DESIGN REVIEW DOCUMENTATION – RESULTS – No: 2293-PDR-004 #

Title: NSTX-U Project PDR _____

CAT: ☒A1 ☐A2 ☐A3

Type of Review: ☐ **Peer** ☐ **CDR** ☒ **PDR** ☐ **FDR**

Cognizant Individual: Peter Dugan Peter Dugan Digitally signed by Peter Dugan Date: 2018.08.21 08:22:13 -04'00' **Date of Review: August 14th and 15th, 2018**____

Review Board Members:	**Attendees:**	**Attendees:**
Chairperson V. Riccardo_____	N. Atnafu_____	G. Ascione (remote)_____
TA (Mech) M. Viola_____	D. Cai_____	D. Battaglia (remote)_____
TA (Electrical) R. Camp_____	R. Ellis_____	D. Bishop (remote)_____
TA (Vacuum) W. Blanchard___	S. Gerhardt_____	A. Brooks_____
TA (Analysis) A. Khodak_____	M. Kalish_____	A. Castaneda _____
ES&H J. Levine_____	J. Klabacha_____	S. Horst_____
QA S. Tiwari _____	D. Loesser_____	A. Jariwala (remote)_____
Reg. Compliance T. Stevenson__	J. Mitchell_____	E. Langan_____
R. Fair (remote) _____	J. Petrella_____	M. Mardenfeld_____
K. Freudenberg _____	M. Smith_____	R. Feder_____
B. Iotti_____	P. Titus_____	M. Safabakhsh_____
R. Viera (remote) _____	I. Zatz_____	H. Schneider (remote)_____
C. Murphy_____		W. Slavin (remote)_____
R. Callis (remote) _____		G. Swider_____
T. Todd (remote) _____		G. Tchilinguirian (remote)_____
		S. Weidner_____
		Y. Zhai_____

Revised 8/10/18

Items Reviewed:	**Sat.**	**Unsat.**	**Comments or n/a if not applicable**
Appropriate requirements identified	☒	☐	_____
Development plans and schedules	☒	☐	_____
Reg. compliance incl. USI/USID and NEPA	☒	☐	_____
Disposition of CHITS from previous reviews	☒	☐	_____
Cost objectives	☐	☐	N/A _____
Other review objectives addressed	☐	☐	N/A _____

SUMMARY OF RESULTS:

Purpose:

The purpose of the project review is to demonstrate that the technical scope, requirements, interfaces, and technical risks are sufficiently understood, addressed in the system design, and mature commensurate for a preliminary

design review (PDR) for establishing a system baseline.

Charge Questions:
1. Is the technical scope well understood, and does it have design maturity appropriate for a PDR stage? Is the design sufficiently mature to establish the baseline and initiate CDE-3a work?
2. Have the requirements for the NSTX Recovery Project, delineated in the General Requirements Document and subsequent System Requirements Documents (SRDs) and Requirements Documents (RDs), been adequately addressed?
3: Are interfaces for the Recovery scope properly identified and addressed in the design, at a level appropriate for PDR stage. Are interfaces for the -3a scope sufficiently well defined to complete the FDR designs and initiate procurements following the CDE-2/3a review?
4. Have previous recommendations from prior reviews (Project CDR in August 2017 and relevant PDRs) been adequately addressed?
5. Have technical risks been appropriately identified? Are project plans adequate to address/retire/mitigate the identified risks?
6. Are ES&H and QA issues properly addressed?

Systems Engineering:
Bob Iotti underlined the importance to have all SRD requirements linked to the GRD, to avoid SRDs developing requirements in conflict with the GRD.
Bob Iotti enquired about the requirement control management, and the need to update SRDs, but only once changes are adopted, considering all implications.
Some RDs are elevated above the SRDs, e.g. Disruptions, but other crucial ones, e.g. Structural Design Criteria, are not mentioned. The RD set needs to be reviewed for completeness and hierarchy.
Kevin Freudenberg asked if we maintain a design compliance matrix; we are developing one.
Bob Iotti was concerned SRDs are split from SDDs: the design could shape the requirements.
Bob Iotti complemented us on having 1-to-1 Interface Control Documents (ICDs).
Rich Hawryluk asked when the ICDs are signed – by FDR.
Kevin Freudenberg asked how we address effects of NCRs; Bob Iotti and Chris Murphy stressed that the effects of a NCRs need to be flown down to the interfaces. Kevin and Chris want to be reassured that changes (NCRs, ECNs) are communicated to the relevant interfaces and these adjusted where needed. At the moment, the Project Engineer is in the loop for NCRs and ECNs, however these need to be fed to the Systems Engineer, too.

