Exhibit D07

DEPARTMENT OF THE NAVY

COMMANDER
NAVY REGION HAWAII
850 TICONDEROGA ST STE 110
JBPHH, HAWAII 96860-5101

5750
Ser N4/0577
July 7, 2019

CERTIFIED NO: 7018 0040 0001 0225 9876

Mr. Omer Shalev
U.S. Environmental Protection Agency
Region IX
75 Hawthorne Street
San Francisco, CA 94105

CERTIFIED NO: 7018 0040 0001 0225 9883

Ms. Roxanne Kwan
State of Hawaii Department of Health
Environmental Management Division
Solid and Hazardous Waste Branch
2827 Waimano Home Road, Suite 100
Pearl City, HI 96782

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 RESULTS REPORT, RED HILL BULK FUEL STORAGE FACILITY (RED HILL), JOINT BASE PEARL HARBOR-HICKAM, OAHU, HAWAII

Pursuant to the Regulatory Agency's conditional approval of the Destructive Testing Scope of Work, AOC/SOW Section 5.3.3, the attached document serves as the Destructive Testing Results Report. This report contains an analysis of the corrosion and material properties of the steel tank liner and the condition of the concrete, as found both by Government personnel and by independent third-party scientists and engineers.

The Navy and DLA submitted the Destructive Testing Scope of Work on 30 May 2017, detailing planned destructive testing for at least one (1) tank at the facility. The Regulatory Agencies conditionally approved this scope of work on 7 July 2017 (Reference 2). The Regulatory Agencies revised Condition 1 on 10 August 2017 (Reference 3). The Navy addressed the conditions for approval stated in References 2 and 3 as follows:

1. The Final Red Hill AOC Paragraph 5.2 Corrosion and Metal Fatigue Report dated April 4, 2016 (Reference 1) summarized the non-destructive evaluation (NDE) process for the clean, inspect, and repair (CIR) program at Red Hill. This includes a basis of the equipment and techniques used; professional codes, standards, and procedures employed; and equipment calibration and performance validation. The Red Hill Non-Destructive Examination Plan dated Oct 2017 (Reference 4) further discusses the NDE criteria. The Regulatory Agencies approved this report on 30 June 2016. The current CIR contractor completed the NDE. NAVFAC validated their credentials and qualifications prior to beginning the NDE.

2. The Navy, DLA and the Regulatory Agencies agreed upon selected coupon locations at face-to-face meetings in March of 2018. The Navy documented these locations in the Red Hill Destructive Testing Plan Supplement dated 1 June 2018 (Reference 5).

3. The Navy provided a detailed plan describing coupon collection and evaluation to the Regulatory Agencies in the Red Hill Destructive Testing Plan Supplement dated 1 June 2018 (Reference 5).

4. The Navy submitted the laboratory testing plan to the Regulatory Agencies in the Red Hill Destructive Testing Plan Supplement dated 1 June 2018 (Reference 5).

5. The Navy reviewed the evaluation of discrepancies between NDE and destructive testing samples with the Regulatory Agencies during the face-to-face meetings in March of 2019. Section 4.0 of Enclosure 1 describes the evaluations for each coupon.

6. Section 4.0 of Enclosure 1 includes a comparison of the NDE and destructive testing results.

7. The Navy included methods for sampling and characterization of exposed concrete in the Red Hill Destructive Testing Plan Supplement dated 1 June 2018 (Reference 5).

8. The Navy included the decision criteria for additional destructive testing in the Red Hill Destructive Testing Plan Supplement dated 1 June 2018 (Reference 5).

9. Section 6.3 of Enclosure 1 discusses additional destructive testing.

10. Section 6.4 of Enclosure 1 discusses metal fatigue.

11. The Red Hill Destructive Testing Plan Supplement dated 1 June 2018 (Reference 5) contains a discussion on the chain of custody.

If you have any questions, please contact Commander Darrel Frame, the acting Navy Region Hawaii Red Hill Program Director, at (808) 312-2652, or email: darrel.e.frame@navy.mil.

