DEFENSE NUCLEAR FACILITIES SAFETY BOARD
Washington, DC 20004-2901

February 24, 2023

The Honorable Jill Hruby
Administrator
National Nuclear Security Administration
US Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-1000

Dear Administrator Hruby:

The Defense Nuclear Facilities Safety Board (Board) recently conducted a review of safety-related welding at the Pantex Plant (Pantex). The review covered the welding program of the site contractor, Consolidated Nuclear Security, LLC (CNS), and implementation of program requirements into welding specifications, welder qualification processes, welding filler material handling practices, and work orders of both CNS and its subcontractors.

Overall, CNS is implementing a robust welding program at Pantex. The Board's review determined that the welding program is consistent with industry practices and that program requirements are being properly implemented. The review did identify opportunities for safety improvement, which are discussed in the enclosed staff report for the National Nuclear Security Administration's information and use.

Sincerely,

Joyce Connery

Joyce L. Connery
Chair

Enclosure

c: The Honorable Jennifer Granholm
Ms. Teresa Robbins
Mr. Joe Olencz

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Report

November 16, 2022

Pantex Plant Welding Review

Summary. The Defense Nuclear Facilities Safety Board's (Board) staff performed a review of safety-related welding at the Pantex Plant (Pantex). The review covered the welding program of the site contractor, Consolidated Nuclear Security, LLC (CNS), and implementation of program requirements in welding specifications, the processes to qualify welders, the processes to control welding filler materials, and a sample of work packages. The staff team also assessed how CNS accepts welds performed either on-site by CNS staff or construction subcontractors, or off-site by vendors. Although Pantex and the Y-12 National Security Complex (Y-12) share a common CNS welding program, this staff review was limited only to the implementation at Pantex. Staff members D. Andersen, J. Anderson, C. Berg, and R. Jackson conducted the review from May 2021 through October 2022.

Overall, CNS is implementing a robust welding program at Pantex. The welding program, as defined by the CNS welding program manual [1], is consistent with industry standards and has clear requirements for control of welding processes and materials, and qualification of welders. In addition, Pantex employs qualified welding engineers and inspectors to oversee the welding program. By comparing both older and newer welding work packages, the staff team assesses that Pantex has implemented significant improvements associated with the quality of work packages and records.

During the review, the staff team identified the following opportunities for safety improvement, discussed in detail later in this report:

- **Welded Aluminum Strength:** During its review, the staff team questioned the material strength value used for welded aluminum in special tooling analyses. CNS generally agreed with the staff observation, performed an extent of condition, and determined that 14 credited tools were using improper strength values. Some analyses used strength values greater than three times the industry recommended values. CNS plans to formally update the analyses for the affected special tooling and has updated its materials database to ensure the appropriate strength of welded aluminum is used in future analyses. CNS could improve its process for validating material properties in the special tooling materials database and special tooling analyses to avoid similar problems in the future.

  CNS indicated it may cease using and maintaining its special tooling materials database, and instead directly cite updated consensus standards in its tooling analyses. The staff team does not believe archiving the database would be prudent unless CNS captures the special tooling materials information in another configuration-controlled document (for example, the special tooling design manual). This would help ensure CNS uses consistent and conservative material values in future analyses.

- **Annual Rod Room Assessment:** CNS Quality had not been conducting an annual welding rod room assessment at Pantex, as required since the CNS welding program manual implemented this requirement in 2017. CNS conducted the first welding rod room assessment in June 2022 after receiving the staff team's review agenda. CNS is taking appropriate corrective actions to add this assessment to a formal CNS Quality assessment schedule. This annual assessment will provide added assurance that weld filler materials continue to be controlled, handled, stored, and accounted for properly.

- **Nonconforming Items:** The staff team observed improper segregation of nonconforming items from other quality hold items in the Pantex shipping and receiving department and the special tooling warehouse. The storage conditions observed conflicted with American Society of Mechanical Engineers (ASME) Nuclear Quality Assurance (NQA)-1, *Quality Assurance Requirements for Nuclear Facility Applications* [2], Requirement 15. In certain areas, nonconforming items were staged amongst, and sometimes directly next to, other quality hold items. Segregation of nonconforming items from other quality hold items can prevent intermixing of items, particularly for small or moderate size items (e.g., bolts, batteries). CNS could address this deficiency by establishing designated staging areas for these items with clearly identifiable boundaries (e.g., cordoned off areas).

