DNGS Units 1-4 SGs Primary Side Cleaning 16 - 38935

Developmental Release Business Case Summary D-BCS-33110-10008-R001

1/ RECOMMENDATION:

Approval is requested to reduce previously approved funding from $4.7M to $2.1M for this Developmental Release of OM&A to complete Darlington SG (steam generator) Primary Side Cleaning (PSC) process qualification and effectiveness testing by a single new external firm, and for subsequent evaluation of the results.

At Darlington, magnetite has always been leaching out of the feeders and the Primary Heat Transport (PHT) System, and depositing on the inner surface of the SG tubes. This tube fouling results in reduced heat transfer and flow in the primary heat transfer system and therefore an increase in reactor inlet and outlet coolant temperatures. At the current rate of flow reduction, the reactor units are projected to reach their end of full power operation by ~ 2013 and will need to be derated from that point on, with a resultant loss of revenue.

The PSC process, developed by an external firm, was applied to Darlington Unit 1 steam generators during the 2004 outage, but the results were not satisfactory. The PSC performed in D411 did not meet the required performance criteria, the firm has not been able to meet testing schedule, and has not made significant improvements to the process. Thus the proposed purchase order to this firm has been cancelled. This will not prevent use of Competitive Bidding process for Site Execution Phase of the Project.

It is proposed to complete the Qualification and Effectiveness testing of the PSC as developed by a new external firm, which has performed four campaigns at another nuclear company. Only after testing will it be possible to determine if the new improved process best meets the cleaning acceptance criteria for DNGS Steam Generators and then to make an informed decision whether it is justifiable to proceed with the Primary Side Cleaning.

An improved primary side cleaning process is expected to provide coolant flow improvements and thus reduced reactor inlet header temperatures, such that unit derating could be postponed until 2016 or 2017, which is very close to the station re-tube date (2018-2021).

This work may be eligible for a Scientific Research and Experimental Development tax credit of 20% on the 2.1M$.

$000's (incl contingency)	Funding	LTD 2007	2008	2009	2010	2011	2012	Later	Total
Currently Released	N/A								-
Requested Now	Developmental		925	1,125	25				2,075.0
Future Funding Req'd					6,000	9,000	20,000	60,300	95,300.0
Total Project Costs		-	925	1,125	6,025	9,000	20,000	60,300	97,375.0
Other Costs									-
Ongoing Costs									-
Grand Total		-	925	1,125	6,025	9,000	20,000	60,300	97,375.0
Investment Type: Sustaining		Class: OM&A		(IEV) Impact on Ec Value: -18 M$		IRR: N/A		Discounted Payback: N/A	

Submitted By:

S. Woods
Director, Engineering

26 MAR 2009
Date:

Finance Approval:

R. Leavitt
VP Nuclear Finance

March 31 2009
Date:

Line Approval (Per OAR Element 1.1 Project in Budget):

Wayne Robbins
SVP - Darlington

2009-04-02
Date:

2/ BACKGROUND & ISSUES

At Darlington, the steam generators have experienced degradation in heat transfer capacity due to the buildup of a magnetite layer on the inner surface of the steam generator tubes. This has resulted in reduced flow in the primary heat transport system and an increase in reactor inlet and outlet coolant temperatures.

The rate of reactor inlet temperature increase is estimated at 0.2 - 0.3 °C per year. At this rate, the reactor inlet temperature of the hottest fuel channels will reach the operating limit of 269.4 °C by 2013, at which point continuous reactor derating will be required.

All Darlington units have exhibited a decreasing trend in primary heat transport flow rate over time, which is estimated at approximately 1% per year. This impacts the rate at which heat can be removed from the fuel, which is also impacted by diametrical creep of the pressure tubes, which increases the diameter of the fuel channel. At this rate of flow reduction, the units are projected to reach the Neutron Over Power limit by ~2013 and will need to be derated from that point on.

In addition, the steam generator tube fouling causes difficulties during eddy current inspection of steam generator tubes, reducing probe service life and introducing the risk of probes sticking in the tubes.

A Primary Side Clean Project (PSC) was developed in 2001 to reduce or remove the magnetite layer on the internal surfaces of the steam generator tubes. A process of abrasive blasting with stainless steel shot previously used at other CANDU stations by an external firm was adopted and qualified for a bounding application pressure of 4 bar. (The original intent was to qualify for 6.5 bar but this was reduced due to concerns related to boiler tube damage.)

