Work Authorization Document

NSTX Upgrade Project

Control Account #:	3300	**Title:**	Bakeout System Mods for CSU
WBS	1.3.3	**Title:**	Bakeout System
Period of Performance:	03 May 2010 through 20 August 2014		
Authorized Budget:	$79	**Control Account Manager:**	Raki
Revision #:	0	**Revision Date:**	July-11

Authorized Work Description:

The Bakeout Heating System provides a heating system to bake out the vacuum vessel. It includes a heating blanket system for the vacuum vessel and the insulation for that system. It includes a supplementary heating system for the center stack coil subsystems. The controls and interlocks for safe operation of this system is included. This WBS element includes the engineering design, analysis, procurement activities and component fabrication.

This WBS element includes the purchase of a new more powerful power supply, to replace the existing one, to be used for electrical heating of the vessel. It is proposed to buy a 0-8V, 8000 amps for the application. Suitable cable leads will be fabricated and necessary interlocks will be incorporated.

Attachments:

1- A detailed Control Account schedule showing all work packages and planning packages.

2- Budgeted Cost by month.

3- Original Work Authorization Form (WAF)

4- WBS Dictionary sheet that defines the scope of work for this WBS element.

Control Account History

ECP#	Implement Date	Prior Budget	New Budget	Signature

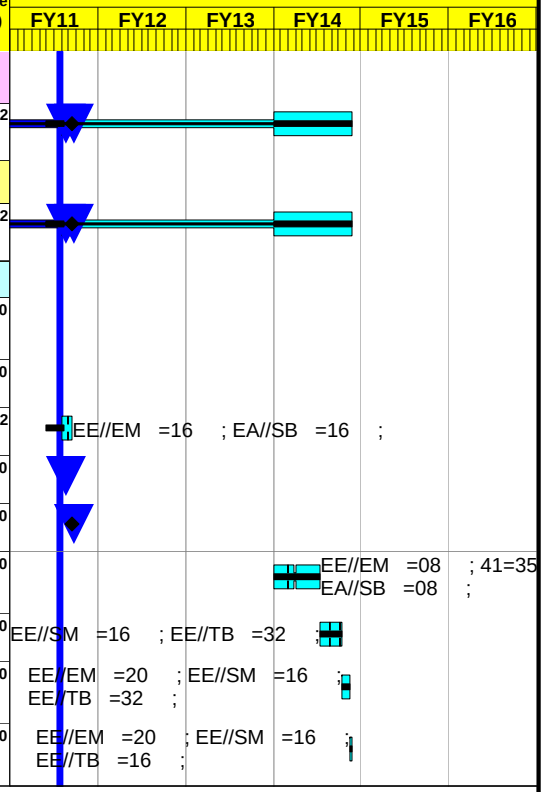
Approvals	Name	Signature	Date
NSTX-U Project Manager	R. Strykowsky		
Control Account Manager	Raki		
Functional Manager	A. vonHalle		

NSTX Upgrade Project

Activity ID	Activity Description	Work Days	BASELINE START	Forecast Start	BASELINE FINISH	Forecast Finish	Schedule Slip (Days)	Total Float	Budgeted Cost	PPCT	Earned value cost (BCWP)	Planned value cost (BCWS)
Subtotal		1,073	03MAY10A	03MAY10A	20AUG14	20AUG14	0	13	79,181.84		0.00	4,193.02

Job: 3300 - Bakeout System Mods for CSU-RAKI

Activity ID	Activity Description	Work Days	BASELINE START	Forecast Start	BASELINE FINISH	Forecast Finish	Schedule Slip (Days)	Total Float	Budgeted Cost	PPCT	Earned value cost (BCWP)	Planned value cost (BCWS)
Subtotal		1,073	03MAY10A	03MAY10A	20AUG14	20AUG14	0	13	79,181.84		0.00	4,193.02
3300-105	Bakeout- Prelim Design	37	03MAY10A	03MAY10A	23JUN10A	23JUN10A	0		0.00	100	0.00	0.00
3300-110	Bakeout-PDR	0			23JUN10A	23JUN10A	0		0.00	100	0.00	0.00
3300-115	Bakeout-Final Design	33	01MAR11*	02MAY11*	09MAY11	16JUN11	-27	127	4,764.80		0.00	4,193.02
3300-117	Bakeout-Peer Review	0				18MAY11*	0	147	0.00		0.00	0.00
3300-120	Bakeout-FDR	0			15JUN11*	22JUN11*	-5	123	0.00		0.00	0.00
3300-125	Bakeout-Procure Hardware	130	01OCT13*	01OCT13*	14APR14	14APR14	0	13	50,007.84		0.00	0.00
3300-130	Bakeout-Assembly	65	15APR14	15APR14	16JUL14	16JUL14	0	13	5,986.24		0.00	0.00
3300-135	Bakeout-Installation	20	17JUL14	17JUL14	13AUG14	13AUG14	0	13	9,988.84		0.00	0.00
3300-140	Bakeout-Test	5	14AUG14	14AUG14	20AUG14	20AUG14	0	13	8,434.12		0.00	0.00



