Independent Oversight Review of the Hanford Site Waste Treatment and Immobilization Plant Construction Quality

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Acronyms

ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ASME	American Society of Mechanical Engineers
ASTM	ASTM International
BNI	Bechtel National, Incorporated
BOF	Balance of Facilities
CDR	Construction Deficiency Report
CM	Commercial
DOE	U.S. Department of Energy
DOE-WTP	DOE-ORP WTP Project Office
FWCL	Field Welding Checklist
HEPA	High Efficiency Particulate Air
HLW	High-Level Waste Facility
LAB	Analytical Laboratory
LAW	Low-Activity Waste Facility
LCQCE	Lead Civil Quality Control Engineer
NCR	Non-conformance Report
NP	Non-Permanent
NQA	Nuclear Quality Assurance
ORP	Office of River Protection
P&ID	Piping and Instrumentation Diagram
PIER	Project Issues Evaluation Report
PTF	Pretreatment Facility
Q	Quality
QA	Quality Assurance
QC	Quality Control
SSC	Structures, Systems, and Components
TC	Tension Control (also called twist-off high strength structural steel bolt)
TPI	Third Party Inspection
WCD	DOE-WTP Construction Oversight and Assurance Division
WTP	Waste Treatment and Immobilization Plant

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1.0 PURPOSE

The U. S. Department of Energy (DOE) Office of Enforcement and Oversight (Independent Oversight), within the Office of Health, Safety and Security, conducted independent reviews of selected aspects of construction quality at the Hanford Site Waste Treatment and Immobilization Project (WTP). The reviews for this report were performed on site during February 6-10, 2012 and April 30 – May 4, 2012, and were the latest in a series of ongoing quarterly assessments of construction quality performed by Independent Oversight at the WTP.

2.0 BACKGROUND

The DOE Office of River Protection (ORP) was established in 1998 to manage the 53 million gallons of liquid or semi-solid radioactive and chemical waste stored in 177 underground tanks at the Hanford Site. ORP serves as DOE line management for two functions: the Tank Farms, which maintain the 177 underground storage tanks; and the WTP, which is responsible for retrieval, treatment, and disposal of the waste stored in the underground tanks. The WTP is an industrial complex for separating and vitrifying radioactive and chemical waste stored in the underground tanks. The WTP complex consists of five major components: the Pretreatment Facility (PTF) for separating the waste, the High-Level Waste (HLW) and Low-Activity Waste (LAW) facilities where the waste will be immobilized in glass, the Analytical Laboratory (LAB) for sample testing, and the balance of facilities (BOF) that will house support functions. The WTP is currently in the design and construction phase. Design and construction activities at WTP are managed by Bechtel National, Incorporated (BNI) under contract to ORP. Construction oversight is provided by the ORP WTP Project Office (DOE-WTP) staff, specifically by the DOE-WTP Construction Oversight and Assurance Division (WCD). Because of the safety significance of WTP facilities, Independent Oversight has scheduled quarterly reviews to assess the quality of ongoing construction.

3.0 SCOPE

The scope of these reviews encompassed various topics, including concrete placement activities, observation of welding inspections, pipe support inspection records, and observation of a pneumatic pressure test on a section of the offgas process system for Melter 2 in the LAW facility. Independent Oversight examined a sample of project issues evaluation reports (PIERs), non-conformance reports (NCRs), and construction deficiency reports (CDRs) identified by BNI under their corrective action program, the Third Party Inspection program, as well as BNI's corrective actions to resolve structural steel bolting issues.

In addition, Independent Oversight reviewed various construction quality documents and conducted several construction site walkthroughs, concurrent with DOE-WTP staff. During the walkthroughs, Independent Oversight observed four concrete placements, a pneumatic pressure test, and various welding inspection activities, and examined pipe supports in the LAW. Independent Oversight also examined drawings, specifications, and procedures that control concrete placement activities; installation of piping,

pipe supports, and mechanical equipment (tanks/vessels); pressure testing of piping systems; and welding inspection activities.

4.0 RESULTS

Activities examined by Independent Oversight are discussed below. Each activity is briefly described, followed by a discussion of the review performed by Independent Oversight. Conclusions are summarized in Section 5. Opportunities for improvement are listed in Section 6, and items for follow-up are presented in Section 7.

NCRs, CDRs, and PIERS

NCRs are issued to document and disposition non-conforming conditions involving quality (Q) structures, systems, and components (SSC). Q components, previously designated QL, are constructed or manufactured in accordance with the WTP quality assurance (QA) program – American Society of Mechanical Engineers (ASME) Nuclear Quality Assurance (NQA)-1. CDRs are issued to document and disposition non-conforming conditions for SSC that are constructed on site by the contractor, BNI, as non-Q, commercial grade, or purchased from vendors as commercial (CM) items. CM components are purchased from vendors who are qualified as commercial grade suppliers. Evaluation for listing as a CM supplier requires assessment of the vendor's QA program against selected QA criteria designated by Engineering. Independent Oversight reviewed the 107 NCRs issued by BNI from November 15, 2011, through May 3, 2012, and 144 CDRs issued by BNI between January 2, 2012, and May 1, 2012, to evaluate the type of non-conforming issues that were identified, subsequent corrective actions, and the apparent cause of the non-conforming conditions.

Approximately two-thirds of the NCRs and one-half of the CDRs were issued to resolve equipment and hardware procurement problems, such as: (1) hardware/components that were delivered to the site without the required supporting documentation demonstrating compliance with purchase specifications, (2) hardware/equipment that did not comply with project specification requirements, (3) improperly labeled hardware, and (4) missing parts or damage that occurred during transit. Independent Oversight found that the BNI engineering organization developed appropriate corrective actions to disposition the identified problems. Corrective actions usually involved rework performed on site, but in some cases the hardware was returned to the vendor. The other one-third of the NCRs and half of the CDRs were initiated to address construction or installation issues. Examples of the issues identified in theses CDRs and NCRs were damage to installed equipment during construction work, failure to follow construction procedures, personnel errors, and installation errors. Independent Oversight also determined that BNI developed appropriate corrective actions to disposition the identified problems. The NCR/CDR process and implementation was adequate to address and resolve procurement and construction quality deficiencies.

PIERs are used to implement the corrective action management process at WTP. Procedure 24590-WTP-GPP-MGT-043, Rev. 3A, *Corrective Action Management*, establishes the process for initiating and resolving PIERs. PIERs are utilized to document and manage improvement opportunities, adverse conditions, deficiencies, and non-compliant conditions, as well as any situation that an employee determines may warrant management attention. PIERs are screened and assigned a significance level, A through D. A PIER can be initiated by any WTP employee via electronic data entry or a paper (hard copy) submittal. After a PIER is initiated, the corrective action program requires screening to determine significance of the issue, performance of a cause analysis, development and implementation of corrective actions, and performance of an effectiveness review.

Corrective actions to disposition CDRs and NCRs may be managed by a PIER. Non-conforming conditions identified in a PIER may result in initiation of a CDR or NCR. Procedure 24590-WTP-GPP-MGT-044, Rev. 1A, *Nonconformance Reporting and Control*, defines the requirements for identifying, reporting, controlling, documenting and dispositioning CDRs and NCRs. Although not clearly stated in the above listed site procedures, BNI personnel stated that all non-conforming conditions affecting structures, hardware, or components are documented with an NCR or CDR.

Independent Oversight reviewed a computer data listing of PIERs and selected 19 PIERs for further review. These PIERs had been identified by several BNI organizations, including Procurement, QA, Engineering, and Construction. The PIERs addressed several topics, including deficiencies in vendor welds on pipe supports, deficiencies in onsite welding, procurement documentation discrepancies, and documentation of issues for resolution, such as requirements for as-built drawings and QA audit findings.

DOE-WTP Welding Inspection Program

The DOE-WTP staff performs independent inspections of one or more inspection attributes for approximately five percent of quality-related welds and is currently reviewing 100 percent of the weld records. DOE-WTP randomly selects the welds they examine. In addition to randomly selected welds, DOE-WTP places witness points on weld inspection documentation to ensure that a variety of welds are inspected by DOE-WTP across all facilities. The witness point requires BNI construction to notify DOE-WTP when the work is scheduled to be performed. The work activity cannot be performed or proceed past that point unless DOE-WTP inspects the construction process or waives the witness point. Welds selected by DOE-WTP for inspection include structural steel, piping, pipe supports, vessel (tank) welds, and weld repairs. Most of the welds examined by DOE-WTP are Q, but the DOE-WTP staff also includes some CM welds in their independent inspection program.

In December 2011, DOE-WTP issued Finding S-11-WCD-RPPWTP-012-F01 when DOE-WTP observed welders performing structural steel welding prior to issue of an approved field welding checklist (FWCL). The FWCL specifies the weld location, the welding process, weld filler material type, preheat/interpass temperature, inspection requirements, and any other requirements. The FWCL is required to be maintained near the worksite and is used to document the details of the process used for the weld, identification of welder, and type and results of the weld inspection. The site procedures for the WTP welding program and the BNI WTP QA program prohibit performance of any Q or CM welding activity without an approved FWCL. A similar problem involving performance of welding without an approved FWCL was documented in PIER-MGT-10-0164B, in 2010.

Independent Oversight observed welding inspections performed by the DOE-WTP staff. The welds and attributes inspected were final visual inspection of a tank to embed weld 24590-HLW-FWCL-CON-10-00712 for Nitric Acid Reagent Tank NAR-TK-00001 (FW-01C), final visual inspection of tank to embed weld 24590-HLW-FWCL-CON-10-00713 for Sodium Hydroxide Reagent Tank SHR-TK-00002 (FW-01C), and final visual inspection of attachment weld 24590-HLW-FWCL-CON-09-00641 for Breathing Service Air System pipe support HLW-BSA-H00162. These welds were pre-selected by DOE-WTP as DOE inspection witness points and are designated as such on the FWCLs. DOE-WTP also reviewed FWCLs, drawings, specifications, and procedures associated with welds. Independent Oversight re-examined the completed welds and the associated documents and concurred with DOE-WTP that the welds were completed in accordance with project requirements. Independent Oversight also independently examined some additional randomly selected tank to embed welds for both tanks and verified that the size, type, and length were as shown on the construction drawings.

All the above welds were classified as CM. The DOE-WTP welding inspection program was found to be satisfactory for the sample reviewed by Independent Oversight.

Concrete Placement Activities

Independent Oversight observed portions of three concrete placements during the February 6-10, 2012, site visit: (1) a wall, numbered 3143 and 3144 East, Elevation 37'-0" to 56'- 0", in the HLW building along Column Line T from Column line 16 to 7' east of Column line 12; (2) LAB placement number ACC011G, a cover slab over drain tanks in the C-3 pit; and (3) LAB placement number ACC015D, a cover slab over a drain tank in the C-5 pits. During the April 30 – May 4, 2012, review, Independent Oversight observed portions of placement number PCC0057, a section of the base mat for the PTF control room. Activities observed were quality control (QC) testing of fresh concrete for slump, temperature, and unit weight; review of concrete batch tickets by QC inspection personnel; placement of the concrete in the forms; and consolidation of the concrete.

Independent Oversight reviewed the concrete pour cards and verified that they were signed to document that all required construction work and inspections were completed prior to the start of concrete placement. Testing of the concrete was performed in accordance with ASTM International (ASTM) standards specified in the project procedures. Test results showed that the delivered concrete met project requirements for slump and temperature. Concrete was sampled for molding of cylinders for unconfined compression testing. Review of the concrete batch tickets indicated that the proper concrete was being delivered.

For the wall placement, preparations were made for cold weather concrete placement and for protection of the concrete during curing in accordance with American Concrete Institute (ACI) recommendations and specification requirements. The temperature of the concrete forms, rebar, and embedded items was measured by QC inspectors and verified to be above the minimum temperatures listed in the specification prior to concrete placement during cold weather. The LAB placements were located inside the LAB where ambient temperature exceeded the minimum temperature specified for cold weather conditions. The four foot thick PTF control room base mat was classified as a mass concrete placement with a maximum concrete temperature of 70 degrees F. Thermocouples were installed to monitor the internal concrete temperature. The ambient temperature during the base mat placement was below the threshold specified for implementation of hot weather concrete operations.

Concrete forms were secure and cleaned (debris removed) before concrete placement began. Equipment to deliver the concrete to the forms was suitable. A sufficient number of vibrators were used for consolidating the concrete, and there was sufficient access to the placement for vibrator operators, other construction craftsmen, and QC inspectors. Concrete drop distances were within specification requirements, vibrators were properly used, and excess water did not accumulate in the forms during placement and consolidation. Independent Oversight observed concrete placement inspections performed by BNI inspectors and found that those inspections were adequately performed.

Independent Oversight reviewed documentation for repairs to four voids (honeycombs or rock pockets) that occurred during placement of wall number 5-36 in the PTF in September, 2011, in both the north and south faces. The wall is along H line, approximately 2'-6" east of 12 line to 4'-0" east of 15 line, elevation +77 to +97. NCR 24590-WTP-NCR-CON-11-0275 was issued to document the problem and repairs to the defective concrete. The repair process is specified in Section 3.10 of Specification No. 24590-WTP-3PS-D000-T0001, *Engineering Specification for Concrete Work*. The specification references ACI 301, Specification for Structural Concrete, for recommendations for repairs to concrete defects. Independent Oversight reviewed the grout request/replacement cards, which documented repairs to the four areas of defective concrete in wall 5-36. The repair process documented on the grout cards included surface preparation, formwork, pre-soaking, release for grout placement, grout material and mixing, curing, and

testing. Test results showed the grout strength was well in excess of the concrete design strength. The repairs complied with the methods specified in Specification No. 24590-WTP-3PS-D000-T0001.

The quality of concrete for the WTP project has been very good. There have been few instances of concrete placement problems resulting in concrete defects, such as voids, honeycombs, or cracks. When concrete defects require repair, BNI performs the repairs in accordance with the methods recommended in ACI specifications. For the repairs to wall 5-36 reviewed by Independent Oversight, the strength of the repair material, grout, was well above design requirements. On May 3, Independent Oversight witnessed performance of unconfined compression testing of two concrete cylinders from the LAW roof slab. The test results showed that the unconfined compressive strength of the concrete was well above the concrete design strength.

Installation of Pipe Supports

Independent Oversight examined pipe supports on a completed section of piping in the LAW structure and reviewed records documenting inspection of pipe support welds. The purpose of this review was to determine whether: (1) the configuration of the pipe supports was in accordance with those shown on the isometric drawings and pipe support detail drawing; (2) the welding records (FWCLs) for the pipe supports were completed in accordance with the requirements of the Welding Control Manual; and (3) the welding records were readily retrievable for review in the WTP records control system. The section of piping selected for review was a four inch diameter stainless steel floor drain piping, Line No. RLD-WU-02174-S11B-4, as shown on Drawing No 24590-LAW-P3-RLD-WU02174004, LAW Vitrification Building Isometric. Independent Oversight examined support numbers LAW-RLD-H20096, -H20097, -H20098, and -H20099 during a walkdown in the LAW and verified that the pipe supports were fabricated as shown on Standard Pipe Support Detail Drawing numbers 24590-WTP-PH-50-00012001, -00012002, -00012004, and -00003001. Detailed weld inspections were not performed since the supports were in a location where they were inaccessible for a detailed, close-up examination during the walkdown. Independent Oversight reviewed the FWCLs for the four pipe supports, in the form of digital images of the FWCLs that had been scanned and were stored on a computer database. The FWCLs documented all data associated with the welds, including location, drawing numbers, welding procedure specification, inspection requirements and procedures, pre-heat requirements, weld filler material requirements, welder identification, and identification of field welding engineers who performed the inspections of the welds. Since the piping system was CM, QC inspectors were not involved the inspections. The inspection records were complete, legible, and readily retrievable.

Material Condition and Protection of Installed Equipment and Facilities

Independent Oversight, accompanied by DOE-WTP personnel, toured the PTF, HLW, LAW, and LAB to examine ongoing construction activities and protection provided for installed equipment. Construction activities have been deferred in the PTF due to ongoing design review and testing for some of the components associated with pre-treatment of the waste, and in the HLW pending outcome of the PTF design review. Construction is proceeding in the LAB, the LAW, and BOF. Installation of heating, ventilation, and air conditioning (HVAC) systems, instrumentation, piping, mechanical equipment, and fire protection components is ongoing. Pressure testing of piping is ongoing. Civil construction activities, including concrete, structural steel, roofing, and siding, are essentially complete for both the LAW and LAB. The overall material condition of installed equipment was good. Instrumentation was wrapped in protective covers, instrument panels were covered, and mechanical equipment, such as cranes, motors, and gloveboxes were protected from construction activities. The following discrepancies were identified during the walkdown inspection:

1. Kegs of structural steel fasteners were stored on the concrete floor in a covered shelter in the PTF. There was standing water in the shelter, and the bottoms of some of the kegs were immersed in water. The lids on some of the kegs were loose. BNI personnel stated that the water probably came from recent rains. Immediate corrective actions were undertaken to correct this problem and place the kegs of fasteners on pallets.
2. The bottom rails for the heavy shield doors that can be opened to provide access to the HLW filter caves are installed in depressions in the floor. These depressions were full of water, which could corrode the steel plates that support the rails and the steel bolts that attach the plates and rails to the building structure. The appearance of the water suggested it had been in the depressions for some time. A similar problem was documented in NCR 09-058, Lower Door Track Degraded due to Weather, which was initiated on February 19, 2009. This NCR was still open as of the May 2012 review date.
3. Some of the structural steel requires painting at beam-column connections and at column splice locations to protect the steel and tensioned bolt assemblies from rusting/corroding.

Discussions with BNI personnel disclosed that an inventory is under way in the PTF and HLW to identify the equipment and hardware stored in these structures. After the inventory, some of the equipment and components may be returned to warehouses for storage to maintain better control and material condition. Establishment of the maintenance and preservation program was identified as an opportunity for improvement.

During the walkdown inspection in the LAW, Independent Oversight also observed that a structural steel cross brace had been removed from a section of the roof framing between columns 9G and 8F. Further review of this issue disclosed that the cross brace was removed under Work Package LCS0176 to provide access for placement of mechanical equipment in the LAW. Independent Oversight reviewed the work package and inspection record, 24590-LAW-SMIR-CON-11-007, which was prepared to document the required structural steel inspections when the cross brace is re-installed.

Pressure Testing of Piping

Independent Oversight observed a pressure test performed on a portion of the LAW primary offgas process system for Melter 2 in the LAW. Testing requirements are specified in ASME Code B31.3, Section 345, Testing. The WTP site work process for conducting the leak testing is specified in Construction Procedure 24590-WTP-GPP-CON-3504, Rev. 7D, *Pressure Testing of Piping, Tubing, and Components*. The pressure test procedure allows the use of piping and instrumentation diagrams (P&IDs) to conduct pressure testing. Independent Oversight questioned field engineering and QC personnel regarding why isometric drawings were not used for the pressure test. Isometric drawings show piping size and configuration, location of welds and other items, such as repairs, valves, supports, and attachments. These discussions disclosed that isometric drawings are generally not used at WTP during pressure testing of piping.

The test was pneumatic, with the pressure gauge located at high point of the portion of system being tested. Independent Oversight attended the pre-test briefing, reviewed drawings and test data sheets, observed pressurization of the system to 10 percent above design pressure (16.5 psi), observed the minimum 10 minute hold time (16.5 psi pressure actually held for 11 minutes), and witnessed the system walkdown and leak testing of pipe joints.

During the pre-job briefing, the following items were discussed: safety guidelines, the emergency plan, the size and setting of the pressure relief valve, test sequence, test boundaries, test pressure, system pressurization and de-pressurization, inspection activities, and work completion. The pressure test and inspection boundaries were shown on marked-up P&IDs, and the attached valve lineup sheets listed the

test valve position and referenced test plug or blind flange locations. Piping within the test boundaries included both Q and CM piping. The locations of limited access/safety barriers were established in accordance with procedure requirements by calculating stored energy. Independent Oversight verified that the calibration stickers on the two test pressure gauges were current and that whip restraints were installed on pressure hoses. The walkdowns and inspections of the joints in the Q portions of the system being tested were performed by both QC inspection and field engineering personnel. No leaks were detected, and the test was declared acceptable. Independent Oversight reviewed the test data sheets, which recorded the test information, test requirements, required signoffs for pre-test reviews, documentation of measuring and test equipment used, test results, and test acceptance by field engineering and QC. The pressure test observed by Independent Oversight was completed in accordance with the requirements specified in Construction Procedure 24590-WTP-GPP-CON-3504.

Follow-up on Structural Steel Erection Concerns

Background. Structural steel members (beams, columns, and braces) are joined by using either bolted or welded connections. Most of the connections at WTP are bolted, and most of the structural steel bolts used for the WTP connections are twist-off type tension control (TC) bolts with splined ends. Proper bolt tension is achieved when the splined end is severed from the bolt by the installation crew when the bolts are tightened. It is extremely important that the splines do not sever from the TC bolts until the tension developed in the bolt meets or exceeds American Institute of Steel Construction (AISC) design requirements.

Connections are classified as snug-tightened, pre-tensioned, or slip critical. Snug-tightened connections provide resistance to shear loads and static tensile loads. Bolts in snug-tightened connections are defined as those tightened to a snug tight condition using an impact wrench or the the full effort of an iron worker using an ordinary spud wrench to bring the faying surfaces of the connected members into full contact. Pre-tensioned joints are those that are subject to shear, combined shear and tension, significant load reversal, or fatigue load with no reversal of the loading direction. Slip critical connections are those that are subject to fatigue loads with load reversal, joints that utilize slotted or oversized holes, and joints for which slip at the faying surfaces would be detrimental to performance of the structure. Pre-tensioned and slip critical connections require that a specified value of bolt pre-tension be applied during construction. The minimum bolt pre-tension is specified in AISC 348 for bolts in pre-tensioned and slip critical connections. The bolt pre-tension improves the performance of connections subjected to cyclic loads, such as those resulting from seismic events (load reversal). For slip critical connections, failure to properly tension structural steel bolts could result in excess joint displacements or fatigue failures, and inability of the joints to dissipate energy resulting from cyclic loads applied to structures during seismic events. Slip critical connections at WTP are shown on the construction drawings and include column splices, beams/columns supporting crane rails, and numerous beam/column connections in the upper elevations of WTP structures. Due to the importance of proper installation and tensioning of bolts in the WTP structures, and in consideration of the significant number of previously identified bolting deficiencies, Independent Oversight continues to closely follow up on these activities.

Failure to Tension Structural Steel Bolts. In April 2010, BNI QC inspectors identified six structural steel bolts in a beam-to-column connection in the HLW that were not properly tensioned; that is, the six bolts still had the splined ends in place. The inspection records were closed for this connection, indicating that all bolts had been tensioned. NCR 24590-WTP-NCR-CON-10-0105 was issued on April 13, 2010, to document and disposition this problem. A number of corrective actions were initiated to disposition this NCR, including re-inspection of a sample of accessible connections in the PTF and HLW and retraining of craft personnel and QC inspectors. PIER 24590-WTP-PIER-MGT-10-0439 B was issued to manage, develop, and implement the corrective actions for closure of the NCR. An apparent cause analysis to determine why the bolts were not tensioned disclosed that the beam-to-column

connection had been put in place before installation of adjacent steel and was left incomplete to allow adjustment when the interfacing steel was installed. Therefore, the bolts had been neither tensioned nor painted yellow to indicate that they were non-permanent (NP). The cause of this non-conforming condition, as stated in the apparent cause analysis dated September 16, 2010, was ironworkers' failure to fully understand the requirement to paint structural steel bolts when they are left in place without completing final tensioning, and insufficient attention to detail by both the ironworkers and QC inspectors.

Action 03 for closure of PIER 24590-WTP-PIER-MGT-10-0439 B required training of structural steel installers and supervisors regarding management of incomplete work when structural steel installation is interrupted, with emphasis on the need to paint bolts yellow if final tensioning is deferred. This training was performed on September 28, 2010. Training was provided to QC inspectors on August 30-31, 2010, on the need to monitor the erection process to be aware of the status of structural steel erection work. Independent Oversight reviewed the records documenting this training and noted that Procedure 24590-WTP-GPP-CON-3206, *Structural Steel Installation and On-Site Fabrication*, was not revised to incorporate or clarify the materials covered by the training regarding the expectation that if final tensioning of TC bolts is to be deferred, they should be treated as NP and painted yellow.

During a field inspection in November 2010 to determine the effectiveness of BNI corrective actions to resolve the problem regarding failure to tension TC bolts, Independent Oversight and DOE-WTP identified two additional permanent bolts in one connection in the PTF that had not been tensioned (i.e., the splined ends were not severed). The same field inspection identified some temporary bolts that had not been painted to identify them as NP. BNI issued NCR 24590-WTP-NCR-CON-10-0359 to document and disposition the two deficient PTF bolts. PIER 24590-WTP-PIER-MGT-10-1220 B was issued to manage the corrective actions for closure of NCR 24590-WTP-NCR-CON-10-0359, which included a full re-inspection of all accessible connections in the PTF, HLW, LAW, and LAB.

DOE-WTP issued a finding for the improperly tensioned PTF bolts and failure to paint NP bolts. Corrective actions included BNI's re-inspection of all accessible bolts in connections in the PTF, HLW, LAW, and LAB facilities to verify that they were properly tensioned.

The re-inspection program was completed in 2011, and the results are documented in a report titled Walk Down for PIER 24590-PIER-MGT-10-1220-B. The report shows that the bolts on 12,700 connections were re-inspected to verify that the bolts had been properly tensioned. The report also states that a few non-tensioned bolts (splined end still in place) were identified on five connections, but these did not include all the bolts in the connection. The number of connections identified with improperly tensioned bolts was less than 0.04 percent of those inspected, and the number of improperly tensioned bolts was less than 0.01 percent of the total inspected. An additional 6200 connections were inaccessible, 2000 because access was restricted by other completed construction activities (although partial re-inspection of some bolts was possible), and 4200 because fire protection coatings had been applied.

Action 04 of PIER 24590-PIER-MGT-10-1220-B requires performance of independent, quarterly quality verification inspections by the BNI Lead Civil QC Engineer (LCQCE) to ensure that the bolts have been twisted off per specification requirements. Independent Oversight reviewed the results of two independent quality verification inspections documented in QA/QC Surveillance Report 24590-WTP-SV-11-200, dated December 21, 2011, for August, September, and October 2011, and QA/QC Surveillance Report 24590-WTP-SV-12-054, dated April 26, 2012, for February, March, and April 2012. A random sample of structural steel bolts in the 1313 connections tensioned during the months of August, September, and October 2011 were examined by the LCQCE. The sample size of 280 connections was based on accepted statistical sampling methods for engineering quality monitoring and field inspection specified in BNI procedures. However, the sample size was increased to 411 to ensure that the

connections inspected and accepted by each Civil QC Engineer were included in the independent quarterly verification inspection. No deficiencies were identified by the LCQCE. In the months of February, March, and April 2012, 493 connections were completed. The LCQCE examined the TC bolts in 208 of these connections and verified that the splines had been severed from the bolts per specification requirements. No deficiencies were identified.

Control of Temporary Erection Bolts. Steel fabricators use temporary bolts to pre-assemble some structural steel members or to temporarily attach smaller pre-fabricated steel components to larger beams or columns during shipping so the smaller components do not get lost or misplaced. Examples would be attaching a splice plate or gusset plate to a beam or column. Erection bolts are also used to temporarily assemble structural steel frames during erection. These are typically hex head type bolts supplied by the steel suppliers for temporary use. However, at WTP, a large number of new TC bolts have been and are still being used as erection bolts.

Section 5.5.5 of Procedure Number 24590-WTP-GPP-CON-3206, Revision 4, *Structural Steel Installation and On-Site Fabrication*, requires permanent bolts used for temporary erection bolting or other temporary installations to be considered NP and marked with yellow or white paint. (Note: In Revision 3 of Procedure Number 24590-WTP-GPP-CON-3206, this requirement was in Section 3.3.6, and required NP bolts to be painted yellow. Since experience at the site has shown that yellow sometimes fades to white, Revision 4 of the procedure was revised to permit use of either white or yellow paint to designate NP bolts.) The basis for this requirement is AISC 348, *Specification for Structural Joints Using ASTM A325 or A490 Bolts*, which provides instructions for installation of the twist off type TC structural bolts. This specification indicates that bolts and other fastener components should be kept in protected storage until they are installed. The intent of painting the bolts used as erection bolts is to prevent these bolts from being used as permanent bolts and included in the completed structures. In cases where TC bolts are used as erection bolts, the paint would show that these bolts had been exposed to the weather and would preclude them from being tensioned and left to remain in a completed connection.

During the 2008 HSS assessment, Finding F-2, Structural Steel Bolting Issues, was issued for improper storage of structural steel bolts and failure to mark temporary erection bolts as required by site procedures. In the November 2010 quarterly site review, Independent Oversight reviewed BNI corrective actions to disposition the 2008 finding. During a field walkdown in conjunction with DOE-WTP, Independent Oversight identified a few bolts in the HLW that were not painted to indicate their temporary status, as well as two permanent bolts in a PTF connection that had not been tensioned. BNI QC inspection records showed that the non-tensioned bolts had been inspected and accepted by BNI QC. All temporary erection bolts examined in the PTF had been painted, although a large number appeared to have been painted white instead of yellow. As discussed under "Failure To Tension Structural Steel Bolts," above, DOE-WTP issued a finding of non-compliance to BNI for failure to tension the two bolts and failure to paint the NP HLW bolts.

During a September 2011 quarterly review, Independent Oversight identified four connections in the PTF at elevation 77, column lines N and 5 where TC bolts had been installed in partially completed connections and had not been tensioned. These bolts, which were installed in late June 2011, were functioning as temporary erection bolts but had not been painted as required to identify them as NP. The bolts were subsequently painted to indicate that they were temporary.

During the same September 2011 quarterly review, Independent Oversight also observed construction pre-assembling structural steel members by using new TC (permanent) bolts loosely installed in the bolt holes. The intent was to perform final tensioning of the bolts when the members were installed in the structure. Approximately 250 beams had been pre-assembled using permanent bolts in the HLW building and the structural steel laydown areas adjacent to the HLW. Most of these nuts were finger tight on the

bolts, but in some of the pre-assembled beams, the nuts were less than finger tight and the mating surfaces of the steel members were not drawn together. In this condition, the portion of the bolt that will be tensioned is not protected from the elements. Also, in some cases the nuts were only loosely threaded on the bolts, leaving the threads where the nut would be seated upon tensioning exposed to the elements. This practice could result in deterioration of the lubricant on the bolt assembly prior to tensioning, as well as contamination of the bolt threads with grit, so that the spline would sever from the bolt before the bolt achieves its designed pre-tension value.

After Independent Oversight questioned the practice, BNI construction discontinued pre-assembling beams for long term future installation using non-tensioned permanent bolts. PIER 24590-WTP-PIER-MGT-11-0866, Rev 0, Bolt up of A325 and A490 Structural Steel Connections, was issued by BNI to document this condition and determine whether the method used to pre-assemble beams complies with AISC 348. DOE-WTP issued an assessment follow-up item to document this issue and perform further review.

BNI QC inspectors perform monthly storage and maintenance walkdown surveillances to determine whether temporary erection bolts are painted per procedure 24590-WTP-GPP-CON-3206. Independent Oversight reviewed a report dated November 21, 2011, which documented the monthly walkdown in portions of the HLW. Independent Oversight also reviewed a report dated December 14, 2011, which documented the monthly walkdown in the PTF. QC identified four erection bolts in the PTF that had not been painted to indicate they were temporary. BNI craft supervision was contacted, and the four bolts were appropriately painted. This corrective action was treated as an on-the-spot correction. Independent Oversight reviewed four additional storage and maintenance surveillance reports documenting walkdowns performed by QC inspectors to verify that NP bolts were painted per procedure 24590-WTP-GPP-CON-3206, dated January 24, 2012; February 27, 2012; March 21, 2012; and April 9, 2012. QC identified temporary bolts in the PTF during the February walkdown and on a piping module (Mod 3L) during the April walkdown that had not been painted to indicate they were temporary. BNI craft supervision was contacted, and the bolts (13 in the PTF and 87 on Mod 3L) were appropriately painted.

