to plan, design, assemble, and prove viability of suitable test assemblies and demonstrate the ability to acquire and interpret test data.

PNNL Response:

PNNL has expertise in several technical disciplines necessary to conduct this work. This includes the planning, conducting and analyzing SCC tests of reactor alloy materials in environments typical of LWRs and the operation of state-of-the-art autoclave testing systems for initiation and crack-growth-rate studies. These high temperature/pressure autoclave test systems enable experimentation to be performed in simulated LWR environments while controlling and monitoring temperature, pressure, water conductivity, and concentrations of dissolved oxygen and hydrogen. Direct current electric potential drop (DCPD) methods are used to measure crack extension routinely at a noise resolution of less than 4 μm and detect crack nucleation at resolutions of ~200 μm. The systems are capable of both dynamic and static loading with load control to better than 1%.

PNNL also has knowledgeable staff and specialized instrumentation for collecting, analyzing and interpreting microstructural and microanalytical data on the test materials. These unique capabilities are necessary to evaluate the PWSCC susceptibility of corrosion-resistant, high-chromium alloys that are being used in replacement components of existing reactors as well as potential new reactors. PNNL has a fully equipped metallographic and fractographic examination facility for inspection of destructively tested specimens as well as access to a radiological facility where radioactive materials from LWR service can be received, sectioned and decontaminated for machining into SCC test samples that might be part of future activities on this project.

Finally, PNNL principal investigators (S. M. Bruemmer and M. B. Toloczko) for this work have been involved with numerous research activities focused on PWSCC of PWR components. Work has included both laboratory testing on Alloy 600/182/690/152/52 materials and detailed evaluations of degradation in components removed from PWR service. As a result, they have obtained important insights on the nickel-base alloys of interest to this project including heat-to-heat aspects, processing and welding histories, compositional and microstructural variations, surface preparation issues, service component characteristics and corrosion/SCC response. Examples indicating this experience and expertise are given in the Appendix A resumes along with the list of recent technical papers.

7. Deliverables and/or Milestones Schedule

Deliverable Number	**Deliverable/Milestone Description** (include NRC acceptance criteria if applicable)	Due Date *(if any)*
1	PNNL shall create and provide a test plan.	Within three (3) months of the contract

		award
2	PNNL shall design, assemble, and prove the viability of testing equipment suitable for crack initiation testing	Within twelve (12) months of the contract award
3	PNNL shall provide a report detailing the as-built equipment setup and viability	Within one (1) month of completion of Deliverable 2

PNNL Response:

Milestones Schedule

Milestone Number	***Milestone Description***	***Completion Date*** *(months after award)*
1	*Test plan will be completed and submitted to the NRC for review.*	*Within 3 months of the contract award*
2	*Two SCC initiation test systems will be designed and assembled, and test viability demonstrated.*	*Within 12 months of the contract award*
3	*A technical letter report will be submitted to the NRC detailing the test equipment and capabilities for SCC initiation experimentation.*	*Within one 1 month of completion of Deliverable 2*

8. Key Personnel

Essential PNNL staff members for this project are S. M. Bruemmer and M. B. Toloczko. Dr. Bruemmer will be the project manager, while Dr. Toloczko will be the lead principal investigator for the research activities. Their resumes are provided in Appendix A along with a list of recent technical papers dealing PWSCC issues. Two technicians (R. J. Seffens and A. Guzman) will play important roles for the assembly and testing of the SCC initiation systems under the guidance of Dr. Toloczko. Minor roles during this first stage of the project are also anticipated for P. W. Eslinger (statistical evaluations to assist in creating the materials test matrix) and M. J. Olszta (microstructural characterization).

9. Subcontractors/Consultants

None are anticipated for the first stage of the project.

10. Meetings and Travel

Project Related Travel

Travel Description for FY 2014-2016	Location	Date	Days	Number of Attendees
FY 2015				
Program Review at NRC	Rockville, MD	June 2015	2	1

All travel requires written Government approval from the CO, unless otherwise delegated to the COR.

Foreign travel for PNNL personnel requires a 60-day lead time for NRC approval. For prior approval of foreign travel, PNNL shall submit an NRC Form 445, "Request for Approval of Official Foreign Travel." NRC Form 445 is available in the MD 11.7 Documents library and on the NRC Web site at: http://www.nrc.gov/reading-rm/doc-collections/forms/. Foreign travel is approved by the NRC Executive Director for Operations (EDO).

PNNL Response:

Domestic travel is anticipated for the performance of the work. Travel anticipated is described in the following table with the purpose of the travel, duration and number of staff specified. Planning and initial results of the NRC sponsored research will be presented at the Alloy 690 Expert Meeting in December 2014. In addition, PNNL staff will travel to NRC Headquarters for a program review each fiscal year expected to begin in June 2015. Deviations from the travel listed in Table 3 will require approval from the NRC project manager.

Project Related Travel

Travel Description for FY 2015	*Location*	*Date*	*Days*	*Number of Attendees*
Alloy 690 Expert Meeting	*Tampa, FL*	*December 2014*	*3*	*1*
Program Review at NRC	*Rockville, MD*	*June 2015*	*2*	*1*

11. Materials Required

PNNL shall be responsible for purchasing all equipment associated with Task 2. However, the specific details of this equipment are at the discretion of PNNL, due to the custom nature of the testing system.

PNNL Response:

PNNL shall be responsible for purchasing supplies as needed in Task 1 and all parts and equipment associated with the test systems in Task 3. The Task 1 supplies will support

metallographic preparation and microscopic characterization activities, while the list of custom parts, components and equipment for Task 3 included more than 150 items. A detailed list of these items can be provided to the NRC along with estimated costs if necessary.

12. Reporting Requirements

PNNL is responsible for structuring the deliverable to follow agency standards. The current agency standard is Microsoft Office Suite 2010. The current agency Portable Document Format (PDF) standard is Adobe Acrobat 9 Professional. Deliverables must be submitted free of spelling and grammatical errors and conform to requirements stated in this section.

Monthly Letter Status Reports

In accordance with Management Directive 11.7, NRC Procedures for Placement and Monitoring of Work with the U.S. Department of Energy, PNNL must electronically submit a Monthly Letter Status Report (MLSR) by the 20th day of each month to the Contracting Officer Representative (COR) with copies to the Contracting Officer (CO) and the Office Administration/Division of Contracts to ContractsPOT.Resource@nrc.gov. If a project is a task ordering agreement, a separate MLSR must be submitted for each task order with a summary project MLSR, even if no work has been performed during a reporting period. Once NRC has determined that all work on a task order is completed and that final costs are acceptable, a task order may be omitted from the MLSR.

The MLSR must include the following: agreement number; task order number, if applicable; job code number; title of the project; project period of performance; task order period of performance, if applicable; COR's name, telephone number, and e-mail address; full name and address of the performing organization; principal investigator's name, telephone number, and e-mail address; and reporting period.

In addition to the Monthly Letter Status Reports, PNNL shall also submit documents as described in the above Tasks, using the guidance for MLSRs when applicable.

PNNL Response:

A Monthly Letter Status Report (MLSR) summarizing technical progress will be submitted to the NRC Project Manager by the 20th of the month for the prior month activities. The MLSR will identify the title of the project, the job code, the Principal Investigator, the period of performance, the reporting period and summarize each month's technical progress. In addition, a second letter report summarizing financial status will be submitted by the 5th of the month following the reported month. It will list monthly spending, total spending to date and the remaining funds. Any administrative or technical difficulties that may affect the schedule or costs of the project will be immediately brought to the attention of the NRC project manager.

13. Period of Performance

The estimated period of performance for this work is from the estimated award date, August 1, 2014 to September 30, 2015.

PNNL Response:

The period of performance for this work is from the estimated award date (August 1, 2014) to September 30, 2015.

14. NRC-Furnished Property/Materials

PNNL Response:

None are anticipated for the first stage of the project.

15. Contracting Officer's Representative

The COR monitors all technical aspects of the agreement/task order and assists in its administration. The COR is authorized to perform the following functions: assure that PNNL performs the technical requirements of the agreement/task order; perform inspections necessary in connection with agreement/task order performance; maintain written and oral communications with PNNL concerning technical aspects of the agreement/task order; issue written interpretations of technical requirements, including Government drawings, designs, specifications; monitor PNNL's performance and notify PNNL of any deficiencies; coordinate availability of NRC-furnished material and/or GFP; and provide site entry of DOE Laboratory personnel.

Contracting Officer's Representative

Name: Matthew Rossi
Agency: U.S. Nuclear Regulatory Commission
Office: Nuclear Regulatory Research, Division of Engineering, Corrosion and Metallurgy
Mail Stop: CSB 05C07
Washington, DC 20555-0001
E-Mail: matthew.rossi@nrc.gov
Phone: (301) 251-7646

Alternate Contracting Officer's Representative

Name: Greg Oberson
Agency: U.S. Nuclear Regulatory Commission
Office: Nuclear Regulatory Research, Division of Engineering, Corrosion and Metallurgy
Mail Stop: CSB 05A24
Washington, DC 20555-0001
E-Mail: greg.oberson@nrc.gov

Phone: (301) 251-7675

16. Research Quality

N/A

17. Standards for Contractors Who Prepare NUREG-Series Manuscripts

N/A

18. Conflict of Interest

As part of this proposal, Pacific Northwest National Laboratory (PNNL) has reviewed its current work, planned work and where appropriate, past work for DOE and others (including NRC licensees, vendors, industry groups or research institutes that represent or are substantially comprised of nuclear utilities) for the past 5 years for work in the same or similar technical area as this proposed NRC project and found no projects that pose a conflict. See Appendix B.