Following qualification, this process was applied to Darlington Unit 1 steam generators during the D411 spring outage. Approximately 60% of the steam generator tubes were cleaned (as compared to the target of >90%) and an improvement in coolant flow rate of 2.5% was seen, with an average reactor inlet header temperature reduction of 0.7°C as compared to the target of 1.75 - 2.5°C. Due to the disappointing results associated with reactor inlet header temperature, subsequent cleaning operations on the other units were postponed until refinements in the process could be made. The Qualification and Effectiveness testing that was performed was found to have several shortcomings as described in an independent audit report, hence requiring re-qualification and effectiveness testing.

The Primary Side Cleaning performed in D411 did not meet the performance criteria. The external firm which performed D411 Primary Side Cleaning (PSC) has not performed any further PSC campaign since D411, has not demonstrated significant improvements to the process, and has not been able to meet the schedule requirements. Therefore, the PSC PO to this firm has been cancelled. This will not prevent from using Competitive Bidding process for Site Execution Phase of the Project.
Subsequent to the D411 PSC campaign, another firm developed a PSC process and applied it successfully at another nuclear company. Thus Qualification and Effectiveness testing of a Primary Side Cleaning Process developed by this external firm is proposed, to determine if the new process can meet the cleaning acceptance criteria for DNGS Steam Generator and be able to make an informed decision whether it is justifiable to proceed with the PSC.

An improved PSC process should provide coolant flow improvements and reduced reactor inlet header temperatures so that unit deratings could be postponed until 2016 or 2017, which is very close to the station re-tube date (2018 - 2021).

Prior to proceeding with PSC process Design Modifications and Site execution, it is necessary to determine whether the improved PSC process can meet the required cleanliness acceptance criteria and project objectives, as described below. PSC Project objectives (Critical Success Factors) are:

- To provide a more effective and efficient PSC process that can be completed within the outage window (40 days scheduled as per approved Generation Plan) for this process.
- Achieve > 90% tube clean of all four boilers per unit.
- Achieve > average 1.5 °C reactor inlet header temperature reduction. (Note: Unit 1 was already cleaned 60% and the second time ID cleaning after six years may not be able to reach this target).
- Achieve > 3% flow increase in the heat transport system.

It is proposed to perform Qualification and Effectiveness testing of the Primary Side Cleaning Processes developed by a new external firm. Only after testing will it be possible to determine if this process can meet the cleaning acceptance criteria for DNGS Steam Generator and be able to make an informed decision whether it is justifiable to proceed with the Primary Side Cleaning. Qualification testing will include not only the short radius tubes and long radius tubes, but also intermediate radii tubes in order to be able to perform PSC at varying optimum pressures for different radii tubes, instead of a single most limiting one.

3/ ALTERNATIVES AND ECONOMIC ANALYSIS

$ Millions	Status Quo	Alt 1 (Recommended)		Alt 2	Alt 3	Alt 4	Alt 5
		Full Cost	Incremental Cost	Delay			
Revenue	11	1	1	-	-	-	
OM&A	60	2	1	-			
Capital				-			
NPV (after tax)	(32)	(50)	(50)	-			
Impact on Economic Value (IEV)	N/A	(18)	(18)				
IRR%	N/A	N/A					
Discounted Payback (Yrs)	N/A	N/A					

Status Quo - Not Recommended
In the Darlington SGs, deposition of magnetite on the inner tube surfaces causes a decreasing trend in primary heat transport flow rate over time, which is estimated at approximately 1% per year. This will result in reactor inlet temperature of the hottest fuel channels reaching the operating limit of 269.4 °C by 2013, at which point continuous reactor derating will be required. The end effect of not doing primary side cleaning is an increasing loss of revenue.

Alternative 1 - Perform Qualification & Effectiveness Testing - Recommended
It is recommended to Complete Qualification and Effectiveness testing of Primary Side Cleaning Process developed by the external firm. Only after testing will it be possible to determine if this process can meet the cleaning acceptance criteria for DNGS Steam Generators and then make an informed decision whether it is justifiable to proceed with the Primary Side Cleaning. An improved primary side cleaning process could provide coolant flow improvements and reduced reactor inlet header temperatures such that unit derating could be postponed until 2016 or 2017, which is very close to the station re-tube date (2018 - 2021).

Alternative 2 - Delay Project - Not Recommended
Feasible but not advisable, as the possible derating window is approaching in a few years.

Alternative 3 – - Not Recommended
Increased margin to dry-out can be achieved by increasing the Primary Heat Transport pressure set-point. The impacts of this change have not been assessed to determine if there are limitations or subsequent effects on the units that would preclude taking this approach.

Alternative 4 – - Not Recommended
Reduction in Reactor Inlet Header Temperature can be achieved by reducing the secondary side pressure set point in the Steam Generator. The impacts of this change have not been assessed to determine if there are limitations or subsequent effects on the units that would preclude taking this approach.