Data Date	**30APR11**	**1105**	**NSTX UPGRADES** **RESOURCE LOADED SCHEDULE** **CD-2 Schedule** **April 2011**	**Sheet 1 of 1**
Run Date	**20MAY11 10:59**			

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Early Bar
Progress Bar
Critical Activity

3300 Bakeout System Mods CSU (Raki)	START	28FEB2009	31MAR2009	30APR2009	31MAY2009	30JUN2009	31JUL2009	31AUG2009	30SEP2009	31OCT2009	30NOV2009	31DEC2009
BCWS	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWS	0	0	0	0	0	0	0	0	0	0	0	0
BCWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWP	0	0	0	0	0	0	0	0	0	0	0	0
ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CV	0	0	0	0	0	0	0	0	0	0	0	0
SV	.	.	.	.	.	.	.	.	.	.	.	.
CPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

3300 Bakeout System Mods CSU (Raki)		31JAN2010	28FEB2010	31MAR2010	30APR2010	31MAY2010	30JUN2010	31JUL2010	31AUG2010	30SEP2010	31OCT2010	30NOV2010	31DEC2010
	BCWS	0	0	0	0	0	0	0	0	0	0	0	0
	CUM BCWS	0	0	0	0	0	0	0	0	0	0	0	0
	BCWP	0	0	0	0	0	0	0	0	0	0	0	0
	CUM BCWP	0	0	0	0	0	0	0	0	0	0	0	0
	ACWP	0	0	0	0	0	0	0	0	0	0	0	0
	CUM ACWP	0	0	0	0	0	0	0	0	0	0	0	0
	CV	0	0	0	0	0	0	0	0	0	0	0	0
	SV	.	.	.	.	.	.	.	.	.	.	.	.
	CPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	SPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

3300 Bakeout System Mods CSU (Raki)	31JAN2011	28FEB2011	31MAR2011	30APR2011	31MAY2011	30JUN2011	31JUL2011	31AUG2011	30SEP2011	31OCT2011	30NOV2011	31DEC2011
BCWS	0	0	2	2	1	0	0	0	0	0	0	0
CUM BCWS	0	0	2	4	5	5	5	5	5	5	5	5
BCWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWP	0	0	0	0	0	0	0	0	0	0	0	0
ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CV	0	0	0	0	0	0	0	0	0	0	0	0
SV	.	.	-2.	-4.	-5.	-5.	-5.	-5.	-5.	-5.	-5.	-5.
CPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

3300 Bakeout System Mods CSU (Raki)	31JAN2012	29FEB2012	31MAR2012	30APR2012	31MAY2012	30JUN2012	31JUL2012	31AUG2012	30SEP2012	31OCT2012	30NOV2012	31DEC2012
BCWS	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWS	5	5	5	5	5	5	5	5	5	5	5	5
BCWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM BCWP	0	0	0	0	0	0	0	0	0	0	0	0
ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CUM ACWP	0	0	0	0	0	0	0	0	0	0	0	0
CV	0	0	0	0	0	0	0	0	0	0	0	0
SV	-5.	-5.	-5.	-5.	-5.	-5.	-5.	-5.	-5.	-5.	-5.	-5.
CPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

3300 Bakeout System Mods CSU (Raki)		31JAN2013	28FEB2013	31MAR2013	30APR2013	31MAY2013	30JUN2013	31JUL2013	31AUG2013	30SEP2013	31OCT2013	30NOV2013	31DEC2013
	BCWS	0	0	0	0	0	0	0	0	0	8	8	8
	CUM BCWS	5	5	5	5	5	5	5	5	5	13	20	28
	BCWP	0	0	0	0	0	0	0	0	0	0	0	0
	CUM BCWP	0	0	0	0	0	0	0	0	0	0	0	0
	ACWP	0	0	0	0	0	0	0	0	0	0	0	0
	CUM ACWP	0	0	0	0	0	0	0	0	0	0	0	0
	CV	0	0	0	0	0	0	0	0	0	0	0	0
	SV	-5.	-5.	-5.	-5.	-5.	-5.	-5.	-5.	-5.	-13.	-20.	-28.
	CPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	SPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