19. Other Considerations

N/A

References

N/A

Access to Non-NRC Facilities/Equipment

N/A

PNNL Response:

None are anticipated for the first stage of the project.

Applicable Publications

N/A

Controls over document handling and non-disclosure of materials

N/A

APPENDIX A – RESUMES AND RELEVANT PAPERS

STEPHEN M. BRUEMMER

Laboratory Fellow, Structural Materials Research
Energy & Environment Directorate, Pacific Northwest National Laboratory

Education

B.S., M.S.	(b)(6) [redacted]	Metallurgical Engineering, University of Illinois
Ph.D.		Materials Science and Engineering Oregon Graduate Institute for Science and Technology

Experience

Dr. Bruemmer has been program manager and principal investigator for a wide range of basic and applied research programs in materials science during his thirty-six years at Pacific Northwest National Laboratory. Research encompasses both simple and advanced materials, physical and mechanical properties, and environmental effects on material behavior. This work has led to more than 330 technical publications and more than 75 invited presentations in the areas of grain boundary science, environmental degradation, crack-tip phenomena and radiation effects on materials. A research emphasis has been the high-resolution measurement, understanding, and prediction of microstructural and microchemical effects on the structural reliability of materials in nuclear power systems.

Expertise in the microstructural and microchemical aspects of materials includes research on interfacial segregation, precipitation, deformation and radiation effects. Relationships between these aspects and degradation mechanisms such as boundary decohesion, cavitation, corrosion, stress-corrosion cracking, and hydrogen embrittlement have been identified and analyzed. Research has centered on materials pertinent to energy production and transportation systems, e.g., stainless and low-alloy steels, nickel-base alloys, aluminum alloys and intermetallics. This work experience has produced an applicable understanding of, and ability to integrate, analytical microscopy and spectroscopy techniques, electrochemistry, mechanical properties and crack-growth-rate testing, failure analysis, and computer modeling to predict material behavior. A key aspect for much of this research has been to link atomistic interfacial processes to macroscopic failure phenomenon. The study of crack-tip processes in relation to corrosion and stress-corrosion cracking mechanisms has been a focus of recent research activities.

Dr. Bruemmer is an adjunct faculty member at Washington State University (WSU) and has mentored PhD students at WSU, the University of Michigan, Oregon Graduate Institute (OGI) for Science & Technology and University of Illinois. He has developed and taught two graduate-level courses in Materials Science (Interfaces in Engineering Materials and Corrosion Processes in Metals) as well as provide guest lectures on materials research topics.

Professional Affiliations and Activities

Dr. Bruemmer is a fellow of ASM International and NACE International, and a member of the Materials Research Society and The Minerals, Metals & Materials Society (TMS). He has received numerous service awards from these societies including the TMS Structural Materials Division Distinguished Service Award. Dr. Bruemmer has organized and chaired more than 25 conferences, symposia and workshops, and has served on several expert panels for the U.S. Department of Energy, U.S. Nuclear Regulatory Commission, Tohoku Nuclear Cluster and the international electric power industry dealing with materials aging, degradation and failure. He is a co-organizer for annual International Cooperative Group Meetings on Environmentally Assisted Cracking and for the International Conferences on Environmental Degradation in Nuclear Power Systems - Water Reactors. In addition, Dr. Bruemmer is a key reader or reviewer for several materials science, nuclear engineering and corrosion science journals.

MYCHAILO B. TOLOCZKO
Research Scientist IV
Energy & Environment Directorate, Pacific Northwest National Laboratory (PNNL)

Education

Ph.D. in Materials Science:	Washington State University, Pullman, WA
M.S. in Nuclear Engineering:	University of California at Santa Barbara, Santa Barbara, CA
B.A. in Physics:	University of California at Berkeley, Berkeley, CA

Experience

Over the last 17 years, Dr. Toloczko has been involved in a wide range of research areas focusing on mechanical properties of structural materials for nuclear reactor applications. These areas include in-pile creep, effects of irradiation on tensile properties, tensile property estimates from miniature specimens, compression testing of irradiated materials, and environmentally assisted cracking of nuclear reactor components.

His efforts in support of fast reactor structural materials include detailed studies of the creep response of austenitic and ferritic/martensitic steels during irradiation. He has mapped out the creep response of both classes of steels over the 400-670°C temperature with applied stress as high as 200 MPa. He has conclusively shown that ferritic/martensitic steels have a factor of two lower base creep rate than austenitic steels in a fast reactor irradiation environment at temperatures up to 600°C. He has also shown that while engineering ferritic/martensitic stainless steels are inherently swelling resistant, these materials are susceptible to stress-induced swelling. His latest research shows that at temperatures from 450°C to 500°C where irradiation creep is thought to dominate, thermal creep in fact accounts for a significant fraction of the total creep response in ferritic/martensitic steels. The database generated from this research will likely be used, in part, as a design basis for the next generation of ferritic/martensitic steel fast reactor cladding. In the area of tensile behavior, Dr. Toloczko has used both standard tensile testing and small specimen test methods to study tensile behavior of irradiated materials and relate it to theory and microstructural observations. His most recent tensile properties research looked at the effect of irradiation at ~50°C to 450°C on the tensile properties of ferritic/martensitic steels. He has shown that the tensile properties of several different 9-12Cr ferritic/martensitic steels are much more sensitive to irradiation temperature from 350°C to 425°C than previously assumed. This finding has helped to reconcile what was thought to be anomalous tensile response of developmental 9Cr steels made in support of the Fusion Reactor Materials program. His work on small specimen test technique and utilization has been primarily in support of the Fusion Reactor Materials program. Dr. Toloczko has refined a small specimen test technique known as the "shear punch test". Through a combination of experimental verification and finite element modeling, a better understanding of the relationship between shear punch test parameters and tensile test properties was gained allowing the test to more accurately estimate tensile properties. The shear punch test has been to estimate tensile property changes of materials in a variety of research programs.

In more recent years, Dr. Toloczko has become involved in the study of environmentally assisted cracking of light water reactor piping and vessel feedthrough structures for the Nuclear Regulatory Commission. Through his participation in this program, he has gained expertise in stress corrosion crack-growth testing and theory.

Dr. Toloczko has over 50 publications in the open literature.

Recent PNNL Papers Relevant to PWSCC Initiation in Nickel-Base Alloys (2009-2014)

D.K. Schreiber, M.J. Olszta and S.M. Bruemmer, Grain Boundary Chromium Depletion and Migration During Selective Oxidation in a Ni–Cr Binary Alloy Exposed to High-Temperature Hydrogenated Water, *Scripta Materialia, in press.*

M. J. Olszta, D. K. Schreiber, M. B. Toloczko and S. M. Bruemmer, "High Resolution Characterization of Film Formation and Localized Corrosion in Alloy 690 Exposed to PWR Primary Water," *Proc. Corrosion 2014,* NACE International, 2014, Paper C2014-4251.

N. R. Overman, M. B. Toloczko, M. J. Olszta and S. M. Bruemmer, "Strain Correlations in Alloy 690 Materials Using Electron Backscatter Diffraction and Vickers Hardness," *Proc. Corrosion 2014,* NACE International, 2014, Paper C2014-4255.

S. M. Bruemmer, M. J. Olszta, N. J. Overman and M. B. Toloczko, "Microstructural Effects on Stress Corrosion Cracking of Cold-Worked Alloy 690 Tubing and Plate Materials," *Proc. 16th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,* NACE International, 2014.

M. B. Toloczko, M. J. Olszta, N. J. Overman and S. M. Bruemmer, "Observations and Implications of Intergranular Stress Corrosion Crack Growth of Alloy 152 Weld Metals in Simulated PWR Primary Water," *Proc. 16th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,* NACE International, 2014.

M. B. Toloczko, M. J. Olszta, N. J. Overman and S. M. Bruemmer, "Stress Corrosion Crack Growth Response for Alloy 152/52 Dissimilar Metal Welds in Simulated PWR Primary Water," *Proc. 16th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,* NACE International, 2014.

D. K. Schreiber, M. J. Olszta, L. E. Thomas and S. M. Bruemmer, "Grain Boundary Characterization of Alloy 600 Prior To and After Corrosion by Atom Probe Tomography and Transmission Electron Microscopy," *Proc. 16th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,* NACE International, 2014.

M. J. Olszta, D. K. Schreiber, M. B. Toloczko and S. M. Bruemmer, "Alloy 690 Surface Nanostructures During Exposure to PWR Primary Water and Potential Influence on Stress Corrosion Crack Initiation," *Proc. 16th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,* NACE International, 2014.

D. S. Dunn, J. Collins, D. Alley, B. Alexandreanu, M. B. Toloczko and S. M. Bruemmer, "Primary Water Stress Corrosion Cracking Tests and Metallurgical Analysis of Davis Besse Control Rod Drive Mechanism Nozzle #4," *Proc. 16th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,* NACE International, 2014.

S. M. Bruemmer, M. J. Olszta, M. B. Toloczko and L. E. Thomas, "Linking Microstructure to Stress Corrosion Cracking of Cold Rolled Alloy 690 in PWR Primary Water," *Corrosion J,* 69-10 (2013) 953.

D. K. Schreiber, M. J. Olszta, D. W. Saxey K. Krusha, K. L. Moore, S. Lozano-Perez and S. M. Bruemmer, "Examinations of Oxidation and Sulfidation in Alloy 600 Grain Boundaries Exposed to Simulated PWR Primary Water," *J. Microscopy and Microanalysis,* 19-03, 2013, 676.

S. M. Bruemmer, M. J. Olszta, M. B. Toloczko and L. E. Thomas, "High-Resolution Characterization of Grain Boundary Damage and Stress Corrosion Cracks in Cold-Rolled Alloy 690," *Proc. 15th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,"* The Minerals, Metals and Materials Society, 2011, p. 301.

M. J. Olszta, D. K. Schreiber, L. E. Thomas and S. M. Bruemmer, “Electron Microscopy Characterizations and Atom Probe Tomography of Intergranular Attack in Alloy 600 Exposed to PWR Primary Water,” *Proc. 15th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,”* The Minerals, Metals and Materials Society, 2011, p. 1503.

M. J. Olszta, D. K. Schreiber, L. E. Thomas and S. M. Bruemmer, “Penetrative Internal Oxidation from Alloy 690 Surfaces and Stress Corrosion Crack Walls during Exposure to PWR Primary Water,” *Proc. 15th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,”* The Minerals, Metals and Materials Society, 2011, p.331.

M. B. Toloczko, M. J. Olszta and S. M. Bruemmer, “One Dimensional Cold Rolling Effects on Stress Corrosion Crack Growth in Alloy 690 Tubing and Plate Materials,” *Proc. 15th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,”* Minerals, Metals and Materials Society, 2011, p. 91.

M. B. Toloczko, M. J. Olszta and S. M. Bruemmer, “Stress Corrosion Crack Growth of Alloy 52M in Simulated PWR Primary Water,” *Proc. 15th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,”* The Minerals, Metals and Materials Society, 2011, p. 225.

M. J. Olszta, L. E. Thomas and S. M. Bruemmer, “Resolving Nanostructures in Complex Penetrative Oxidation for Ni-30Cr Alloys Exposed to High-Temperature Water using APT and TEM,” *J. Microscopy and Microanalysis,* 17-02, 2011, 734.

S. M. Bruemmer, M. Olszta and M. B. Toloczko, “Cold Rolling Effects on Grain Boundary Damage and SCC Crack Growth in Alloy 690,” *Fontevraud 7 International Symposium on Contributions of Materials Investigations to Improve the Safety and Performance of Light-Water Reactors,* French Nuclear Energy Society, 2010, A062-T04.

S.M. Bruemmer, M.B. Toloczko, M.J. Olszta, R.J. Seffens, and P.G. Efsing, "Characterization of Defects in Alloy 152, 52 and 52M Welds," *Proc. 14th International Conference on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors,* American Nuclear Society (ANS), 2009, p. 319.

M.J. Olszta, L.E. Thomas, K. Asano, S. Ooki, and S.M. Bruemmer, "Crack Initiation Precursors Originating from Surface Grinding," *Proc.14th International Conference on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors,* ANS, 2009, p. 549.

L.E. Thomas, M.J. Olszta, B.R. Johnson, and S.M. Bruemmer, "Microstructural Characterization of Primary Water Stress-Corrosion Cracks in Alloy 182 Welds from PWR Components and Laboratory Tests," *Proc.14th International Conference on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors,* ANS, 2009, p. 409.

M.B. Toloczko and S.M. Bruemmer, "Crack-Growth Response of Alloy 690 in Simulated PWR Primary Water," *Proc.14th International Conference on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors,* ANS, 2009, p. 706.

M.B. Toloczko and S.M. Bruemmer, "Crack-Growth Response of Alloy152 and 52 Weld Metals in Simulated PWR Primary Water," Proc.14th International Conference on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors, ANS, 2009, p. 690.

Dr. Bruemmer and co-workers have also published many earlier PWSCC-relevant papers (1996-2009). These documents are also available on request. In addition, recent Department of Energy reports for our ongoing SCC Initiation project as part of the Light Water Reactor Sustainability program can be provided:

M. B. Toloczko, M. J. Olszta, D. K. Schreiber and S. M. Bruemmer, “Stress Corrosion Crack Initiation of Alloy 600 in PWR Primary Water Environments,” Technical Milestone Report, Light Water Reactor Sustainability Program, DOE Office of Nuclear Energy, March 2013.

M. J. Olszta, D. K. Schreiber, L. E. Thomas, M. B. Toloczko and S. M. Bruemmer, “Grain Boundary Attack of Alloy 600 in PWR Primary Water Environments,” Technical Milestone Report, Light Water Reactor Sustainability Program, DOE Office of Nuclear Energy, September 2012.

S. M. Bruemmer and M. B. Toloczko, “Stress Corrosion Crack Initiation of Nickel-Base Alloys in LWR Environments,” Technical Milestone Report, Light Water Reactor Sustainability Program, DOE Office of Nuclear Energy, September 2011.

APPENDIX B – CONFLICT OF INTEREST INFORMATION

Agreement Number NRC-HQ-60-14-D-0014

Upon submitting a proposal to the NRC, each DOE Laboratory would continue to acknowledge the disclosure requirements of: 1) MD 11.7, "Organizational Conflict of Interest"; and 2) the provisions of the Memorandum of Understanding (MOU) between DOE and NRC, dated 1998 (which states, in part, that DOE recognizes that Section 170A of the Atomic Energy Act of 1954, as amended, requires that NRC be provided with disclosures on potential conflicts when NRC obtains technical, consulting, research and other supporting services). DOE further recognizes that the assignment of NRC work to DOE laboratories must satisfy NRC's organizational conflict of interest (OCOI) standards.

Therefore, each DOE Laboratory, in its proposal to NRC (which will be incorporated into an interagency agreement between NRC and DOE), is required to make an assertion per #1 or #2 of Part A below for themselves and all subcontractors proposed prior to their award. If the Laboratory selects #1, then, it must also fill out the accompanying Part B – whereby the Laboratory must, again, make an assertion by answering each of the five (5) NRC OCOI provisions per the NRC Acquisition Regulation (NRCAR).

As part of this proposal, Pacific Northwest National Laboratory (PNNL) has reviewed its current work, planned work and where appropriate, past work for DOE and others (including NRC licensees, vendors, industry groups or research institutes that represent or are substantially comprised of nuclear utilities) for the past 5 years for work in the same or similar technical area as this proposed NRC project and found no projects that pose a conflict.

PART A:

"In accordance with PNNL's role in, and responsibility for, disclosing its relationships with organizations which conduct business in the same and/or similar technical area as described by the present and/or ongoing NRC project's scope of work, and in accordance with the NRC clause as stated herein, PNNL hereby asserts that it has examined its relationships with all such organizations, and has also examined its current and future/planned work, and where appropriate, its past work (generally for the previous five years), for DOE and other organizations, and PNNL states the following:

1) PNNL hereby discloses the following relationships that may give rise to a potential OCOI. (DOE Laboratory must answer the questions in Part B below);

Or

2) PNNL to the best of its knowledge and belief, asserts that it has no current work, planned work, and where appropriate, past work for DOE and others (to mean - organizations in the same and/or similar technical area as the present and/or ongoing NRC project scope of work); and PNNL hereby asserts that it is not aware of any same/similar technical work that would give rise to any potential OCOI as defined in the Atomic Energy Act of 1954, as amended, and in the NRC/DOE MOU.

Signed: Sheena Kanyid

PART B:

In accordance with PNNL's role/responsibility regarding OCOI disclosure, as stated in Part A, above PNNL further discloses, to the best of its knowledge and belief, that:

1) PNNL and/or any of its organizational affiliates* as defined in Part A above [does/does not] provide advice and recommendations to the NRC in the same technical area (e.g., fire protection, PRA, seismic, vulnerability analysis, fracture mechanics) where it is also providing consulting assistance to any organization regulated by NRC. If PNNL "does" – the PNNL hereby discloses such organization(s) in Part A above;

2) PNNL and/or any of its organizational affiliates as defined in Part A above [does/does not] provide advice and recommendations to the NRC on the same or similar matter (e.g., particular licensing amendment, particular EIS, particular high level waste repository site) on which it is also providing assistance to any organization regulated by NRC. If PNNL "does" - the PNNL hereby discloses such organization(s) in Part A above;

3) PNNL and/or any of its organizational affiliates as defined in Part A above [will/will not] be required to evaluate its own products or services, or has been substantially involved in the development or marketing of the products or services of another entity. If PNNL "does" - the PNNL hereby discloses such organization(s) in Part A above;

4) PNNL and/or any of its organizational affiliates as defined in Part A above [does/does not] have a conflicting role, given the award of the present and/or ongoing NRC project, in which its judgment or the judgment of any of its organizations may be biased in relation to its work for NRC. If PNNL "does" – the PNNL hereby discloses such conflicting role(s) with organization(s) in Part A above;

5) PNNL and/or any of its organizational affiliates as defined in Part A above [are/are not] soliciting or performing concurrent work at an applicant or licensee site, while performing work in the same/similar technical area for NRC at the same site. If PNNL "does" – then the PNNL hereby discloses such organization(s) in Part A above."

Signed: Sheena Kanyid

*Organization affiliate – Business concerns which are affiliates (related) to each other when either directly or indirectly, one concern or individual controls or has the power to control another, or when a third party (i.e. parent firm) has the power to control both.

** The Atomic Energy Act of 1952 uses the term "person" to mean any entity – e.g., sole proprietorship, partnership, joint venture, corporation; university; limited partnership, subchapter S corporation; limited liability company, etc.

Pacific Northwest
NATIONAL LABORATORY

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Tel: (509) 372-4201
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sheena.kanyid@pnnl.gov

July 23, 2014

Jeffery Mitchell
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Mitchell:

SUBJECT: Crack Initiation Testing For Primary Water Stress Corrosion Cracking
NRC NO. NRC-HQ-60-14-D-0014
PNNL NO. 66756 Rev 1

Pursuant to your request PNNL is please to submit the enclosed revised proposal for your review. Upon approval, please transmit the appropriately executed NRC Form 173, Standard Order for DOE Work, to U.S. Department of Energy, Pacific Northwest Site Office, P.O. Box 350 (MS K9-42), Richland, WA 99352.

If there will be any classified and/or sensitive information associated with the work, please provide classification determination and guidance. All work will be performed on a best-efforts, cost-reimbursement basis under the terms and conditions of the DOE Operating Contract DE-AC05-76RL01830 with Battelle Memorial Institute (BMI).

The proposed work will be performed in Department of Energy (DOE) facilities. NRC is responsible for reviewing the entire effort for compliance with the National Environmental Policy Act (NEPA) prior to PNNL commencing work.

Consistent with DOE's full cost recovery policy, DOE collects, as part of its standard indirect cost rate, a Laboratory Directed Research and Development (LDRD) cost levied on all monies received at the laboratory. The estimated amount of LDRD costs is identified in the proposal cost estimate section. DOE believes that LDRD efforts provide opportunities in research that are instrumental in maintaining cutting edge science capabilities that benefit all of the customers at the laboratory. DOE will conclude that by approving and providing funds to DOE to perform the work under this proposal, you acknowledge that such activities are beneficial to your organization and consistent with appropriations acts that provide funds to you. Please note that the LDRD costs do not represent a new charge. Rather, the new Congressional requirement is for DOE to separately identify this indirect cost element.

Technical questions regarding this proposal should be referred to Stephen Bruemmer on 509-

371-7316 or stephen.bruemmer@pnnl.gov. Contractual questions should be referred to me at the contact information above.

Very truly yours,

Sheena Kanyid

Sheena Kanyid
Contracting Officer

Enclosure

cc: WFO Office, DOE-PNSO, w/encl.

Statement of Work

<table>
<tr><td>NRC Agreement Number

NRC-HQ-60-14-D-0014</td><td colspan="2">NRC Agreement Modification Number</td><td>NRC Task Order Number (If Applicable)</td><td colspan="2">NRC Task Order Modification Number (If Applicable)</td></tr>
<tr><td colspan="6">Project Title

Crack Initiation Testing for Primary Water Stress Corrosion Cracking</td></tr>
<tr><td colspan="2">Job Code Number</td><td colspan="2">B&R Number</td><td colspan="2">DOE Laboratory

PNNL</td></tr>
<tr><td colspan="6">NRC Requisitioning Office

Office of Nuclear Regulatory Research</td></tr>
<tr><td colspan="3">NRC Form 187, Contract Security and Classification Requirements

☐ Applicable

☒ Not Applicable</td><td colspan="3">☐ Involves Proprietary Information

☐ Involves Sensitive Unclassified</td></tr>
<tr><td colspan="3">☒ Non Fee-Recoverable</td><td colspan="3">☐ Fee-Recoverable (If checked, complete all applicable sections below)</td></tr>
<tr><td colspan="3">Docket Number (If Fee-Recoverable/Applicable)</td><td colspan="3">Inspection Report Number (If Fee Recoverable/Applicable)</td></tr>
<tr><td colspan="3">Technical Assignment Control Number (If Fee-Recoverable/Applicable)</td><td colspan="3">Technical Assignment Control Number Description (If Fee-Recoverable/Applicable)</td></tr>
</table>

1. Background

The purpose of this project is to obtain crack initiation data for reactor component nickel based alloys by establishing a testing program at Pacific Northwest National Laboratory (PNNL). PNNL performs primary water stress corrosion crack (PWSCC) growth rate tests under contract to NRC and, over a number of years, has established a strong knowledge base and a high level of technical experimental and analytical capability. PNNL also conducts PWSCC initiation testing under the sponsorship of the Department of Energy's (DOE's) Light Water Reactor Sustainability Research (LWRS). This research will build upon these already established efforts.

Primary water stress corrosion cracking (PWSCC) can occur in nickel-based alloy components in pressurized water reactors (PWRs) at locations such as dissimilar metal welds that join stainless and low-alloy steel control rod drive mechanism penetrations in the reactor pressure vessel upper head, and at instrument penetrations in the lower head. In the U.S., PWSCC has led to coolant leakage at V.C. Summer (2000), Arkansas Nuclear One Unit 1 (2001), Davis Besse (2002), and Wolf Creek (2006), among others. Many plants have systematically replaced components fabricated from the nickel-based Alloy 600 and Alloy 82 or 182 weld metals with higher chromium-content alloys, which are considered to be more resistant to PWSCC, particularly Alloy 690 and variants of Alloy 52 and 152 weld metals.

The evolution of PWSCC can be divided into periods of initiation and propagation. During the initiation period, processes such as the rupture of passive oxide film and internal (grain boundary) oxidation serve as precursors to the formation of macroscopically stable cracks. During the propagation period, the crack growth is affected by the electro chemical and mechanical (stress-related) interactions. While the initiation period may be much longer than the propagation period for a plant component, most NRC research to date has focused on crack propagation because staff assumes the presence of a postulated initial flaw to evaluate relief requests and to develop regulatory technical bases for inspection frequencies. Probabilistic approaches incorporating consideration of PWSCC initiation, such as EPRI MRP-105 and MRP-113, were reviewed by the NRC staff and were not accepted. To better understand the process of crack initiation, several organizations, including the DOE, Knolls Atomic Power Laboratory (KAPL), and international groups have pursued more robust initiation testing programs, but data are still limited and have not led to well-supported analytical models that could be used to predict the time to crack initiation after a component enters service.

The development of the Extremely Low Probability of Rupture (xLPR) computational code by NRC and the Electric Power Research Institute, however, has highlighted the need for additional data to support model assumptions. Data may also support the technical bases for new inspection requirements for nickel-based alloy components. The NRC is seeking testing plans and equipment (destructive and nondestructive examination) capable of producing viable (as defined by reproducibility, and the identification and/or establishment of accuracy, precision,

and bias) data to further develop xLPR. This data may include, but is not limited to, effects of cold work; effects of the dilution zone of alloying element; and, the effects of surface morphology on crack initiation time distribution.

PNNL Response:

Primary water stress corrosion cracking (PWSCC) can occur in nickel-base alloy components in pressurized water reactors (PWRs) at locations such as dissimilar metal welds that join stainless and low-alloy steel control rod drive mechanism penetrations in the reactor pressure vessel upper head, and at instrument penetrations in the lower head. PWSCC has led to coolant leakage at V.C. Summer (2000), Arkansas Nuclear One Unit 1 (2001), Davis Besse (2002), and Wolf Creek (2006), among others in the U.S. Many plants have replaced components fabricated from the nickel-base Alloy 600 and Alloy 82/182 weld metals with higher chromium-content alloys, which are considered to be more resistant to PWSCC, particularly Alloy 690 and variants of Alloy 52/152 weld metals.

The evolution of PWSCC can be divided into periods of crack initiation and growth. During the initiation period, processes such as the rupture of the protective oxide film and grain boundary oxidation can serve as precursors to the formation of stable, propagating stress corrosion cracks. While the initiation period may be much longer than the growth period for a plant component, most NRC research to date has focused on crack propagation because a postulated initial flaw is assumed to be present to evaluate relief requests and to develop the regulatory technical basis for inspection frequencies. Probabilistic approaches incorporating consideration of PWSCC initiation, such as EPRI MRP-105 and MRP-113, were reviewed by the NRC staff and were not accepted. To better understand the process of SCC initiation, several organizations including the Knolls Atomic Power Laboratory (KAPL), Pacific Northwest National Laboratory (PNNL) and international groups have pursued more robust initiation testing programs. However, data are still limited and have not led to well-supported analytical models that could be used to effectively predict the time to SCC initiation after a component enters service.

The development of the Extremely Low Probability of Rupture (xLPR) computational code by the NRC and the Electric Power Research Institute (EPRI) has highlighted the need for SCC initiation data in addition to the better-established SCC growth response to support model assumptions. More detailed and reproducible SCC initiation data on Alloy 600/82/182 and Alloy 690/152/52 materials may also support the technical basis for new inspection requirements for nickel-base alloy components. In order to meet this testing need, the ability to establish reproducible and statistically valid SCC initiation data is required using high-temperature autoclave systems where crack nucleation in a large number of actively loaded specimens can be detected in situ. The current proposal addresses this critical first step to construct state-of-the-art, SCC initiation test systems, and the development of a detailed experimental test plan including selection of nickel-base alloys in well-controlled material conditions.

2. Relationships to Other Projects

Several projects led by the proposal principal investigators are underway at PNNL that deal directly with PWSCC mechanistic and applied issues for nickel-base alloys. To some degree, each of these projects will provide key knowledge to support the new research and support a common general objective. However, information from these projects is not required to accomplish the proposed new research. A brief summary of these related projects is given below.

Stress Corrosion Crack Initiation of Nickel-Base Alloys in LWR Environments, DOE Office of Nuclear Energy, Light Water Reactor Sustainability Program, 2009 - current

The focus of the work is to identify mechanisms controlling IGSCC nucleation in nickel-base alloys under PWR primary water conditions. Research is investigating important material (composition, processing and microstructure) and environmental (water chemistry, temperature and electrochemical potential) effects on the SCC initiation. Of particular importance to the proposed work has been the design, development and operation of state-of-the-art test systems. In addition, SCC initiation experiments have been performed or are underway on alloy 600 and alloy 690 materials of direct interest to the new research.