Alternative 5 – - Not Recommended

4/ THE PROPOSAL

The scope of Work proposed for the current developmental phase of the project is summarized as below:

(1) Perform Qualification Testing to determine the Optimum bounding parameters for most effective cleaning

The previously used process was adopted and qualified for a bounding application pressure of 4.5 bar based on the minimum radius tubes. (Steam generator tubes form a U-bend within the vessel with the tubes closer to the centre of the tubesheet bent in a tighter radius, which is the most limiting case for primary clean qualification.) It is proposed to perform qualification testing of the intermediate radii tubes as well, allowing higher cleaning pressures and more effective cleaning.

Proposed qualification testing will also include laboratory tests and inspections to ensure steam generator tubes will not be damaged during the actual cleaning operation.

(2) Perform Effectiveness Testing to confirm that Cleaning Effectiveness and Performance Targets Can be Met

Simulated fouling was used in the previous qualification testing, which projected successful performance but yielded significantly worse results when actually implemented in the field. Testing of a pulled tube sample, prior to D411, did not provide any useful data. During the current proposed qualification testing, actual tube samples removed from Darlington steam generators will be used to provide more realistic projections of cleaning effectiveness.

(3) Gather data to finalize the decision on whether to proceed with Primary Side Cleaning at Darlington

The scope of the Primary Side Cleaning Project requires process re-development, modification, and re-qualification to provide a more efficient and effective cleaning process than the one used during the D411 outage. If qualification and effectiveness results favour going forward with primary side cleaning, this will be documented in a Full Release BCS for subsequent approval.

(4) Select the Vendor Capable of Providing the Best Results for Darlington

Only one company was available prior to Unit 1 D411 cleaning execution. Since then, another firm has developed a primary side cleaning process and performed four Primary Side Cleaning campaigns at another Nuclear Company. Current information does not allow a determination of which of the two processes will better meet project goals while minimizing overall cost. Qualification and effectiveness testing results from the new firm, and actual cleaning performance results from D411, will allow determination of the most suitable vendor.

Following is the list of deliverables that will be completed as part of this Developmental Release BCS.
(1) Qualification and Effectiveness Test Plan, Procedures, and Inspection and Test Plans
(2) Tube Samples and Test Materials supply.
(3) Qualification and Effectiveness Testing Execution using Contractor's Test Rig, Equipment and Tooling
(4) Final Reports
(5) Results Evaluation

5/ QUALITATIVE FACTORS

- Determine the optimum Qualification Bounding Parameters for Most Effective Cleaning.
- Confirm that Cleaning Effectiveness and Performance Targets can be met.
- Provide data to finalize the decision on whether to proceed with Primary Side Cleaning at Darlington.
- Provide basis to be able to select the Vendor capable of providing the best results for Darlington.

6/ RISKS

Description of Risk	Description of Consequence	Risk Before Mitigation	Mitigating Activity	Risk After Mitigation
Cost				
Qualification and Effectiveness Testing is more demanding than originally estimated.	Exceed budgeted cost. May not be able to complete scope within allocated budget.	**Medium**	Contingency funding ($200K) has been included in this release.	**Low**
Scope				
Additional tests may be required.	Cost increase and/or schedule extensions.	**Low**	Any scope changes will be challenged and if found necessary then scope changes will be entertained, once approvals have been obtained from stakeholders in accordance with the scope change process. Contingency funding ($200K) has been included in this release.	**Low**
Schedule				
Qualification and Effectiveness Testing not completed on schedule.	Delay in evaluation of PSC process performance.	**Medium**	Ensure coordination with all supporting work groups.	**Low**
Delay in procurement of Tube sample material for Qualification and Effectiveness Testing.	Delay in completion of Qualification and Effectiveness Testing.	**Medium**	The procurement of new tube samples is included in the Contractors scope of work, if sample tubes are not available in time, expediting fees (additional cost) may be required.	**Low**
Resources				
Insufficient resources to perform testing	Delay in evaluation of PSC process performance	**Medium**	Resources will be provided by Contractor	**Low**