- **Material Test Reports:** CNS was unable to provide the testing accreditation of foreign laboratories that generated certified material test reports for AL-R8 Sealed Insert (SI) containers for pit staging and indicated the purchase order predated the adoption of ASME NQA-1 for certain weapons-related items such as special nuclear material (SNM) containers. CNS could better ensure that SNM containers procured in the future will reliably perform their safety functions by instituting improved commercial grade dedication requirements for such procurements; this can be addressed via implementation of NQA-1. In addition, CNS could improve assurance that existing containers will reliably perform their safety functions by taking actions to validate materials from previous procurements where the accreditation of the testing laboratories could not be confirmed.

- **Welding Filler Metal Control:** CNS has taken positive actions to enhance its welding filler metal log. Overall, CNS has excellent processes in place to track NQA-1 welding filler metal materials at Pantex. However, CNS could improve assurance that on-site contractors will produce welds of adequate quality by taking additional actions to verify that the same level of control of material is implemented by on-site subcontractors. The staff review team observed a subcontractor's deviation from a code-specified practice for handling welding filler metal outside of holding ovens. CNS agreed with the concern and is working with the subcontractor to correct the work instruction for future use.

- **Recommendation 2019-1:** Partly in response to Board Recommendation 2019-1, *Uncontrolled Hazard Scenarios and 10 CFR 830 Implementation at the Pantex Plant* [3], CNS developed a weld verification implementation plan [4] to qualify existing and newly manufactured or acquired credited special tooling where welds exist in the critical load path. CNS is qualifying existing special tooling with visual examination and load testing. This approach is reasonable for qualifying existing tools for working loads. While it is not clear if the load testing approach is adequate for rare event loads, it is encouraging that CNS is developing plans to incorporate nondestructive evaluation (NDE) beyond visual examination into the qualification for new special tooling. A recent audit of the CNS welding program by corporate parent Bechtel notes Pantex should take efforts to develop a formal NDE program similar to the one that exists at Y-12. Establishing such a program and applying it to new special tooling would significantly improve assurance that welded special tooling at Pantex will reliably perform its safety functions.

Background. The Board's staff has been following the progress of various upgrades of safety-related infrastructure at Pantex. Over the past few years, CNS has upgraded or repaired safety-related steel structures that have involved structural welding. These projects include adding seismic braces to ramp structures,[1] repairing a damaged ramp beam, and adding seismic braces to the 12-117 loading dock. Also, ongoing upgrades as part of replacing the 12-44 cells' false ceilings[2] involve welding of safety class deluge fire piping. Lastly, safety-related welds are present in certain credited special tooling and SNM containers. The goal of the staff review was to evaluate the Pantex welding program and how welding requirements flow down to CNS and its subcontractors.

CNS Welding Program—In 2017 CNS combined the welding programs of Pantex and Y-12 and created E-PROC-0037, *Welding Program Manual* [1]. Much of the CNS welding program, including welding process specifications (WPS) and procedure qualification records (PQR), were adopted from existing Y-12 processes. E-PROC-0037 is divided into sections that address storage and handling of welding filler materials, welder qualifications, welding temperature control (preheat and interpass temperature), and controls for various welding applications (pipe, structural, sheet metal, general repair, and special tooling welding). The WPSs address the specifics for each welding process, including welding variables, material compatibilities, permissible filler materials, and permissible weld sizes. CNS' WPSs and PQRs only apply to welding conducted on-site by the CNS Mechanical Maintenance department. Subcontractors work to their own welding programs, which CNS reviews and accepts to ensure they meet industry standards identified in engineering specifications required contractually.

CNS Quality Program—The CNS welding program has several interfaces with the CNS quality assurance program. These interfaces include procurement and handling of welding filler materials; processes for accepting subcontractor welding programs; processes for receipt, inspection, and acceptance of procured items; and processes for managing nonconforming items.

[1] Ramps are hallways that connect various nuclear material and nuclear explosive facilities. They are generally constructed of steel framing and covered by corrugated steel.
[2] In 2007, the Pantex site contractor replaced the wood-framed false ceilings for 12-44 Cells 2, 3, and 4. CNS recently completed replacement of the false ceiling in 12-44 Cell 5 and is beginning replacement of 12-44 Cell 6.