3300 Bakeout System Mods CSU (Raki)		31JAN2014	28FEB2014	31MAR2014	30APR2014	31MAY2014	30JUN2014	31JUL2014	31AUG2014	30SEP2014	31OCT2014	30NOV2014	31DEC2014
	BCWS	8	7	8	5	2	2	7	13	0	0	0	0
	CUM BCWS	37	44	51	56	58	60	66	79	79	79	79	79
	BCWP	0	0	0	0	0	0	0	0	0	0	0	0
	CUM BCWP	0	0	0	0	0	0	0	0	0	0	0	0
	ACWP	0	0	0	0	0	0	0	0	0	0	0	0
	CUM ACWP	0	0	0	0	0	0	0	0	0	0	0	0
	CV	0	0	0	0	0	0	0	0	0	0	0	0
	SV	-37.	-44.	-51.	-56.	-58.	-60.	-66.	-79.	-79.	-79.	-79.	-79.
	CPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	SPI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Annex I – WBS Dictionary

This Work Breakdown Structure (WBS) organizes and defines the scope of the NSTX Upgrade using the WBS as established by the original NSTX project and modified to accommodate the NSTX Upgrade.

WBS L1	L2	L3	Description
1			**NSTX UPGRADE PROJECT**
	1.1		**Torus Systems**
		1.1.0	Project Integrated Model
		1.1.1	Plasma Facing Components
		1.1.2	Vacuum Vessel and Support Structure
		1.1.3	Magnet Systems
	1.2		**Plasma Heating and Current Drive Systems**
		1.2.1	High Harmonic Fast Wave (HHFW)
		1.2.2	Coaxial Helicity Injection (CHI) Current Drive
		1.2.3	Electron Cyclotron Heating (ECH)
		1.2.4	Neutral Beam Injection (NBI)
	1.3		**Auxiliary Systems**
		1.3.1	Vacuum Pumping System
		1.3.2	Coolant Systems
		1.3.3	Bakeout Heating System
		1.3.4	Gas Delivery System
		1.3.5	Glow Discharge Cleaning System
	1.4		**Plasma Diagnostics**
		1.4.1	Plasma Diagnostics
	1.5		**Power Systems**
		1.5.1	AC Power Systems
		1.5.2	AC/DC Converters
		1.5.3	DC Systems
		1.5.4	Control and Protection System
		1.5.5	General Power Systems and Integration
	1.6		**Central Instrumentation and Controls (I&C)**
		1.6.1	Control System
		1.6.2	Data Acquisition System
	1.7		**Project Support & Integration**
		1.7.1	Project Management and Integration
		1.7.2	Project Physics
		1.7.3	Integrated Systems Tests
	1.8		**Site Preparation and Assembly**
		1.8.1	Site Preparation
		1.8.2	Torus Assembly and Construction

- Evacuate the spent plasma constituents at the end of each pulse prior to the next plasma pulse;
- Remove impurities liberated during bakeout and/or discharge cleaning of the vacuum vessel interior; and
- Provide instrumentation and a Residual Gas Analyzer.

This WBS element also includes the controllers for all pumps and any baffles for backstreaming.

In order to accommodate the installation of the 2nd NBI on NSTX the existing Vacuum Pumping System will be modified. This WBS element includes the design, fabrication, and installation of a new vessel pumping system and includes new pump ducts off of the Neutral Beamline 2 duct, mechanical and electrical isolation of the system, vacuum diagnostic relocation, magnetic shielding and support of TVPS TMPs, and TMP service connections.
{NSTX NB2 TVPS (Job 2485)}

WBS Element: 1.3.2 **WBS Level: 3**
WBS Title: Coolant Systems
Definition: The Coolant System provides cooling water to remove heat generated from NSTX systems during experimental operations. The systems include the:

- TF/PF bus and coil cooling water system;
- Center stack cooling water system;
- Component cooling water system; and the
- Ohmic heating cooling water system.