Sincerely,

M. R. DELAO
Captain, CEC, U.S. Navy
Regional Engineer
By direction of the
Commander

Reference:
1. Final Red Hill AOC Para 5.2 Corrosion and Metal Fatigue Practices Report dated April 4, 2016
2. Letter to Mr. Mark Manfredi from Mr. Bob Pallarino and Mr. Steven Chang dated July 7, 2017, Re: Conditional Approval of Scope of Work for Destructive Testing Dated May 30, 2017 submitted to the Regulatory Agencies Pursuant to Section 5.3.2 of the Red Hill Administrative Order on Consent
3. Letter to Mr. Mark Manfredi from Mr. Bob Pallarino and Mr. Steven Chang dated August 10, 2017, Re: Conditional Approval of Scope of Work for Destructive Testing Dated May 30, 2017 submitted to the Regulatory Agencies Pursuant to Section 5.3.2 of the Red Hill Administrative Order on Consent
4. Red Hill Non-Destructive Examination Plan dated Oct 2017
5. Red Hill Destructive Testing plan Supplement dated 1 June 2018

Enclosure: Red Hill Bulk Fuel Storage Facility Destructive Testing Results Report

Red Hill Administrative Order on Consent, Attachment A Scope of Work Deliverable

Section: 5.3.3 Destructive Testing Results Report

In accordance with the Red Hill Administrative Order on Consent, paragraph 9, DOCUMENT CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fines and imprisonment for knowing violation.

Signature: ______________________________

CAPT Marc Delao, CEC, USN
Regional Engineer, Navy Region Hawaii

Date: 7 July 2019

Site Specific Report
SSR-NAVFAC EXWC-CI-1941

RED HILL BULK FUEL STORAGE FACILITY DESTRUCTIVE TESTING RESULTS REPORT, AOC/SOW 5.3.3

NAVFAC EXWC

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Robert Jamond, Lean-Miguel San Pedro, Frank Kern, Terri Regin

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NAVFAC Engineering and Expeditionary Warfare Center
1100 23rd Avenue
Port Hueneme, CA

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Naval Facilities Engineering and Expeditionary Warfare Center, Defense Logistics Agency-Energy

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Approved for public release; distribution is unlimited.

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None

14. ABSTRACT

As identified in Red Hill Bulk Fuel Storage Facility Scope of Work for Destructive Testing Administrative Order on Consent (AOC) and Statement of Work (SOW) Section 5.3.2, the purpose of this effort is to verify the findings of the Corrosion and Metal Fatigue Practices Report, using destructive testing on at least one tank at the Facility. In 2018, ten coupons were removed from Tank 14, so that a metallurgical and corrosion analysis of the coupons could be undertaken, with the primary aim of validating non-destructive examination (NDE) results. The steel coupons, concrete powder samples, and corrosion product were submitted to a certified third-party laboratory to perform this analysis. Chemical analysis indicated that the steel tank liner was made from steel that generally conformed to ASTM A36 specification. Metallurgical analysis validated NDE results in terms of the presence or absence of indications for repair. Testing of concrete powder samples indicated that the concrete behind the steel tank liner is in sound condition. No spalling or cracks were detected. Sufficient confidence can be placed in the NDE processes for effectively identifying areas of corrosion within a tank which could result in metal loss below the minimum threshold before the next inspection interval. Obtaining additional data through more destructive testing does not justify the added investment in terms of time and funding. However, the Navy continually seeks means of improving performance of tank maintenance and repair processes and is open to further discussions.

15. SUBJECT TERMS
Red Hill, Administrative Order on Consent, Corrosion, Metal Fatigue, Concrete, Non-Destructive Examination, Destructive Testing

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U	U	U	UU	259	Robert Jamond
					19b. TELEPHONE NUMBER *(include area code)* 805-982-1061

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EXECUTIVE SUMMARY

As identified in Red Hill Bulk Fuel Storage Facility Scope of Work for Destructive Testing Administrative Order on Consent (AOC) and Statement of Work (SOW) Section 5.3.2, the purpose of this effort is to verify the findings of the Corrosion and Metal Fatigue Practices Report, using destructive testing on at least one tank at the Facility.

