



OFFICE OF INSPECTOR GENERAL

U.S. Department of Energy

INSPECTION REPORT

DOE-OIG-22-13

December 2021

**ALLEGATIONS OF QUALITY ASSURANCE
IRREGULARITIES IN THE NATIONAL
SPHERICAL TORUS EXPERIMENT
UPGRADE RECOVERY PROJECT**



Department of Energy
Washington, DC 20585

December 7, 2021

MEMORANDUM FOR MANAGER, PRINCETON SITE OFFICE

SUBJECT: Inspection Report on Allegations of Quality Assurance Irregularities in the National Spherical Torus Experiment Upgrade Recovery Project

The attached report discusses our review of allegations of quality assurance irregularities in the National Spherical Torus Experiment Upgrade Recovery project. This report contains five recommendations that, if fully implemented, should help ensure that the issues identified during this inspection are corrected. Management fully concurred with our recommendations.

We conducted this inspection from April 2021 through November 2021 in accordance with the Council of the Inspectors General on Integrity and Efficiency's *Quality Standards for Inspection and Evaluation*. We appreciated the cooperation and assistance received during this inspection.

A handwritten signature in black ink, appearing to read "Anthony Cruz".

Anthony Cruz
Assistant Inspector General
for Inspections, Intelligence Oversight,
and Special Projects
Office of Inspector General

cc: Deputy Secretary
Chief of Staff



Department of Energy Office of Inspector General

Allegations of Quality Assurance Irregularities in the National Spherical Torus Experiment Upgrade Recovery Project (DOE-OIG-22-13)

WHY THE OIG PERFORMED THIS REVIEW

The Office of Inspector General received two complaints of noncompliance with quality assurance procedures for the National Spherical Torus Experiment Upgrade (NSTX-U) Recovery project. The allegations were related to: (1) bypassing quality control hold points; (2) failure to submit nonconformance reports; (3) loss of material traceability for critical parts; (4) welding being conducted without in-progress inspections; and (5) center stack casing damage.

We initiated this inspection to determine the facts and circumstances regarding allegations of quality assurance irregularities in the NSTX-U Recovery project.

What Did the OIG Find?

We substantiated the allegations that quality control hold points were bypassed and that nonconformance reports were not always submitted; however, we were unable to determine if the actions were intended to hide fabrication and welding errors. We also substantiated the allegations that the material traceability was not maintained for items used to fabricate critical parts and that welding was being conducted without in-progress inspections. In addition, we found that Travelers, a folder that contains key items, and nonconformance reports were not always completed in accordance with Princeton Plasma Physics Laboratory procedures. We attributed these issues to the complexity of Travelers, a lack of Traveler training, and personnel not following procedures.

We did not substantiate the allegation that the Department of Energy was not made aware of extensive damage that had occurred to the center stack casing being fabricated at a subcontractor facility.

What Is the Impact?

NSTX-U operations have been suspended since July 2016 partially due to project assurance processes that were not adequate that caused component failure. Without improved project assurance processes and procedures to ensure fabrication of designs are completed as intended, the project could potentially suffer from another component failure. Finally, potential delays and rework could increase the cost of the NSTX-U Recovery project.

What Is the Path Forward?

To address the issues identified in this report, we made five recommendations that, if fully implemented, should help ensure that issues identified during our inspection are corrected.

BACKGROUND

The Department of Energy's Princeton Plasma Physics Laboratory (PPPL), located in Plainsboro, New Jersey, is a collaborative national center for fusion energy science, basic sciences, and advanced technology. The laboratory is managed by Princeton University for the Department's Office of Science, which is the largest single supporter of basic research in the physical sciences in the United States. PPPL is a world-class fusion energy research laboratory dedicated to developing the scientific and technological knowledge base for fusion energy as a safe, economical, and environmentally-attractive energy source for the world's long-term energy requirements.

PPPL constructed an innovative magnetic fusion device called the National Spherical Torus Experiment to research results that may develop fusion energy as an abundant, safe, affordable, and environmentally sound means of generating electricity. Its mission is to establish the configuration as a means of achieving practical fusion energy and to contribute to the unique scientific understanding of magnetic confinement in research areas. If successful, the National Spherical Torus Experiment could be followed by a larger experiment to explore the issues needed for eventually harnessing fusion power continuously from a reactor. The National Spherical Torus Experiment Upgrade (NSTX-U) was completed in 2015; however, the NSTX-U is currently undergoing repair with a total project cost of \$199.4 million.

In February 2021, the Office of Inspector General received two complaints of noncompliance with quality assurance procedures that, if true, could cause catastrophic failure of the NSTX-U project according to the complainant. Specifically, the allegations stated: (1) quality control hold points were purposely bypassed to hide fabrication and welding errors; (2) material traceability was not maintained for items used to fabricate critical parts; (3) nonconformance reports (NCRs) were not submitted to hide fabrication and welding errors; (4) welding was being conducted without in-progress inspections; and (5) the Department was not made aware of extensive damage that had occurred to the center stack casing being fabricated at a subcontractor facility.

We initiated this inspection to determine the facts and circumstances regarding allegations of quality assurance irregularities in the NSTX-U Recovery project.

QUALITY CONTROL HOLD POINTS BYPASSED

We substantiated the allegation that quality control hold points were bypassed; however, we were unable to determine if the hold points were bypassed to hide fabrication and welding errors. PPPL uses Travelers, a folder that contains paper documents such as procedure steps, planned inspections, hold points¹, and other key items related to the manufacturing process steps for project components. The Traveler is designed to move with, track, and document the history of the component through the entire fabrication process. We reviewed a selected sample of 26 Travelers from the 273 Travelers provided by PPPL and determined that hold points were not always signed off as complete prior to moving on to the subsequent steps in the fabrication

¹ Hold points refer to a stop in fabrication activities until an inspection is passed. Hold points are particularly important when work cannot be inspected later because it will be covered up or when the cost of rework would be high if problems are found later. PPPL uses hold points to prevent manufacturing and fabrication errors.

process in 3 Travelers. For example, in one Traveler, a quality control hold point created to ensure that welding was acceptable was not signed prior to additional welding being completed and signed off. A Quality Control Inspector would be unable to view the initial welding if the additional welds were made prior to the quality control inspection. A Welding Engineer stated that Travelers are complex due to the number of different parts they contain and delays in signatures could occur when parts contained in the same Traveler are progressing through the fabrication process at different rates. Due to the complex nature of welding and fabrication, we were unable to determine if this signature was delayed or if the first pass of welding was not inspected prior to the subsequent passes.

In addition, during our review of Travelers, we determined that Travelers were not processed in accordance with PPPL's *Process Plan/Traveler for PPPL Built Components* (ENG-059). Specifically, (1) changes to processing steps were not made by revision; (2) steps were not always completed sequentially; (3) hold points were signed off although the inspection had not been fully completed; (4) quality control and machine shop hold points were signed by an employee that was not a quality control inspector instead of the subcontractor who completed the work; (5) Travelers did not always stay with the part(s); and (6) personnel did not always sign the Printed Name/Initial Legend, as required. PPPL personnel stated that these issues occurred due to a lack of Traveler training, an insufficient amount of quality control personnel, and the complexity of Travelers.

Specifically, we determined that three Travelers contained changes to processing steps that were not made by revision. ENG-059 states, "All changes to processing steps, other than minor typographical corrections, shall be done by revision only." However, in one example, serial numbers were added to multiple steps when it was determined that the previous quantity of serial numbers provided did not meet the drawing requirements. In a second example, a procedure step was changed from using a waterjet machine to cut parts to using a saw and Bridgeport machine to cut the parts. The procedure step description directs that the part be waterjet cut. These issues occurred, in part, due to a potentially unclear understanding of what comprises a minor typographical correction.

In addition, we determined that hold points in two Travelers were signed off although the inspection had not been fully completed. For example, a Quality Control Inspector completed a visual inspection of items and noted on the inspection document the certain items needed to be tested on additional equipment; however, the Traveler hold point was signed off without a note to indicate the inspection was not fully completed. Our review did not identify written guidance on how inspections by multiple inspectors or partially completed inspections should be processed.

Finally, Quality Control and Machine Shop hold points in two Travelers were signed by a PPPL employee instead of by the vendor who completed the work. For example, the Tech Shop Section Head, who is a supervisor, signed a Traveler as having completed a Quality Control hold point for visually inspecting welds but had not completed the inspection. There is documentary support that the inspection was completed by the vendor; however, the Traveler procedure steps do not indicate that the step would be completed or had been completed by a vendor. Although the employee is a Certified Welding Inspector, the individual did not work in the Quality Control

Department and was not authorized to sign off on Quality Control hold points. The Quality Control Manager stated that this issue highlighted the need for a process to identify and modify steps conducted by third parties.

MATERIAL TRACEABILITY NOT MAINTAINED

We substantiated the allegation that material traceability was not maintained for items used to fabricate NSTX-U critical parts. Material traceability ensures that the appropriate material is used during the fabrication process and can be verified by Quality Control Inspectors. The complainant's allegation, dated February 15, 2021, stated that he notified quality control and other PPPL personnel that a hold point was bypassed, and that traceability was lost for the items; however, no action was taken. As a result of the allegation and subsequent reviews, PPPL personnel created a NCR on April 6, 2021. The NCR indicated that the traceability between the certifications and material was not satisfactorily established due to a hold point step being bypassed, as well as a step that was performed before material certifications were located and traceability established.

In addition, during our site visit, PPPL personnel identified that PPPL's QA-003, *Procurement Quality Assurance and Supplier Qualification*, procedures were not always followed. Specifically, a PPPL employee stated that there were instances when material was temporarily lost but later found, delivered directly to the shop bypassing the receiving inspection, and utilized for fabrication prior to the receiving inspection being completed. Further, a PPPL employee stated that PPPL personnel need to do a better job at transferring the heat brand information onto materials to ensure traceability of material after it is cut into multiple pieces. The PPPL employee noted that a process should be implemented to ensure full traceability of materials. We noted that PPPL created a place for tracking items that had material certifications; however, at the time of our review, it was not fully developed.

NCRS NOT SUBMITTED

We substantiated the allegation that NCRs were not always submitted; however, we were unable to determine if reports were not submitted to hide fabrication and welding errors. A nonconformance is a deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate. A NCR is a provision used to segregate the item and potentially stop the specific nonconforming activity or condition from continuing. We determined that seven Travelers contained steps that were completed out of sequence. ENG-059 states that all steps are to be performed sequentially unless otherwise noted in the Traveler. No sequential step shall be performed unless the preceding required steps have all required entries and have been signed off. Despite steps not being completed sequentially, NCRs were not created for these deviations, and notes were not included in the Travelers. The Quality Control Manager stated that steps should be completed in order; however, if he previously saw signatures out of sequential order, he would not write a NCR if he determined that there was no significant impact to the form, fit, or function of the part or component, but the information still needed to be documented in the Traveler. The Quality Control Manager further stated that he no longer allows work steps to be completed out of order.

We also determined that three NCRs were not submitted at the time the nonconformance occurred. As noted above in the Material Traceability Not Maintained section, a NCR was not created at the time material traceability for materials was lost. Further, a NCR was not created on or near April 22, 2021, when a closeout review indicated that two parts had not been inspected despite the Quality Inspection Plan's requirement for 100 percent inspection. Although the work was not fully inspected and the NCR had not been created, the Traveler closeout was signed off by the Quality Control Manager. ENG-059 states that the "Quality Assurance/Quality Control Representative verifies that all NCRs have been closed, and all Quality Related Documents and Reports are in the Traveler and completes the Closeout Signature Approval." PPPL personnel stated that the NCR delay was caused by a hold placed on the components by laboratory leadership. However, we determined that the hold was lifted on June 18, 2021, and a NCR was created on July 25, 2021, after an Office of Inspector General request for the NCR.

In addition, we determined that NCRs were not always processed as required by PPPL procedures. We reviewed the universe of NCRs within our scope and determined that 55 of the 144 NCRs were not dispositioned within 10-working days as required by QA-005, *Control of Nonconformances*, and Q-007, *QA Processing of Nonconformance Reports*. We also completed an in-depth review of 14 of the 144 NCRs and determined that for 3 NCRs, the Quality Assurance Engineer/Quality Control Manager neither reviewed the proposed NCRs for completeness nor indicated concurrence on the document as required by Q-007, *QA Processing of Nonconformance Reports*.

INCONSISTENT WELDING INSPECTIONS

We substantiated the allegation that welding was being conducted without in-progress inspections. Specifically, the complaint noted concerns related to welding of structural support components used to support other critical parts within the NSTX-U. During our review, PPPL hired a consultant to conduct a technical review to determine if specific components were manufactured, inspected, accepted, and documented based on approved designs and in accordance with applicable standards, processes, and procedures. The technical review found that inspections performed by a vendor were not consistent with PPPL's policy for in-house inspectors that required a Certified Welding Inspector to complete the review. The review also noted that although the vendor did not meet the PPPL in-house policy, the inspector's qualifications were consistent with qualification requirements defined in the industry standard *American Society of Mechanical Engineers B31.3*. The Technical Review Report identified that visual inspection of welds prior to removal were not completed and hold points were not created in the Traveler to ensure the step was completed; therefore, the steps were inconsistent with the drawings. In addition, the technical review also found that a weld inspector was not involved in verifying/inspecting the welds during weld setup or when additional welding was performed, resulting in work practices not meeting the requirements for in-progress examinations in *American Society of Mechanical Engineers B31.3*. The report identified that the intent was to have qualified welding procedures and welders for visual inspections only; however, that was not clear in the drawings. Due to the technical review's findings, we did not conduct additional work in this area.

EXTENSIVE DAMAGE TO CENTER STACK CASING

We did not substantiate the allegation that the Department was not made aware of extensive damage that had occurred to the NSTX-U center stack casing being fabricated at a subcontractor facility. The center stack casing provides primary vacuum interface and support for plasma facing components. Specifically, our review of documents and e-mails showed that on January 21, 2021, the NSTX-U Federal Project Director notified Headquarters Fusion Energy Science personnel the day after the center stack casing damage occurred on January 20, 2021. In addition, the damage was reviewed during an Integrated Project Team meeting on January 21, 2021. The Integrated Project Team includes Department and PPPL personnel.

IMPACT

NSTX-U operations have been suspended since July 2016 partially due to inadequate project assurance processes that caused component failure. Without improved project assurance processes and procedures to ensure that fabrication of designs is completed, as intended, the project could potentially suffer from another component failure. In addition, potential delays and rework could increase the cost of the NSTX-U project.

RECOMMENDATIONS

We recommend that the Manager, Princeton Site Office, direct PPPL to:

1. Revise ENG-059 to address third party inspectors, partial Quality Control Inspector review, and the definition of minor changes within Travelers.
2. Conduct ENG-059 and NCR training to ensure personnel are aware of all requirements.
3. Ensure PPPL personnel follow all of PPPL's quality assurance processes and procedures.
4. Ensure PPPL completes implementation of the material tracking system.
5. Review open Travelers to ensure they are compliant with PPPL's ENG-059.

MANAGEMENT RESPONSE

Management fully concurred with our recommendations and stated that the estimated completion date for corrective actions is the first quarter of fiscal year 2023. The Princeton Site Office noted significant actions taken by PPPL to improve the design and fabrication processes. These actions include: (1) hiring an Associate Laboratory Director and funding two deputy positions to address span of control concerns; (2) completing a Compliance and Cultural Assessment; (3) addressing quality assurance concerns related to welds; and (4) strengthening and clarifying roles and responsibilities to improve supervisory engagement with in-process Travelers.

Management comments are included in Appendix 2.

INSPECTOR COMMENTS

Management's comments and corrective actions are responsive to our recommendations.

Appendix 1: Objective, Scope, and Methodology

OBJECTIVE

We initiated this inspection to determine the facts and circumstances regarding allegations of quality assurance irregularities in the National Spherical Torus Experiment Upgrade Recovery project.

SCOPE

The inspection was performed from April 2021 through November 2021 at the Princeton Plasma Physics Laboratory in Plainsboro, New Jersey, and Holtec International in Camden, New Jersey. Our scope included the National Spherical Torus Experiment Upgrade Recovery project from January 2019 through June 2021. The inspection was conducted under Office of Inspector General project number S21HQ016.

METHODOLOGY

To accomplish our inspection objective, we:

- Conducted interviews with the alleging parties to gain an understanding of the allegations;
- Conducted interviews with personnel at Princeton Plasma Physics Laboratory;
- Conducted interviews with personnel at Holtec International;
- Reviewed applicable policies and procedures;
- Reviewed prior reviews conducted by Princeton Site Office;
- Reviewed the Technical Review Report completed by outside consultants;
- Reviewed Travelers and associated documents; and
- Reviewed nonconformance reports.

We conducted our inspection in accordance with the *Quality Standards for Inspection and Evaluation* (December 2020) as put forth by the Council of the Inspectors General on Integrity and Efficiency. We believe that the work performed provides a reasonable basis for our conclusions.

We held an exit conference with management officials on November 5, 2021.

Appendix 2: Management Comments



Department of Energy
Princeton Site Office
P.O. Box 102
Princeton, New Jersey 08542

PSO-22-0008

October 21, 2021

MEMORANDUM FOR: Anthony Cruz
Assistant Inspector General for Inspections,
Intelligence Oversight, and Special Projects

FROM: Sandra Rogan
Site Office Manager, Princeton Site Office

SUBJECT: Response to Draft Inspection Report on "Allegations of Quality Assurance Irregularities in the National Spherical Torus Experiment Upgrade Recovery Project"

Sandra S. Rogan
Digitally signed by
Sandra S. Rogan
Date: 2021.10.21
17:29:08 -04'00'

Thank you for the opportunity to review and comment on the subject draft report. The Princeton Site Office (PSO) appreciates the Office of Inspector General's (OIG) work performed in the review of the quality assurance irregularities at PPPL on the National Spherical Torus Experiment Upgrade (NSTX-U) Recovery Project. The insights resulting from your work and recommendations will aid the Princeton Plasma Physics Laboratory (PPPL) in the continued improvement of their operations in support of the nation's science, research, and development enterprise.

PSO recognizes several significant actions that PPPL has already taken that aid in ensuring on-going excellence in the design and fabrication processes for their scientific infrastructure. Among them are:

- PPPL has hired a new Associate Laboratory Director (ALD) to lead and oversee engineering and fabrication processes. This position was formerly the Head of Engineering, but it has been elevated to an ALD directly reporting to the Laboratory Director. Two deputy positions have also been funded and active searches are underway. The addition of deputy positions will aid in addressing long-standing span of control concerns with head of engineering and enable them to focus on leadership and continual improvement of engineering and fabrication processes.
- PPPL conducted a "Compliance and Cultural Assessment" to determine obstacles on-going within compliance assurance. The assessment included a review of policies and procedures and interviews with 25 staff members with representation from management and technical staff from multiple work groups. Recommendations focused on the need for enhanced supervisory and leadership development to strengthen processes and practices to address employee concerns effectively and efficiently. PPPL has expressed its commitment to DOE in pursuing the recommendations of the assessment team.
- PPPL specifically addressed the concerns regarding the quality and assurance of sling fabrication, including revision of drawings to clarify specifications and inspection criteria. All slings to be installed in the NSTX-U were subject to and passed 100% radiographic weld inspection.
- PPPL strengthened and clarified roles and responsibilities to improve shop-floor supervisory engagement with in-process travelers and component fabrication.

In addition to noting the above actions, PSO provides the below response, Attachment I, to each recommendation in the report.

Appendix 2: Management Comments

Attachment 1

Management Response - Draft Inspection Report on "Allegations of Quality Assurance Irregularities in the National Spherical Torus Experiment Upgrade Recovery Project"

Recommendation 1: *Revise ENG-059 Process Plan/Traveler for PPPL Built Components to address third party inspectors, partial Quality Control Inspector review, and the definition of minor changes within Travelers.*

PSO Response: Concur

Estimated Completion Date: Q2FY22

Corrective Action: PSO will review procedure ENG-059 to ensure recommended changes are incorporated by PPPL.

Recommendation 2: *Conduct ENG-059 Process Plan/Traveler for PPPL Built Components and nonconformance report training to ensure personnel are aware of all requirements.*

PSO Response: Concur

Estimated Completion Date: Q2FY22

Corrective Action: PSO will verify training was attended by the appropriate PPPL personnel involved in the ENG-059 process through training record review. Additionally, PSO will verify the methodology for new PPPL personnel required to complete the training are identified and complete the training timely.

Recommendation 3: *Ensure PPPL personnel follow all of PPPL's quality assurance processes and procedures.*

PSO Response: Concur

Corrective Actions and Completion Dates: PSO will work with PPPL to verify that:

- PPPL communicates a clear message of procedural conformance from Laboratory leadership, which is reinforced through line supervision during personnel meetings, and then periodically reinforced going forward. Q1FY22
- PPPL strengthens on-going monitoring and measurement of procedural conformance. Q1FY22
- PPPL conducts an effectiveness review of actions with PSO as an observer. Q4FY22
- PPPL completes actions to address recommendations of the Compliance and Cultural review to enhance supervisory and leadership development, strengthen processes and practices, and address employee concerns effectively and efficiently. Q4FY22

Recommendation 4: *Ensure PPPL completes implementation of the material tracking system.*

PSO response: Concur

Estimated Completion Date: Q2FY22

Corrective Action: PSO will validate the completion of the material tracking system implementation.

Recommendation 5: *Review open Travelers to ensure they are compliant with PPPL's ENG-059 Process Plan/Traveler for PPPL Built Components.*

PSO Response: Concur

Estimated Completion Date: 1QFY23

Corrective Action: PSO will observe the compliance review which will be performed 6 months after revisions under recommendation 1 are complete.

FEEDBACK

The Office of Inspector General has a continuing interest in improving the usefulness of its products. We aim to make our reports as responsive as possible and ask you to consider sharing your thoughts with us.

Please send your comments, suggestions, and feedback to OIG.Reports@hq.doe.gov and include your name, contact information, and the report number. You may also mail comments to us:

Office of Inspector General (IG-12)
Department of Energy
Washington, DC 20585

If you want to discuss this report or your comments with a member of the Office of Inspector General staff, please contact our office at 202-586-1818. For media-related inquiries, please call 202-586-7406.