These systems will provide cooling water for normal operations and discharge cleaning of the vacuum vessel. This WBS includes engineering design, analysis, procurement activities, component fabrication and installation to the coil, bus and component cooling manifolds at the torus.

The new Center Stack on NSTX will require modifications to the existing coolant system. This WBS element will provide water cooling services to the new Center Stack and ancillary equipment in the NSTX test cell.
{Water System Coolant Modifications for CSU (Job 3200)}

WBS Element: 1.3.3 **WBS Level: 3**
WBS Title: Bakeout Heating System
Definition: The Bakeout Heating System provides a heating system to bake out the vacuum vessel. It includes a heating blanket system for the vacuum vessel and the insulation for that system. It includes a supplementary heating system for the center stack coil subsystems. The controls and interlocks for safe operation of this system is included. This WBS element includes the engineering design, analysis, procurement activities and component fabrication.

This WBS element includes the purchase of a new more powerful power supply, to replace the existing one, to be used for electrical heating of the vessel. It is proposed to buy a 0-8V, 8000 amps for the application. Suitable cable leads will be fabricated and necessary interlocks will be incorporated.
{NSTX CSU Bakeout System Mods (Job 3300)}

WBS Element: 1.3.4 **WBS Level: 3**
WBS Title: Gas Delivery Systems
Definition: The Gas Delivery Systems provides storage and delivery of gases to and from NSTX systems during experimental operations. These systems provide:

- Storage of on-site inventories of gases for use in NSTX plasma physics and future neutral beam experiments;
- Delivery of prescribed quantities of gases at prescribed purity levels and flow rates;
- Delivery of gases continuously or in pulses of prescribed shape and duration; and
- Evacuation of delivery lines and components required for delivery.

This WBS includes engineering design, analysis, procurement activities, component fabrication and installation to the coil, bus and component cooling manifolds at the torus.

This WBS element includes the design, fabrication and installation, and test of two center stack fueling lines and modifications of the gas delivery assemblies.
{Gas delivery system modifications (Job 3400)}

WBS Element: 1.3.5 **WBS Level: 3**
WBS Title: Glow Discharge Cleaning System
Definition: The Glow Discharge Cleaning (GDC) System establishes and controls the GDC process in NSTX. GDC is a mode of vacuum conditioning in which the vacuum vessel internal surfaces are cleaned by the bombardment of ions formed during the glow process. This WBS includes engineering design, analysis, procurement activities, component fabrication and installation of the GDC system. There are no changes to the Glow Discharge Cleaning system as part of the NSTX Upgrade Project.

WBS Element: 1.4 **WBS Level: 2**
WBS Title: Plasma Diagnostics
Definition: The Plasma Diagnostics provide information on discharge parameters to characterize NSTX plasmas and guide its operation for optimized performance. The near term emphasis will be on detailed measurements of plasma profiles, using equipment presently available at PPPL. The long term objective will be to provide input for advanced plasma control systems, using new concepts and systems developed by the national NSTX team.

Work Approval Form (WAF)

Cost Center: 9417
Job Number: 3300
Job Title: NSTX Center Stack Upgrade - Bakeout System Mods
Job Manager: S. Ramakrishnan

Description:

A new power supply will be purchased and used for the electrical heating of the vessel. It is proposed to buy a 0-8V, 8000 amps for the application.Suitable cable leads will be fabricated and necessary interlocks will be incorporated.

Schedule:

Refer to Primavera Data-Base

Approvals:

7/20/10
Job Manager

8/3/10
Project Manager

8/3/10
Engineering Department Head

Cost Center:	**9417**																											
Job Number:	**3300**																											
Job Title:	**NSTX Center Stack Upgrade - Bakeout System Mods**																											
Job Manager:	**S. Ramakrishnan**																											
WBS			*TASK DESCRIPTION*							*M&S*						*Design/ Procurement*		*Installation*				*Commissioning*				*Line Total*	*Cont.*	
					Multiplier	Qnty	Units	Qnty	Units	Qnty	Units	Unit Cost	Cost	Spare Units	Spare Cost	EEEM	EASB	EEEM	EESM	EETB	Sub contrac	EEEM	EESM	EETB			
												(k$/unit)	($K)		($K)	(md)	(md)	(md)	(md)	(md)	($K)	(md)	(md)	(md)	($K)		
100 - Bake out Power feed																												
			Bake out Power Feed	Design & Supervision	1											3.0	3.0		10.0						$19.1	20%	
				Materials & Installation	1						1	$35.0	$35.0			2.0	2.0		4.0	8.0			2.0	2.0	$61.5	20%	
	592 - System Testing	13.136	13.136																									
			Procedures PTPs, ISTPs	Procedures	1											2.0	2.0								$5.2	20%	
				Pwr Supply PTP	1																	2.0	2.0	4.0	$7.9	20%	
			TOTALS										$35.0			7.0	7.0		14.0	8.0		2.0	4.0	6.0	$93.8		
RATES												M&S -->	$35.0														
EEEM	*1.421*																										
EESM	*1.203*											M&S with Overhead	$42.9														
EETB	*0.66*																										
G&A	*1.2260*																										
EASB	*0.9504*																										
																								EEEM	9		
																								EESM(D)	7		
																								EESM	18		
																								EETB=	14		
																								M&S			
																								Total			
		FY2010 Hourly Rates																									
EEEM	1.1932	149.2	1.1932	1.3680																							
EESM	1.1910	148.9	1.1910	1.1600																							
EETB	0.7136	89.2	0.7136	0.6400																							
G&A (MHX)	1.2260	1.178		1.2500																							
DM	0.9504	118.8	0.9504	0.9900																							

Cost Center:	9417
Job Number:	3300
Job Title:	NSTX Center Stack Upgrade - Bakeout System Mods
Job Manager:	S. Ramakrishnan

Uncertainty of the Estimate

	High	Medium	Low	Uncertainty Range (%)	Comments/Other Considerations
Design Maturity	x				
Design Complexity			x		

Residual Impacts

	Risk Description	Likelihood of Occurring	Mitigation Plan	Basis of estimate	Cost Impact Low ($K)	Cost Impact High ($K)	Schedule Impact Low (weeks)	Schedule Impact High (Weeks)
1								
2								
3								
4								
5								

Notes:

(1) Cost impacts should NOT include standing army costs which are separately calculated from the schedule impact

(2) The schedule impacts should be entered as the min and max impacts on the critical path.
If there is no critical path impact then the schedule entries should be zero.

(3) Likelihood of occurrence should be entered consistent with our risk classification methodology, i.e.
VL= Very Likely (P>80%), L=Likely (80%>P>40%), U=Unlikley (40%>P>10%), VU=Very Unlikely (P<10%), NC=Non-credible (P<1%)

Design Maturity	Design Complexity					
	Low		Medium		High	
Low	-15%	+25%	-20%	+40%	-30%	+60%
Medium	-10%	+15%	-15%	+25%	-20%	+40%
High	-5%	+10%	-10%	+15%	-15%	+25%

Design Maturity Definition

High	Final design available. All design features/requirements well known. No further design development or evolution expected that will impact estimate.
Medium	Preliminary design available. Some additional design evolution likely. Further developments can be somewhat expected or anticipated and reflected in estimate.
Low	No better than conceptual design basis currently available. Design details, procedures, etc. still need much development and evolution of requirements beyond estimate basis is likely and expected.

Design Complexity Definition

Low	Work is fairly well understood -- either standard construction or repetition of activities performed in past. Little likelihood of estimate not being well understood and requirements not being well defined.
Medium	More complex work requirements that have potential to impact cost and schedule estimates. Limited experience performing similar tasks, so ability to estimate accurately is somewhat suspect
High	Extremely challenging tasks and/or requirements. Unique or firstof-a-kind assembly or work tasks. No good basis for estimating work exists so there is a high degree of estimate uncertainty.

Based on standard industry and DOE estimate classifications (Per AACEI Recommended

Cost Center:		**9417**					
Job Number:		**3300**					
Job Title:		**NSTX Center Stack Upgrade - Bakeout System Mods**					
Job Manager:		**S. Ramakrishnan**					

Materials and Subcontracts (M&S)				**Basis of Estimate**			
Description:							
DC Power Supply				Quotee from vendor			
				Previous experience			

CATEGORIZATION CODES:
1 - National Standards
2 - Engineering Judgement/Experience
3 - Estimates/Data from External Sources (e.g., W7X, ATF, etc.)
4 - Previous PPPL/ORNL Experieince (e.g., TFTR, NSTX, PLT, etc.)
5 - Prototype Data/Test Results
6 - Catelogue Price/Vendor Quote
7 - Placed Contracts
8 - Actual experience for NCSX Work
9 - Other