Design Point Spreadsheet:
Rich Hawryluk asked how this tool is used and controlled. Bob Iotti sees this as a convenient tool, but not a document to be subject to configuration control.

Chit Review:
Tom Todd asked whether there is a particular trend in the chits and whether addressing them is prevented by lack of resources. Stefan Gerhardt explained that several integration chits will be resolved when the Project Description Document (PDD) is updated. As the PDD is a picture of the project as it will be, it should be considered as a convenience document, not one to track at this point.

Integrated Analysis:
There is a need to identify critical areas that can still affect the design, and how the acceleration plan can shape the analysis plan.
As well as engineering analysis, plans for component monitoring were also discussed. Surendra Tiwari asked how the components were selected for monitoring. Peter Titus explained that the components not passing the structural analysis criteria are listed.
Chris Murphy complemented the use of independent analysis to confirm the most critical results, and the use of checkers.
As some of the casing critical stresses are due to thermal loads, Peter Titus and Stefan Gerhardt discussed whether a spectrum of thermal cases, similar to that of plasma current and pulse duration, needs to be developed to avoid overdesigning.

Tolerance Analysis:

The Dimensional Control RD sets the maximum allowable error on dimensions. Although achieving tighter control is encouraged, when a component comes in very comfortably within tolerance, the saving is not going to be automatically transferred to the other components in the tolerance chain, but it is used as an additional margin. Chris Murphy warned that the use of contractors for metrology is not a strong long term strategy. It was clarified that the contractors are going to set the framework for PPPL to continue to carry out their metrology independently. Rich Callis started a conversation on the merits of measuring the magnetic geometry of the magnets, rather than their space envelope. Mike Kalish explained that with the new magnet layout, the geometry of the magnet is an accurate proxy for the geometry of the field.

Magnets:
As in the tolerance analysis, the inner PFs have their magnetic geometry equal to their physical geometry. Tom Todd asked about turn transitions. If these are localized they cause error fields. In the new design the winding is a helix, which makes it easier to produce (although at the cost of turns) and allows the magnetic and physical geometry to be the same.
Another error field source is at the busbar connections where in/out branches create large loops. Although their effect is local these need to be improved.
There are concerns the water velocity is too high causing erosion. Water velocity is better <1 m/s, and needs to be <3 m/s. Although high inlet pressure prevents cavitation, the pressure drop might be high. Features like the water inlet/outlet with a sharp right angle were noted. This particular feature is going to be far smoother than pictured. Bob Iotti worried vendors might not qualify and urged to develop fallback plans to be ready to award in November.

Center Stack Casing:
The TF/OH axis needs to be perpendicular to the plane to which the inner PF coils are mounted to avoid error fields. The cylinder sections supporting the vertical divertors are well aligned relatively to each other. The modifications to the flanges might affect this; we are working to minimize the risk.
It was clarified that the angled sections of the casing will not change, but we are considering not including the cooling tube behind these. The material for the tubing was copper in the Upgrade, needs to be stainless to reduce EM loads.

Polar Regions:
The material to be used in the inner PFs sling was discussed. Currently these are planned to be Inconel 718. This is difficult to weld and the geometry does not allow it to be formed.
The overall stiffness of the magnets was questioned because different assessments provide rather different estimates. This needs to be clarified if it affects the integrity of the structure.

Plasma Facing Components:
Tim Stevenson asked if the effects of erosion were considered while developing very precise plasma facing surface details. They were and it is expected that up to 3 thousandths can be eroded. Mike Viola asked whether lithium deposition can affect the features of this geometry. Lithium lingers and builds up in recessed areas not in the divertor.
Chris Murphy questioned the ability to machine graphite with the details present in the AM parts circulated for review. A sample will be delivered at the end of the month.
The ability to have vendors guarantee minimum properties was discussed. Typically these tests are included in their scope. Vendors are refusing to guarantee properties because they vary too much. PPPL will carry out tests to measure bending strength and thermal conductivity, but it is not clear how the test results will be used, when the design relies on properties very close to the best vendors can achieve.
Chris Murphy suggested subjecting the tile assembly to heat cycles representative of operation to quantify the non-elastic compression of the grafoil layer.

Passive Plates:
Tom Todd was concerned that the full toroidal loop achieved by providing good electrical contacts between the plate and its support will affect the ability to breakdown. Doug Loesser clarified that the resistance still has to be tuned to satisfy the requirements. Stefan Gerhardt read the requirements, which do not offer a minimum loop resistance, nor prescribe the toroidal uniformity. The strap is to ensure predictable electrical contact to avoid arcing, the resistance can be large, unless the current path through this strap is the preferred / required for the EM loads.

Bakeout:
Tom Todd asked whether the ball valve was sufficient to provide enough fine control. Joe Petrella explained that the valve selection is driven by the need to operate at high temperature, and that the amount of flow change predicted is achievable with this valve.
Rich Callis asked how the welds of the helium system are qualified: a background of helium is expected, so helium leak checking could be ineffective. Danny Cai explained that before the helium test the system is purged in hydrogen.

CAD Integration:
The ability to check in/out components in the master configuration was discussed. The software (Pro-E Windchill) offers these tools. However, at the moment there is no master configuration. The objective of CAD integration is to develop a single model that the configuration of which can be managed, by collecting the models as defined at the FDR stage.
The intent was applauded, and it was suggested this is planned and not left to the project to defund when the installation is complete.
Tom Todd suggested including the results of metrology, to avoid surprises next time modifications are executed.
The trade-off between annotating "as built" and updating the configuration was discussed. When a NCR affects interfaces, this needs to trigger an ECN and be implemented. NCRs that do not affect interfaces can be annotated on the drawings.

Diagnostics:
Chris Murphy asked for details on the reliability of in-vessel diagnostics, and Rui Vieira about their redundancy. Chris made Rob Ellis discuss which steps are being taken to prevent failures like the few after the Upgrade. There was agreement that all reasonable steps had been taken. The PDR was about 8 months ago and since then there has been little progress; this is because the scope has been put on hold while other areas are progressed to reach a similar level of maturity.

Interspace Pumping:
-

Machine Instrumentation:
Chris Murphy checked that calibration will be at the working temperature. Apart regions where the final design is pending, and hence the instrumentation cannot be detailed yet, the design has progressed as expected.

PF1B Power Loop:
This sub-project exercises significant value engineering: one spare and one OH converter are re-purposed; the re-use of the OH convertor results in the OH over-voltage protection system not being required. Tim Stevenson asked whether the TFTR converter was on the AC Power maintenance list; only basic maintenance was carried out for the last 20 years, so its recommissioning will be challenging.

Test Cell Shielding:
Mike Viola (the Mechanical TA) found the test cell shielding design to be comprehensive but intrusive on the heavily occupied South High Bay area. He asked if it would be possible to consider an external concrete door. George Ascione responded that an external door concept could be easily modeled.
Bob Iotti was surprised that after all the effort put to increase quality (e.g. the requirement to qualify vendors for A-1 and A-2) and rigor (e.g. all calculations completed before FDR), recycled concrete blocks are used in the ceiling of the new extension of the shielding, with uncertainties on their certificates and with potential personal safety consequences in seismic events. It was clarified that seismic analysis had been carried out and passed.

Assembly:
Rich Hawryluk asked how the interfaces are documented when a component is delivered for Assembly. Stefan Gerhardt explained that the condition of the component being delivered (e.g. tested, cleaned…) is stated in the WAF and the effort required to achieve that condition planned. Tim Stevenson suggested having a technical procedure collecting many travelers and smaller technical procedures to ensure no step is forgotten.
Chris Murphy asked whether the unusual configuration of the machine (e.g. a hole instead of the center column) is

accounted for when planning installation work. The unusual configuration is mitigated by additional infrastructure and processes.
Tom Todd was unsure the variability in the outer TF leg installation did not affect the error field, this was confirmed.
Bob Iotti was concerned that there is no continuous safety presence in the Test Cell. It was clarified that ES&H respond promptly when needed and routinely monitor work but nobody is stationed permanently in the test cell.

Vessel / Auxiliaries / Systems Engineering breakout:
Methods for welding the Polar Region slings was extensively discussed as well as the selection of materials used to meet the anticipated loads.
CAD Integration model:

- the objective is to have a single master configuration at the end of the project;
- parts will start to be added in an orderly manned once they have completed FDR;
- as built modifications will be reflected in the master configuration if they affect interfaces (NCR… ECN)
- a gate keeper to the configuration is needed: once the master goes under configuration management parts will be checked out for modification and given to one user only and checked back in when approved (configuration verification being a part of the approval process)
- projects need to be held responsible to deliver the as built configuration

Metrology:

- clarity whether this is a lab capability that is needed
- if a lab capability it needs to be funded sufficiently to be useful
- relying on contractors for long term reference measurements is risky

Angled section cooling:

- If analysis shows this is OK, it is less disruptive to keep it than to design it out
- The net saving achieved by eliminating it might be very small

Plasma Facing / Magnets / PF1B loop breakout:
Two PFC topics were discussed in depth in this sub-group:

1) Why is the PFC design so dependent on accurate knowledge of properties?
    a. The property values vary from vendor to vendor for material of the same grade. This is of particular concern for the tensile properties.
    b. Vendors say they cannot guarantee properties precisely, or even a range. Some offered test by pallet.
    c. PPPL has decided to self-test to verify properties.
    d. Staying within half of the ultimate stress for a brittle material is tight.
    e. Committee recommends no change.
2) Is the failure of any single component (whether one of 100s or individual) the right question?
    a. Current PFC design based on half ultimate tensile stress, some tile types are struggling to meet this requirement.
    b. Can the requirements be changed to help? Can the design criteria be changed to help?
    c. Committee recommends investigate options for allowable stresses.

The material presented to the Change Review Board of August 9th was discussed.

Shielding / Instrumentation / Assembly breakout:
The shielding discussion focused on the seismic questions from the presentation and discussions of other options used in the past by Rich Callis. Rich also questioned diagnostic instrumentation details and recommended that the proposed sheathing on one be tested at high temperature. The instrumentation discussion covered a wide variety of topics and machines. A very detailed discussion ensued regarding the o-ring groove design with respect to the machine assembly step where o-rings are required to stay in place upside down while flanges are mated. It was verified that the o-ring grooves are half dovetail and that the o-rings are captured. Concomitantly, it was discussed and verified that the o-rings stood adequately proud of the flange to permit appropriate compression. The overall flatness of the ceramic on its full circumference was discussed as a concern; metrology to verify flatness was recommended by Joe Petrella so full o-ring compression could be obtained without bottoming them out and thus carrying load on the ceramic.

Generic remarks

Vendor qualification, especially for A-1 and A-2 is a risk to the smooth progress of procurements. The qualification process needs to be tailored to the type of component being procured, the effort spent on COTS needs to be minimized.
In preparation to the Directors' Review, it is important to identify what is not complete yet and how it could affect the design. It is clear there has been significant progress since the OPA review, but the cost has increased and the end date has moved further in the future. The causes of these changes need to be discussed.