Primary Water Stress Corrosion Cracking of High-Chromium Nickel-Base Alloys, NRC Office of Nuclear Regulatory Research, 2010 - current

The objective of this program is to obtain crack-growth-rate data to evaluate the PWSCC susceptibility of high-chromium, nickel-base Alloy 690 and its Alloy 152/52 weld metals and determine the relationship between PWSCC susceptibility and metallurgical characteristics. As a result, a unique collection of Alloy 690/152/52 materials have been examined and PWSCC response has been established in various conditions including isolating the influence of cold work on SCC growth rates. It is expected that many of these materials will be represented in the SCC initiation test matrix for the proposed project.

Mechanisms of Environment-Assisted Degradation in Reactor Materials, Rolls Royce, 2006 - current

The focus of this research is to investigate mechanisms controlling the degradation and cracking of iron- and nickel-base alloys in high-temperature, LWR environments and help establish an improved basis for the interpretation of stress corrosion crack initiation and growth processes. Collaborative research has been performed over the last several years with the DOE and NRC projects described above, in particular high-resolution characterization of intergranular attack in Alloy 600 and electron backscatter diffraction measurements of strain evolution in cold-worked Alloy 690 materials. These results and ongoing examinations will provide important microstructural information on materials as part of the SCC initiation test matrix for the proposed project.

3. Objective of Proposed Work

The objective of this program is to obtain PWSCC initiation data for reactor component nickel-based alloys, including Alloys 600/82/182 and Alloys 690/52/152. The data will support the development of the xLPR code and the technical bases for formulating inservice inspection requirements of nickel-based alloys.

<u>*PNNL Response:*</u>

The long-term objective of this program is to obtain PWSCC initiation data for reactor component nickel-base alloys including Alloy 600/182 and Alloy 690/52/152 materials. This data will support the development of the xLPR code and the technical basis for formulating in-service inspection requirements. The first stage of the work proposed here focuses on the development of an experimental test plan and construction of two SCC initiation test systems.

4. Scope of Work

PNNL shall be responsible for submitting a plan for designing the experimental apparatus and test plan; procuring necessary materials and components, including dedicated data capture and analysis capability; assembling; and pre-testing the equipment and data acquisition and analysis (systems) for viability in carrying the test plan. Section 4 of this statement of work describes these tasks in greater detail.

The general scope is divided into the following tasks:

Task 1: Design a test plan
Deliverable(s): A letter report detailing the test plan, which demonstrates testing and data viability.

Task 2: Design and assemble testing apparatus
Deliverable(s): A letter report detailing the system specifications, assembly of the apparatus, possible testing conditions, such as temperature, pressure, chemistry of the test environment, including controls, measurement and analysis test systems, and a demonstration of the system viability.

<u>*PNNL Response:*</u>

Research activities for this project are divided into the 3 major tasks: (1) Identification of Alloy 600/690 Materials and 182/152/52 Welds for the Test Matrix; (2) Experimental Test Plan Development and (3) Design, Construction and Validation of SCC Initiation Test Systems. See Section 5 for more details.

5. Specific Tasks

PNNL must perform the following tasks:

Task 1: Test Plan Development

Data produced under the Test Plan should address the need mentioned in Section 1 above with respect to producing viable data suitable for use in xLPR. Ultimately, the data should be able to: a) correlate with Operation Experience data; b) provide a statistical basis to provide an informed description of the distribution in crack initiation times; and, c) provide a correlation between the material variables, test variables and crack initiation times.

PNNL shall develop a test plan to meet the following requirements:

- Two (2) test machines will be used, each of which has the capability to test at least thirty (30) specimens in simulated primary water (PWR conditions). One test machine will be used for Alloys 600/82/182 and the other for Alloys 690/52/152. The test plan will describe the equipment used for the test machines and criteria for evaluating its functionality. The test equipment shall include capability to simulate reactor coolant environment (coolant loop, pressure and temperature) in a highly controlled manner. The equipment shall also include an appropriate automatic data acquisition and analysis system, preferably with proven commercial software.

- The test plan will describe materials to be tested, including such information as alloy chemistry, heat treatment, level of cold work, surface finish, and other relevant parameters.

- The test plan will describe the experimental procedure, including specimen geometries, any applicable Standards or Codes, and must also include criteria for determining when a crack has initiated in a specimen. The test plan must include evaluations of experiments for viability, and a description of the means to do so. ASTM Standards may apply to the viability of the test plan, which should be documented in the test plan.

- The test plan must include details and expectations of the data collected. This includes, but is not limited to, means of data viability and collection of data from Operation Experience.

- The test plan will describe any planned pre- and post-test sample qualification and analysis, e.g. material examination and characterization necessary to interpret the testing results and will include microscopy and microstructural characterization.

- The test plan will propose a schedule for conducting the tests, based on previous PNNL experience with initiation testing of these alloys.

This test plan shall be furnished in a letter report consistent with NRC document guidelines, and must detail assumptions, expectations, potential issues and research gaps, and the justifications for each.

PNNL Response:

Task 1: Identification and Acquisition of Materials for the Test Matrix

An essential first step for the project will be to identify and acquire specific Alloy 600/690 heats and Alloy 182/152/52 welds that meet key project criteria for heat-to-heat variability in composition and microstructure with established processing histories representative of PWR service components. In addition, material sources must be adequate to obtain a sufficient quantity of specimens for a statistically relevant number of SCC initiation tests. While many Alloy 690 materials and a few Alloy 152/52 welds are available from other PNNL projects or from a materials stockpile controlled by EPRI, obtaining a proper distribution Alloy 600 materials (e.g., mill-annealed CRDM tubing and plate) and Alloy 182 welds may be more difficult. It is anticipated that extra activities will be required to section, ship and prepare several Alloy 600 materials and Alloy 182/152/52 welds to fill out the matrix. A subset of these Alloy 600 materials (minimum of 3 heats) will be used for the SCC initiation test system validation experiments in Task 3 and may require additional preparation. Obtaining a reasonable number of Alloy 182 welds is expected to be the biggest challenge, since project timing and budget limitations appear to preclude the production of new welds for the project. Alloy 182 represents the most important material to xLPR and will need to be the first set of specimens in test. Therefore, efforts will be made to acquire a minimum of 3 Alloy 182 welds capable of extracting a minimum of ~20 test specimens in an acceptable microstructural orientation for SCC initiation and growth from each weld. Additional high-chromium alloy welds will also be obtained with a goal to obtain a minimum of 3 Alloy 152 and 3 Alloy 52 welds for the materials matrix. If possible, a few special weld conditions will be considered such as dissimilar metal welds and welds with pre-existing defects.

Task 2: Experimental Test Plan Development

The test plan will address the need to produce a viable data base suitable for use in xLPR and enable a quantitative comparison between the SCC initiation response for cold-worked Alloy 600/182 and Alloy 690/152/52 materials.

The test plan will be developed and include the following aspects:

- *Two SCC initiation systems will be used that enable 30-36 specimens to be tested simultaneously in simulated PWR primary water. Initial expectations are that one system will be used for Alloy 600/182 materials and the other for Alloy 690/52/152 materials.*
- *The test plan will describe materials to be tested, including such information as alloy chemistry, heat treatment, level of cold work, surface finish and other relevant parameters.*
- *The test plan will describe the experimental procedure, specimen geometries, criteria for determining when a crack has initiated and evaluations of experimental viability.*
- *The test plan will include details and expectations of the data collected.*

- *The test plan will describe planned pre- and post-test sample qualification and analyses including characterizations necessary to interpret/quantify the testing results.*

- *The test plan will propose a schedule for conducting the tests based on previous PNNL experience with SCC initiation testing of Alloy 600 and Alloy 690 materials.*

This test plan will be submitted to the NRC as a technical letter report consistent with NRC document guidelines. Assumptions, expectations, potential issues and research gaps will be described along with the justifications for each.

Task 2: Construction and Viability of Test Machines

PNNL shall design, procure materials and components, assemble, and prove the viability of testing equipment (systems) capable of carrying out the Test Plan as described in Task 1. Two (2) systems shall be constructed for crack initiation testing, each with the capability to test at least thirty (30) concurrent specimens. PNNL shall also design and implement a program to prove as-designed efficacy. PNNL shall submit a letter report detailing the system viability, including details of, and justifications for, any major assumptions within the testing system. ASTM Standards may apply to the viability of the system, which should be documented in the letter report. Additionally, PNNL shall provide the necessary staff to service and maintain the testing systems, as needed, for the proper function of such systems.

PNNL Response:

Task 3: Design, Construction and Validation of SCC Initiation Test Systems

Two SCC initiation test systems will be designed, test frames will be fabricated, individual components will be purchased and assembled, and a demonstration experiment will be performed to document system capabilities. The 2 systems will have the capability to test 30-36 concurrent specimens in 360°C simulated PWR primary water under active constant load conditions. Test system instrumentation will allow continuous measurement of the applied load, temperature and water conductivity along with DC potential drop for the detection of crack nucleation on individual specimens. PNNL has extensive experience in the construction and operation of these SCC test systems with 8 crack-growth and 3 initiation systems being used for near-continuous testing of nickel-base alloys in 360°C simulated PWR primary water. The most recent system was assembled in 2012 and is essentially identical to those being built for this proposed project. This experience provides confidence that the component purchasing, construction and validation testing can be effectively completed within 12 months after the project is started. A technical letter report will be submitted to the NRC detailing the system characteristics and a summary of the demonstration tests to establish test viability.