In 2018, ten coupons were removed from Tank 14, so that a metallurgical and corrosion analysis of the coupons could be undertaken, with the primary aim of validating non-destructive examination (NDE) results. The steel coupons, concrete powder samples, and corrosion product were submitted to a certified third-party laboratory to perform this analysis.

The goals of this effort were to:

- Validate the results of NDE inspection technologies used at Red Hill.
- Characterize the metallurgy of the steel material used in the tank liner.
- Record observations and chemical characteristics of the concrete behind the liner.
- Assess procedures for calculating corrosion rates and recommend improvements as warranted.
- Evaluate results against current corrosion-mitigation practices and recommendations.

The on-site and third-party analysis yielded the following results:
Chemical analysis indicated that the steel tank liner was made from steel that generally conformed to ASTM A36 specification. The yield strength, tensile strength and ductility values are appropriate for this application as a steel fuel-storage tank.

Coupon 1 was found to have significantly less metal loss than what was identified by the NDE. Coupon 7 had less metal loss than what was predicted by NDE. Coupons 2, 5, 8, 10, A1 and A2 all had measured thicknesses consistent to what was found with the NDE. Coupon 3 destructive testing showed actionable metal loss whereas the NDE did not identify any in this exact location. An actionable indication was found adjacent to where Coupon 3 was cut out. During the follow-on repair process, however, the metal loss at the Coupon 3 location would have been detected. Coupon 6 showed more metal loss than was predicted by the NDE and was just below the repair threshold. The destructive testing identified this to be a pit of very small volume. The NDE method used, Low-Frequency Electromagnetic Technique (LFET), does not always detect metal losses of very small volume.

On-site testing and laboratory testing of concrete powder samples indicated that the concrete behind the steel tank liner is in sound condition. No spalling or cracks were detected in the concrete behind the coupons, and the concrete was found to be in good condition.

There is an ongoing integrity management program to clean, inspect and repair the Red Hill tanks to be suitable for service for 20-year intervals. The standard of care used to assess integrity of the tanks is modified from and consistent with API Standard 653, Tank Inspection, Repair, Alteration, and Reconstruction (Ref 6). The AOC Section 2.2 Tank Inspection, Repair, and Maintenance

(TIRM) Report contains details about the integrity management program. Improvements to TIRM procedures are continuously evaluated, and when improvements are identified, they are implemented.

The TIRM report includes details about how the corrosion rate assessment in the modified API Standard 653 inspection is performed. The results of the destructive testing validate that the method is conservative. No changes to the corrosion rate assessment are recommended.

The Navy's overall assessment of the information obtained through the removal and destructive testing of the 10 steel coupons from Tank 14 is that sufficient confidence can be placed in the NDE processes for effectively identifying areas of corrosion within a tank which could result in metal loss below the minimum threshold before the next inspection interval. Further efforts to obtain additional data through more destructive testing, in attempts to refine this analysis, do not justify the added investment in terms of time and funding. However, as mentioned above, the Navy continually seeks means of improving performance of tank maintenance and repair processes, and as such is open to further discussions as described in AOC/SOW Section 5.4.

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1.0 INTRODUCTION

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 federal and state regulators, respectively the Environmental Protection Agency (EPA) and the State of Hawaii Department of Health (DOH) to provide for the management and oversight of a release assessment, responses to releases, 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.

As identified in Red Hill Bulk Fuel Storage Facility Scope of Work for Destructive Testing as required by the Administrative Order on Consent (AOC) Statement of Work (SOW) Section 5.3.2, the purpose of the work performed and deliverables is 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.

1.1 Non-Destructive Examination (NDE)

NDE includes a variety of industry methods used to evaluate the condition of fuel storage tanks and pipelines. Technologies are used to scan steel plate and welds for indications as well as to quantify the size of indications and amount of metal loss. The intent of AOC/SOW Section 5.3 is to validate the results of NDE technologies and processes used to scan the Red Hill storage tanks.

1.2 Coupons for Testing for NDE Evaluation

The NDE data were analyzed and validated by the Navy. Expected results, determined from the NDE inspection, were compared to actual observations and measurements made from the coupons.

The Navy provided EPA and DOH the Tank 14 NDE data spreadsheet documenting the NDE scan results from the Clean, Inspect and Repair (CIR) contract for Red Hill Tank 14. This spreadsheet contained LFET scan data that showed location coordinates, minimum thickness identified, and prove-up thickness measurements. The spreadsheet also identified repairs required. These data provided the basis for coupon selection. The final EPA- and DOH-approved coupon-selection locations are shown in Table 1.

It must be noted that the inspection-repair process used by the Navy was incomplete at the time coupon site selection was made. As part of the inspection process, the contractor scanned 100% of the tank shell to identify indications of metal loss. The indications were proved-up with a different technology, phased array ultrasonic testing (PAUT), and locations needing repair were entered into the spreadsheet. Based on those preliminary data, the tank inspector made recommendations for repair to the Government. As part of the repair process and as required in API Standard 653, the contractor further tests for metal loss at the repair sites using ultrasonic methods. During this phase known as layout, actual dimensions and locations of many of the repairs changed from the preliminary data in order to ensure the work was compliant with API standards. At the time the coupon site selection was made, the NDE data spreadsheet was preliminary and the layout phase to determine the actual dimensions and locations of repair patch plates was in progress.

The expected conditions of the backside of the coupons were documented using a sketch showing indications identified in the Tank 14 NDE data spreadsheet. The sketches also indicated if there were areas of general corrosion (between 20 and 50 mils) expected. The specified repair for the indications at the coupon locations as stated in the spreadsheet was also shown on each sketch. Any other pertinent information was added as a note on each sketch.

Due to the large surface area of the steel tank liner, acquiring sufficient number of samples for meaningful statistical analysis is infeasible. Therefore, coupons were selected strategically not to characterize the condition of the tank but to verify the NDE findings in areas throughout the tank. With input from Regulators and their Subject Matter Experts (SMEs), coupons with isolated pitting, general corrosion, pitting with general corrosion, and no identified corrosion were selected. The expected results were compared with the destructive test results to validate the NDE process. Ten (10) coupons were removed. The size of the coupons was 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 was to obtain sufficient data points for the NDE validation, while minimizing the number of coupons cut out of the operational tank.

1.3 Coupon Selection Process

Coupon locations were obtained as follows:

- After the LFET 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.
- The Navy presented complete scan data spreadsheet for Tank 14 and proposed coupon locations to the regulators for review and comment.
- During a face-to-face meeting with EPA and DOH coupon locations were decided upon.

2.0 COUPON REMOVAL AND ON-SITE TESTING PROCEDURES

The coupon locations are shown in Table 2-1. The overall ID number indicates the coupon location. For example for Coupon 1's overall ID is 14-UD-A-42-45-107, meaning Tank 14 (14), Upper Dome (UD), Course A (A), Plate 42 (42), X-coordinate 45 (45), Y-coordinate 107 (107). X- and Y-coordinates are in inches from the lower-left corner of each steel plate, as viewed from the inside of the tank. Coupon 6 and Coupon A3 are listed as N/A (Not Applicable) because they were chosen as controls and have no reported indication locations.

Alternative coupon locations were selected in the event that certain coupons could not be removed due to proximity to welds, or other tank features that would prelude coupon removal at that location.

Coupon 4 could not be removed due to its close proximity to a grout nozzle. Removal would have required sectioning the coupon into small pieces. Therefore, Coupon A1 was substituted for removal.

Coupon 9 could not be removed due to its proximity to a vertical weld. Behind the vertical welds, there is an embedded angle. Removal would have required cutting the coupon into small pieces. Therefore, Coupon A2 was substituted for removal.

Table 2-1 Tank 14 Coupon Locations

#	Row in Master Table	Overall ID	Contractor Repair No.	Region	Course	Plate	X-Coord	Y-Coord	Ind Type	Screening Measurement (in)	Prove-up Measurement (in)	Actual Minimum Thickness (in)
1	2282	14-UD-A-42-45-107	14-UD-A-42-45-107-3	UD	A	42	45	107	BC	0.147	0.112	0.208
2	2892	14-ER-E3-12-33-40	14-ER-E3-12-34-44-5	ER	E3	12	33	40	BC	0.157	0.150	0.152
3	2903	14-ER-E3-13-9-18	14-ER-E3-13-7-5-2	ER	E3	13	0-18	18	BC	0.033	No prove-up	0.131
4	2959	14-ER-E2-3-32-232	14-ER-E2-3-32-232-5	ER	E2	3	32	232	BC	0.110	No prove-up	Not used
5	3706	14-BA-26-15-15-8	14-BA-26-15-28-3-1	BA	26	15	27	8	BC	0.047	No prove-up	0.224
6	N/A	N/A	N/A	BA	24	8	N/A	N/A	N/A	N/A	No prove-up	0.158
7	3944	14-BA-23-7-38-49	14-BA-23-7-32-36-1	BA	23	7	38	49	BC	0.157	0.135	0.164
8	4300	14-BA-20-13-236-43	(No Repair)	BA	20	13	236	43	BC	0.069	0.200	0.206
9	4625	14-BA-17-13-4-41	14-BA-17-13-4-41-1	BA	17	13	4	41	BC	0.037	No prove-up	Not used
10	6492	14-LD-3-9-24-215	(No Repair)	LD	3	9	24	215	BC	0.198	0.200	0.242
A1	3962	14-BA-23-9-95-50	14-BA-23-9-94-53-2	BA	23	9	87-103	45-55	BC	0.134	No prove-up. Weld repair	0.122
A2	5176	14-BA-11-4-226-50	(No Repair)	BA	11	4	226	50	BC	0.161	No prove-up	0.248
A3	N/A	N/A	N/A	BA	3	3	N/A	N/A	N/A	N/A	No prove-up	Not used

Note: Coupons 4 and 9 were not used due to anticipated difficulties in removing them, as explained in the text of Section 2.0, so Coupons A1 and A2 were substituted for them. Coupon A3 was an alternate coupon that was not used.

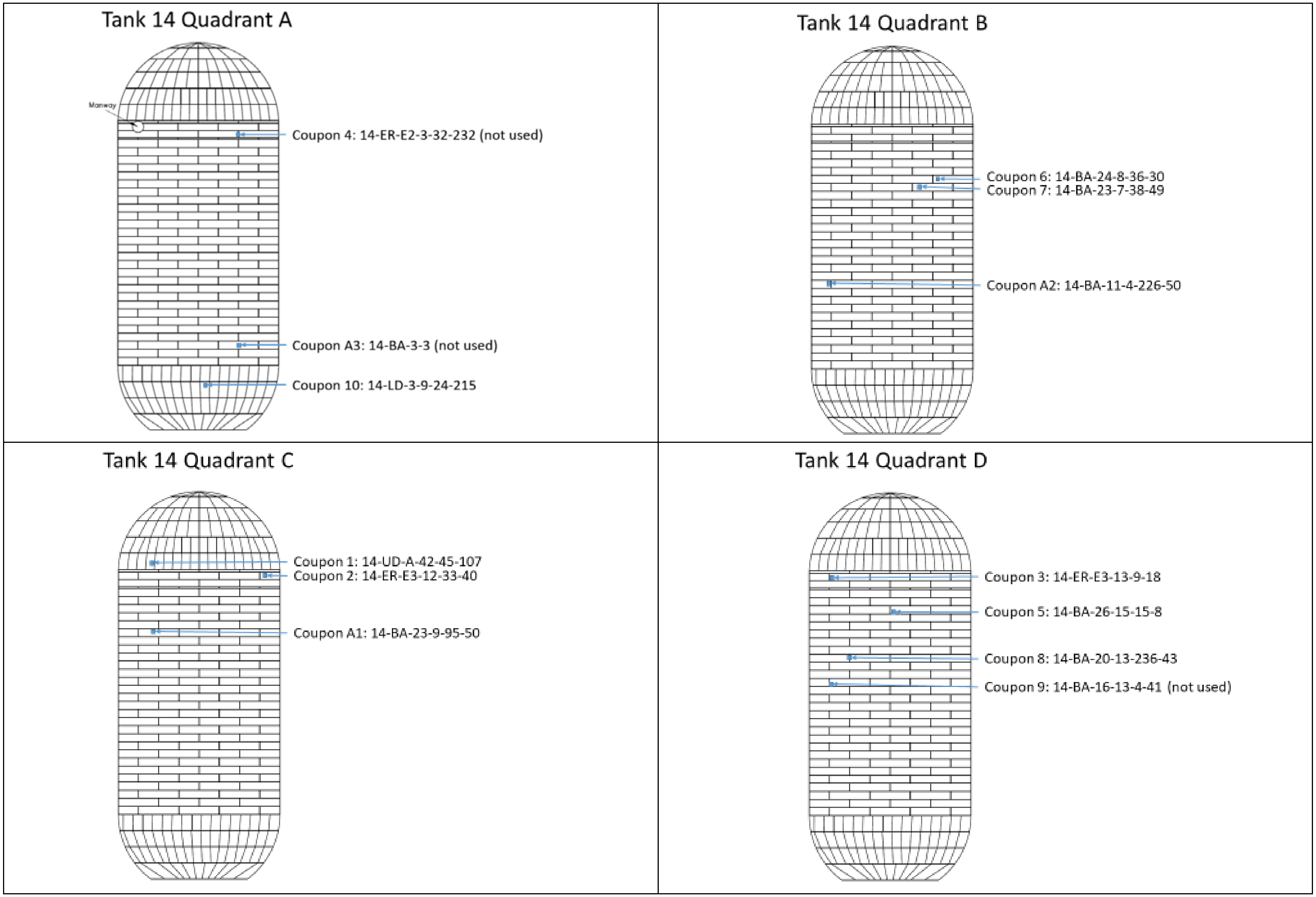


Figure 2-1 Schematic of Tank 14 Coupon Locations

2.1 Coupon Removal and On-Site Testing

2.1.1 On-Site Coupon Assessment

The following observations were noted on-site immediately after coupon removal.

- Identify any deposits, coatings, debris scale or biological materials.
- Note any presence of moisture.
- Note any smells.
- Note any presence of petroleum product between steel and concrete surface.
- Provide a sketch of the coupon showing the indications.
- Note any presence of corrosion.
- Note any isolated pitting or isolated pitting within areas of general corrosion.
- Identify color of corrosion products.

2.1.2 On-Site Concrete Assessment

The following procedures were performed to evaluate the concrete containment immediately upon removal of each coupon.

- Note the condition of the concrete.
- Observe or measure the void space between the concrete and the liner, if any, in the area surrounding the coupon site. Check to determine if the material behind the coupons taken is grout or concrete.
- Measure the temperature at the concrete/liner interface. Note the presence of moisture. Also measure pH of exposed medium (if wet).
  Reinforcing steel in concrete is usually in a passive state due to the high alkalinity of the concrete pore solution. However, the passivity may be lost and the corrosion can occur on the steel by a decrease of pH due to carbonation.
- Measure the structure-to-electrolyte potential of the steel liner-to-concrete at the coupon site.
  Structure-to-electrolyte potential is an indicator of corrosion activity of steel in concrete. The following qualitative criteria do not address the corrosion rate, but the guideline for potential measurements based on structure-to-electrolyte (S/E) potential with respect to a copper/copper-sulfate electrode (CSE) is:
  More positive than -0.20 volts: Passive
  -0.20 to -0.35 volts: Active or passive
  More negative than -0.35 volts: Active
- Measure concrete bulk resistivity.
  Concrete resistivity measurements give an indication of the moisture content, the potential for increased chloride content or the presence of other contaminants. These factors all affect the corrosion potential of steel in contact with the concrete.

2.1.3 Coupon Chain of Custody, Viewing and Shipment to Third-Party Laboratory

- Upon receipt of coupon from the contractor, specimen information and any other notes were entered into an official logbook or on pre-printed sheets of paper with Table 3 “Characterization of Steel Coupon” and Table 4 “On-site Visual Inspection and Testing of Concrete" in the Red Hill AOC SOW Section 5 Destructive Testing Scope of Work. Coupon collection, labeling and storage was in accordance with ASTM E1188 − 11 "Standard Practice for Collection and Preservation of Information and Physical Items by a Technical Investigator".

- Specimens were placed in labeled specimen bag and transported to a staging area and the specimens were wrapped in clear polyethylene sheeting. Coupons were placed in a shipping container and transported to a storage location where viewing by regulators and stakeholders occurred.
- Viewing by regulators and stakeholders occurred on 25 June 2018.
- After the viewing was concluded, specimens were shipped to the third-party laboratory for analysis.
- Chain of custody of the coupons was identified and maintained in the official logbook.

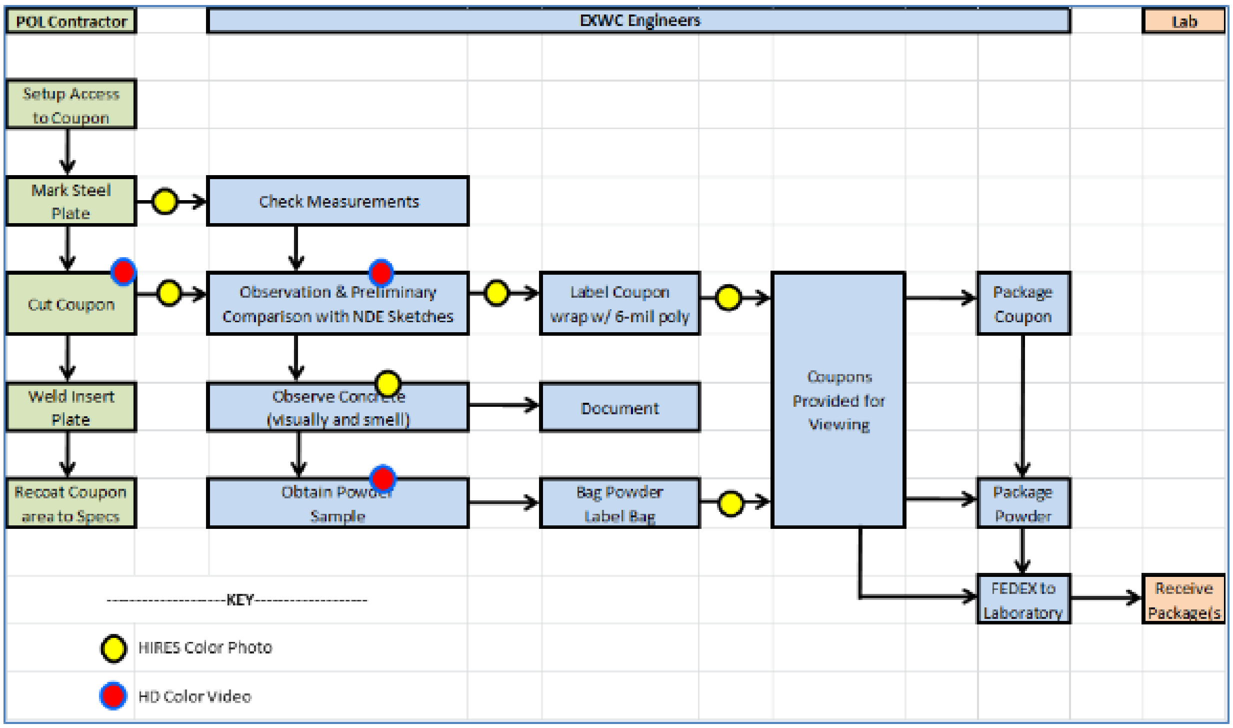


Figure 2-2. Flow Chart of On-Site Coupon Removal and Testing Procedures

A flow chart detailing the processes in cutting the coupons from Tank 14 is displayed in Figure 2-2. Unfortunately, although videos were planned to be taken, the live wireless communication technology that was planned to be used in taking the videos did not work inside the RHBFSF.

2.2 Third-Party Laboratory Testing

Laboratory testing on the steel coupons was performed by a third-party National Aerospace and Defense Contractors Accreditation Program (NADCAP)-accredited materials testing laboratory.