Conclusions:
This PDR consolidates the integration among the body of about 40 sub-system PDRs held in FY18, including an early Integration PDR that set the framework. The technical scope is well understood and the sub-systems and elements already subject of a PDR are mature enough to establish the baseline and well integrated. The requirements are clearly understood and only a handful of the 247 requirements are not fully defined (e.g. the resistance of the passive plate loop and the graphite allowable stresses).
A process to identify and quantify interfaces is on-going and is progressing rapidly. Currently the 3A scope includes inner PFs, plasma facing components, CS casing and HTT/HTP. Their interfaces to the rest of the scope are clearly defined. However, some of the internal interfaces are being re-assessed with the objective to accelerate the manufacturing phase of the project.
Chits from previous reviews (DVVR, Project CDR, early integration PDR) have been adequately addressed; their status is tracked and their closure is subject to independent review, per revised ENG-033.
In June, the project held a risk management workshop which has helped reshaping the risk register. Risks have been re-phrased to spell out the event and the consequence and to support the definition of mitigating action. The phase of the project after which each risk can be retired has been identified. In short, technical risk management has progressed to a much healthier condition.
Apart from the lack of a permanent presence of ES&H in the test cell, safety and QA issues have been properly addressed. A very conservative approach to QA has been applied, which could result itself in a risk, by diverting the staff resources from doing engineering to fulfilling QA requirements, hence with the potential of increasing cost and schedule.
This review has been deemed acceptable pending resolution of the chits.

Disposition: [check one]
_____ **Acceptable**
X_____ **Acceptable pending resolution of concerns**- CHITS identified above must be resolved prior to installation.
_____ **Incomplete** - Additional design work is required prior to another design review.
_____ **Unsuccessful** – Corrective actions must be taken and another review process must be initiated.

Design Review Chair Person Valeria Riccardo Digitally signed by Valeria Riccardo Date: 2018.08.20 11:54:58 -04'00' Date: _____

Cognizant Individual Acceptance _____ Date: _____

Distribution: Review Board Members, Operations Center, Responsible Engineer (RE), Cognizant Individuals, Project Manager, Project Director, relevant Technical Authorities (TAs), Chief Engineer (CE), Fire Protection Engineer, Attendees, QA, ES&H, Security, Requesting & Performing Dept. Head

Chits from https://docs.google.com/spreadsheets/d/14WtXAHwg-A62fihlEZ5tQRPIxti9TdNGyO_Ybv62vyk/edit#gid=540527268 (8/17/18)

Originator (First & Last Name):	Organizational Breakdown Structure (OBS)	Subject: (Check as Applicable)	Comment/Concern/Recommendation:	Review Board Comment	Review Board Recommendation
Russell Feder	VV & Internal Hardware, Plasma Facing Components, Magnets, Systems Engineering & Integration	Requirements	There is a set of important enterprise-level requirements that should be highlighted and shown how they connect in to the project. It was odd to see RD-010 for Magnetic Permeability highlighted at a high requirements level but no mention of the general SDC or Vacuum Handbook, etc...We should clean this up for the Director's Review. More Importantly, how do we prove that these basic guidelines are followed. --> Side question...Can RD-010 just be part of one of these handbooks?	hierarchy of RDs, identify the really foundational ones	concur
Russell Feder	Systems Engineering & Integration	Requirements	The Design Point Spreadsheet (DPSS) needs to be placed under configuration control. It is a critical requirements "document" that A-1 designs are based on.	need to define which design documents really need to be configuration managed, and only trust the CMed ones	consider
Peter Titus	Plasma Facing Components, Magnets	Analysis, Performance	Consider a feasibility assessment of adding correction coils at some future date	NCC design was carried to CDR	out of scope
Tom Todd	Magnets, Systems Engineering & Integration	Requirements, Performance, Quality	(I don't know what the categories A1-A3 mean, hence choosing A2!) It was said that PPPL does not intend to measure the magnetic centres of the PF coils and would rely on destructive examination of prototype coils to gauge the discrepancy between the insulation surface and the nominal conductor locus, performing only mechanical alignment. This begs the questions of a) provisions for QA oversight of the production coils, e.g. turn transition locations, and b) whether or not the anticipated errors could be trimmed out by the error field correction coils on the outer surface of the vacuum vessel.	The error field correction coil can produce enough to compensate the errors out of the inner PF coils	redundant

Originator (First & Last Name):	Organizational Breakdown Structure (OBS)	Subject: (Check as Applicable)	Comment/Concern/Recommendation:	Review Board Comment	Review Board Recommendation
Tom Todd	Magnets, Systems Engineering & Integration	Requirements, Analysis, Performance, Hardware, Configuration	A brief discussion of the gravity support skirt immediately underneath PF1AL suggested that the four (?) sections it comprises do not include any insulating shims and insulating bolts to prevent this component from carrying toroidal current. If true, please analyse the effect on the poloidal fields, required PF1BL current, EM loads etc.. Or just insulate it, as I think the new system design requirements "require"!		consider
Tom Todd	VV & Internal Hardware, Plasma Facing Components, Vacuum & Fueling Systems, Cooling Systems, Bakeout System, Systems Engineering & Integration	Requirements, Configuration, Cost/Schedule	A few times today (Weds) we have heard that the tapered part of the centre tube might be done away with. This surely implies considerable impact on many of the design details of the adjacent components inside and outside the vacuum boundary in that region, top and bottom of the machine of course. Is this issue one of the risks already identified?	misunderstanding	rejected
Tom Todd	VV & Internal Hardware, Operations, Systems Engineering & Integration	Requirements, Analysis, Performance, Hardware, Configuration	The people present in 318 appeared to have very different views about the possible effect on plasma initiation of adding the "yellow" passive plate brackets paralleling parts of the old brackets and adding the copper electrical straps enforcing a low-resistance path to the short lengths of VV wall between the brackets welded to it. I advise checking that with the intended modifications, the four rings of PPs don't generate too much vertical field during OH-only plasma initiation.	assess that the toroidal resistance of the PP is not too small	consider
Kevin Freudenberg	Systems Engineering & Integration	Requirements	Tractability spreadsheet for requirements should be managed by RE’s. Template for this design requirements matrix (ITER term) could be provided by system engineering but filling out the table should be done by the responsible engineer and/or analyst.		consider

Originator (First & Last Name):	Organizational Breakdown Structure (OBS)	Subject: (Check as Applicable)	Comment/Concern/Recommendation:	Review Board Comment	Review Board Recommendation
Kevin Freudenberg	Systems Engineering & Integration	Requirements, Analysis	currently no tractability from analysis calc to analysis calc on loading. Please state loading and ref DAC by version # in the ICD.		concur
Kevin Freudenberg	Magnets	Analysis	TF debonding on inner surfaces: Consider using cohesive zone modeling (CZM) in ANSYS to show propagation or stoppage of delamination/ failing elements over cycles.		consider
Kevin Freudenberg	Magnets	Analysis	Stitch welding of CS case: Peak stresses show ~550 MPa peak stress vs ~350 MPa for the complete weld. In both plots the extreme edge elements show highly localized stress. Remesh and or smoothening of the stress should be done. Unclear if stitch welding should be discounted. Consider using peening (conventional or ultrasonic hammer) around the edges to knock down the weld residual stress. This impacts the mean stress correction factors used to calculate Seq for an SN assessment.	if analysis fails try peening	concur
Kevin Freudenberg	Systems Engineering & Integration	Requirements	For a PDR level review, there was not an abundance of drawings presented. Several designs past PDR did not have any drawings available to review but claimed to be >70% complete. Although a deep dive of the drawings is not needed or typically performed at a PDR, a list of the needed drawings (drawing tree) and a status of the drawings should be stated. List of analysis calculations and status should also be presented.	quantification of what is due and what is done for FDRs in various OBS could be defined better	out of scope
Kevin Freudenberg	Magnets	Analysis	For welding of flanges for CS case: recommend welding trials to determine proper technique to reduce distortion. Consider using not only a bolted connection, but a bolted and match drilled pin connection for further strength/reinforcement. Using fasteners to tackle the same loading of a weld is usually problematic because of the fatigue	prototyping planned (polar 2 chit) - not welding 718 in the field	redundant

Originator (First & Last Name):	Organizational Breakdown Structure (OBS)	Subject: (Check as Applicable)	Comment/Concern/Recommendation:	Review Board Comment	Review Board Recommendation
			thread factor. Pins can handle the shear forces and the bolts provide pure axial clamping (no bend on the first thread).		
Kevin Freudenberg	Magnets	Performance	On preload mechanism for PF coils: How is the setcrew and/or faster restrained? Recommend a locking feature so as to not have the faster/screw back out during thermal cycles. Is there instrumentation on the straps to detect creep or loss or preload over time?	checking pre-load does not decrease if prepared a long time before installation	concur
Kevin Freudenberg	Magnets	Analysis, Performance	PF coil Inconel shell: Since the design calls for welded Inconel: recommend that in addition to SN assessment, a LEFM calc be done as well to determine min flaw size in weld and HAZ. Further, CT specimens should be made of the welded material to determine K1c and the Paris constants for use in the LEFM.	also talked about the imperfect mating of welds which should be analysed	consider
Kevin Freudenberg	Magnets	Analysis	Unclear if Inconel 718 is the only option for material. Assume we are geometry locked as we always are with magnet design and turn count for coils. Still, superaustenitic sst's have lower yield and ultimate but generally better fatigue/crack growth performance. Is the preload so high that it discounts their use? If Inconel 718 is the clear choice, consider break bending the material to reduce the amount of welds. Welds will need to be full pen and ground and may still need a weld reduction factor depending on inspection and ASME code source.	Confident 718 can be annealed, welded and heat treated to obtain good welds. The slings are not made on the field.	consider
Kevin Freudenberg	Magnets	Analysis	Continue Inconel straps: Are assembly gaps and tolerances in the analysis model for the connection of the straps to the mating preload structure. It appears that you will need some clearance to assemble the top and these gaps will introduce bending stresses to the straps right above the weld line. General contact analysis		concur

Originator (First & Last Name):	Organizational Breakdown Structure (OBS)	Subject: (Check as Applicable)	Comment/Concern/Recommendation:	Review Board Comment	Review Board Recommendation
			should be used.		
Kevin Freudenberg	Cooling Systems	Analysis	Piping stress: Noting that 256 MPa (even with the Brooks brace) is quite high for a piping stress. According to Table K-1 of ASME B31.3-2010, the allowable yield stress for 316LN at room temperature is 205 MPa. 316L is slightly worse at 173 MPa. Is B31.3 the code of record for your pipe stress assessments? The actual allowable stress (membrane) in calcs actually would be 2/3 of the 205 MPa at 138 MPa for 316LN.	ensure the right allowables are used for piping - we need to state how the allowables are developed, e.g. in the Structural Design Criteria RD; B31.3 not applicable here	consider
Kevin Freudenberg	Magnets	Analysis, Performance	Recommend using the existing prototype coils to verify modulus and cte of the smeared packs used in the analysis models. Various numbers were stated at the review in terms of what is being used which should be a range for both modulus and expansion. The exiting prototypes could be cut into smaller pieces for placement in an MTS machine to verify these values.	if no further tests possible, property range in analysis needs to be broad enough to ensure actual coil falls into it, FDR report sets range already	consider
Richard Callis	Magnets	Requirements	Water flow in copper coil conductors can lead to erosion/corrosion issues if the velocity is too high. Design requirements should be developed identifying maximum allowed water flow velocity. There is a temperature dependence of this phenomena and this should be included in the requirements	confirm by calculation that we are safely away from cavitation (at the highest temperature); velocity below 9 feet/s	concur
Richard Callis	Magnets	Configuration	The coil insulation turn-to-turn design has co-wound 5 mil glass and 3.5 mil Kapton design. Does the 5 mil glass allow sufficient wicking of the epoxy to form a acceptable bond between the insulation and the copper conductor?	insulation layout tried on preprotype and prototype to confirm not a concern, still on going	concur
Richard Callis	Magnets	Hardware	Erosion/corrosion issues are enhanced when there is a discontinuity in the flow passage. If the 90° elbows are to be manufactured the review of discontinuities should be evaluated and added to the Risk matrix.	geometry will be smoother than shown	concur

Originator (First & Last Name):	Organizational Breakdown Structure (OBS)	Subject: (Check as Applicable)	Comment/Concern/Recommendation:	Review Board Comment	Review Board Recommendation
Richard Callis	Magnets	Configuration	Some of the busswork used to connect the magnets to the power supplies appear to generate dipole error fields. Have these error fields been evaluated for their affect on the plasma rotation?	evaluated - negligible effect, no change	resolved
Tom Todd	VV & Internal Hardware, Magnets, Diagnostics, Systems Engineering & Integration	Hardware, Configuration, Cost/Schedule	It appears that currently there is no intention to systematically incorporate the results of metrology into revisions of the CAD configuration model, because it is not considered to be within the scope of the present project. This thinking dogged JET for many years and resulted in many examples of new equipment being impossible to fit without significant reworking after planned installation jobs failed. I recommend that the configuration files are updated in the light of metrology "as soon as resources permit" and definitely before any new equipment has to be fabricated which has mechanical interfaces with the tokamak load assembly or anything in the hot cell area.	long term but to be planned, and not dropped	consider
Tom Todd	Plasma Facing Components, Diagnostics, Operations	Performance	We discussed the possibility of making the ends of the thermocouple accommodation drillings smoothly rounded so as to allow them to be drilled nearer to the heated surface of the castellation without introducing too much stress concentration in the graphite. Bob said he wanted to have good thermal contact by pushing a flat-ended BN sheath against a conical end of the drilling, but I'd go with better time response and a different shape or material (Grafoil?) for the sheath end to recover decent thermal contact (without raising stresses in the graphite significantly!). Stefan noted that deeper drillings would also separate the heat loads on the individual castellations better for local dynamic calorimetry. (Grafoil inside the BN sheath tip as	pending analysis	consider

Originator (First & Last Name):	Organizational Breakdown Structure (OBS)	Subject: (Check as Applicable)	Comment/Concern/Recommendation:	Review Board Comment	Review Board Recommendation
			well?)		
Jonathan Klabacha	Plasma Facing Components	Performance	How the Grafoil under the HHF tiles will react to pre-loads + heating is not understood. Testing should be done to make sure the tiles will maintain the proper pre-loads and positioning.		consider
T. Stevenson	Systems Engineering & Integration	Configuration	Consider developing and using a mega-traveller for machine assembly to assure that steps are not missed		consider
Richard Callis	VV & Internal Hardware	Configuration	The assembly of the center stack onto the TF center core has two O-rings facing down where they engage the flange on the bottom of the vacuum vessel. Gravity encourage the O-rings to fall out of their slots, has mitigation steps been identified to keep the O-rings in place during assembly	appeared also in PDR, being resolved	concur
Richard Callis	Diagnostics	Requirements	In vessel rogowskies cables should be tested at high temperatures		consider
Joe Petrella	VV & Internal Hardware	Hardware	Consider performing metrology on the ceramic break g-10 spacers and ceramic break to ensure that stacked as-built tolerances do not result in compression of the ceramic break.	flatness of the mating surface	concur
Stefan	Test Cell	Cost/Schedule	Consider adding a formal "issues expediter" to the WCC...somebody with a technical background to help Frank and Steve run things to ground through the full engineering system.		consider
Michael Mardenfeld	Project & Operations Management	Cost/Schedule	There is a general high level plan that engineers doing detail design will transition into assembly related tasks, such as installation oversight, procedure writing, field metrology measurements, tooling and lifting fixtures, etc. However, there is a risk that these design oriented tasks continue longer than expected, and the design engineers will not be available in time. (Design engineers may become involved in procurement oversight,	make tooling design part of plan	consider

Originator (First & Last Name):	Organizational Breakdown Structure (OBS)	Subject: (Check as Applicable)	Comment/Concern/Recommendation:	Review Board Comment	Review Board Recommendation
			Title III, etc.). Consider developing more detailed staffing requirements for tasks like tooling design, metrology engineers, etc, which can be integrated into the project level resource loaded schedule. This will identify a "drop dead date" by which these assembly support tasks need to start before becoming the critical path.		