6. Technical and Other Special Qualifications Required

This project requires unique knowledge of the metallurgy and PWSCC behavior of nickel-based alloys used for nuclear reactor components, including the effects of temperature, stress level,

thermo-mechanical processing, microstructure, chemical composition, and welding parameters. Prior experience with PWSCC testing is also required to plan, design, assemble, and prove viability of suitable test assemblies and demonstrate the ability to acquire and interpret test data.

PNNL Response:

PNNL has expertise in several technical disciplines necessary to conduct this work. This includes the planning, conducting and analyzing SCC tests of reactor alloy materials in environments typical of LWRs and the operation of state-of-the-art autoclave testing systems for initiation and crack-growth-rate studies. These high temperature/pressure autoclave test systems enable experimentation to be performed in simulated LWR environments while controlling and monitoring temperature, pressure, water conductivity, and concentrations of dissolved oxygen and hydrogen. Direct current electric potential drop (DCPD) methods are used to measure crack extension routinely at a noise resolution of less than 4 μm and detect crack nucleation at resolutions of ~200 μm. The systems are capable of both dynamic and static loading with load control to better than 1%.

PNNL also has knowledgeable staff and specialized instrumentation for collecting, analyzing and interpreting microstructural and microanalytical data on the test materials. These unique capabilities are necessary to evaluate the PWSCC susceptibility of corrosion-resistant, high-chromium alloys that are being used in replacement components of existing reactors as well as potential new reactors. PNNL has a fully equipped metallographic and fractographic examination facility for inspection of destructively tested specimens as well as access to a radiological facility where radioactive materials from LWR service can be received, sectioned and decontaminated for machining into SCC test samples that might be part of future activities on this project.

Finally, PNNL principal investigators (S. M. Bruemmer and M. B. Toloczko) for this work have been involved with numerous research activities focused on PWSCC of PWR components. Work has included both laboratory testing on Alloy 600/182/690/152/52 materials and detailed evaluations of degradation in components removed from PWR service. As a result, they have obtained important insights on the nickel-base alloys of interest to this project including heat-to-heat aspects, processing and welding histories, compositional and microstructural variations, surface preparation issues, service component characteristics and corrosion/SCC response. Examples indicating this experience and expertise are given in the Appendix A resumes along with the list of recent technical papers.

7. Deliverables and/or Milestones Schedule

Deliverable Number	**Deliverable/Milestone Description** (include NRC acceptance criteria if applicable)	Due Date *(if any)*
1	PNNL shall create and provide a test plan.	Within three (3) months of the contract

		award
2	PNNL shall design, assemble, and prove the viability of testing equipment suitable for crack initiation testing	Within twelve (12) months of the contract award
3	PNNL shall provide a report detailing the as-built equipment setup and viability	Within one (1) month of completion of Deliverable 2

PNNL Response:

Milestones Schedule

Milestone Number	***Milestone Description***	***Completion Date*** *(months after award)*
1	*Test plan will be completed and submitted to the NRC for review.*	*Within 3 months of the contract award*
2	*Two SCC initiation test systems will be designed and assembled, and test viability demonstrated.*	*Within 12 months of the contract award*
3	*A technical letter report will be submitted to the NRC detailing the test equipment and capabilities for SCC initiation experimentation.*	*Within one 1 month of completion of Deliverable 2*

8. Key Personnel

Essential PNNL staff members for this project are S. M. Bruemmer and M. B. Toloczko. Dr. Bruemmer will be the project manager, while Dr. Toloczko will be the lead principal investigator for the research activities. Their resumes are provided in Appendix A along with a list of recent technical papers dealing PWSCC issues. Two technicians (R. J. Seffens and A. Guzman) will play important roles for the assembly and testing of the SCC initiation systems under the guidance of Dr. Toloczko. Minor roles during this first stage of the project are also anticipated for P. W. Eslinger (statistical evaluations to assist in creating the materials test matrix) and M. J. Olszta (microstructural characterization).

9. Subcontractors/Consultants

None are anticipated for the first stage of the project.

10. Meetings and Travel

Project Related Travel

Travel Description for FY 2014-2016	Location	Date	Days	Number of Attendees
FY 2015				
Program Review at NRC	Rockville, MD	June 2015	2	1

All travel requires written Government approval from the CO, unless otherwise delegated to the COR.

Foreign travel for PNNL personnel requires a 60-day lead time for NRC approval. For prior approval of foreign travel, PNNL shall submit an NRC Form 445, "Request for Approval of Official Foreign Travel." NRC Form 445 is available in the MD 11.7 Documents library and on the NRC Web site at: http://www.nrc.gov/reading-rm/doc-collections/forms/. Foreign travel is approved by the NRC Executive Director for Operations (EDO).

PNNL Response:

Domestic travel is anticipated for the performance of the work. Travel anticipated is described in the following table with the purpose of the travel, duration and number of staff specified. Planning and initial results of the NRC sponsored research will be presented at the Alloy 690 Expert Meeting in December 2014. In addition, PNNL staff will travel to NRC Headquarters for a program review each fiscal year expected to begin in June 2015. Deviations from the travel listed in Table 3 will require approval from the NRC project manager.

Project Related Travel

Travel Description for FY 2015	*Location*	*Date*	*Days*	*Number of Attendees*
Alloy 690 Expert Meeting	*Tampa, FL*	*December 2014*	*3*	*1*
Program Review at NRC	*Rockville, MD*	*June 2015*	*2*	*1*

11. Materials Required

PNNL shall be responsible for purchasing all equipment associated with Task 2. However, the specific details of this equipment are at the discretion of PNNL, due to the custom nature of the testing system.

PNNL Response:

PNNL shall be responsible for purchasing supplies as needed in Task 1 and all parts and equipment associated with the test systems in Task 3. The Task 1 supplies will support

metallographic preparation and microscopic characterization activities, while the list of custom parts, components and equipment for Task 3 included more than 150 items. A detailed list of these items can be provided to the NRC along with estimated costs if necessary.

12. Reporting Requirements

PNNL is responsible for structuring the deliverable to follow agency standards. The current agency standard is Microsoft Office Suite 2010. The current agency Portable Document Format (PDF) standard is Adobe Acrobat 9 Professional. Deliverables must be submitted free of spelling and grammatical errors and conform to requirements stated in this section.

Monthly Letter Status Reports

In accordance with Management Directive 11.7, NRC Procedures for Placement and Monitoring of Work with the U.S. Department of Energy, PNNL must electronically submit a Monthly Letter Status Report (MLSR) by the 20th day of each month to the Contracting Officer Representative (COR) with copies to the Contracting Officer (CO) and the Office Administration/Division of Contracts to ContractsPOT.Resource@nrc.gov. If a project is a task ordering agreement, a separate MLSR must be submitted for each task order with a summary project MLSR, even if no work has been performed during a reporting period. Once NRC has determined that all work on a task order is completed and that final costs are acceptable, a task order may be omitted from the MLSR.

The MLSR must include the following: agreement number; task order number, if applicable; job code number; title of the project; project period of performance; task order period of performance, if applicable; COR's name, telephone number, and e-mail address; full name and address of the performing organization; principal investigator's name, telephone number, and e-mail address; and reporting period.

In addition to the Monthly Letter Status Reports, PNNL shall also submit documents as described in the above Tasks, using the guidance for MLSRs when applicable.

PNNL Response:

A Monthly Letter Status Report (MLSR) summarizing technical progress will be submitted to the NRC Project Manager by the 20th of the month for the prior month activities. The MLSR will identify the title of the project, the job code, the Principal Investigator, the period of performance, the reporting period and summarize each month's technical progress. In addition, a second letter report summarizing financial status will be submitted by the 5th of the month following the reported month. It will list monthly spending, total spending to date and the remaining funds. Any administrative or technical difficulties that may affect the schedule or costs of the project will be immediately brought to the attention of the NRC project manager.

13. Period of Performance

The estimated period of performance for this work is from the estimated award date, August 1, 2014 to September 30, 2015.

PNNL Response:

The period of performance for this work is from the estimated award date (August 1, 2014) to September 30, 2015.

14. NRC-Furnished Property/Materials

PNNL Response:

None are anticipated for the first stage of the project.

15. Contracting Officer's Representative

The COR monitors all technical aspects of the agreement/task order and assists in its administration. The COR is authorized to perform the following functions: assure that PNNL performs the technical requirements of the agreement/task order; perform inspections necessary in connection with agreement/task order performance; maintain written and oral communications with PNNL concerning technical aspects of the agreement/task order; issue written interpretations of technical requirements, including Government drawings, designs, specifications; monitor PNNL's performance and notify PNNL of any deficiencies; coordinate availability of NRC-furnished material and/or GFP; and provide site entry of DOE Laboratory personnel.

Contracting Officer's Representative

Name: Matthew Rossi
Agency: U.S. Nuclear Regulatory Commission
Office: Nuclear Regulatory Research, Division of Engineering, Corrosion and Metallurgy
Mail Stop: CSB 05C07
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Alternate Contracting Officer's Representative

Name: Greg Oberson
Agency: U.S. Nuclear Regulatory Commission
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16. Research Quality

N/A

17. Standards for Contractors Who Prepare NUREG-Series Manuscripts

N/A

18. Conflict of Interest

As part of this proposal, Pacific Northwest National Laboratory (PNNL) has reviewed its current work, planned work and where appropriate, past work for DOE and others (including NRC licensees, vendors, industry groups or research institutes that represent or are substantially comprised of nuclear utilities) for the past 5 years for work in the same or similar technical area as this proposed NRC project and found no projects that pose a conflict. See Appendix B.