Technical				
The Qualification and Effectiveness Testing Rig / process equipment not available.	Unable to perform Qualification and Effectiveness Testing.	**Medium**	Vendor is responsible to provide Qualification and Effectiveness Test rig and process equipment, as per Scope of Work.	**Low**
Unable to ship contaminated PSC Process equipment / pulled tube samples to the external firm (off-site).	Radioactive shipment will be required.	**Medium**	Vendor is responsible to provide Qualification and Effectiveness Test rig and process equipment and shipment of equipment and tube samples.	**Low**
Unable to find facility to perform effectiveness testing on contaminated (radioactive) pulled tubes on a full scale mock-up.	Effectiveness Testing will have to be performed on a reduced scale mock-up.	**Medium**	External Firm has to present Strategy and acceptance criteria to ensure reduced scale mock-up testing will replicate the results of full scale mock-up. OPG will review and accept the disposition.	**Low**
Regulatory				
N/A		**N/A**		**N/A**
Environmental				
N/A				
Health & Safety				
N/A		**N/A**		**N/A**
Investment				
Scientific Research and Experimental Development tax credit on Developmental portion is disallowed.	OPG loses 20% tax credit on 2.1M$	**Low**	Work with tax staff and consultant to ensure that the tax credit is allowed.	**Low**

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7/ POST IMPLEMENTATION REVIEW PLAN

Type of PIR:	Targeted Final AFS Date:	Targeted PIR Approval Date:	PIR Responsibility (Sponsor Title)
TBD in Next Release			

Comments:

	Measurable Parameter	Current Baseline	Targeted Result	How will it be measured?	Who will measure it? (person / group)
1.	Binding Qualification Pressure (large radius tubes)	4 bar	>4 bar	Qualification Test Pressure gauge	Contractor / Engineer EMD
2.	Binding Qualification Pressure (Intermediate radius tubes)	4 bar	>4 bar	Qualification Test Pressure gauge	Contractor / Engineer EMD
3.	Binding Qualification Pressure (short radius tubes)	4 bar	TBD	Qualification Test Pressure gauge	Contractor / Engineer EMD
4.	Effectiveness of magnetite removal from pulled tube sample	None	TDB	Weighing of the tube sample before and after PSC Effectiveness Test.	Contractor / Engineer EMD
5.	No Damage to the tube at qualified parameters, during PSC Qualification & Effectiveness Testing	No damage to the tube samples	No damage to the tube samples	Visual Inspection and NDT of tube samples	Contractor / Engineer EMD / Kinectric

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Appendix "A" **Glossary** (acronyms, codes, technical terms)

PSC	Primary Side Cleaning
NOP	Neutron Over Power
NDT	Non Destructive Testing
TBD	To Be Determined
BCS	Business Case Summary
ALARA	As Low as Reasonably Achievable
JSA	Job Safety Analysis
ITP	Inspection and Test Plan
PEP	Project Execution Plan
PJB	Pre-Job Briefing

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Appendix "B" Project Funding History

$ 000's		All Existing and Planned Releases (incl contingency) Cumulative Values									
Release Type	Month	Year	2007	2008	2009	2010	2011	2012	2013	Later	Total
Developmental	May	2008		3,505	1,125	25					4,655
Developmental	Feb	2009		925	1,125	25					2,075
											0
											0
											0
											0
											0
											0

LTD Spent				925							925

Comments:

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Appendix "C" Financial Model – Assumptions

Project Cost Assumptions:

Cost based on budgetary quote provided by the external firm selected to do the Primary Side Cleaning qualification testing.

Financial Assumptions:

Project / Station End of Life Assumptions:

Base Case	Unit 1	Unit 2	Unit 3	Unit 4
Date of 1st Derate	2013	2013	2013	2013
Derate %	0.5%	0.5%	0.5%	0.5%
# Years Duration	3	3	3	3
Date of 2nd Derate	2016	2016	2016	2016
Derate %	1.0%	1.0%	1.0%	1.0%
Fluence Limit (EFPH) ***	210,240	210,240	210,240	210,240
# Years Duration	EOL	EOL	EOL	EOL

Project	Unit 1	Unit 2	Unit 3	Unit 4
Outage (Clean Date)	2014	2013	2012	2013
Benefit of Clean (years)	5	5	5	5
Benefit of Clean (%)	3.0%	3.0%	3.0%	3.0%
1st Derate % after Clean	0.5%	0.5%	0.5%	0.5%
Length of Derate (yrs)	3	3	3	3
2nd Derate % after Clean	1.0%	1.0%	1.0%	1.0%
# Years (or to Fluence limit)	EOL	EOL	EOL	EOL

Energy Price / Production Assumptions:

	Unit 1	Unit 2	Unit 3	Unit 4
Net Output per Unit (MW)	878	878	878	878
EFPH Time at YE 2007	119,837	118,873	113,530	110,288
Fluence Limit (EFPH) ***	210,240	210,240	210,240	210,240
Rate / MWH (2009)	$54.58	$54.58	$54.58	$54.58
Inflation / Rate Increase				
Revenue infl (2009 to EOL)	2.0%	2.0%	2.0%	2.0%
Base Cost infl (2009 to EOL)	2.0%	2.0%	2.0%	2.0%

Operating Cost Assumptions:

Per 2008-2012 Business Plan, increasing by 2% pa thereafter.