The staff team reviewed these interfaces with the welding program, to include reviewing a sampling of purchase orders and welding filler material procurement documentation and observing on-site welding by a CNS subcontractor.

The CNS quality assurance program is defined in E-SD-0002, *Quality Assurance Program Description* [5], and implements the requirements of ASME NQA-1[3] [2]. CNS acquires many safety-related items, including welding filler materials, welded special tooling[4], and welded SNM containers, from off-site suppliers. CNS approves these suppliers in accordance with E-PROC-3006, *Conducting Supplier Audits and Updating the Quality Approved Supplier List* [6], and adds them to the site Quality Approved Supplier List (QASL) once approved. For items that cannot be procured from an NQA-1 supplier, CNS implements commercial grade dedication as described in E-SD-2024, *Commercial Grade Dedication Program* [7]. Based on a procured item's importance to safety and specific technical requirements, CNS assigns an acquisition level (AL) designation [8] [9]. The AL establishes specific requirements for procurement, where the most prescriptive requirements are for AL-1 items (typically NQA-1 materials), intermediate requirements are for AL-4 items, and the least requirements are for AL-0 items. ALs are assigned as follows:

- **AL-1:** Items are required to meet specific technical and quality assurance requirements and are procured from suppliers on the QASL,

- **AL-4:** Commercial grade items not subject to properties or features unique to Pantex and not altered, and

- **AL-0:** Items not required to meet specific quality requirements (typically assigned to non-safety related items).

CNS designates welding filler materials as AL-1 items and procures them from an approved NQA-1 supplier that performs the dedicating activities. Once received at Pantex, welding filler material is controlled, stored, and segregated in the welding electrode rod room. CNS Quality performs supplier evaluations and assessments of electrode suppliers and manufacturers of items with welds, consistent with NQA-1 expectations. In addition, CNS Quality is required, according to E-PROC-0037, to annually assess the electrode storage area.

Receipt, inspection, and acceptance of items from off-site suppliers are first conducted at the 16-19 shipping and receiving building. Once items pass this acceptance, they may either be transferred to another facility for additional approvals (for example, to the special tooling warehouse for additional tests and validation) or stored in controlled areas at the 16-19 shipping and receiving building or other facilities until needed.

Specific to certain weapons-related items (e.g., special tooling and SNM containers), in 2017 CNS Quality adopted the use of NQA-1 for future procurements and performed a gap analysis to accept existing items for continued use. This analysis is documented in RPT-0015,

[3] The version currently incorporated by CNS is NQA-1-2008, with the NQA-1a-2009 and NQA-1b-2011 addenda.
[4] Approximately 85 percent of special tooling is fabricated by off-site vendors. A large portion of welding on special tooling conducted on-site by CNS consists of special tooling modifications and repairs.

Acceptance of Previously Procured, Received, Inspected, and Tested Nuclear Safety Credited Weapons Related Items at the Pantex Plant [10]. This report addressed how previously procured items subject to the requirements of National Nuclear Security Administration (NNSA) Policy Letter NAP-24A, *Weapons Quality Policy* [11], will continue to meet their safety-related performance requirements. This evaluation specifically cites performance history, past quality practices, surveillances, and configuration control as the basis for accepting previously procured weapons-related items.

Staff Review. From May 2021 through October 2022, the staff team reviewed documentation associated with the welding program, including the program manual, WPSs, PQRs, filler metal logs, as well as sampling structural, special tooling, and SNM container fabrication work orders that involved welding. The staff team reviewed CNS work packages associated with ramp seismic upgrades and repairs, 12-44 false ceiling replacement, and special tooling repairs. Procurement documents reviewed included those for special tooling and SNM containers manufactured by off-site vendors.

During the week of August 8, 2022, the staff team performed walkdowns and discussed with CNS and NNSA Production Office representatives the lines of inquiry associated with the Pantex welding program. The staff team conducted a follow-on teleconference with the site on November 1, 2022. NNSA and CNS provided written responses in advance of these interactions, which facilitated productive and efficient discussions.

Staff Observations. The staff team identified opportunities for safety improvement in the following areas: (1) aluminum weld evaluations, (2) annual rod room assessment, (3) control of nonconforming items, (4) SNM container material test reports, (5) welding filler metal control, and (6) special tooling NDE. These areas are discussed in detail below.

Aluminum Weld Evaluations—In the review agenda, the staff team questioned the strength of welded aluminum assumed in a special tooling analysis [12]. Broadly, steel welds are considered as strong as the base metal of the materials being joined; however, aluminum welds are considered weaker than the base metal being joined. The staff team noted that the 2020 Aluminum Design Manual [13], published by The Aluminum Association, specifies the tensile yield strength of 6061-T6 aluminum welded using an R4043 electrode to be 11 ksi, whereas the special tooling evaluation reviewed by the staff team used an older value of 20 ksi.

CNS generally agreed with this observation, evaluated it as new information, and performed an extent of condition review to determine whether other tools had been analyzed using current strength values for welded aluminum. CNS limited its extent of condition review to credited special tooling with welds in the load path and those currently authorized in active nuclear explosive operations. CNS found that it had not maintained its special tooling analyses consistent with current industry guidance, and in addition, some special tooling evaluations improperly used the tensile strength of the aluminum base metal (35 ksi) for the weld strength, more than three times the industry-recommended value for welds (11 ksi). CNS found that analyses of 14 tools did not use the current strength value for welded aluminum and checked whether these tools still complied with their functional requirements when compared to yield

strength—i.e., a 3:1 margin for normal loads and a 1.25:1 margin for rare event loads. CNS found that all 14 tools still met the requirements for margin on yield strength.

CNS plans to formally update the analyses for the affected special tooling and has updated its formal materials database to ensure the appropriate strength of welded aluminum is used in future analyses. It would be prudent for CNS to validate other material properties in the special tooling materials database and special tooling analyses. CNS has indicated it may cease using and maintaining its special tooling materials database, and instead directly cite updated consensus standards in its tooling analyses. The staff team does not believe archiving the database would be prudent unless the special tooling materials information is captured in another configuration-controlled document (for example, the special tooling design manual). This would help ensure CNS uses consistent and conservative material values in future analyses.

Annual Rod Room Assessment—In 2017, CNS created a new requirement in E-PROC-0037 that each facility storing welding filler material be evaluated annually by CNS Quality. However, this organization was never made aware of the new requirement, and thus had not conducted such an assessment. CNS conducted the first welding rod room assessment in June 2022 in response to the staff team's agenda and documented no issues [14]. CNS plans to add this annual review to its formal assessment schedule. This annual assessment will provide added assurance that weld filler materials continue to be controlled, handled, stored, and accounted for properly. As follow-up, the Board's staff confirmed that CNS conducted this annual assessment at Y-12 in 2022 per the CNS requirement.

Control of Nonconforming Items—At both the 16-19 shipping and receiving building and the 12-26 special tooling warehouse, the Board's staff observed improper segregation of nonconforming materials from other quality hold items or items procured from NQA-1 vendors. NQA-1 Requirement 15 states,

> *Nonconforming items shall be segregated, when practical, by placing them in a clearly identified and designated hold area until properly dispositioned.*

The NQA-1 statement "when practical" is intended to exclude segregation of larger nonconforming items (e.g., diesel generators), where segregation would be difficult and intermixing less plausible. The implementing guidance in Subpart 3.1-15.1 of ASME NQA-1 discusses alternate methods to physical segregation, such as electronic processes when physical segregation is impractical or impossible.

The CNS quality assurance program description, E-SD-0002 [5], implements the NQA-1 segregation requirement by stating:

> *Nonconforming items are segregated, when practical, by placing in a clearly identified and designated hold area until properly dispositioned. When segregation is impractical or impossible due to physical conditions, such as size, weight, or access limitations, other precautions are employed to preclude inadvertent use of a nonconforming item.*

CNS procedure E-PROC-0050, *Control of Nonconforming Items* [15], notes the following requirement:

> *Segregate the nonconforming item(s) in a clearly posted nonconforming item storage area or zone, and*
>
> - *Ensure compliance with the item(s) storage requirements*
> - *Ensure nonconforming area postings contain point of contact information and are legible….*
>
> *If methods above are not feasible, practical, or acceptable, typically due to physical, operational, safety, or security constraints, then apply alternative controls, such as:*
>
> - *Label the item's container or package as nonconforming*
> - *Post the item's current location as a nonconforming storage/staging area and create a temporary boundary around the item(s) to achieve segregation from acceptable inventory.*
> - *Update equipment records, as appropriate.*

Segregation of nonconforming items was practical and possible in both storage areas and should be more formally implemented. Segregation of nonconforming items from other quality hold items can prevent intermixing of items, particularly for small or moderate size items (e.g., bolts, batteries). During the walkdown of the 16-19 shipping and receiving building, the staff team observed several nonconforming items staged directly next to other quality hold items. For example, a pallet of nonconforming batteries was staged directly adjacent to a pallet of batteries subject to a routine quality hold. In addition, shelves holding smaller nonconforming items, although identified as nonconforming, were not cordoned off to limit access from the normal quality hold area. At the special tooling warehouse, nonconforming special tooling was located next to other special tooling subject to routine inspections. These items could be better segregated to meet the intent of NQA-1. CNS contends that existing controls (e.g., item labeling and access control to storage areas) reduce the risk of inadvertent access to and use of these nonconforming items.

Material Test Reports—During the review, the staff team examined procurement records for a 2016 purchase of AL-R8 SI containers. As part of the review, the staff team asked CNS to provide the accreditation of foreign testing laboratories that had generated certified material test reports for the stainless steel container body, stainless steel flanges, and copper gaskets of these Al-R8 SI containers as would normally be required per quality assurance standards. CNS was unable to provide these accreditations. These containers were procured before CNS started applying NQA-1 to certain weapons-related items (e.g., special tooling and SNM containers), and subsequently were evaluated by CNS for continued use in RPT-0015, *Acceptance of Previously Procured, Received, Inspected, and Tested Nuclear Safety Credited Weapons Related Items at the Pantex Plant* [10]. This evaluation relies on positive performance and past inspections of the containers to justify their continued use; however, material validation is still important to provide confidence in long-term performance of these containers. The site

contractor procured the last set of AL-R8 SI containers one year prior to the issuance of RPT-0015. As a result, performance history on its own may not ensure long-term adequacy. Although CNS now implements NQA-1 requirements for certain weapons-related procurements, additional material property validation could be undertaken to enhance the confidence that previously procured items will be able to perform their safety function, particularly when material testing accreditation cannot be verified. CNS asserts that qualification tests performed during procurement (e.g., leak and drop testing) fulfill this function. Qualification based on strength testing does not address long-term performance, particularly corrosion resistance. Components that initially perform in a satisfactory manner may fail in service if fabricated using a material with adequate strength but unsatisfactory corrosion resistance.

Welding Filler Metal Control—Overall, CNS is applying robust controls for storing, handling, and tracking welding filler materials at Pantex. CNS is implementing proper controls for the welding electrode rod room including limiting access to authorized personnel; maintaining proper storage and segregation of materials, both before and after removal from hermetically sealed containers; maintaining proper surveillance of electrode holding oven temperatures; ensuring tracking and accountability of welding electrodes; and preventing introduction of cellulose covered electrodes into holding ovens.[5] The staff team limited the scope of its walkdowns to the CNS electrode storage area and did not visit electrode storage areas for on-site subcontractors. The staff team did discuss with CNS personnel how they perform oversight of those storage areas and subcontractors' work on-site.

Some entries in the welding filler metal log re-used filler metal codes, and other entries provided extraneous or incomplete procurement information. In response to questions from the staff team, CNS took actions to correct and better organize the filler metal log. With these changes, the updated filler metal log will provide enhanced tracking of filler materials.

The requirements in the subcontractor's work instruction for the 12-44 Cell 5 false ceiling replacement did not meet a requirement of American Welding Society (AWS) D1.1, *Structural Welding Code – Steel* [16], Table 7.1, *Allowable Atmospheric Exposure of Low-Hydrogen Electrodes*, regarding control of welding electrodes after removal from holding ovens and transportation in oven caddies. The code requires E7018 weld filler material to be re-baked if outside of a holding oven (which has a minimum temperature of 250°F) or hermetically sealed container for more than nine hours and exposed to the atmosphere. Per the 12-44 cell 5 false ceiling replacement work instruction, the subcontractor allows its electrodes to be held in an oven caddy at 125°F for 12 hours. CNS agreed with the staff concern and is working with the subcontractor to correct the work instruction for future use. In addition, CNS has identified other issues with the work instruction that will be corrected.