19. Other Considerations

N/A

References

N/A

Access to Non-NRC Facilities/Equipment

N/A

PNNL Response:

None are anticipated for the first stage of the project.

Applicable Publications

N/A

Controls over document handling and non-disclosure of materials

N/A

APPENDIX A – RESUMES AND RELEVANT PAPERS

STEPHEN M. BRUEMMER

Laboratory Fellow, Structural Materials Research
Energy & Environment Directorate, Pacific Northwest National Laboratory

Education

(b)(6) [redacted]

B.S., M.S. — Metallurgical Engineering, University of Illinois

Ph.D. — Materials Science and Engineering
Oregon Graduate Institute for Science and Technology

Experience

Dr. Bruemmer has been program manager and principal investigator for a wide range of basic and applied research programs in materials science during his thirty-six years at Pacific Northwest National Laboratory. Research encompasses both simple and advanced materials, physical and mechanical properties, and environmental effects on material behavior. This work has led to more than 330 technical publications and more than 75 invited presentations in the areas of grain boundary science, environmental degradation, crack-tip phenomena and radiation effects on materials. A research emphasis has been the high-resolution measurement, understanding, and prediction of microstructural and microchemical effects on the structural reliability of materials in nuclear power systems.

Expertise in the microstructural and microchemical aspects of materials includes research on interfacial segregation, precipitation, deformation and radiation effects. Relationships between these aspects and degradation mechanisms such as boundary decohesion, cavitation, corrosion, stress-corrosion cracking, and hydrogen embrittlement have been identified and analyzed. Research has centered on materials pertinent to energy production and transportation systems, e.g., stainless and low-alloy steels, nickel-base alloys, aluminum alloys and intermetallics. This work experience has produced an applicable understanding of, and ability to integrate, analytical microscopy and spectroscopy techniques, electrochemistry, mechanical properties and crack-growth-rate testing, failure analysis, and computer modeling to predict material behavior. A key aspect for much of this research has been to link atomistic interfacial processes to macroscopic failure phenomenon. The study of crack-tip processes in relation to corrosion and stress-corrosion cracking mechanisms has been a focus of recent research activities.

Dr. Bruemmer is an adjunct faculty member at Washington State University (WSU) and has mentored PhD students at WSU, the University of Michigan, Oregon Graduate Institute (OGI) for Science & Technology and University of Illinois. He has developed and taught two graduate-level courses in Materials Science (Interfaces in Engineering Materials and Corrosion Processes in Metals) as well as provide guest lectures on materials research topics.

Professional Affiliations and Activities

Dr. Bruemmer is a fellow of ASM International and NACE International, and a member of the Materials Research Society and The Minerals, Metals & Materials Society (TMS). He has received numerous service awards from these societies including the TMS Structural Materials Division Distinguished Service Award. Dr. Bruemmer has organized and chaired more than 25 conferences, symposia and workshops, and has served on several expert panels for the U.S. Department of Energy, U.S. Nuclear Regulatory Commission, Tohoku Nuclear Cluster and the international electric power industry dealing with materials aging, degradation and failure. He is a co-organizer for annual International Cooperative Group Meetings on Environmentally Assisted Cracking and for the International Conferences on Environmental Degradation in Nuclear Power Systems - Water Reactors. In addition, Dr. Bruemmer is a key reader or reviewer for several materials science, nuclear engineering and corrosion science journals.

MYCHAILO B. TOLOCZKO
Research Scientist IV
Energy & Environment Directorate, Pacific Northwest National Laboratory (PNNL)

Education

Ph.D. in Materials Science:	Washington State University, Pullman, WA
M.S. in Nuclear Engineering:	University of California at Santa Barbara, Santa Barbara, CA
B.A. in Physics:	University of California at Berkeley, Berkeley, CA

Experience

Over the last 17 years, Dr. Toloczko has been involved in a wide range of research areas focusing on mechanical properties of structural materials for nuclear reactor applications. These areas include in-pile creep, effects of irradiation on tensile properties, tensile property estimates from miniature specimens, compression testing of irradiated materials, and environmentally assisted cracking of nuclear reactor components.

His efforts in support of fast reactor structural materials include detailed studies of the creep response of austenitic and ferritic/martensitic steels during irradiation. He has mapped out the creep response of both classes of steels over the 400-670°C temperature with applied stress as high as 200 MPa. He has conclusively shown that ferritic/martensitic steels have a factor of two lower base creep rate than austenitic steels in a fast reactor irradiation environment at temperatures up to 600°C. He has also shown that while engineering ferritic/martensitic stainless steels are inherently swelling resistant, these materials are susceptible to stress-induced swelling. His latest research shows that at temperatures from 450°C to 500°C where irradiation creep is thought to dominate, thermal creep in fact accounts for a significant fraction of the total creep response in ferritic/martensitic steels. The database generated from this research will likely be used, in part, as a design basis for the next generation of ferritic/martensitic steel fast reactor cladding. In the area of tensile behavior, Dr. Toloczko has used both standard tensile testing and small specimen test methods to study tensile behavior of irradiated materials and relate it to theory and microstructural observations. His most recent tensile properties research looked at the effect of irradiation at ~50°C to 450°C on the tensile properties of ferritic/martensitic steels. He has shown that the tensile properties of several different 9-12Cr ferritic/martensitic steels are much more sensitive to irradiation temperature from 350°C to 425°C than previously assumed. This finding has helped to reconcile what was thought to be anomalous tensile response of developmental 9Cr steels made in support of the Fusion Reactor Materials program. His work on small specimen test technique and utilization has been primarily in support of the Fusion Reactor Materials program. Dr. Toloczko has refined a small specimen test technique known as the "shear punch test". Through a combination of experimental verification and finite element modeling, a better understanding of the relationship between shear punch test parameters and tensile test properties was gained allowing the test to more accurately estimate tensile properties. The shear punch test has been to estimate tensile property changes of materials in a variety of research programs.

In more recent years, Dr. Toloczko has become involved in the study of environmentally assisted cracking of light water reactor piping and vessel feedthrough structures for the Nuclear Regulatory Commission. Through his participation in this program, he has gained expertise in stress corrosion crack-growth testing and theory.

Dr. Toloczko has over 50 publications in the open literature.

Recent PNNL Papers Relevant to PWSCC Initiation in Nickel-Base Alloys (2009-2014)

D.K. Schreiber, M.J. Olszta and S.M. Bruemmer, Grain Boundary Chromium Depletion and Migration During Selective Oxidation in a Ni–Cr Binary Alloy Exposed to High-Temperature Hydrogenated Water, *Scripta Materialia, in press.*

M. J. Olszta, D. K. Schreiber, M. B. Toloczko and S. M. Bruemmer, "High Resolution Characterization of Film Formation and Localized Corrosion in Alloy 690 Exposed to PWR Primary Water," *Proc. Corrosion 2014*, NACE International, 2014, Paper C2014-4251.

N. R. Overman, M. B. Toloczko, M. J. Olszta and S. M. Bruemmer, "Strain Correlations in Alloy 690 Materials Using Electron Backscatter Diffraction and Vickers Hardness," *Proc. Corrosion 2014,* NACE International, 2014, Paper C2014-4255.

S. M. Bruemmer, M. J. Olszta, N. J. Overman and M. B. Toloczko, "Microstructural Effects on Stress Corrosion Cracking of Cold-Worked Alloy 690 Tubing and Plate Materials," *Proc. 16th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,* NACE International, 2014.

M. B. Toloczko, M. J. Olszta, N. J. Overman and S. M. Bruemmer, "Observations and Implications of Intergranular Stress Corrosion Crack Growth of Alloy 152 Weld Metals in Simulated PWR Primary Water," *Proc. 16th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,* NACE International, 2014.

M. B. Toloczko, M. J. Olszta, N. J. Overman and S. M. Bruemmer, "Stress Corrosion Crack Growth Response for Alloy 152/52 Dissimilar Metal Welds in Simulated PWR Primary Water," *Proc. 16th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,* NACE International, 2014.

D. K. Schreiber, M. J. Olszta, L. E. Thomas and S. M. Bruemmer, "Grain Boundary Characterization of Alloy 600 Prior To and After Corrosion by Atom Probe Tomography and Transmission Electron Microscopy," *Proc. 16th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,* NACE International, 2014.

M. J. Olszta, D. K. Schreiber, M. B. Toloczko and S. M. Bruemmer, "Alloy 690 Surface Nanostructures During Exposure to PWR Primary Water and Potential Influence on Stress Corrosion Crack Initiation," *Proc. 16th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,* NACE International, 2014.

D. S. Dunn, J. Collins, D. Alley, B. Alexandreanu, M. B. Toloczko and S. M. Bruemmer, "Primary Water Stress Corrosion Cracking Tests and Metallurgical Analysis of Davis Besse Control Rod Drive Mechanism Nozzle #4," *Proc. 16th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,* NACE International, 2014.

S. M. Bruemmer, M. J. Olszta, M. B. Toloczko and L. E. Thomas, "Linking Microstructure to Stress Corrosion Cracking of Cold Rolled Alloy 690 in PWR Primary Water," *Corrosion J,* 69-10 (2013) 953.

D. K. Schreiber, M. J. Olszta, D. W. Saxey K. Krusha, K. L. Moore, S. Lozano-Perez and S. M. Bruemmer, "Examinations of Oxidation and Sulfidation in Alloy 600 Grain Boundaries Exposed to Simulated PWR Primary Water," *J. Microscopy and Microanalysis,* 19-03, 2013, 676.

S. M. Bruemmer, M. J. Olszta, M. B. Toloczko and L. E. Thomas, "High-Resolution Characterization of Grain Boundary Damage and Stress Corrosion Cracks in Cold-Rolled Alloy 690," *Proc. 15th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,"* The Minerals, Metals and Materials Society, 2011, p. 301.

M. J. Olszta, D. K. Schreiber, L. E. Thomas and S. M. Bruemmer, "Electron Microscopy Characterizations and Atom Probe Tomography of Intergranular Attack in Alloy 600 Exposed to PWR Primary Water," *Proc. 15th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,"* The Minerals, Metals and Materials Society, 2011, p. 1503.

M. J. Olszta, D. K. Schreiber, L. E. Thomas and S. M. Bruemmer, "Penetrative Internal Oxidation from Alloy 690 Surfaces and Stress Corrosion Crack Walls during Exposure to PWR Primary Water," *Proc. 15th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,"* The Minerals, Metals and Materials Society, 2011, p.331.

M. B. Toloczko, M. J. Olszta and S. M. Bruemmer, "One Dimensional Cold Rolling Effects on Stress Corrosion Crack Growth in Alloy 690 Tubing and Plate Materials," *Proc. 15th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,"* Minerals, Metals and Materials Society, 2011, p. 91.

M. B. Toloczko, M. J. Olszta and S. M. Bruemmer, "Stress Corrosion Crack Growth of Alloy 52M in Simulated PWR Primary Water," *Proc. 15th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors,"* The Minerals, Metals and Materials Society, 2011, p. 225.

M. J. Olszta, L. E. Thomas and S. M. Bruemmer, "Resolving Nanostructures in Complex Penetrative Oxidation for Ni-30Cr Alloys Exposed to High-Temperature Water using APT and TEM," *J. Microscopy and Microanalysis,* 17-02, 2011, 734.

S. M. Bruemmer, M. Olszta and M. B. Toloczko, "Cold Rolling Effects on Grain Boundary Damage and SCC Crack Growth in Alloy 690," *Fontevraud 7 International Symposium on Contributions of Materials Investigations to Improve the Safety and Performance of Light-Water Reactors,* French Nuclear Energy Society, 2010, A062-T04.

S.M. Bruemmer, M.B. Toloczko, M.J. Olszta, R.J. Seffens, and P.G. Efsing, "Characterization of Defects in Alloy 152, 52 and 52M Welds," *Proc. 14th International Conference on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors,* American Nuclear Society (ANS), 2009, p. 319.

M.J. Olszta, L.E. Thomas, K. Asano, S. Ooki, and S.M. Bruemmer, "Crack Initiation Precursors Originating from Surface Grinding," *Proc.14th International Conference on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors,* ANS, 2009, p. 549.

L.E. Thomas, M.J. Olszta, B.R. Johnson, and S.M. Bruemmer, "Microstructural Characterization of Primary Water Stress-Corrosion Cracks in Alloy 182 Welds from PWR Components and Laboratory Tests," *Proc.14th International Conference on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors,* ANS, 2009, p. 409.

M.B. Toloczko and S.M. Bruemmer, "Crack-Growth Response of Alloy 690 in Simulated PWR Primary Water," *Proc.14th International Conference on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors,* ANS, 2009, p. 706.

M.B. Toloczko and S.M. Bruemmer, "Crack-Growth Response of Alloy152 and 52 Weld Metals in Simulated PWR Primary Water," Proc.14th International Conference on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors, ANS, 2009, p. 690.

Dr. Bruemmer and co-workers have also published many earlier PWSCC-relevant papers (1996-2009). These documents are also available on request. In addition, recent Department of Energy reports for our ongoing SCC Initiation project as part of the Light Water Reactor Sustainability program can be provided:

M. B. Toloczko, M. J. Olszta, D. K. Schreiber and S. M. Bruemmer, "Stress Corrosion Crack Initiation of Alloy 600 in PWR Primary Water Environments," Technical Milestone Report, Light Water Reactor Sustainability Program, DOE Office of Nuclear Energy, March 2013.

M. J. Olszta, D. K. Schreiber, L. E. Thomas, M. B. Toloczko and S. M. Bruemmer, "Grain Boundary Attack of Alloy 600 in PWR Primary Water Environments," Technical Milestone Report, Light Water Reactor Sustainability Program, DOE Office of Nuclear Energy, September 2012.

S. M. Bruemmer and M. B. Toloczko, "Stress Corrosion Crack Initiation of Nickel-Base Alloys in LWR Environments," Technical Milestone Report, Light Water Reactor Sustainability Program, DOE Office of Nuclear Energy, September 2011.

APPENDIX B – CONFLICT OF INTEREST INFORMATION

Agreement Number NRC-HQ-60-14-D-0014

Upon submitting a proposal to the NRC, each DOE Laboratory would continue to acknowledge the disclosure requirements of: 1) MD 11.7, "Organizational Conflict of Interest"; and 2) the provisions of the Memorandum of Understanding (MOU) between DOE and NRC, dated 1998 (which states, in part, that DOE recognizes that Section 170A of the Atomic Energy Act of 1954, as amended, requires that NRC be provided with disclosures on potential conflicts when NRC obtains technical, consulting, research and other supporting services). DOE further recognizes that the assignment of NRC work to DOE laboratories must satisfy NRC's organizational conflict of interest (OCOI) standards.

Therefore, each DOE Laboratory, in its proposal to NRC (which will be incorporated into an interagency agreement between NRC and DOE), is required to make an assertion per #1 or #2 of Part A below for themselves and all subcontractors proposed prior to their award. If the Laboratory selects #1, then, it must also fill out the accompanying Part B – whereby the Laboratory must, again, make an assertion by answering each of the five (5) NRC OCOI provisions per the NRC Acquisition Regulation (NRCAR).

As part of this proposal, Pacific Northwest National Laboratory (PNNL) has reviewed its current work, planned work and where appropriate, past work for DOE and others (including NRC licensees, vendors, industry groups or research institutes that represent or are substantially comprised of nuclear utilities) for the past 5 years for work in the same or similar technical area as this proposed NRC project and found no projects that pose a conflict.

PART A:

"In accordance with PNNL's role in, and responsibility for, disclosing its relationships with organizations which conduct business in the same and/or similar technical area as described by the present and/or ongoing NRC project's scope of work, and in accordance with the NRC clause as stated herein, PNNL hereby asserts that it has examined its relationships with all such organizations, and has also examined its current and future/planned work, and where appropriate, its past work (generally for the previous five years), for DOE and other organizations, and PNNL states the following:

1) PNNL hereby discloses the following relationships that may give rise to a potential OCOI. (DOE Laboratory must answer the questions in Part B below):

Or

2) PNNL to the best of its knowledge and belief, asserts that it has no current work, planned work, and where appropriate, past work for DOE and others (to mean - organizations in the same and/or similar technical area as the present and/or ongoing NRC project scope of work); and PNNL hereby asserts that it is not aware of any same/similar technical work that would give rise to any potential OCOI as defined in the Atomic Energy Act of 1954, as amended, and in the NRC/DOE MOU.

Signed: Sheena Kanyid

PART B:

In accordance with PNNL's role/responsibility regarding OCOI disclosure, as stated in Part A, above PNNL further discloses, to the best of its knowledge and belief, that:

1) PNNL and/or any of its organizational affiliates* as defined in Part A above [does/does not] provide advice and recommendations to the NRC in the same technical area (e.g., fire protection, PRA, seismic, vulnerability analysis, fracture mechanics) where it is also providing consulting assistance to any organization regulated by NRC. If PNNL "does" – the PNNL hereby discloses such organization(s) in Part A above;

2) PNNL and/or any of its organizational affiliates as defined in Part A above [does/does not] provide advice and recommendations to the NRC on the same or similar matter (e.g., particular licensing amendment, particular EIS, particular high level waste repository site) on which it is also providing assistance to any organization regulated by NRC. If PNNL "does" - the PNNL hereby discloses such organization(s) in Part A above;

3) PNNL and/or any of its organizational affiliates as defined in Part A above [will/will not] be required to evaluate its own products or services, or has been substantially involved in the development or marketing of the products or services of another entity. If PNNL "does" - the PNNL hereby discloses such organization(s) in Part A above;

4) PNNL and/or any of its organizational affiliates as defined in Part A above [does/does not] have a conflicting role, given the award of the present and/or ongoing NRC project, in which its judgment or the judgment of any of its organizations may be biased in relation to its work for NRC. If PNNL "does" – the PNNL hereby discloses such conflicting role(s) with organization(s) in Part A above;

5) PNNL and/or any of its organizational affiliates as defined in Part A above [are/are not] soliciting or performing concurrent work at an applicant or licensee site, while performing work in the same/similar technical area for NRC at the same site. If PNNL "does" – then the PNNL hereby discloses such organization(s) in Part A above."

Signed: Sheena Kanyid

*Organization affiliate – Business concerns which are affiliates (related) to each other when either directly or indirectly, one concern or individual controls or has the power to control another, or when a third party (i.e. parent firm) has the power to control both.

** The Atomic Energy Act of 1952 uses the term "person" to mean any entity – e.g., sole proprietorship, partnership, joint venture, corporation; university; limited partnership, subchapter S corporation; limited liability company, etc.