Other Assumptions:

N/A

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Attachment "A" Project Cost Summary

$000's Capital & OM&A	LTD Prior Yr 2007	This Release 2008	This Release 2009	This Release 2010	Future Release 2010	Future Release 2011	Future Release 2012	Later	Total
Project Management (OPG)	-	33	92	25					150
Engineering & Drafting (OPG)	-	10	68						78
Material									-
Installation – PWU, BTU		-	-						-
Contract - Design	-								-
Contract - Installation									-
Contract - Other		-	105						105
Future Releases					6,000	9,000	20,000	60,300	95,300
Contract Qualif. & Effective. Test		882	660						1,542
Interest (Capital Project Only)									-
Project Costs (excl contingency)	-	925	925	25	6,000	9,000	20,000	60,300	97,175
General Contingency		-	200						200
Specific Contingency									-
Project Costs (incl contingency)	-	925	1,125	25	6,000	9,000	20,000	60,300	97,375
2008-2012 Business Plan	-	1,600	4,300	25,500	25,500	25,500	-	-	82,400
Variance to Business Plan	-	(675)	(3,375)	(25,475)	(19,500)	(16,500)	20,000	60,300	14,775
MFA			-						-
Inventory Write Off Required			-						-
Spare Parts / Inventory			-						-
Total Release (excl contingency)	-	925	925	25	6,000	9,000	20,000	60,300	97,175
Total Release (incl contingency)	-	925	1,125	25	6,000	9,000	20,000	60,300	97,375

Ongoing OM&A (non-project)									-
Removal Costs (incl in above)									-

Note: Contract-Other include independent Lab./Reviews and Rental charges for SIVABLAST Equipment off-site storage.
First Primary Side Cleaning Campaign will start in Spring 2012.

Basis of Estimate					
Design Complete	Zero to Minimal		Quality of Estimate	Release + 15% to - 10%	
3rd Party Estimate	No	OPEX used	Yes	Lessons Learned	Yes
Reviewed by Sponsor	Yes	Budgetary Quote(s)	Yes	Phase 1 Actual Used	N/A
Similar Projects	Yes	Contracts in place	No	Competitive Bid	Yes

Variance to Business Plan

The estimated variance(s) to the 2008-2012 Business Plan will be addressed through the portfolio management process.
A PCRAF is not required .

Reviewed By:

Ricardo Fiorini — 9 MAR 2009
Ricardo Fiorini
Project Manager — Date:

Approved By:

Dianne Gaine — March 9/09
Dianne Gaine
Eng & Mods Manager (Strat IV) — Date:

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Attachment "B" **Project Variance Analysis**

OM&A	LTD Dec 2007	Choose One: Last BCS Jun 2008	Choose One: This BCS Feb 2009	Variance	Comments
Project Management (OPG)		180	150	-30	
Engineering & Drafting (OPG)		120	78	-42	
Material				0	
Installation – PWU, BTU		40	0	-40	
Contract - Design				0	
Contract - Installation				0	
Contract - Other		215	105	-110	
Previous Releases (OM&A + Cap)				0	Scope Reduction as explained in BCS.
Contract Qualification & Effectiveness Testing		3,600	1,542	-2,058	
Interest (Capital Project Only)				0	
Project Costs (excl contingency)	**0**	**4,155**	**1,875**	**-2,280**	
General Contingency		**500**	**200**	-300	
Specific Contingency				0	
Project Costs (incl contingency)	**0**	**4,655**	**2,075**	**-2,580**	
MFA			0	0	
Inventory Write Off Required				0	
Spare Parts / Inventory				0	
Total Release (incl contingency)	**0**	**4,655**	**2,075**	**-2,580**	
Total Release (excl contingency)	**0**	**4,155**	**1,875**	**-2,280**	

Ongoing OM&A (non-project)				**0**	
Removal Costs (incl in above)				**0**	

Comments:

Attachment "C"

Key Milestones

Completion Date			Description
Day	Mth	Yr	
28	AUG	2008	Qualification & Effectiveness Testing Contract Award
04	JUL	2009	Qualification and Effectiveness Testing Complete
02	NOV	2009	Final Report Complete
19	DEC	2009	Evaluation of Primary Side Cleaning Processes Complete

A Project Execution Plan (PEP) is not required

Comments: