Final Design Review Panel Report

for the

NATIONAL COMPACT STELLARATOR EXPERIMENT (NCSX) PROJECT

May 19-20, 2004

NCSX Final Design Review
May 19-20, 2004

Panel Report

CONTENTS

Summary Response to Charge

A Final Design Review for the National Compact Stellarator Experiment (NCSX) was held at the Princeton Plasma Physics Laboratory (PPPL) from May 19-20, at the request of the PPPL Director. This was a key technical review of the NCSX design prior to the approval of Critical Decision 3 (CD-3), Department of Energy (DOE) approval for fabrication.

The NCSX project is an innovative magnetic fusion configuration consisting of a stellarator plasma with three field periods surrounded by eighteen modular coils (six per field period.) A vacuum vessel fills the internal volume of the modular coils to provide maximum space for plasma shape flexibility. The complete NCSX system also includes toroidal and poloidal field coils, a cryostat, power subsystems, and numerous other subsystems. The modular coils and vacuum vessel are the two critical subsystems because of their technical, cost, and schedule risks. The eighteen modular coil winding forms (the structures upon which the coil windings will be fabricated and permanently supported) and the three vacuum vessel sub-assemblies (the vessel body segments and port extensions) are the project's two long-lead components. Both are to be fabricated in industry. This Final Design Review focused on the project's readiness to proceed with these two procurements.

The Final Design Review (FDR) committee found that the designs for the Vacuum Vessel Subassembly (VVSA) and the Modular Coil Winding Forms (MCWF) satisfy the technical requirements and needs of the project and are ready to proceed with procurement and fabrication. Some comments and recommendations developed during this review were provided to the NCSX team to improve the design and the procurement strategies and further reduce the risks associated with component delivery. Design-related recommendations and issues identified during the October, 2003, preliminary design review have been adequately addressed.

As noted in prior reviews, the modular coils and the vacuum vessel comprise the most technically challenging subsystems on NCSX, embody the most risk and are on the project's critical path schedule. The key challenges associated with these components are: (1) controlling distortion during fabrication and assembly of the VVSA to minimize potential impacts on the tight tolerance budget; and (2) meeting the aggressive production schedule for the modular coils.

The VVSA design configuration satisfies all operational requirements and the procurement plan is well-founded. Prototype manufacturing activities have demonstrated that the manufacturing plan is sound and the risks associated with fabrication can be managed. Fabrication tolerances appear to be within the proposed supplier capabilities. The VVSA supplier selection plan is reasonable and the planned procurement schedule supports delivery of the final VVSA hardware in time to meet project integration and assembly requirements. There have been some cost increases associated with added scope and risk mitigation activities; the project should ensure that sufficient contingency is maintained to manage the risks associated with production. The project should continue to place high priority on completion of R&D on the final vessel assembly weld process which is essential to reducing the risks associated with the final field weld joints.

There is excellent progress in the design, analysis and manufacturing R&D for the MCWF. The MCWF prototype contracts have been very successful in demonstrating the feasibility of the manufacturing process. The specifications and technical documentation are well-developed and ready to proceed to procurement with some minor revisions. The NCSX team has done an excellent job in qualifying two vendor teams; this experience should ensure competitive, realistic responses during the selection process. The delivery schedule for the production MCWF is aggressive and presents some schedule risk to the project critical path. The NCSX team in conjunction with procurement personnel should investigate the best strategy for structuring the RFP with an eye to mitigating this schedule risk. Also, additional effort and consultation is recommended to ensure an adequate materials testing database for characterization of the cast materials service requirements, especially for fatigue life qualification.

Technical Findings, Comments, and Recommendations

1. Introduction

The NCSX is a fusion research facility included in the FY-03 and subsequent years' DOE budgets for fabrication at the Princeton Plasma Physics Laboratory (PPPL). The compact stellarator is one of several innovative magnetic fusion plasma configurations supported by the DOE Office of Fusion Energy Sciences (OFES) and has the attractive potential of operating continuously and without plasma disruptions. Also, when extrapolated to a fusion power plant, the compact stellarator is projected to require low operating power compared with that produced by the power plant.