Procedure Revisions To Address Exposure of TC Bolts to the Environment Prior to Tensioning. Research has established the importance of performing the final tensioning of the twist-off TC bolts as soon as practical after removal from protected storage because this type of bolt is affected by environmental conditions of storage and exposure. Some of the TC bolts used at WTP are manufactured by Nucor Fastener. The manufacturer's technical data sheet, titled Tru-Tension Fastening System, re-states the AISC 348 requirements for storage of fastener components, emphasizing that only as many fasteners as are expected to be installed and tightened during a work shift shall be taken from protected storage. The technical data sheet further states that unused fasteners shall be returned to protected storage at the end of the shift. Research sponsored by the steel industry at the University of Toronto determined that the average pre-tensions in TC bolts exposed to the weather prior to final tensioning showed a progressive decline after two, four, and eight weeks of exposure. The tests showed that TC bolt pre-tension values appeared to decrease as the time delay between installation (thus exposure to the weather) and final tensioning increases. Deterioration of the lubricant is the primary cause of reduced pre-tension load. The condition of fastener assemblies must be replicated in pre-installation verification, which is performed on as-received nuts and bolts to demonstrate that the twist-off TC bolts will develop the proper tension when the spline is severed. Bolt assemblies must be used in the as-delivered, clean, lubricated condition. For TC bolts, adherence to requirements for storage, cleanliness, and verification is necessary for proper use, as is limiting the time between removal from protected storage and final twist-off of the splined end. For other types of structural steel bolts, AISC 348 permits cleaning and re-lubricating the bolt assemblies prior to tensioning in the event they become dirty or corroded. However for TC bolt assemblies, re-lubrication is specifically prohibited by AISC 348 and ASTM F1852, which is the standard specification for TC bolt assemblies, unless it is performed by the manufacturer.

Procedure 24590-WTP-GPP-CON-3206, *Structural Steel Installation and On-Site Fabrication*, was revised and re-issued as Revision 4, with an effective date of January 25, 2012. Revision 4 of the procedure included a new requirement for QC inspectors to visually inspect TC bolts, prior to final tensioning, for signs of deterioration of the lubrication (such as rust) or lack of snug tightness prior to final tensioning to identify assemblies that require replacement. This requirement was added to address concerns identified by Independent Oversight regarding installing TC bolts in connections and not performing the final tensioning for several weeks or months after the TC bolts had been removed from protected storage. Prior to Revision 4, Procedure 24590-WTP-GPP-CON-3206 specified that inspection of connection details, such as verifying snug tightness of TC bolts prior to tensioning, were monitored or routinely observed on a random basis by QC. However, inspection of the condition of the fastener assemblies, such as identifying the presence of rust, was not specified in earlier procedure revisions. Revisions prior to Revision 4 required that bolt assemblies be inspected after tensioning was performed and the results documented on a bolt inspection tracker stating the type and grade of bolt, nut, and washer; method of tensioning; and, for TC bolts, verification that the spline was severed.

After Independent Oversight's February 2012 site visit, Revision 4A to Procedure 24590-WTP-GPP-CON-3206 was issued, with an effective date of February 28, 2012. This revision provides guidance for testing representative samples of bolt assemblies whose condition is in question, or replacing the bolt assemblies whose condition is in question.

During the review of Revisions 4 and 4A of Procedure 24590-WTP-GPP-CON-3206, Independent Oversight identified several discrepancies in the instructions for completing several of the data sheets in the appendices of the procedure. Correction of these discrepancies was identified as an opportunity for improvement.

Testing of TC Bolts. Three A-325 bolts, 7/8" in diameter, were removed from two beams stored in the laydown area adjacent to the HLW and tested on November 8, 2011. The test results showed these bolts were acceptable; that is, the bolts achieved the designed pre-tension value before the spline severed from the bolt. Additional testing of a sample of six A325 bolts (two lots of three in each lot) was completed on February 2, 2012. All bolts in the first lot were acceptable. These were 3" long, 7/8" diameter bolts obtained from pre-assembled beams stored on El 37'-0" at the west side of the filter cave in the HLW. One of three bolts from the other lot – 2-1/4" long, 7/8" bolts from HLW stairwell #3 – failed to meet test acceptance criteria. All bolts represented by this test lot in stairwell #3 that have not been tensioned will be replaced. Two additional lots (three bolts in each lot) of non-tensioned HLW TC bolts were removed from beams for testing. In one of the lots, all bolts were acceptable. In the other lot, which were bolts removed from beams for the HLW filter cave, one bolt failed to meet the acceptance criteria. All bolts represented by this lot will be replaced.

Observations of Structural Steel Erection Work. During the February 2012 visit, Independent Oversight examined structural steel in the proximity of HLW stairwell #3, which is located between Column lines 19 and 20 at Column line T5. Independent Oversight identified connections in several beams adjacent to HLW stairwell #3, between Column lines 17 to 19, and T-4 to T-5, Elevation 20 to 37, that had non-tensioned bolts. In some of these connections, all the bolts had been installed, but none were tensioned. A few connections contained both tensioned and non-tensioned bolts, while other connections contained only one or two bolts, which appeared to be functioning as temporary erection bolts. None of the non-tensioned bolts were painted to indicate that they were temporary erection bolts. BNI QC inspectors said that these bolts had been installed several months ago, but work was stopped in this area prior to completion of bolt installation and tensioning.

Subsequent to the February 2012 site visit, BNI QC performed a surveillance inspection to evaluate the non-tensioned bolts identified by Independent Oversight in the HLW, discussed above. The surveillance inspection, documented in Surveillance 24590-WTP-SV-QC-12-023, concluded that some bolts were not hand tight. These bolts were painted to indicate they were temporary. The surveillance report indicated that samples of other bolts in connections in this area will be tested to verify that the spline will not sever before the bolts achieve their designed pre-tension value. Independent Oversight noted that the surveillance report indicated that a procedure change notice for Revision 4A of Procedure 24590-WTP-GPP-CON-3206 was in review to add the option to test bolts found in suspect conditions, i.e., permanent bolts that have been installed in the structural steel for an extended period and have not been tensioned. (This revision is discussed in more detail under "Procedure Revisions To Address Exposure of TC Bolts to the Environment Prior to Tensioning," above.)

Structural steel erection work in the section of the HLW between Column lines 17 to 19, and T-4 to T-5, Elevation 20 to 37, with the non-tensioned bolts had been stopped (interrupted) for several months. As discussed under "Failure To Tension Structural Steel Bolts," above, training had been provided to emphasize the need to identify non-tensioned bolts with paint when work is delayed or interrupted, but this information was never included in Procedure 24590-WTP-GPP-CON-3206. There appeared to be no hold points in the work packages that would have prevented the craft workers from continuing work on this structural steel and performing final tensioning of the non-tensioned bolts that Independent Oversight identified in the HLW; hold points would require the craft to notify QC prior to tensioning the bolts. Before January 25, 2012, when Revision 4 of Procedure 24590-WTP-GPP-CON-3206 became effective, there were no written instructions in the procedure requiring QC to visually inspect the condition of the TC bolts prior to tensioning.

During the April-May 2012 quarterly site visit, Independent Oversight, accompanied by DOE-WTP, examined structural steel in the PTF and HLW. Independent Oversight observed that all non-tensioned TC bolts in the PTF have been painted yellow to identify them as NP. Structural steel erection work in the PTF has been deferred pending resolution of some design and process questions. Structural steel in the HLW between Column lines 17 to 19, and T-4 to T-5, Elevation 20 to 37, has been completed. Structural steel erection work is continuing in the HLW. Independent Oversight did not observe any non-tensioned TC bolts in the HLW that had not been painted to identify them as NP. Independent Oversight also examined structural steel laydown areas on the south and west side of the HLW, where all non-tensioned TC bolts in pre-assembled structural steel members were found to be painted to identify them as NP.

Review of Structural Steel Inspection Records. Erection and inspection of structural steel are documented in the inspection records specified in Procedure 24590-WTP-GPP-CON-3206, which are filed in the project computer database. These records include structural or miscellaneous steel inspection reports, a list of drawings and applicable documents, concrete strength data (compressive strength of concrete must equal or exceed 75% of design strength prior to structural steel erection), the bolt inspection tracker (now called the structural steel connection tracker), bolt connection location plans, a list of weld inspection records, and lists of other applicable inspection records.

Independent Oversight reviewed a sample of structural steel inspection records, including those documenting completed structural steel installation and some in-process inspections in the PTF and HLW structures. Completed structural steel inspection records reviewed were as follows:

1. Record number 24590-HLW-SMIR-CON-09-055, HLW West Annex South, Column lines H to T, 1 to 5, Elevation 14.0 to 37.0, completed August 4, 2010
2. Record number 24590-HLW-SMIR-CON-10-022, Platform HM 0126, top of steel Elevation 17'6", HLW Column lines 17 to 10, D to F, completed October 11, 2011

3. Record number 24590-PTF-SMIR-CON-09-045, structural steel framing, top of steel Elevation 76.0, PTF Column lines 17 to 26, AA to G, completed February 3, 2011
4. Record number 24590-PTF-SMIR-CON-08-016, Elevation 32 column splices and structural steel beams, top of steel Elevation 55.0, PTF Column lines 26 to 32, G to N, completed July 29, 2009.

Independent Oversight also reviewed in-process structural steel inspection records, including: (1) Record number 24590-HLW-SMIR-CON-11-044, for erection of structural steel for a high efficiency particulate air (HEPA) filter support in the HLW; (2) Record number 24590-PTF-SMIR-CON-11-073, structural steel framing, Column lines 17.1 to 30, E to H, top of steel Elevation 97.0 in the PTF; and (3) Record number 24590-PTF-SMIR-CON-11-049, Column lines 17 to 26, L to N, top of steel Elevation 97.0 in the PTF.

No deficiencies were noted in the completed records or the in-process HLW HEPA filter support records. For the two in-process PTF records (24590-PTF-SMIR-CON-11-073 and 24590-PTF-SMIR-CON-11-049), the structural steel connection trackers were completed by the field engineer before the structural steel erection work was completed. The data the field engineer completed on the structural steel connection tracker was obtained from the design drawings. This data included type and strength of bolts, size and number of bolts, washer type, and tension method used. The instructions on the connection tracker form imply that the data completed by the field engineer should be entered in the records by the QC inspector when he performs the inspection, and not prior to erection of the steel and tensioning of the bolts. The QC inspector initials and dates each line item on the connection tracker form when he completes the inspection and notes any changes to the bolt data on the connection tracker. The QC inspectors in the HLW complete the connection tracker forms when they perform the inspections of each line item and connection, documenting on the data sheets the type and strength of bolts, size and number of bolts, washer type, and tension method used.

Dangerous Waste Permit Third Party Inspection Program

A third party inspection (TPI) program has been implemented at WTP to provide independent inspection for the State of Washington of SSC that are classified as Dangerous Waste Permitted. These SSC are listed in the permit issued by the State for construction and operation of the WTP. The TPI personnel witness various construction activities and place hold points on various activities, such as welding, so they will be notified when an activity is ready to proceed,

Independent Oversight reviewed the qualifications of the two of the TPI inspectors and a sample of the reports issued in 2011 by TPI to document their activities. Two of the PIERs reviewed by Independent Oversight addressed concerns identified by TPI. Independent Oversight noted that TPI personnel witnessed the concrete placement in HLW wall 3143 and 3144 and the pressure test of the LAW primary offgas process system for Melter 2 in the LAW. Based on Independent Oversight's limited review, the TPI program appears adequate.

5.0 CONCLUSIONS

With the exception of structural steel bolting, Independent Oversight determined that construction quality at WTP is adequate in the areas that were reviewed. BNI Engineering developed appropriate corrective actions to disposition the NCRs, CDRs, and PIERs that Independent Oversight reviewed. Concrete placement and inspection activities are adequate, as is pressure testing of installed piping. Independent Oversight continued to identify problems with structural steel bolting during its review in February 2012, including failure to paint temporary erection bolts to identify them as NP and not tensioning the twist-off structural steel bolts for an extended period of time after installation. BNI has made progress with addressing the latest bolting issues, but an additional area for improvement was identified during the May 2012 review.

6.0 OPPORTUNITIES FOR IMPROVEMENT

Independent Oversight identified the following opportunities for improvement. These recommendations are not intended to be mandatory. Rather they are offered to the project to be reviewed and evaluated by the responsible line management organization and be accepted, rejected, or modified as appropriate, in accordance with site-specific program objectives and priorities:

- Consider establishing a formal inspection program to maintain and preserve the PTF and HLW structures. This program should include periodic inspections in the PTF and HLW, timely correction of identified deficiencies, and resolution of previously identified issues. Examples of items that should be included in the program include hardware items such as structural steel, supports, and reinforcing steel that could be affected by corrosion; incomplete piping systems (verify ends are capped to prevent internal contamination); various construction materials temporarily stored in the HLW and PTF; and any installed equipment not included in the established WTP maintenance and preservation programs.

- Consider revising the sample data sheets in the appendices of Construction Procedure 24590-WTP-GPP-CON-3206 to correct discrepancies between the data sheets and instructions for completing the data sheets.

7.0 ITEMS FOR FOLLOW-UP

Independent Oversight will continue to follow up on review of structural steel bolting issues and will also continue inspection of piping and pipe support installation activities.

APPENDIX A
SUPPLEMENTAL INFORMATION

Review Dates

February 6-10 and April 30 – May 4, 2012

Office of Health, Safety and Security Management

Glenn S. Podonsky, Chief Health, Safety and Security Officer
William A. Eckroade, Principal Deputy Chief for Mission Support Operations
John S. Boulden III, Director, Office of Enforcement and Oversight
Thomas P. Staker, Deputy Director for Oversight
William E. Miller, Deputy Director, Office of Safety and Emergency Management Evaluations

Quality Review Board

John Boulden III
William Eckroade
Thomas Staker
George Armstrong
Robert Nelson
Michael Kilpatrick

Acting Independent Oversight Site Lead for Hanford Site

William Miller

Independent Oversight Team Composition

Joseph Lenahan
William Miller (April 30 – May 4 only)

Documents Reviewed

- DOE-WTP Surveillance Reports for November and December 2011 and March 2012
- Construction Procedure 24590-WTP-GPP-CON-3203, Rev. 09D, Concrete Operations (Including Supply), November 24, 2010
- Construction Procedure 24590-WTP -GPP-CON-3206, Rev. 4, Structural Steel Installation and On-Site Fabrication, January 25, 2012, and Rev. 4A, Effective Date February 28, 2012
- Construction Procedure 24590-WTP-GPP-CON-3212, Rev. 0, Concrete Excavation, June 6, 2005
- Construction Procedure 24590-WTP-GPP-CON-3503, Rev. 5D, Aboveground Piping Installation, August 11, 2011
- Construction Procedure 24590-WTP-GPP-CON-3509, Rev. 2B, Pipe Support Installation, January 10, 2012
- Specification No. 24590-WTP-3PS-D000-T0001, Rev. 7, Engineering Specification for Concrete Work, March 29, 2007

- Specification No. 24590-WTP-3PS-DB01-T0001, Rev. 8, Engineering Specification for Furnishing and Delivering Ready-Mix Concrete, March 26, 2007
- Specification No. 24590-WTP-3PS-SS00-T0001, Rev. 7, Engineering Specification for Welding of Structural Carbon Steel, January 30, 2008
- Specification No. 24590-WTP-3PS-PS02-T0003, Rev. 9, Engineering Specification for Field Fabrication and Installation of Piping, March 25, 2011
- Specification No. 24590-WTP-3PS-PH01-T0002, Rev. 6, Engineering Specification for Installation of Pipe Supports, July 13, 2011
- Specification No. 24590-WTP-3PS-SS02-T0001, Rev. 3, Engineering Specification for Erection of Structural Steel, December 1, 2008
- Construction Procedure 24590-WTP-GPP-CON-3601, Rev. 2, Equipment Installation, April 19, 2010
- Specification No. 24590-WTP-3PS-M000-T0010, Rev. 4, Engineering Specification for Mechanical Equipment Installation Tolerances and Guidelines, May 16, 2010
- Construction Procedure 24590-WTP-GPP-CON-3504, Rev. 7D, Pressure Testing of Piping, Tubing and Components, September 22, 2011, and Rev. 8, May 1, 2012
- Construction Procedure 24590-GPP-MGT-043, Rev. 3, Corrective Action Management, January 26, 2012, and Rev. 3A, May 1, 2012
- Construction Procedure 24590-GPP-MGT-044, Rev. 1, Nonconformance Reporting and Control, January 17, 2012, and Rev. 1A, February, 28, 2012
- Document No. 24590-WTP-MN-CON-01-001-10-10, Rev. 6, Welding Control Manual, VT-AWS D1.1, Visual Examination Standard, August 15, 2006
- Document No. 24590-WTP- MN-CON-01-001-10-09, Rev. 7, Nondestructive Examination Standard Visual Examination VT-ASME, August 24, 2011
- Nonconformance Report 24590-WTP-NCR-CON-11-0275, PTF Rock Pockets PCC0536; North and South Face +77' El to +97 El
- Project Issues Evaluation Report 24590-WTP-PIER-MGT-11-0866, Bolt up of A325 and A490 Structural Steel Connections
- Project Issues Evaluation Reports numbers 24590-WTP-PIER-MGT11-1260D, 11-1294, -11-1297, 24590-WTP-PIER-MGT-12-007B, -0008D, 0011D, -0016C, -0023C, -0024C, -0040C, -0045C, -0057C, -0075C, -0154, -0305C, -0395B, -0412D, -0448C, and -0525C
- Construction Deficiency Reports numbers 24590-WTP-CDF-CON-12-0001 through -0011, 24590-WTP-CDF-CON-12-0013 through -0023, 24590-WTP-CDF-CON-12-0025 through 24590-WTP-CDF-CON-12-0032, 24590-WTP-CDF-CON-12-0034 through -0087, 24590-WTP-CDF-CON-12-0087, 24590-WTP-CDF-CON-12-0089 through -0042F-CON-12-0129, and 24590-WTP-CDF-CON-12-0131 through -0149. Note: Numbers 24590-WTP-CDF-CON-12-0012, -0024, -0033, -0086, -0088, and -0130 were not issued.
- Nonconformance Report numbers 24590-WTP-NCR-CON-11-0357 through -0381, 24590-WTP-NCR-CON-12-0001 through -0068., and 24590-WTP-NCR-CON-12-0070 through -0084. Note: Number 24590-WTP-NCR-CON-12-0069 was not issued.
- Grout Request/Replacement Card numbers PTF-0078 through PTF-0080, and PTF-0083
- Nucor Fastener Technical Data Sheet titled Tru-Tension Fastening System
- Final Report Phase 1, Installation Characteristics of ASTM F1852 Twist-Off Type Tension Control Structural Bolt/Nut/Washer Assemblies, Department of Civil Engineering, University of Toronto, dated June 2005
- Structural Engineering Report No. 270, Slip Critical Bolted Connections – A Reliability Analysis for Design at the Ultimate Limit State, Department of Civil and Environmental Engineering, University of Alberta, dated October 2007
- Drawing No. 24590-WTP-PH-50-00012001, Standard Pipe Support Details Guide – U Bolts GU, Rev. 7

- Drawing No. 24590-WTP-PH-50-00012002, Standard Pipe Support Details Guide – U Strap GU, Rev. 6
- Drawing No. 24590-WTP-PH-50-00012004, Standard Pipe Support Details Guide – U Bolt and U Strap GU, Rev. 0
- Drawing No. 24590-WTP-PH-50-00003001, Standard Pipe Support Details Cantilever CC, Rev. 4