Recommendation 2019-1—Partly in response to Board Recommendation 2019-1 [3], CNS revised the special tooling program within the safety basis—as well as the special tooling design manual [17]—to require that all code welds are visually inspected and all tools with welds in the credited load path are verified through either load testing or enhanced NDE techniques

[5] For shielded metal arc welding of carbon steel, the two main electrodes used at Pantex are the E7018 and E6010 electrodes. E6010 electrodes are cellulose covered and cannot be introduced into holding ovens. If they were, their cellulose would degrade and ruin low hydrogen E7018 electrodes that might be stored in the same oven.

beyond visual examination. This weld verification requirement applies to both new and existing tooling and is discussed in detail in the weld verification implementation plan [4]. The staff discussed the identification of credited special tooling with critical welds and plans for load testing and NDE for existing and future procured tools with CNS. In addition, the staff team discussed with CNS the challenges with performing NDE on existing special tooling welds. These challenges include complex weld geometries which make radiography difficult. Furthermore, most welds in existing special tooling are covered by seals or coatings, which would make weld surface NDE, like dye penetrant tests, impossible without removing these coverings.

For existing tools, CNS has decided to perform load testing for weld verification and has identified more than 600 copies of existing special tooling that needed to be brought into compliance with the verification requirement. At the time of the on-site review, CNS had conducted load testing—or implemented a hold on use of the tooling until such testing is accomplished—on all but six copies of existing special tooling. The load testing applies a load of 1.25 times the maximum working load supported by the tooling during operations. To date, CNS has noted no tooling issues or failures as a result of this testing. The CNS approach is reasonable for qualifying existing tools for working loads; however, it is not clear if the load testing approach is adequate for rare event loads (i.e., from seismic events and falling technician scenarios).

CNS is developing plans to incorporate NDE into the weld qualification plan for newly manufactured special tooling. Appropriately selected NDE methods for new special tooling will provide added confidence that special tooling with welds in the critical load path will perform its credited safety functions. An April 2022 audit of the CNS welding program by CNS' Bechtel corporate parent [18] noted the lack of a formal and centralized NDE certification program at Pantex outside of weapons-related operations. Establishing such a program and applying it to new special tooling would significantly improve assurance that welded special tooling at Pantex will reliably perform its safety functions.

Conclusion. Overall, CNS is implementing a robust welding program at Pantex. In addition, in recent years the Board's staff has observed improvements in quality assurance practices at Pantex. This review identified further opportunities for safety improvement, particularly associated with special tooling evaluations, welding quality assessments, management of nonconforming items, procured materials validation practices, welding filler metal handling, and NDE of special tooling.

References

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[5] Consolidated Nuclear Security, LLC, *Quality Assurance Program Description*, E-SD-0002, Rev. 6, October 12, 2020.

[6] Consolidated Nuclear Security, LLC, *Evaluating Suppliers and Updating the Quality Approved Supplier List*, E-PROC-3006, Rev. 4, August 23, 2021.

[7] Consolidated Nuclear Security, LLC, *Commercial Grade Dedication Program*, E-SD-2024, Rev. 1, May 9, 2019.

[8] Consolidated Nuclear Security, LLC, *Acquisition Level Determination*, TABLE-0078, Issue 12.

[9] Consolidated Nuclear Security, LLC, *System Engineering and Configuration Management Program*, MNL-00054, Issue 37, May 2022.

[10] Consolidated Nuclear Security, LLC, *Acceptance of Previously Procured, Received, Inspected, and Tested Nuclear Safety Credited Weapons Related Items at the Pantex Plant*, RPT-0015, May 2017.

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[12] Consolidated Nuclear Security, LLC, *Analysis for 083-2-0105, FWD Support Lift Fixture*, Issue 0, March 11, 2021.

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[18] Bechtel Welding & Applied Technology Center, *Bechtel Parent Company Welding Assessment of CNS Enterprise Welding Program at Y-12 and Pantex*, April 22, 2022.