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5750
Ser N4/0522
June 1, 2018

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Ms. Roxanne Kwan
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Dear Mr. Shalev and Ms. Kwan:

**SUBJECT: ADMINISTRATIVE ORDER ON CONSENT (AOC) STATEMENT OF WORK (SOW) SECTION 5
CORROSION AND METAL FATIGUE PRACTICES, DESTRUCTIVE TESTING PLAN, RED HILL
BULK FUEL STORAGE FACILITY (RED HILL), JOINT BASE PEARL HARBOR-HICKAM,
OAHU, HAWAII**

In accordance with AOC/SOW section 5.3, Destructive Testing, the purpose of the work performed and deliverables to be developed are to verify the findings of the Corrosion and Metal Fatigue Practices Report through the use of destructive testing at the Facility.

The Navy and DLA submitted the Destructive Testing Scope of Work on 30 May 2017, detailing planned destructive testing to be conducted on at least one (1) tank at the facility. This scope of work was conditionally approved by the Regulatory Agencies on 7 July 2017. Condition 1 was revised on 10 August 2017.

Pursuant to the Regulating Agency's conditional approval of the Destructive Testing Scope of Work, AOC/SOW Section 5.3.2, the attached document serves as the Destructive Testing Plan.

If you have any questions, please contact Mark Manfredi, our Red Hill Program Director, at (808) 473-4148, or at mark.manfredi@navy.mil.

Sincerely,

R. D. HAYES, III
Captain, CEC, U.S. Navy
Regional Engineer
By direction of the
Commander

5750
Ser N4/0522
June 1, 2018

Enclosure: 1. Red Hill Bulk Fuel Storage Facility Scope of Work for Destructive Testing Supplement Destructive Testing Plan. Supplement to Administrative Order on Consent (AOC) and Statement of Work (SOW) Section 5.3.2. 1 June 2018



RED HILL BULK FUEL STORAGE FACILITY

SCOPE OF WORK FOR DESTRUCTIVE TESTING SUPPLEMENT

DESTRUCTIVE TESTING PLAN

**Supplement to Administrative Order on Consent (AOC) and
Statement of Work (SOW) Section 5.3.2**

1 June 2018

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DESTRUCTIVE TESTING PLAN

1.0 BACKGROUND

On December 9, 2013, the Navy placed Tank No. 5 at the Red Hill Bulk Fuel Storage Facility back into service after it had undergone routine scheduled maintenance. The maintenance work consisted of cleaning, inspecting, repairing the tank, and certifying, by an API inspector, that it was suitable for service. Upon placing Tank No. 5 back into service, the Navy commenced filling the tank with JP-8 fuel. On January 13, 2014, Navy discovered a loss of fuel from Tank No. 5, immediately notified the State of Hawaii Department of Health (DOH) and the United States Environmental Protection Agency (EPA), and defueled the tank.

In response to the fuel release reported by the Navy, the Navy and the Defense Logistics Agency (DLA) entered into an [Administrative Order on Consent \(AOC\)](#) with the EPA and the DOH to provide for the management and oversight of a release assessment, response(s) to release(s), and actions to minimize the threat of future releases in connection with the field-constructed bulk fuel underground storage tanks (USTs), at the Red Hill Bulk Fuel Storage Facility located near Pearl Harbor, on the island of Oahu in the State of Hawaii.

2.0 PURPOSE AND SCOPE

As identified in Red Hill Bulk Fuel Storage Facility Scope Of Work For Destructive Testing (AOC Statement of Work (SOW) Section 5.3.2), the purpose of the work performed and deliverables to be developed are to verify the findings of the [Corrosion and Metal Fatigue Practices Report](#) through the use of destructive testing on at least one tank at the Facility. Pursuant to the Regulating Agency's conditional approval of the Destructive Testing Scope of Work, AOC/SOW Section 5.3.2, this document serves as the Destructive Testing Plan.

2.1 AOC-SOW Requirement

The Navy and DLA submitted the Destructive Testing Scope of Work on 30 May 2017, detailing planned destructive testing to be conducted on at least one (1) tank at the facility. This scope of work was conditionally approved by the Regulatory Agencies on 7 July 2017. Condition 1 was revised on 10 August 2017.

In accordance with the AOC, within twenty-four (24) months from the Regulatory Agencies' approval of the Destructive Testing Scope of Work, Navy and DLA shall submit the Destructive Testing Results Report to the Regulatory Agencies for approval. Following the Regulatory Agency's conditional approval on 30 May 2017, the Destructive Testing Results Report is due 30 May 2019. All destructive testing work under this section should be

completed within twenty (20) months of the approval of the Destructive Testing Scope of Work to allow ample time for preparation of the final report.

2.2 Goals and Desired Outcomes

The goals and desired outcomes of this section are to:

- a. Validate the results of Non-destructive examination (NDE) inspection technologies, specifically the NDE process used at Red Hill.
- b. Characterize the metallurgy of the steel material used in the tank liner.
- c. Record observations/chemical characteristics of the concrete behind the liner.
- d. Analyze corrosion rate calculation procedures and recommend improvements as warranted.
- e. Evaluate results and compare them with current corrosion mitigation practices and recommendations for modifications/improvements to [tank inspection, repair, and maintenance \(TIRM\) procedures](#) and [tank upgrade alternatives \(TUA\)](#).

3.0 DESTRUCTIVE TESTING DISCUSSION

NDE includes a variety of industry methods used to evaluate the condition of fuel storage tanks and pipelines. Technologies are used to scan plate steel and welds for indications as well as to quantify the size of indications and amount of metal loss. The intent of this section is to validate the results of NDE technologies and processes used to scan the Red Hill storage tanks.

3.1 Coupons for Testing for NDE Evaluation

The NDE results will be analyzed and validated by documenting expected results determined from the NDE inspection and directly comparing them to actual observations and measurements made from selected coupons.

- a. The Navy provided EPA and DOH a spreadsheet documenting the scan results from the clean, inspect and repair contract for Red Hill tank 14. These scan results provide the basis for coupon selection. The final EPA/DOH approved coupon selection locations are provided in Table 1.
- b. The expected condition of the backside of the coupons are documented using a sketch showing all indications identified in the Tank 14 NDE data

spreadsheet. The sketches also indicate if there are areas of general corrosion (between 20 -50 mils) expected. Any other pertinent information is added as a note on each sketch. The sketches documenting expected results for each coupon location are provided in **Appendix B**.

- c. The specified repair for the indications at the coupon locations as stated in the spreadsheet is shown on the sketches. (Note: This is the repair that would be performed if the coupons were not being cut out.) Although, this is not the NDE Contractor's final report, the specified repairs at these selected coupon locations are not anticipated to change.

After on-site observations and third-party laboratory testing is completed, NAVFAC EXWC will then compare the expected outcomes (sketches and notes) identified in this document with the photographs and on-site observations made by NAVFAC EXWC and the third-party laboratory's actual pit-depth and metal loss measurements. These results will be presented in a subsequent meeting with Navy, Regulators and SMEs to determine if the NDE process is validated.

3.1.1 Screening Criteria

Current [TIRM](#) procedures will be validated using the screening criteria described below. Accuracy of detecting defects below the established screening criteria is less of a concern, as they are not expected to cause integrity issues before the next tank inspection based upon current, conservative corrosion rate calculation methodology.

- Pitting. Analyze scans for indications of back side pitting with remaining thickness in the range of 160 mils and 100 mils. Current [TIRM](#) procedures indicate actionable items for remaining thickness less than 160 mils. Accordingly, 160 mils thickness is selected as the upper limit. The lower limit of 100 mils represents the minimum thickness for tank integrity per API 653. Based on current corrosion rate calculations (subject to change) 160 mils is the conservative minimum thickness required to ensure thickness will be at least 100 mils at the next inspection.
- Thinning. Analyze scans for indications of back side thinning with remaining thickness in the range of 160 mils and 100 mils. Current [TIRM](#) procedures indicate actionable items for remaining thickness less than 160 mils. Accordingly, 160 mils thickness is selected as the upper limit. The lower limit of 100 mils represents the minimum thickness for tank integrity per API 653. Based on current corrosion rate calculations (subject to change) 160 mils is the conservative minimum thickness required to ensure thickness will be at least 100 mils at the next inspection.

In addition to this qualitative validation of the expectations based on the NDE data a quantitative validation will be performed based on the following criteria:

- Backside Pitting. Prove-up measurement (pit depth) within 20 mils of actual laboratory results.
- Wall Thinning. Prove-up measurement within 5% of actual laboratory results.
- Welds. (If any identified) Detecting a surface-breaking crack with minimum width dimension of 0.025 inch.

3.2 Coupon Locations

Selection of coupon locations was based on scanning data from LFET, PAUT and BFET inspections of the tank. Target areas based on reported reductions in wall thickness, pitting, and weld defects were chosen to provide a representative sampling.

3.3 Coupon Size

Due to the destructive nature of this effort and practical aspects of coupon handling, the Navy limited the size of the coupons to 12 inches by 12 inches.

3.4 Quantity of Coupons

Due to the huge surface area presented by the steel tank liner, acquiring sufficient number of samples for worthwhile statistical analysis of a particular tank's status and behavior with respect to corrosion would be an inordinate task. Therefore coupons were selected strategically to characterize the tank and the various NDE findings. With input from Regulators and SMEs, coupons with isolated pitting, general corrosion, pitting with general corrosion, and no identified corrosion were selected. Comparison of these anticipated results from the NDE testing with the destructive test results will provide validation of the NDE process.

Removal of 10 coupons is planned. The size of the coupons are 12 inches by 12 inches and were selected to include, as much as practicable, multiple indications of backside thinning, back side pitting, and other actionable flaws. The intent is to obtain sufficient data points for the NDE validation, while minimizing the number of coupons cut out of the operational tank. In addition coupons were selected to include areas of where no defect was indicated. After noting initial observations, NAVFAC EXWC will ship the coupons to a third-party laboratory for material analysis, and surface characterization.

3.5 Coupon Selection Process

Coupon locations were obtained as follows:

- After the LFET and BFET inspections, the contractor, under Navy direction, conducted prove-up and inspection as necessary per normal tank inspection procedures.
- The Navy reviewed the Inspection Results and determined proposed coupon locations in accordance with the screening criteria listed in paragraph 3.1.1.
- The Navy presented complete scan data spreadsheet for tank 14 as well Navy proposed coupon locations along with rationale for selection to the regulators for review and comment.
- Based on EPA/DOH approved coupon locations the Navy will direct the tank inspection contractor where to cut out coupons. Table 1 shows the approved coupon locations.
- A Navy representative will perform on-site testing, record observations, and ensure coupons will be preserved in accordance with ASTM E1188 when sending for third-party laboratory analysis.
- NAVFAC EXWC will review the lab results to ensure they are acceptable in accordance with the requirements of the contract. Third-party laboratory analysis results will be provided to regulators for review.

Table 1 Tank 14 Coupon Locations

| # | Row in Master Table | Overall ID | CTR Repair No. | Region | Course | Plate | Ind ID | X-Coord | Y-Coord | Ind Type | Screening Measurement (in) | Prove-up Measurement (in) | Agreed Upon or Alternate? |
|----|---------------------|--------------------|---------------------|--------|--------|-------|--------|---------|---------|----------|----------------------------|---------------------------|---------------------------|
| 1 | 2282 | 14-UD-A-42-45-107 | 14-UD-A-42-45-107-3 | UD | A | 42 | 8 | 45 | 107 | BC | 0.147 | 0.112 | Agreed Upon |
| 2 | 2892 | 14-ER-E3-12-33-40 | 14-ER-E3-12-34-44-5 | ER | E3 | 12 | 7 | 33 | 40 | BC | 0.157 | 0.150 | Agreed Upon |
| 3 | 2903 | 14-ER-E3-13-9-18 | 14-ER-E3-13-7-5-2 | ER | E3 | 13 | 3 | 0-18 | 18 | BC | 0.033 | * | Agreed Upon |
| 4 | 2959 | 14-ER-E2-3-32-232 | 14-ER-E2-3-32-232-5 | ER | E2 | 3 | 7 | 32 | 232 | BC | 0.110 | * | Agreed Upon |
| 5 | 3706 | 14-BA-26-15-15-8 | 14-BA-26-15-28-3-1 | BA | 26 | 15 | 2 | 27 | 8 | BC | 0.047 | * | Agreed Upon |
| 6 | N/A | N/A | N/A | BA | 24 | 8 | N/A | N/A | N/A | N/A | N/A | * | Agreed Upon |
| 7 | 3944 | 14-BA-23-7-38-49 | 14-BA-23-7-32-36-1 | BA | 23 | 7 | 3 | 38 | 49 | BC | 0.157 | 0.135 | Alternate |
| 8 | 4300 | 14-BA-20-13-236-43 | (NR) | BA | 20 | 13 | 4 | 236 | 43 | BC | 0.069 | 0.200 | Agreed Upon |
| 9 | 4625 | 14-BA-17-13-4-41 | 14-BA-17-13-4-41-1 | BA | 17 | 13 | 1 | 4 | 41 | BC | 0.037 | * | Alternate |
| 10 | 6492 | 14-LD-3-9-24-215 | (NR) | LD | 3 | 9 | 1 | 24 | 215 | BC | 0.198 | 0.200 | Agreed Upon |
| A1 | 3962 | 14-BA-23-9-95-50 | 14-BA-23-9-94-53-2 | BA | 23 | 9 | 6 | 87-103 | 45-55 | BC | 0.134 | * | Agreed Upon |
| A2 | 5176 | 14-BA-11-4-226-50 | (NR) | BA | 11 | 4 | 2 | 226 | 50 | BC | 0.161 | * | Agreed Upon |
| A3 | N/A | N/A | N/A | BA | 3 | 3 | N/A | N/A | N/A | N/A | N/A | * | Alternate |

* Not recorded

3.6 Summary of Coupon Quantity, Size and Decision Process

The following bullets summarize the coupon sampling process. **Figure 1** is a flow chart of the selection process.

- The Contractor conducts NDE (3rd quarter calendar year (CY) 2017). The regulators are provided the examinations results for review.
- NAVFAC EXWC analyzes the data and selects proposed coupon sites (seek feedback from Regulators).
- The contractor will obtain the coupons. The Government will then conduct the visual examinations and on-site testing.
- The coupons will be packed and shipped per ASTM E 1188.
- The certified third-party laboratory will conduct the testing.
- A determination will be made by the Navy if additional coupons and any additional actions are necessary based upon NDE evaluation.

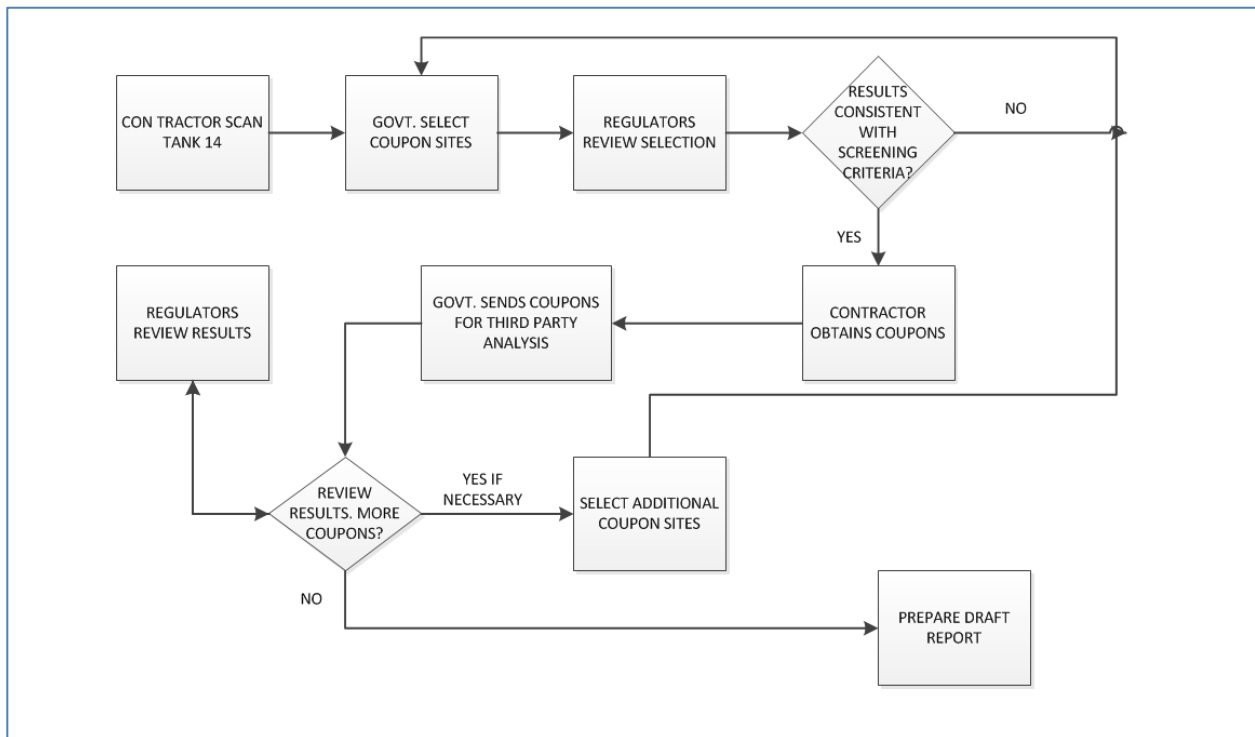


Figure 1 Coupon selection process flowchart

Subsequent to the work in this Section 5.3 of the AOC- SOW, Section 5.4 of the AOC- SOW will provide opportunity to discuss possible modifications to TIRM procedures.

4.0 ON-SITE AND LABORATORY TEST PROCEDURES

4.1 On-Site Investigations by Government (NAVFAC EXWC)

Figure 2 illustrates the coupon removal and on-site testing process.

4.1.1 Coupon Removal

Prior to cutting the coupon from the tank liner, the Tank inspector of record (IOR) will verify the coupon site and cut markings to ensure they match that listed in Table 1. NAVFAC EXWC will label the coupon with a permanent marker on the interior surface. Orientation of the coupon shall be marked on the interior surface with an arrow pointing in the vertical direction. Coupons will be cut from Tank 14 using a cutting process with a rotary metal-cutting blade to minimize heat generation. The contractor will ensure that coupon orientation is maintained while handing cut coupon to the NAVFAC EXWC on-site.

4.1.2 Labeling and Packaging and Storage of Coupons to Ensure Preservation of Coupons

- a. Upon receipt of coupon from contractor, NAVFAC EXWC will ensure previous coupon labeling is not smeared/altered/damaged and correct as necessary with the permanent marker on the interior surface. This specimen information and any other notes will be entered into an official log book. Coupon collection, labeling and storage will follow ASTM E1188 – 11 “Standard Practice for Collection and Preservation of Information and Physical Items by a Technical Investigator”
- b. Initial visual inspections will be conducted (See Table 2) and the specimen will be photographed on both exterior and interior sides. Photographs will be of sufficient resolution to preserve the essential aspects of the appearance of the coupons and also be capable of producing images that can be reproduced and enlarged. The date, time, and location of the photography and the identity of the photographer will be documented. Preliminary comparison with the NDE expected outcome sketches and the actual observed condition of the coupons will be noted on the sketches.
- c. Specimens will then be placed in labeled specimen bag and transported down to staging area where NAVFAC EXWC will carefully wrap specimen in 6 Mil, clear polyethylene sheeting. The sheeting will also be labeled with permanent marking

pen to indicate coupon number. Coupon will be placed in shipping container and transported to storage location where viewing by regulators and stakeholders will occur. The coupons will not be touched and/or handled by any person, other than the construction contractor and the NAVFAC EXWC project engineer in order to keep the ASTM E1188-11 protocol requirements.

- d. Coupon removal is scheduled for the week of 18 June 2018. Viewing by regulators and stakeholders is scheduled for 25 June 2018.
- e. After viewing is concluded, specimens will be returned to shipping containers, packed appropriately so that specimens and any associated corrosion products are completely preserved and shipped to the third-party laboratory for analysis.
- f. Chain of custody of the coupons will be identified and maintained in the official log book. In the official log book the following information for each coupon will be annotated and maintained:
 - Initial Collection Information
 - Coupon identification label.
 - Location where coupon was cut out.
 - Date and time the coupon was obtained.
 - Name and affiliation of the individual who initially cut the coupon from the tank.
 - Name and affiliation of the NAVFAC EXWC individual who received coupon from contractor cutting the coupon.
 - Subsequent Custody Transfer Information
 - Name and affiliation of each subsequent custodian along with the date of transfer.
 - Modification or repackaging of items by each custodian.
 - Configuration and condition when transferred to the new custodian.
 - The coupons and documentation are to remain unchanged to the fullest extent possible.

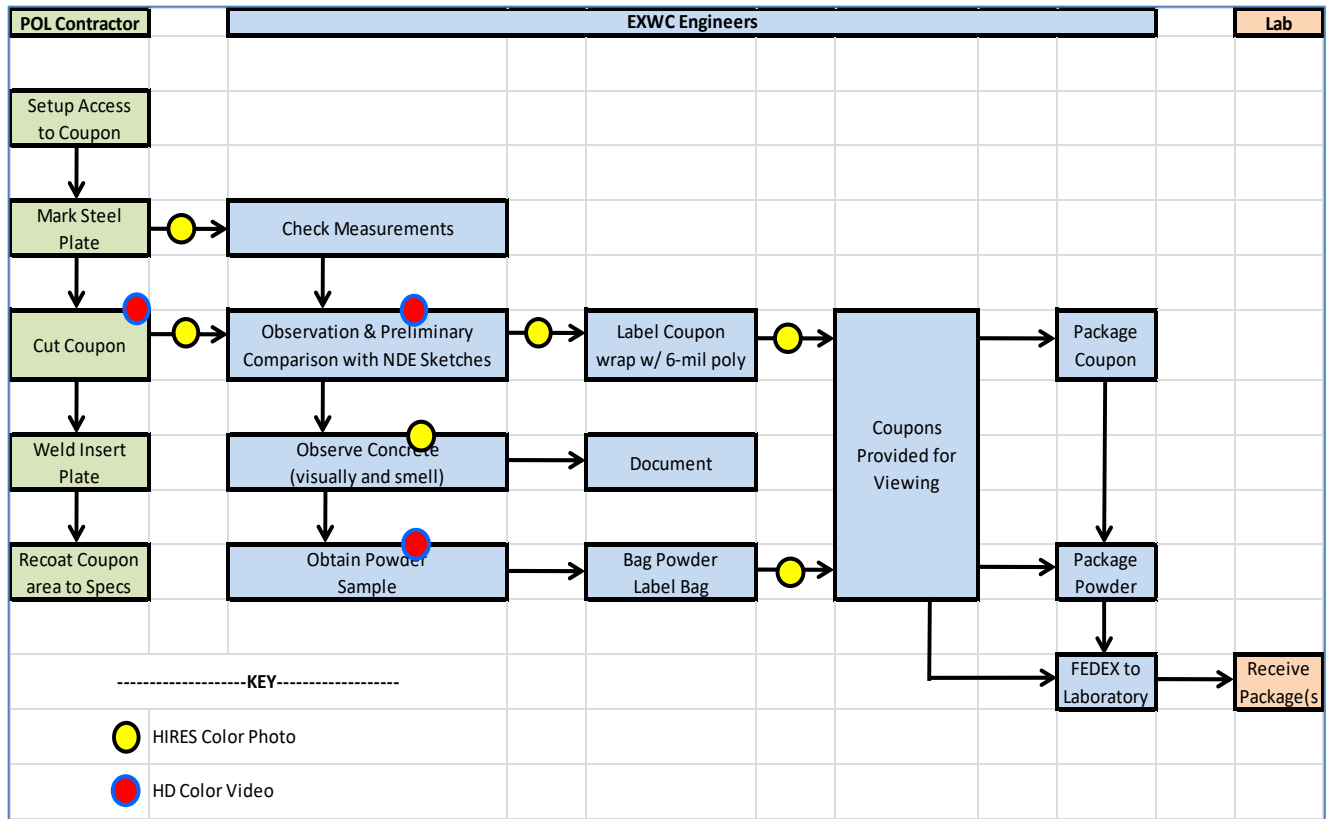


Figure 2 On-site coupon removal and testing procedures flow chart

4.1.3 Characterization of the Steel Coupons

Table 2 is the field inspection data sheet that provides guidelines for the tests and observations that will be conducted for the steel coupon.

Table 2. On-Site Characterization of Steel Coupon

| COUPON SPECIFICS | | |
|---|--------------|----------|
| Coupon ID # | | |
| Coupon Location | | |
| Coupon Dimensions | | |
| Coupon Thickness | | |
| Locations of Welds (If Any) | | |
| ON-SITE VISUAL EXAMINATION | | |
| Checks | Observations | |
| | Exterior | Interior |
| Deposits, Coatings, Debris | | |
| Scale | | |
| Observed biological Materials | | |
| Wet or Dry | | |
| Smell | | |
| Presence of petroleum product between steel and concrete surface, and on or above the leg of the angle backer bar embedded in the concrete. | | |
| Provide a sketch of the coupon showing all indications. Provide ID#s for all indications on coupon and compare with NDE expected results sketch | | |
| Presence of corrosion | | |
| Isolated pitting | | |
| Isolated pitting within areas of general corrosion | | |
| Linked pitting within areas of general corrosion | | |
| Identify color of corrosion products | | |
| Identify if selective attack at welds | | |
| Provide photo documentation with a minimum resolution of 2560 x 1920 of the coupon, front and back | | |

4.1.4 Exterior Concrete Containment

Conduct the following procedures for evaluating the concrete containment immediately upon removal of each coupon.

- Note the visual condition of the concrete.
- **Table 3** is the field inspection data sheet that provides guidelines for the tests and observations that may be conducted for the concrete.

- Photograph concrete using a high-resolution camera at a minimum resolution of 2560 x 1920.
- Observe/measure the void space between the concrete and the liner in the area surrounding the coupon site.
- Measure the temperature at the concrete/liner interface. Note the presence of moisture.
- Measure pH of exposed concrete. Follow NACE SP0308-2008 "Inspection Methods for Corrosion Evaluation of Conventionally Reinforced Concrete Structures."
- Measure carbonation with a phenolphthalein indicator solution (From colorless to purple-red over a pH range from 8-10). Follow NACE SP0308-2008 "Inspection Methods for Corrosion Evaluation of Conventionally Reinforced Concrete Structures."
- Measure the structure-to-electrolyte potential of the steel liner-to-concrete/exposed medium at several locations around the circumference of the coupon site. Reference electrode will be saturated copper-copper sulfate electrode.
- Measure concrete bulk resistivity (or conductivity), pH, and observe condition at the liner/concrete interface. Procedures outlined in NACE SP0308-2008 "Inspection Methods for Corrosion Evaluation of Conventionally Reinforced Concrete Structures" will be followed.
- Note presence of contaminants at the coupon site, chlorides, sulfates/sulfides, biological materials. Note presence of hydrocarbons.

After the initial inspection, a small hand drill equipped with a ¼" masonry bit will be used to collect powder samples of the concrete. Powder samples will be collected from each coupon location. Obtain approximately 30 mL (2 tablespoons) of powder per coupon site. The samples will be collected to a depth no greater than one inch. The presence of residual corrosion products in the concrete powder specimens will be noted. Powder samples will be bagged, and each bag will be labeled such that it can be associated with their respective location. The powder samples will be included with the coupons where chain of custody procedures specified in Section 4.1.2 will be followed.

Table 3. On-site Visual Inspection and Testing of Concrete

| CONCRETE SAMPLE SPECIFICS | | |
|---|--------------|----------|
| Sample ID # | | |
| Sample Location | | |
| Sample Dimensions | | |
| ON-SITE TESTS/VISUAL EXAMINATION | | |
| Checks | Observations | |
| | Exterior | Interior |
| Void space between concrete and liner (if any) | | |
| Biological Materials | | |
| Wet or Dry | | |
| Smell | | |
| Temperature | | |
| Surface pH | | |
| General condition | | |
| Provide a minimum resolution of 2560 x 1920 photo of the concrete | | |

4.2 Third-Party Laboratory Analysis

Laboratory testing on ten (10) steel coupons, each no larger than 12” by 12”, will include:

- a. Photographing, at a minimum resolution of 2560 x 1920, all sides of the metal specimen:
 - Before specimen is cleaned and before any rust is removed.
 - After specimen has been cleaned.
 - Before specimen undergoes any lab testing.
 - After specimen has undergone all lab testing.
 - Provide full resolution images in electronic format on digital versatile disc.
- b. Performing metallurgical and chemical analysis of the coupons. Determine the physical and mechanical characteristics of the liner steel and weldments.
 - Conduct chemical analysis of general-corrosion products on each coupon’s back surface, on at least three points on each coupon (or, if fewer than three

general-corrosion points exist on a coupon, then all of them), using scanning electron microscopy (SEM) with energy dispersive X-ray analysis (EDXA). Lab may cut out, as necessary, portions of each coupon provided by NAVFAC EXWC so those portions fit inside SEM or EDXA equipment.

- Conduct chemical analysis of substrate inside pit areas using EDXA.
 - Conduct chemical analysis of any coatings to determine coating type.
 - Perform complete elemental analysis of the steel to determine AISI steel type.
 - Conduct microscopic examination of surfaces, before and after cleaning. Examination and analysis of metallographic sections, determine microstructure.
 - Conduct hardness measurements, bulk and cross-sectional.
 - Conduct tensile testing to establish yield strength, ultimate tensile strength, and ductility, cutting out portions of each coupon provided by NAVFAC EXWC so those portions can undergo tensile testing. Testing will be in accordance with ASTM E8 Standard Test Methods for Tension Testing of Metallic Materials.
 - Evaluate results for validation of conformance with any material specification(s).
- c. Measuring coupon wall thickness at the three largest pits on each coupon, or, if there are fewer than three pits on a coupon, then all pits on that coupon.
- d. Measuring all pit depths using appropriate procedures outlined in ASTM G46 “Standard Guide for Examination and Evaluation of Pitting Corrosion”. Pit depth will be measured using a microscopical technique depending on the pit geometry.
- e. Performing surface characterization of the exterior and interior surfaces of the steel coupon using three-dimensional profilometry after the coupon is cleaned.
- f. Performing chemical analysis (including pH) of concrete powder samples taken.
- g. Determining chloride and sulfate content of concrete powder samples using ion chromatography.
- h. Analyzing coupons quantitatively to validate NDE process for detecting areas

without indications of:

- Back-side thinning or pitting. (For this effort, a remaining thickness under 160 mils is considered an indication of back-side thinning or pitting.) Pit depths shall be ascertained through microscopy.
- Non-full-penetration welds, welding discontinuities, and welding defects, including corrosion on welds.

4.3 Comparison of Expected Outcomes from NDE with Laboratory Results

After the third-party laboratory submits their final report, NAVFAC EXWC will then compare the expected outcomes identified in this document with the third-party laboratory's actual pit-depth and metal loss measurements. These results will be discussed in a Technical Meeting with Navy, Regulators and SMEs to determine if the NDE process is validated.

4.3.1 NDE Validation Meets Criteria

If the validation meets the accepted criteria, then the Navy will produce the Destructive Testing Results Report with no further action required.

4.3.2 NDE Validation Does Not Meet Criteria

If the NDE validation criteria are not met, possible causes will be evaluated with input from regulators and SMEs. Requirements for additional testing and the path forward will be evaluated. Possible actions could include obtaining additional coupons from representative plate material. The Destructive Testing Results Report will document any further actions as deemed necessary.

5.0 REPAIR OF COUPON SITES

Coupon sites will be repaired in accordance with current [TIRM](#) procedures and as designed by the engineer of record. Repair procedures include:

- a. Minimize time between removing a coupon and repairing the hole.
- b. Repair in accordance with an approved procedures and details. Mark each weld with the identification symbol of the individual welding personnel.
- c. Accurately match repair plate to the tank shell and retain in position with erection tabs during welding operation. Tack welding shall not remain in finished joints.
- d. Inspect to ensure proper fit-up. Misalignment shall not exceed API Std 650 tolerance for misalignment in joints.

- e. Repair with an insert plate covered with a fillet welded plate.
- f. Weld in accordance with an approved procedure.
- g. Inspect each pass of welds in accordance with approved procedure. Perform MT on all root passes, and MT and VBT on the final pass of the insert plate welds and the cover plate fillet welds.
- h. Inspect each repair by the API inspector of record.
- i. Prepare surfaces and coat patch plate and disturbed areas in accordance with Unified Facilities Guide Specification (UFGS) Section 09 97 13.15 - Low VOC Polysulfide Interior Coating of Welded Steel Petroleum Fuel Tanks. Overlap new coating two inches into existing.
- j. Provide coating inspector qualified to SSPC QP 5 Level III and employed by the SSPC QP 5-certified coating inspection company. Inspect coating repairs.

6.0 IMPLEMENTATION PLAN

6.1 Method of Accomplishment

The destructive testing work under this section will be conducted as summarized in **Table 4**.

Table 4. Red Hill Tank Destructive Testing Work Performance Summary

| Destructive Testing Process | Work Performance | Quality Assurance |
|---|---|--|
| NDE | Tank inspection/repair contractor | NAVFAC EXWC |
| Data Analysis and Coupon Site Selection | NAVFAC EXWC | Regulator/SME review |
| Obtaining Coupons | Tank inspection/repair contractor | NAVFAC EXWC. Possible observation by Regulators |
| On-site Examination and Testing at Coupon Site | NAVFAC EXWC | NAVFAC EXWC SMEs. Possible observation by Regulators |
| Coupon Packing/ Preservation for Lab Analysis | Tank inspection/repair contractor and NAVFAC EXWC | NAVFAC EXWC. Possible observation by Regulators |
| Analysis of Coupons and concrete powder samples | Third-party laboratory | NAVFAC EXWC. Regulator/SME review |

6.2 Proposed Schedule

A summary of the planned schedule is provided in Figure 3 below.

| MAJOR MILESTONES | CY17 | | | | | | CY18 | | | | | | | | | | | |
|---|------|---|---|---|---|---|------|---|---|---|---|---|---|---|---|---|---|---|
| | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O | N | D |
| Tank 14 | | | | | | | | | | | | | | | | | | |
| Perform NDE (Contractor) | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | |
| Process/Analyze Data (Contractor/EXWC) | | | | | | | ■ | ■ | ■ | | | | | | | | | |
| Obtain Coupons (EXWC/Contractor) | | | | | | | | | | | | ■ | | | | | | |
| Conduct Lab Testing (Third Party) | | | | | | | | | | | | ■ | ■ | ■ | | | | |
| Prepare Preliminary Lab Reports (Third Party) | | | | | | | | | | | | ■ | ■ | | | | | |
| Review, Approve Prelim Lab Reports (EXWC/Regulators) | | | | | | | | | | | | | ■ | ■ | ■ | | | |
| Finalize Lab Reports (Third Party) | | | | | | | | | | | | | ■ | ■ | | | | |
| Organize Data for Report (EXWC) | | | | | | | | | | | | | | ■ | ■ | ■ | | |
| DT Results Report | | | | | | | | | | | | | | | | | | |
| Prepare Preliminary DT Results Report (EXWC) | | | | | | | | | | | | | ■ | ■ | ■ | ■ | | |
| Review, Approve Prelim DT Results Report (Regulators) | | | | | | | | | | | | | | | | ■ | ■ | |
| Prepare Final DT Results Report (EXWC)* | | | | | | | | | | | | | | | | | ■ | ■ |

*Per AOC final DT report is due August 2019

Figure 3 Project Schedule

7.0 REPORT CONTENT

The Destructive Testing Results Report will provide detailed discussions of the destructive testing examination effort including discussions of test processes and rationale, tabulation of test data, identification of appropriate reference criteria or standards, and narrative explanation of the results including:

- a. Correlation of destructive testing data/observation with NDE test data.
- b. Records of on-site visual examinations and tests.
- c. Analysis of corrosion rate calculation procedures and recommendations for improvement.
- d. Evaluation of results against current corrosion mitigation practices and recommendations for modifications/improvements to TIRM procedures and tank upgrade alternatives.
- e. Recommendations for additional destructive testing and additional actions as described in paragraph 4.3.2.

Upon approval of the report the Navy and Regulators will proceed into scoping meetings as necessary in accordance with AOC-SOW Section 5.4 to address any needs for further evaluation, development, or implementation of practices to control corrosion or metal

fatigue.

APPENDIX A
GLOSSARY

ACRONYMS

| | |
|-------------|--|
| AOC | Administrative Order on Consent |
| ASNT | American Society for Nondestructive Testing |
| ASTM | American Society for Testing and Materials |
| BFET | Balanced Field Electromagnetic Technique |
| CY | Calendar Year |
| DE | Destructive Examination |
| DLA | Defense Logistics Agency |
| DoD | Department of Defense |
| DOH | (State of Hawaii) Department of Health |
| EPA | Environmental Protection Agency |
| IOR | Inspector of Record |
| LFET | Low Frequency Electromagnetic Technique |
| MT | Magnetic Particle Testing |
| NACE | National Association of Corrosion Engineers |
| NAVFAC | Naval Facilities Engineering Command (NAVFACENGCOM) |
| NAVFAC EXWC | NAVFAC Engineering and Expeditionary Warfare Center |
| NDE | Non Destructive Evaluation |
| PAUT | Phased Array Ultrasonic Testing |
| pH | The negative logarithm of the hydrogen ion concentration |
| SOW | Statement of Work |
| SWUT | Shear Wave Ultrasonic Testing |
| TIRM | Tank Inspection, Repair and Maintenance |
| TUA | Tank Upgrade Alternatives |
| UFGS | Unified Facilities Guide Specification |
| UST | Underground Storage Tank |

UT

Ultrasonic Testing

VBT

Vacuum Box Leak Testing

DEFINITION OF TERMS

Coating: A dielectric material applied to a structure to separate it from its environment.¹

Conductivity: The measurement of a material's ability to conduct electrical current.

Corrosion: The deterioration of a material or its properties due to a reaction of that material with its chemical environment.

Corrosion rate: The rate at which corrosion proceeds.¹

Defect: Flaw whose characteristics or properties do not meet acceptance criteria and is rejectable.

Electrode: A conductor used to establish electrical contact with an electrolyte and through which current is transferred to or from an electrolyte.¹

Electrolyte: A chemical substance or mixture containing ions that migrate in an electric field. Examples are soil and seawater.

Evaluation: Determination whether a relevant indication is cause to accept or reject (the repair).

Flaw: Imperfection or discontinuity detectable by nondestructive testing; not necessarily rejectable.

Galvanic cell: A corrosion cell in which anode and cathode are dissimilar conductors, producing corrosion because of their innate difference in potential.

Galvanic corrosion: Corrosion resulting from the coupling of dissimilar metals in an electrolyte.

Holiday: A discontinuity in a coating that exposes the metal surface to the environment.

Imperfection: Departure of a quality characteristic from its intended condition.

Indication: Results of a non-destructive examination.

Interpretation: Determination whether an indication is relevant, non-relevant, or false.

Optical Emission Spectroscopy: An analytical technique used to determine the elemental composition of a broad range of metals. An OES analyzer works by

emitting an electric arc onto a sample, whose atoms transmit an elemental signature of light to the analyzer. The analyzer then processes the incoming light signals to determine the elemental composition of the sample.

pH: A measure of hydrogen ion activity defined by: $\text{pH} = \log_{10} (1/a\text{H}^+)$ where $a\text{H}^+$ = hydrogen ion activity = molal concentration of hydrogen ions multiplied by the mean ion activity coefficient (= 1 for simplified calculations).

Pitting: Localized corrosion of a metal surface that is confined to a small area and takes the form of cavities called pits.

Relevant Indication: An NDT indication that requires evaluation.

Resistivity: The measurement of a material's ability to oppose the flow of electric current.

Rust: A reddish-brown corrosion product of iron that is primarily hydrated iron oxide.

Safe Shell Access: Compliance with the ventilation, degassing, confined space, and other safety requirements when entering fuel storage tanks. Refer to the TIRM Report

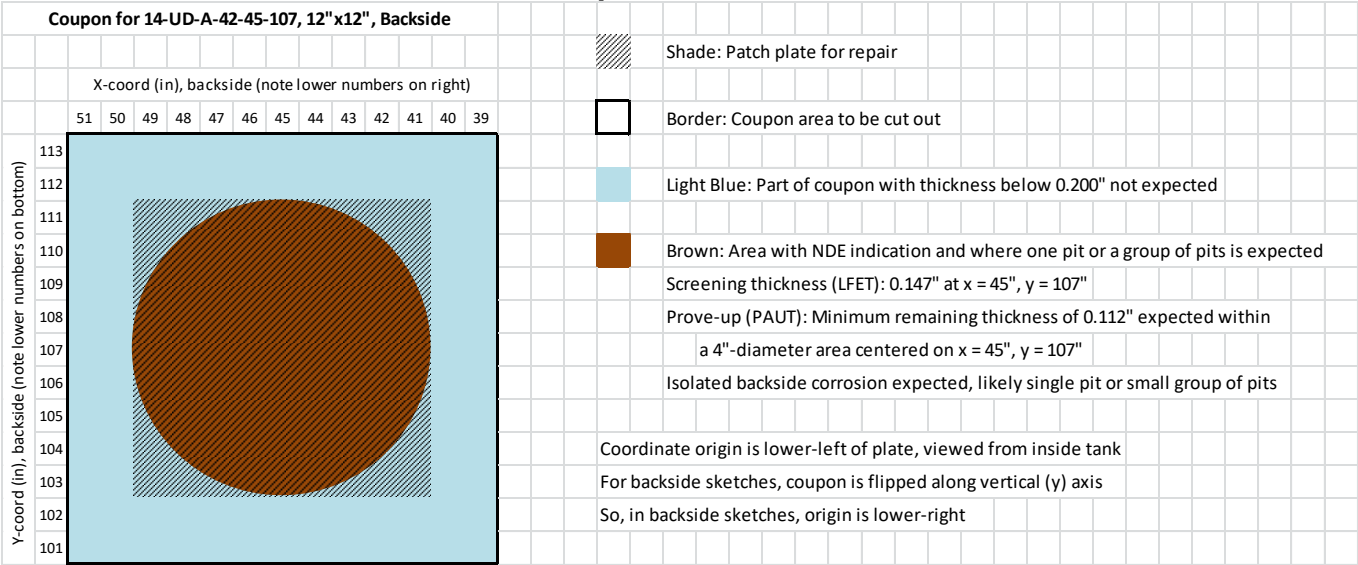
Structure-to-electrolyte potential (also structure-to-soil potential): The potential difference between a buried metallic structure surface and electrolyte that is measured with reference to an electrode in contact with the electrolyte. See also pipe-to-soil potential.

(Wall) Thinning (Uniform corrosion): Corrosion attack of a metal that is essentially the same at all exposed areas of its surface.

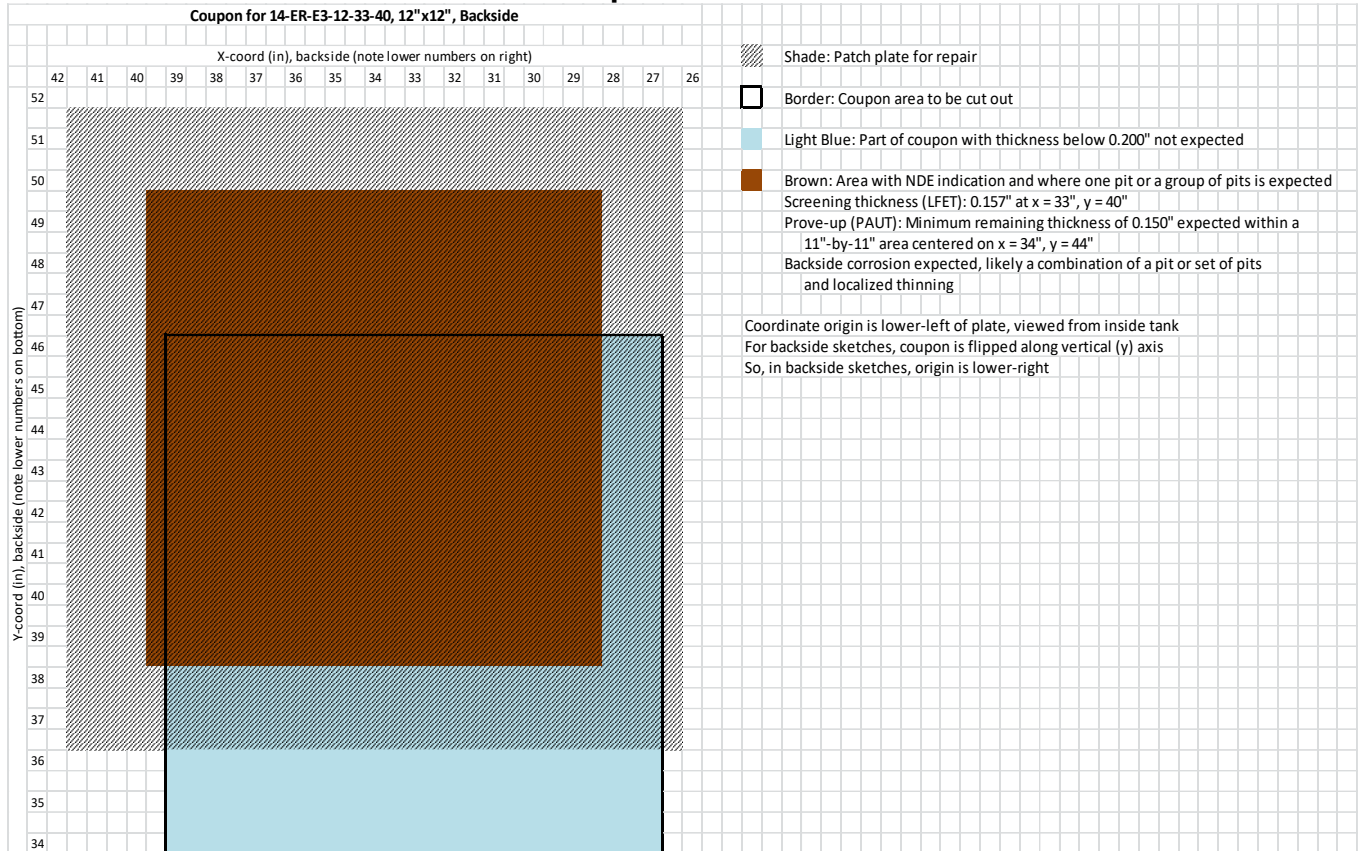
APPENDIX B

NDE Expected Outcome Sketches

Coupon 1

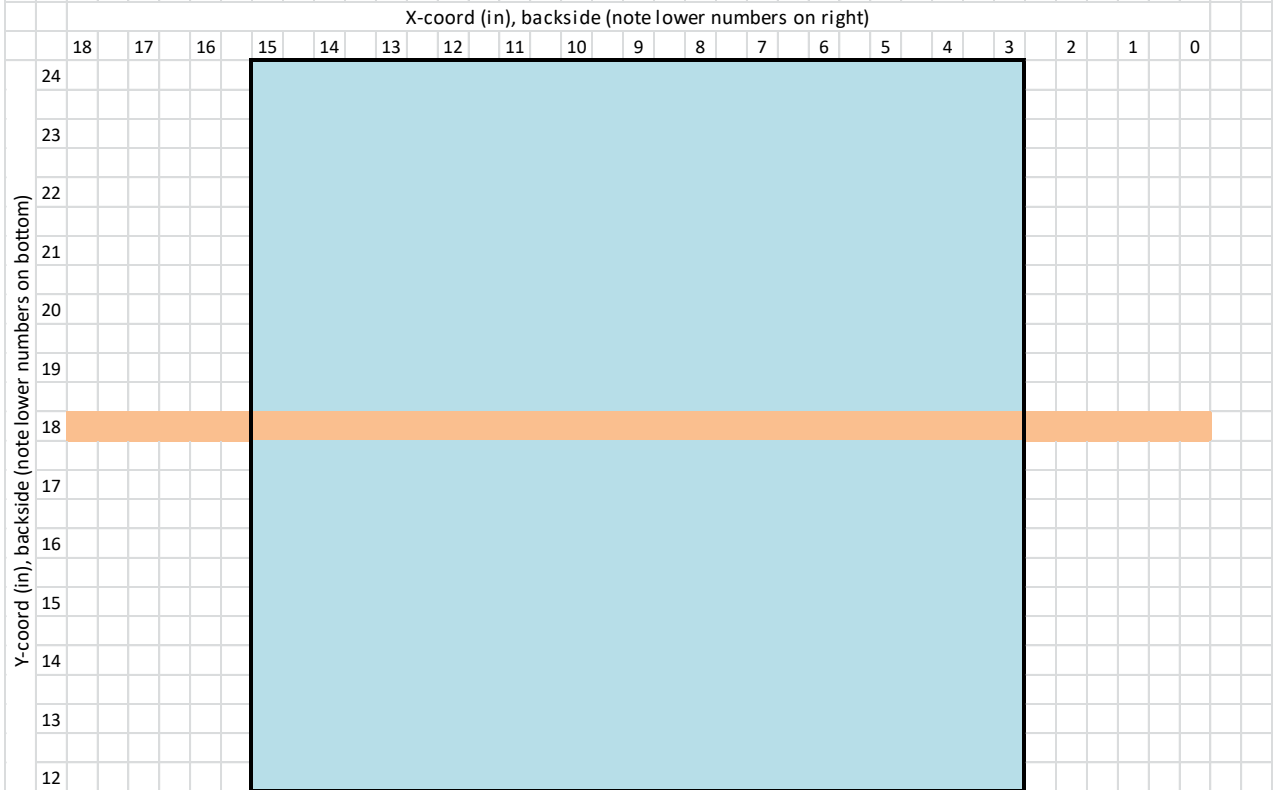


Coupon 2



Coupon 3

Coupon for 14-ER-E3-13-9-18, 12"x12", Backside



- Border: Coupon area to be cut out
- Light Blue: Part of coupon with thickness below 0.200" not expected
- Light Brown: Area where an indication was found in the screening phase (x = 0" to 18", y = 18")
 This area is not backside corrosion
 Screening thickness (LFET): 0.033"; Prove-up thickness (PAUT): No indication noted, so no repair recommended
 Horizontal indication at y = 18" believed to be a plate manufacturing flaw; PAUT prove-up determined no repair

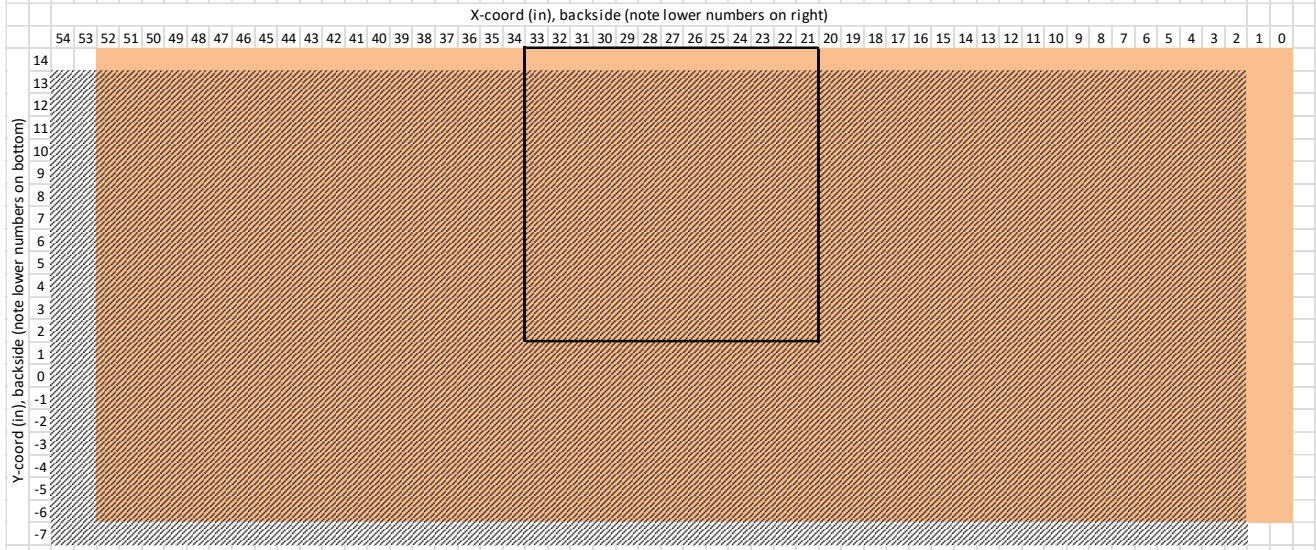
Coordinate origin is lower-left of plate, viewed from inside tank
 For backside sketches, coupon is flipped along vertical (y) axis
 So, in backside sketches, origin is lower-right


Coupon 4


| Coupon for 14-ER-E2-3-232-32, 12"x12", Backside | | | | | | | | | | | | | | | | | |
|---|--|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| X-coord (in), backside (note lower numbers on right) | | | | | | | | | | | | | | | | | |
| | 240 | 239 | 238 | 237 | 236 | 235 | 234 | 233 | 232 | 231 | 230 | 229 | 228 | 227 | 226 | 225 | 224 |
| Y-coord (in), backside (note lower numbers on bottom) | 42 | | | | | | | | | | | | | | | | |
| 41 | | | | | | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | | | | | | |
| 39 | | | | | | | | | | | | | | | | | |
| 38 | | | | | | | | | | | | | | | | | |
| 37 | | | | | | | | | | | | | | | | | |
| 36 | | | | | | | | | | | | | | | | | |
| 35 | | | | | | | | | | | | | | | | | |
| 34 | | | | | | | | | | | | | | | | | |
| 33 | | | | | | | | | | | | | | | | | |
| 32 | | | | | | | | | | | | | | | | | |
| 31 | | | | | | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | | | | | | |
| | Shade: Patch plate for repair | | | | | | | | | | | | | | | | |
| | Border: Coupon area to be cut out | | | | | | | | | | | | | | | | |
| | Brown: Area with NDE indication and where one pit or a group of pits is expected | | | | | | | | | | | | | | | | |
| | Screening thickness (LFET): 0.110" at x = 232", y = 32" | | | | | | | | | | | | | | | | |
| | Prove-up (PAUT): Minimum remaining thickness below the repair threshold (0.160") expected inside a 12"-by-16" (width by height) area centered on x = 232", y = 32" | | | | | | | | | | | | | | | | |
| | Backside corrosion expected to be a combination of solitary pit or grouping of pits | | | | | | | | | | | | | | | | |
| | Minimum remaining thickness expected within +/- 6" of x = 232" and within +/- 8" of y = 32" | | | | | | | | | | | | | | | | |
| | There is an existing repair to a pipe cap in the area covered by the new recommended repair | | | | | | | | | | | | | | | | |
| | The corroded area lies below the existing repair | | | | | | | | | | | | | | | | |
| Coordinate origin is lower-left of plate, viewed from inside tank | | | | | | | | | | | | | | | | | |
| For backside sketches, coupon is flipped along vertical (y) axis | | | | | | | | | | | | | | | | | |
| So, in backside sketches, origin is lower-right | | | | | | | | | | | | | | | | | |


Coupon 5

Coupon for 14-BA-26-15-15-8, 12"x12", Backside



 Shade: Patch plate for repair

 Border: Coupon area to be cut out

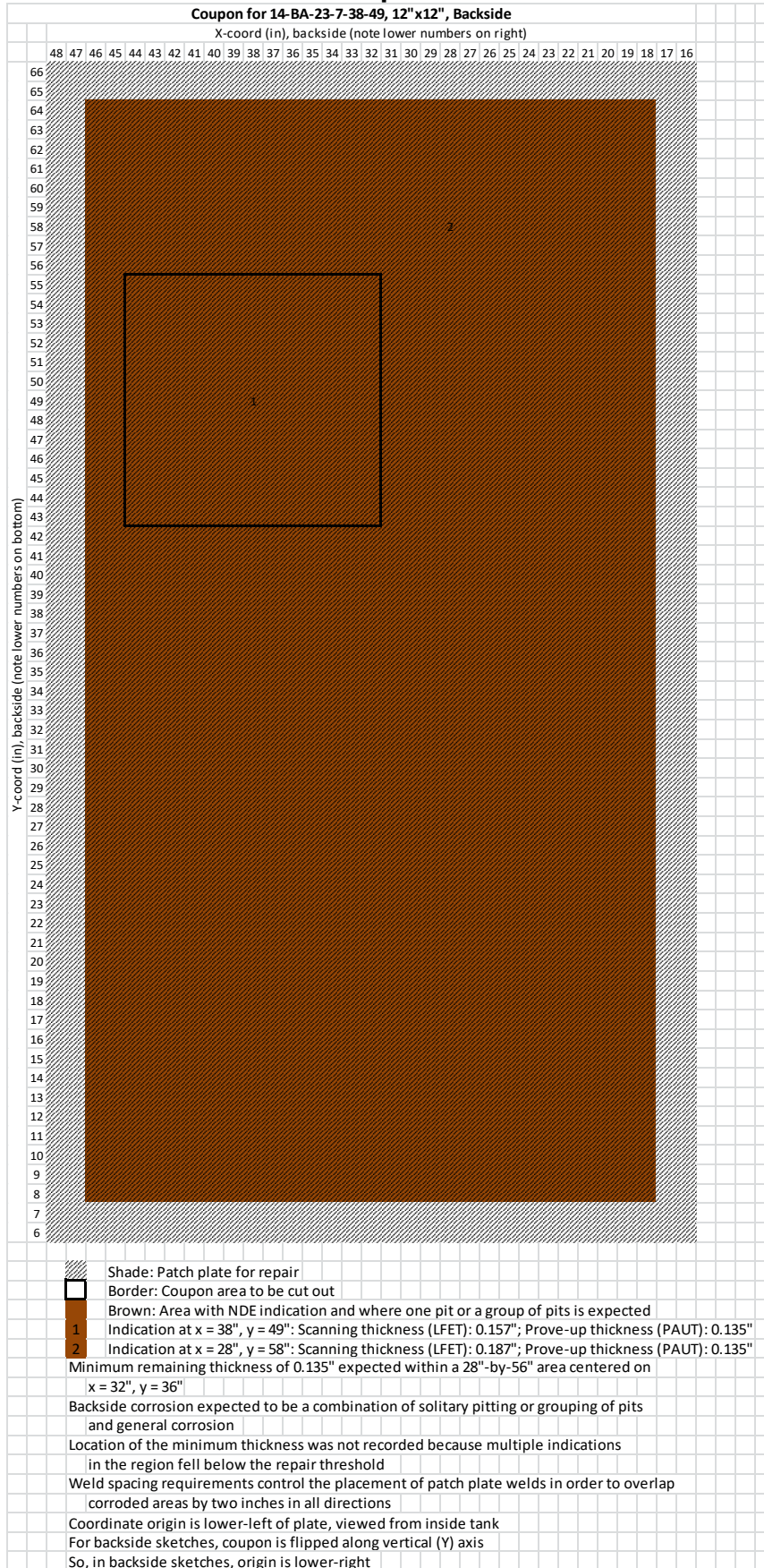
 Light Brown: Part of coupon where NDE indication below threshold of 0.160" is expected; manufacturing flaw, not backside corrosion
 Screening thickness (LFET): 0.047" at x = 0" to 30", y = 8"; Prove-up thickness (PAUT): Below 0.160"
 A horizontal laminar-type manufacturing flaw is expected within a 52"-by-20" (width by height) area centered on x = 26", y = 4"
 It is being repaired because the flaw extends to a welded edge
 Weld spacing requirements result in a repair that covers portions of both horizontal and vertical seam welds

Coordinate origin is lower-left of plate, viewed from inside tank
 For backside sketches, coupon is flipped along vertical (Y) axis
 So, in backside sketches, origin is lower-right

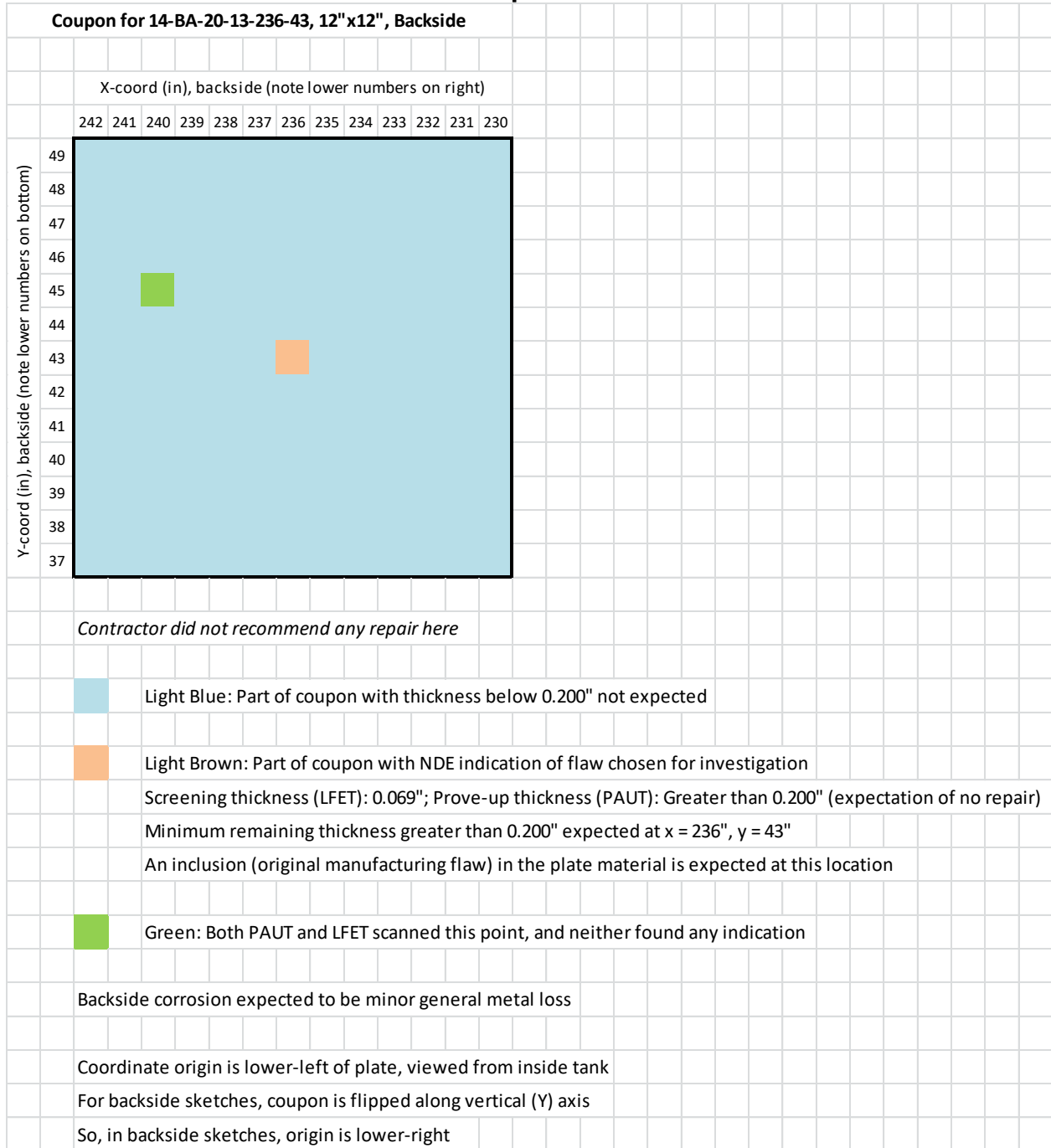
Coupon 6

| Coupon for Barrel, Course 24, Plate 8, 12"x12", Backside | | | | | | | | | | | | | | |
|---|----|---|----|----|----|----|----|----|----|----|----|----|----|----|
| | | X-coord (in), backside (note lower numbers on right) | | | | | | | | | | | | |
| | | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 |
| Y-coord (in), backside (note lower numbers on bottom) | 14 | | | | | | | | | | | | | |
| | 13 | | | | | | | | | | | | | |
| | 12 | | | | | | | | | | | | | |
| | 11 | | | | | | | | | | | | | |
| | 10 | | | | | | | | | | | | | |
| | 9 | | | | | | | | | | | | | |
| | 8 | | | | | | | | | | | | | |
| | 7 | | | | | | | | | | | | | |
| | 6 | | | | | | | | | | | | | |
| | 5 | | | | | | | | | | | | | |
| | 4 | | | | | | | | | | | | | |
| | 3 | | | | | | | | | | | | | |
| | 2 | | | | | | | | | | | | | |
| <i>Contractor did not recommend any repair here</i> | | | | | | | | | | | | | | |
| | | Light Blue: Part of coupon with thickness below 0.200" not expected | | | | | | | | | | | | |
| | P | Brown: Part of coupon with NDE indication of pit (P) (none here) | | | | | | | | | | | | |
| | | Neither LFET nor PAUT found indications | | | | | | | | | | | | |
| Coordinate origin is lower-left of plate, viewed from inside tank | | | | | | | | | | | | | | |
| For backside sketches, coupon is flipped along vertical (Y) axis | | | | | | | | | | | | | | |
| So, in backside sketches, origin is lower-right | | | | | | | | | | | | | | |
| Backside corrosion expected to be insignificant. | | | | | | | | | | | | | | |

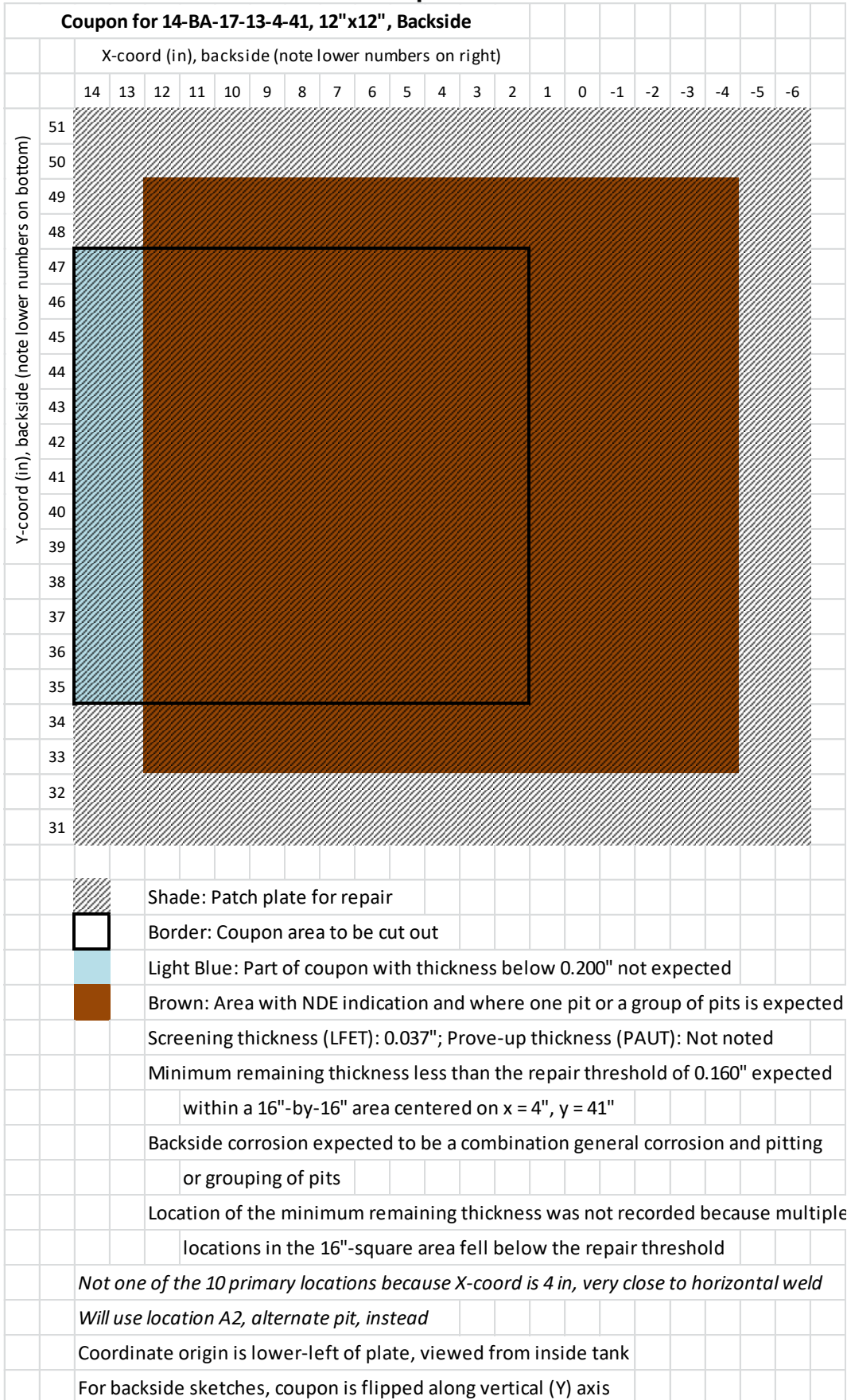
Coupon 7



Coupon 8



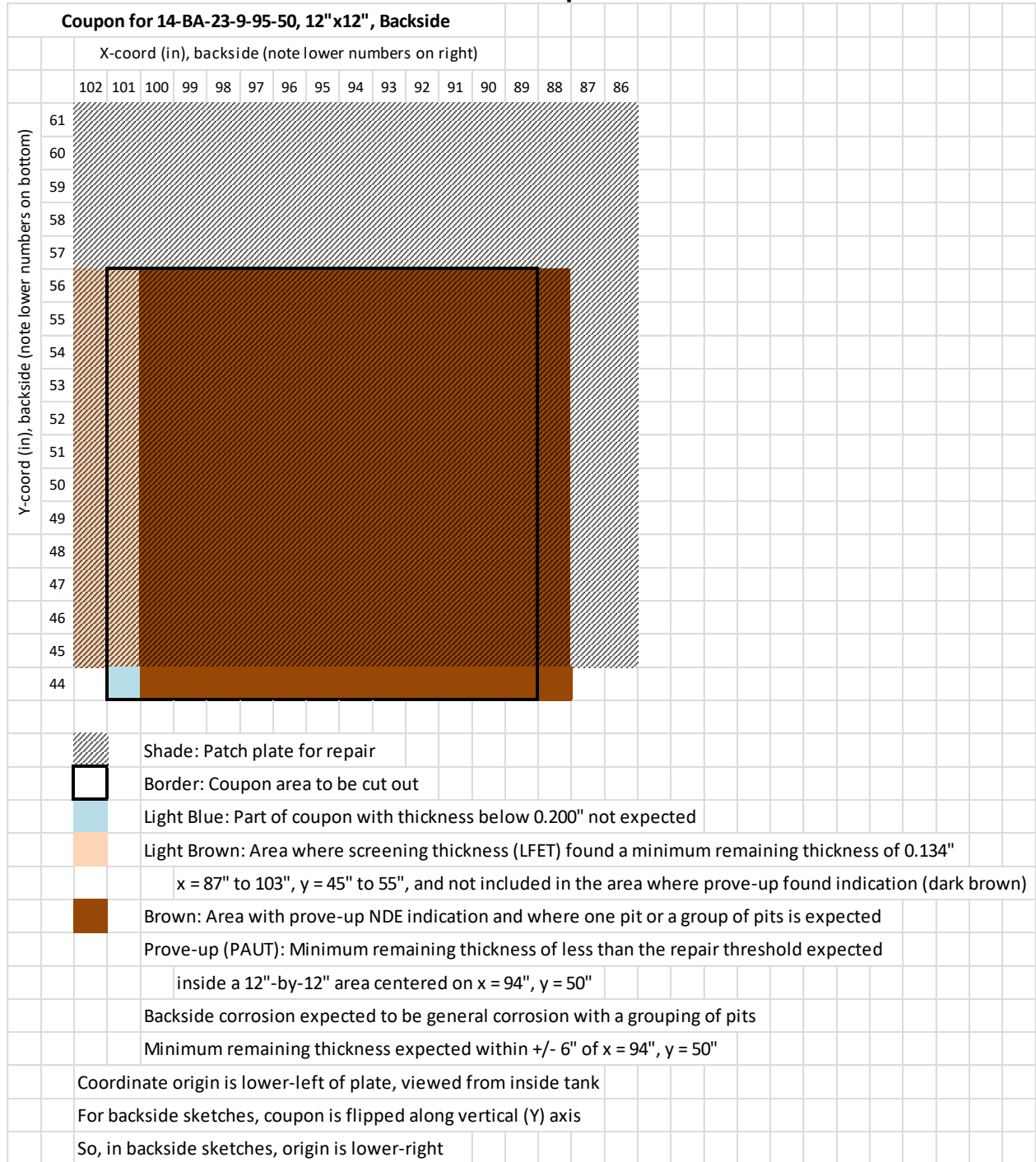
Coupon 9



Coupon 10

| Coupon for 14-LD-3-9-24-215, 12"x12", Backside | | | | | | | | | | | | | |
|---|--|----|----|----|----|----|----|----|----|----|----|----|----|
| | X-coord (in), backside (note lower numbers on right) | | | | | | | | | | | | |
| | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 |
| Y-coord (in), backside (note lower numbers on bottom) | 221 | | | | | | | | | | | | |
| 220 | | | | | | | | | | | | | |
| 219 | | | | | | | | | | | | | |
| 218 | | | | | | | | | | | | | |
| 217 | | | | | | | | | | | | | |
| 216 | | | | | | | | | | | | | |
| 215 | | | | | | | | | | | | | |
| 214 | | | | | | | | | | | | | |
| 213 | | | | | | | | | | | | | |
| 212 | | | | | | | | | | | | | |
| 211 | | | | | | | | | | | | | |
| 210 | | | | | | | | | | | | | |
| 209 | | | | | | | | | | | | | |
| <i>Contractor did not recommend any repair here</i> | | | | | | | | | | | | | |
| | Light Blue: Part of coupon with thickness below 0.200 in not expected | | | | | | | | | | | | |
| * | Asterisk: Thickness greater than the reporting threshold of 0.200" expected at x = 24", y = 215" (at this location, the screening phase [LFET] reported 0.198", but the prove-up phrase [PAUT] reported a thickness greater than 0.200") Backside corrosion expected to be general metal loss Remaining thickness expected to exceed 0.200" within +/- 1" of x = 24", y=215" | | | | | | | | | | | | |
| Coordinate origin is lower-left of plate, viewed from inside tank | | | | | | | | | | | | | |
| For backside sketches, coupon is flipped along vertical (Y) axis | | | | | | | | | | | | | |
| So, in backside sketches, origin is lower-right | | | | | | | | | | | | | |

Alternate Coupon A1



Alternate Coupon A2

| Coupon for 14-BA-11-4-226-50, 12"x12", Backside | | | | | | | | | | | | | |
|---|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| X-coord (in), backside (note lower numbers on right) | | | | | | | | | | | | | |
| | 232 | 231 | 230 | 229 | 228 | 227 | 226 | 225 | 224 | 223 | 222 | 221 | 220 |
| Y-coord (in), backside (note lower numbers on bottom) | | | | | | | | | | | | | |
| 56 | | | | | | | | | | | | | |
| 55 | | | | | | | | | | | | | |
| 54 | | | | | | | | | | | | | |
| 53 | | | | | | | | | | | | | |
| 52 | | | | | | | | | | | | | |
| 51 | | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | | |
| 49 | | | | | | | | | | | | | |
| 48 | | | | | | | | | | | | | |
| 47 | | | | | | | | | | | | | |
| 46 | | | | | | | | | | | | | |
| 45 | | | | | | | | | | | | | |
| 44 | | | | | | | | | | | | | |
| <i>Contractor did not recommend any repair here</i> | | | | | | | | | | | | | |
| | Light Blue: Part of coupon with thickness below 0.200 in not expected | | | | | | | | | | | | |
| I | "I": Thickness greater than the repair threshold of 0.160" expected at x = 226", y = 50" (at this location, the screening phase [LFET] reported 0.161", but the prove-up phrase [PAUT] reported a minimum remaining thickness greater than 0.160") Backside corrosion expected to be general metal loss Remaining thickness in excess of 0.160" expected within +/- 1" of x = 226, y = 50" | | | | | | | | | | | | |
| Coordinate origin is lower-left of plate, viewed from inside tank | | | | | | | | | | | | | |
| For backside sketches, coupon is flipped along vertical (Y) axis | | | | | | | | | | | | | |
| So, in backside sketches, origin is lower-right | | | | | | | | | | | | | |

Alternate Coupon A3

| Coupon for Barrel, Course 3, Plate 3, 12"x12", Backside | | | | | | | | | | | | | | |
|---|----|---|----|----|----|----|----|----|----|----|----|----|----|----|
| | | X-coord (in), backside (note lower numbers on right) | | | | | | | | | | | | |
| | | 36 | 35 | 34 | 33 | 32 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| Y-coord (in), backside (note lower numbers on bottom) | 36 | | | | | | | | | | | | | |
| 35 | | | | | | | | | | | | | | |
| 34 | | | | | | | | | | | | | | |
| 33 | | | | | | | | | | | | | | |
| 32 | | | | | | | | | | | | | | |
| 31 | | | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | |
| <i>Contractor did not recommend any repair here</i> | | | | | | | | | | | | | | |
| | | Light Blue: Part of coupon with thickness below 0.200 in not expected Neither LFET nor PAUT found indications, but this area may be studied as an alternate control in case one of the 10 main locations is unworkable Backside corrosion expected to be insignificant | | | | | | | | | | | | |
| | | Brown: Part of coupon with NDE indication of pit (none here) | | | | | | | | | | | | |
| Coordinate origin is lower-left of plate, viewed from inside tank | | | | | | | | | | | | | | |
| For backside sketches, coupon is flipped along vertical (Y) axis | | | | | | | | | | | | | | |
| So, in backside sketches, origin is lower-right | | | | | | | | | | | | | | |