The mission of NCSX is to acquire the scientific and technological knowledge needed for understanding the behavior of a compact stellarator plasma, evaluating the attractiveness of this fusion concept, and advancing the state-of-the-art, three-dimensional analysis of fusion plasmas. The NCSX mission need (Critical Decision 0) was approved by OFES in May 2001. That year a panel of plasma physicists and engineers conducted a Physics Validation Review of the NCSX design. The panel concluded that the physics approach to the NCSX design was appropriate and that the concept was ready for the next stage of development, namely proof-of-principle. The Fusion Energy Sciences Advisory Committee endorsed the panel view.

The NCSX project involves the design, fabrication, installation, and integrated system tests of a compact stellarator core device consisting of a highly shaped vacuum vessel, surrounding coil systems, enclosing cryostat and various auxiliary power, heating, cooling, vacuum, cryogenic, and control systems, as well as a set of startup diagnostics. All of this equipment plus a control room will be located in existing buildings at PPPL that were previously used for other fusion experiments. Further, many of the NCSX auxiliary systems will be made available to the project from equipment used on the previous experiments. The project is led by PPPL with Oak Ridge National Laboratory (ORNL) providing major leadership and support as a partner.

Because the project involves the fabrication of new equipment and considerable re-use of existing facilities and hardware systems, with minimal civil construction, DOE designated the project as a Major Item of Equipment (MIE) and included it as such starting with the FY 2003 budget.

The NCSX Project completed a DOE conceptual design review (CDR) in May 2002. Following the CDR, the DOE approved an acquisition plan for NCSX based on a preliminary cost estimate of $73.5M and an execution period of October 2002 through June 2007. In November 2002, the Department approved Critical Decision 1 (CD-1), authorizing the start of preliminary design. Because of the delay in the Congressional budget appropriation in early FY-03, the NCSX advanced conceptual design phase was extended through March 2003, during which time the project continued to resolve design issues and initiated R&D activities. The NCSX project execution phase, beginning with preliminary design, started on April 1, 2003.

The project completed a preliminary design review (PDR), a DOE performance baseline review, and a DOE external independent review (EIR) in October and November of 2003. After incorporating recommendations from these reviews and DOE modifications to the funding profile, the project received DOE approval of CD-2, establishing the performance baseline, in February, 2004. The baseline budget is $86.3M with project completion (CD-4) scheduled for May, 2008.

2. WBS 12, Vacuum Vessel Sub-Assembly (VVSA)

Technical Findings

The NCSX vacuum vessel is a highly shaped, three-period structure. The geometry also has stellarator symmetry; i.e., it is mirrored every 60º so that the top and bottom sections of the first (0º to 60º) segment can be flipped over and serve as the corresponding sections of the adjacent (60º to 120º) segment. The vessel will be baked to 350ºC and operate with a nominal operating temperature of 40-100ºC. The vessel is maintained at temperature by helium gas circulated through tracing lines attached to the vessel exterior. The vessel is insulated on its exterior surface to provide thermal isolation from the modular coils, which operate at cryogenic temperature (80K). The vessel must be fabricated from low magnetic permeability materials and provide an ultra-clean, high vacuum environment for the plasma. Inconel 625 was chosen for the vessel shell. It was selected over stainless steel primarily because of its low permeability (both in the parent and weld material), high electrical resistivity, and high strength at elevated temperature.

The vessel includes 90 radial and vertical ports for diagnostic and utility access to the plasma, including future upgrade requirements. The ports are arranged to best utilize the limited space between modular coils. The large neutral beam (NB) ports and the ports immediately adjacent to the NB injection ports are designed to permit personnel access into the vacuum vessel interior for final assembly welding of the three vessel sub-assemblies and for maintenance of diagnostics and in-vessel components during operation. The vessel is delivered by the VVSA supplier with only the NB ports and vertical ports installed since they do not interfere with the modular coils and TF coils during field period assembly. Port stubs are provided on the vessel for all remaining extensions to locate them for welding, while permitting the modular coils to slip over the vessel during assembly. All welding of the port extensions is completed from the inside surface of the ports after the modular coils are installed. The extensions are Inconel and protrude through the modular coil structural shell terminating at a stainless steel flange.

The NCSX team has worked with two different candidate vendors to demonstrate fabrication of two identical 20-deg prototype sections of the vessel. The prototype sectors included one small-diameter port extension. This represents an important vessel fabrication risk reduction activity that has successfully qualified both vendors to compete for the final VVSA production award. It also provided the NCSX team with the opportunity to ring out many of the vendor coordination, performance tracking, and dimensional inspection / quality assurance processes required to successfully complete the vessel production contract on schedule and within budgeted cost. Key demonstrations included: CAD model exchange, forming, machining, welding and inspection / quality assurance processes required to fabricate this highly-shaped, 0.375-in thick, In 625 structure. The panel is confident that the shaped vessel can be successfully fabricated.

Remaining panel concerns involve dimensional tolerance control during large port extension / 60-deg segment welding and final field assembly welding of the 120-deg vessel sub-assemblies. These are discussed below.

The panel reviewed presentations, documents, and design data pertaining to the VVSA. In response to the charge questions, the panel found:

1. *Do the VVSA designs satisfy the requirements, can they be manufactured and inspected, and are they ready to proceed with fabrication?*
   The VVSA panel finds that the design configuration satisfies all operational requirements and that the procurement plan is well-founded. In particular, prototype R&D activities have shown that the manufacturing plan is sound and that the risks associated with sector fabrication can be managed. Inspection / quality assurance plans are in-place and were successfully exercised on the prototype hardware. The panel notes that close coordination with the fabrication vendors will be required as the first full 120-deg sector subassembly fabrication proceeds to maintain required dimensional tolerance while completing the activity within cost and schedule constraints. Several recommendations are provided below in addition to the planned vendor coordination and reporting activities to address this issue.

2. *Are the VVSA product specifications and other technical documentation adequate to proceed with procurement?*
   The panel finds that VVSA product specifications and other technical documentation are comprehensive, clear, and ready to proceed with final procurement bids from the candidate suppliers, pending final drawing checking and resolution of the FDR panel recommendations noted below. Final design configurations (drawings and CAD models) are nearly finished and technical analyses have verified that vessel thermal-structural performance is within standard ASME code allowables for the proposed materials. Fabrication tolerance requirements are challenging, but appear to be within the supplier capabilities based on the prototype sector fabrication results.

3. *Are there sound plans in place for executing the VVSA procurements?*
   The panel finds that the proposed supplier selection plan is reasonable and that the planned procurement schedule supports delivery of the final VVSA hardware to meet the overall project integration and assembly requirements. The panel further recognizes that projected budget increases for the VVSA are primarily based on: (1) further risk mitigation work associated with dimensional control during the final 60-deg sector assembly welds and associated large port extension welds and (2) provisions for 30 additional ports to improve diagnostic access. These supplier scope changes should be accounted for in a way that does not affect the remaining VVSA budget for dealing with actual production contingency issues.

4. *Have recommendations from previous reviews that affect readiness to proceed with these procurements been appropriately addressed?*
   The panel finds that all technical recommendations from prior design reviews that affect readiness to proceed with the vessel procurement have been addressed. The panel is satisfied with the resolution of these issues and accepts the design team dispositions. In particular, the switch to a 350°C vacuum bakeout of the entire vessel was viewed as a significant design improvement considering plans for future operation with C-C plasma facing components. There is ongoing R&D work on final vessel assembly weld process development that is essential to completing the risk reduction activities associated with the VVSA final field weld joints. The panel attaches a high priority to completing these activities as soon as possible since they will impact the final 120-deg sector weld joint preparation details.

Comments

- Dimensional control issues associated with final sector assembly and port extension weld joints and associated vacuum integrity issues represent risk areas that the panel feels have not been fully addressed in the risk reduction activities to-date. All meaningful ways to help mitigate these fabrication risks need to be considered as VVSA production work proceeds. Two possible risk reduction activities discussed by the panel are outlined below.

- The team should consider cutting and rewelding one of the prototype vessel sections to help develop techniques for maintaining dimensional control while making the large, circumferential poloidal welds that join the 60-deg vessel sectors together. This could help address supplier cost / schedule risks associated with final dimensional tolerances and vacuum integrity requirements.

- Alternatively, the team could consider using the prototype parts to evaluate distortion effects associated with the larger, one-sided vessel-vacuum port welds. A larger representative port extension could be welded, cut off, and the opening machined to assess effects of weld stresses and removal of locked-in vessel fabrication stresses over the large port areas. This would provide an opportunity to assess vacuum integrity effects and inspection criteria at port/vessel weld cross-over locations. It would also provide a test bed to verify the concept of cutting and re-welding the ports, in particular the adjustment of the weld gap prior to welding and the control of the orientation of the port during welding. Since the shape of the weld is neither planar nor perpendicular to the axis of the port, automatic welding could be difficult.

Recommendations

The following recommendations should be considered prior to placing the VVSA contract:

2-1. Assure that the product specification makes clear reference to the manufacturing tolerances and that all piece-part and sub-assembly tolerances are clearly specified.

2-2. Finalize reference datums for sector final inspections and plans for metrology during final assembly. Only three primary datums should be used to inspect and locate parts.

2-3. Specify more clearly some of the test requirements; e.g., the scope of tests after the thermal cycling, the tolerable leak rate of the VV.

2-4. Describe more clearly the metrology strategy and the transfer of data between PPPL and the potential vendor to assure that proposed costs reflect the PPPL final inspection plans.

2-5. Clarify and agree on the type of metrology equipment to be used by the company as well as the involvement of PPPL in the measurements at the vendor's workshop. Check whether the temperature in the vendor's workshop is adequately controlled to ensure the measuring accuracy required.

2-6. Request a breakdown of the costs into engineering, manufacturing, tooling, and testing categories in the proposals to ease the evaluation of the proposals and identify cost drivers.

2-7. Require a complete vacuum leak check after 375C thermal cycling of the 120-deg VVSA. This should include all port extension interface welds in addition to the vessel.

2-8. Consider increasing the VV tolerances in some local areas (where possible) in an effort to keep cost down. This could be addressed by asking vendors to provide an alternative quote to a more relaxed final tolerance specification in non-critical clearance areas of the vessel to determine the impact of dimensional control measures on the proposed fabrication costs.

The following recommendations are not essential to releasing the procurement packages but should be integrated into the final work plans:

- Define the interface of the magnetic diagnostics with the vacuum vessel and check for any interference with the He bake out tubes at an early stage
- Measure the deformations and strains during the leak test of one sector and compare the measurements with the predictions of the structural calculation
- Assure that the instrument measurement errors are considered in the final tolerance budget
- Other design review comments and panel feedback are documented in the reviewer chits that were provided to the NCSX team.

3. WBS 14, Modular Coil Winding Form (MCWF)

Technical Findings

The panel reviewed presentations, documents, and design data pertaining to the Modular Coil Winding Forms (MCWF) and found that the NCSX team has made excellent progress in the design, analysis, and manufacturing R&D for these critical components. The modular coil set consists of three field periods with 6 coils per period, for a total of 18 coils. Due to symmetry, only three different coil shapes are needed to make up the complete assembly. The function of the winding forms is to provide an accurate means of positioning the conductor during the winding and vacuum-pressure impregnation (VPI) process. The winding forms are permanent structures that also provide mechanical support for the windings during coil operation. The complete assembly of winding forms is referred to as the structural shell and as such, provides the primary structural support of the stellarator core, including supporting the weight of the Vacuum Vessel.

Essential features of the MCWF include:

1) Accurately machined surfaces for the conductor, so that the final position of the winding center conforms to the prescribed geometry within a tolerance of +/- 1.5mm.
2) A poloidal break to meet electrical (eddy current) requirements
3) Construction using a low magnetic permeability (<1.02) material.

Design requirements for the modular coils and forms include operation from 77K, 150 cooldown cycles, and 130,000 pulses over >10 years of operation.

Due to the complexity of these shapes, the winding forms will be fabricated as castings, with a tolerance of +/- 0.25 inch on all the as-cast features of the part. Machining of only the winding cavity, flanges and other interfaces is then necessary to achieve the desired accuracy.

During the past ~18 months a detailed manufacturing R&D program has been underway to assess the manufacturing feasibility of the MCWF. This work has been carried out through two contracts to independent manufacturing vendor teams, one lead by Energy Industries of Ohio (EIO) and one lead by JP Pattern. This phase includes the manufacturing of a “C” type prototype form including mold design, casting, inspection, repair, heat treatment and final machining. Each vendor has used a 316 stainless steel type alloy with proprietary modifications to keep the magnetic permeability below 1.02, especially in weld repaired areas.

In response to the charge questions, the panel found:

1. *Does the MCWF design satisfy the requirements, can it be manufactured and inspected, and is it ready to proceed with fabrication?*

   The panel finds that the manufacturing R&D and prototype contracts have been very successful in demonstrating the overall feasibility of the MCWF manufacturing process by first establishing the manufacturing methods in detail, followed by manufacturing of two prototype forms which are not yet completed.

   Two teams are almost fully qualified as suppliers for the MCWF, and will soon be able to deliver Firm Fixed Price offers and schedules. The present NCSX project cost and schedule for the MCWF components are based on preliminary cost/schedule estimates from the two teams and based on a hybrid cost (intermediate to high and low estimates) and the longer schedule estimates. Each team has developed Manufacturing/Inspection/Test/ Quality Assurance (MIT/QA) plans documenting all key elements.

   One of the teams is more advanced in the prototype form manufacturing and is likely to be finished before the final offer is due. The other team is about 1 month behind and it is not likely that all prototype machining will be completed before the final bid is due. That implies that the full development experience may not be fully accounted for in that offer.

   The panel is concerned about the modifications to the chemistry of the casting alloy and the affect that might have on qualification of the material (base and weld) for this service. Although the basic alloy both teams are using is essentially a standard 316 alloy (CF8M), there are proposed chemistry deviations outside the normal specification to achieve low permeability, especially in the welds. This needs to be considered when determining the required test database. The panel also questioned the relevance of Charpy Impact data for materials at 77K. Although inexpensive, it might not be required. Other methods of evaluating fatigue life such as S/N curves will be performed, however the panel feels this is inappropriate for cast material that is known to have many defects--some of which are repaired as “upgrades.” The existence of flaws deemed acceptable by the cited standard may have an impact on fatigue qualification.

   The NCSX criteria document references ASME. The panel is concerned about the relevant stress allowables for ASME cast 316-like materials. The materials table, section II table 2a of the 1998 ASME Code showed:

Material	Spec	Min Yield (ksi)	Min Tensile (ksi)	Sm (ksi)
CF8M	ASA SA 351	30	70	20

The ASME materials tables show 2/3 yield as the appropriate Sm allowable. However, Bob Keilbach was consulted, and he indicated that a factor of 0.8 was to be applied. It was subsequently found that the 0.8 factor need not be applied for components which are fully radiographed. This is probably discussed in the design sections of the ASME code. The appropriate code section should be reviewed and an interpretation of this should be added to the NCSX criteria document.

The MCWF vendors will repair minor defects defined as less than 10% of the cross sectional area at the region of the repair. There may be very many of these defects (order 100) and too numerous for documentation due to the complex geometry. Major defects (>10% of material thickness) must be documented as deviations and referred to the NCSX team for confirmation of repair. The NCSX team may determine that these major defects are too numerous or large and reject the entire component. The panel finds that this defect criterion as given in the SOW (MSS SP 54) allows some distribution of unrepaired small flaws. This has consequences for the evaluation of fatigue life.

The as-cast material will be sampled for each form from near the fill riser and there is a concern that the material collected from there may not be representative of the bulk material in the center of cast MCWF. Samples taken from the internal regions of the prototype forms may be used to determine the validity of the nominal sampling location material. The panel also suggests that the NCSX team evaluate the use of an arc-spark spectrometer to test the uniformity of the casting chemistry throughout the form.

Although the MCWF are fully inspected after casting, there is only a visual inspection after machining. A full dye penetrant test performed after machining would provide a better method to determine that no flaws or cracks remain at the surface of the sections. The NCSX project is concerned about how to fully clean the pieces after the dye penetrant test since residual dye could have a negative effect on the VPI process of the winding. After discussions the NCSX project team agreed that the dye penetrant test would be added after machining.

2. *Are the MCWF product specifications and other technical documentation adequate to proceed with procurement?*

The panel finds the specifications and technical documentation to be well-developed in an overall sense and ready to proceed to procurement with some revisions.

More specifically the panel notes the following three details which have not yet been incorporated into the design:

1) Machined features to hold an epoxy-filled bladder to support the wing areas of coil "B" to limit deflections are not adequately documented and incorporated into the models.
2) MCWF fiducials (landmarks) are not specified on the drawings.
3) The whole stellarator core assembly is highly 'captured' and would be difficult to disassemble if there was a problem. It might be feasible at this time to incorporate access regions in the MCWF to allow, for example, diamond saw cutting of the VV welds from outside.

3. *Are there sound plans in place for executing the MCWF procurement?*

The panel finds that the NCSX Team has done an excellent job in qualifying two vendor teams through the fabrication of two prototype MCWFs. The experience gained will ensure competitive, realistic quotations from the vendors without the need for large contingencies. The delivery schedule for the production MCWFs is aggressive and presents some schedule risk to the project, as this is on the critical path.

4. *Have recommendations from previous reviews that affect readiness to proceed with this procurement been appropriately addressed?*

The panel finds that the recommendations from previous reviews have been appropriately addressed and thus do not affect the readiness to proceed with this procurement.

Comments

In addition, the panel identified a number of specific concerns or issues which were documented as chits and provided to the NCSX team.

Some additional comments are noted concerning items not directly part of the MCWF procurement:

- Conductor shear stresses along the conductor length are a concern because the individual strands may not be fully bonded to each other even though the interstitial spaces are filled. This may produce the unusual behavior of having the insulation between conductors stronger in shear than the conductor. If there is a situation where the shear in the conductor exceeds the capacity, this could dump load to the insulator and exceed its capacity causing insulation failure. Excessive shear stresses may occur where there is no consequence to conductor shear failure, for example where the conductor is laying-up hard against the vane. There may be other areas where the conductor is pulling away from the vane and conductor shear failure will increase insulation shear stresses. The shear capacity was measured in a small punch shear test that could probably be improved, and LN2 temp results are needed.

- During the tour of the test winding (or "inchworm") the process of sequential clamping of the conductor during winding appeared especially unwieldy. In discussions with L. Myatt and W. Reiersen, the value of further field quality calculations was discussed. Freeing up tolerance constraints in a specific clamping direction might save a great deal of time and money. If for example guides were used parallel to the vane, and the conductor stack was compressed after it was fully wound, there might be a larger shift in current center along the vane rather than normal to it. If this was allowable in terms of field quality, the winding operation might be speeded up.

Recommendations

Based on our review and specific technical findings noted above, the panel recommends the following**:**

To be completed before release of the drawing package:

3-1. Perform full dye penetrant inspection of the MCWF after machining (note: already agreed by NCSX project team).

3-2. Incorporate inflatable bladder details into the models and drawings.

3-3. Establish a set of hierarchical fiducials. The primary fiducials to set up the casting for machining should be located in regions where they will not be machined away at a later time. Secondary fiducials should be inserted with each change of machining set up.

3-4. Review details of the poloidal break shim including use of a taper to help insertion and/or machining as an integral part of the casting.

To be completed before procurement is finalized:

3-5. Consult a materials scientist and/or code expert to determine the appropriate materials testing database required to insure proper characterization of the cast materials for the service requirements, especially for the appropriate fatigue life qualification.

3-6. Update the design criteria to reflect the appropriate maximum stress allowable for cast modified CF8M alloy.

3-7. The NCSX Team should investigate with the PPPL procurement department the best strategy for structuring the RFP for the production MCWFs. Having an option for a split-order, or a backup vendor could provide schedule contingency.

To be completed before first production form is cast:

3-8. Cut material and test samples from the body portion of the finished prototype forms to confirm that samples taken from the casting fill riser tubes correctly represent the bulk casting properties.

3-9. Evaluate methods to facilitate disassembly of the stellarator core should this ever be required, including possible modifications of the MCWF (such as access holes for diamond saw).

Appendix 1.

NCSX Final Design Review Charge

April 21, 2004

Mr. Carl N. Strawbridge
Deputy Director, Spallation Neutron Source Project
Oak Ridge National Laboratory
P.O. Box 2008, MS 6477
Oak Ridge, TN 37831-6477

Dear Carl:

Thank you for agreeing to chair the final design review of the NCSX project on May 19-20. We are looking forward to your committee's assessment of the project's readiness to proceed with fabrication of the modular coil winding forms (MCWF) and vacuum vessel sub-assembly (VVSA), the project's two long-lead procurements. Please respond to the following charge:

1. Do the MCWF and VVSA designs satisfy the requirements, can they be manufactured and inspected, and are they ready to proceed with fabrication?
2. Are the MCWF and VVSA product specifications and other technical documentation adequate to proceed with procurement?
3. Are there sound plans in place for executing the MCWF and VVSA procurements?
4. Have recommendations from previous reviews that affect readiness to proceed with these procurements been appropriately addressed?

Please document specific open issues in the form of chits. Electronic chit forms will be made available for the committee’s convenience. In order to support the project's schedule we need to receive your conclusions in a closeout briefing on May 20 and your final written report by May□8.

Again, my thanks to you and all the members of the committee for contributing your time and energy to this important review. I look forward to meeting with you on May 19.

Sincerely,
Prof. Robert J. Goldston
Director

Appendix 2.

NCSX Final Design Review Panel Members

Carl Strawbridge, Chair	ORNL/SNS	strawbridgec@ornl.gov
Larry Dudek, Deputy Chair	PPPL	ldudek@pppl.gov
VVSA Sub-committee		
Dan Driemeyer, Chair	Boeing Co.	daniel.e.driemeyer@boeing.com
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Appendix 3

Agenda for Final Design Review

Agenda

Wednesday, May 19, 2004

Morning, Room LSB-318

7:45 Continental breakfast (LSB 318)

Committee Executive Session

8:00 Committee discussion, C. Strawbridge

Project Overviews (Plenary Session) Facilitator: R. Hawryluk

8:30 PPPL Welcome, R. Hawryluk

8:40 DOE Perspectives, G. Pitonak, G. Nardella

8:45 NCSX FDR Introduction, H. Neilson

9:15 Break (Coffee refresh in LSB 318)

Late Morning, Room A-104 (Display Wall Room) Facilitator: H. Neilson

9:30 NCSX FDR: System Engineering Perspective, W. Reiersen

10:15 Discussion

10:30 Stellarator Core Design Overview (WBS 1), B. Nelson

11:30 Group photograph (in front of LSB, weather permitting)

12:00 Working lunch for committee (Director's Office)

May 19 Afternoon, Breakout Sessions

VVSA (WBS 12) Breakout, LSB-318	**MCWF (WBS 14) Breakout, A-104 (Display Wall Rm.)**
Facilitator: W. Reiersen **Reviewers:** D. Driemeyer (chair), G. Johnson, M. Wanner, P. Anderson **Agenda** 12:45 Design, Analysis, and Product Specifications, P. Goranson 2:30 Break 2:45 Procurement Plans: SOW, QA, Cost & Schedule update, M. Viola 3:45 Discussion and Chit Disposition 4:30 Adjourn	**Facilitator:** H. Neilson **Reviewers:** J. Minervini (chair), D. Anderson, T McManamy, P. Titus **Agenda** 12:45 Design, Analysis, and Product Specifications, D. Williamson 2:30 Break 2:45 Procurement Plans: SOW, QA, Cost & Schedule update, P. Heitzenroeder 3:45 Discussion and Chit Disposition 4:30 Adjourn

Committee Executive Session, Room LSB-318

4:30 Committee discussion, formulation of questions for NCSX team, C. Strawbridge.
5:15 Meeting with NCSX team.
6:00 Adjourn

7:00 Dinner for Committee and NCSX Team at Carlucci's, West Windsor

Thursday, May 20, 2004

Morning, Room LSB-318

7:45 Continental breakfast (LSB 318)

Committee Executive Session

8:00 Committee discussion, C. Strawbridge

8:30 Adjourn

8:30 Optional tour of NCSX facilities (J. Chrzanowski)

Breakout Sessions

VVSA (WBS 12) Breakout, LSB-318	**MCWF (WBS 14) Breakout, A-104 (Display Wall Rm.)**
Facilitator: W. Reiersen	**Facilitator:** H. Neilson
Reviewers: D. Driemeyer (chair), G. Johnson, M. Wanner, P. Anderson	**Reviewers:** J. Minervini (chair), D. Anderson, T McManamy, P. Titus
NCSX Team responses to questions Presentations if needed Chit disposition Discussion	NCSX Team responses to questions Presentations if needed Chit disposition Discussion

Committee Executive Session

10:00 Committee drafts report and conducts dry run of closeout briefing.

12:00 Working lunch for committee (Director's Office)

Committee continues to work on report and closeout briefing.

Closeout Session with Committee and NCSX Team

4:00 Closeout Briefing (Video Link with DOE-OFES)

4:45 Discussion

5:00 Adjourn