The following tests and analyses were performed:

a. Photograph all sides of the metal specimen.
b. Perform metallurgical and chemical analysis of the coupons to include:
    - Chemical analysis of general-corrosion products on each coupon's back surface, on at least three points on each coupon using scanning electron microscopy (SEM) with energy dispersive X-ray analysis (EDXA).
    - Chemical analysis of any coatings to determine coating type.
    - Complete elemental analysis of the steel to determine American Iron and Steel Institute (AISI) steel type.
    - Microscopic examination of surfaces, before and after cleaning.
    - Hardness measurements, bulk and cross-sectional.
    - Tensile testing to establish yield strength, ultimate tensile strength, and ductility.
    - Chemical analysis of substrate inside pit areas using EDXA.
    - Chemical analysis of corrosion product inside corrosion pits using X-ray diffraction (XRD).
c. Measure coupon wall thickness at the three largest pits on each coupon.
d. Perform surface characterization of the exterior and interior surfaces of the steel coupon using three-dimensional profilometry after the coupon is cleaned.
e. Perform chemical analysis (including pH) of concrete powder samples taken.
f. Determine chloride and sulfate content of concrete powder samples using ion chromatography.

2.3 Comparison of Expected Outcomes from NDE with Laboratory Results

The expected condition of the backside of the coupons was predicted using sketches, which were based on the preliminary Tank 14 NDE data spreadsheet. The sketches also noted if there were areas of general corrosion (between 20 and 50 mils) expected, based on the preliminary spreadsheet. Other pertinent information was added as a note on each sketch. The sketches for each coupon location are provided in Section 4 of this report and Reference 3.

After the laboratory submitted its final report, NAVFAC EXWC compared the expected outcomes identified in this document with the Laboratory's actual pit-depth and metal loss measurements. These results were discussed in a technical meeting with Navy, Regulators and SMEs on 12-13 March 2019.

3.0 COUPON EVALUATION

The Laboratory's Destructive Testing Report is contained in Appendix A. Field notes showing sketches of coupons made on-site are contained in Appendix B. Gas test holes were drilled in the coupons to enable testing for explosive vapors, a requirement for hot work prior to cutting the coupons.

Figure 3-1 Coupon Removal Tank 14

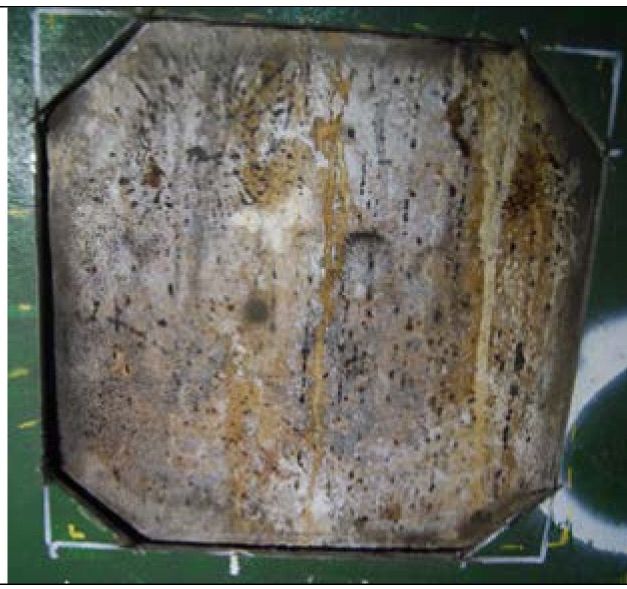
3.1 Coupon 1

Coupon was located in the upper dome at location 14-UD-A-42-45-107. Backside corrosion was identified by LFET with a minimum wall thickness of 0.147 inch. Prove-up measurement using phased array ultrasonic testing (PAUT) indicated a minimum wall thickness of 0.112 inch.

3.1.1 On-Site Evaluation of Coupon 1

The concrete behind Coupon 1 was sound concrete with no cracks or delaminations. Table 3-1 contains the on-site concrete observations and test results.

Table 3-1 Coupon 1 On-Site Condition Assessment

		6/20/2018: 1400
CONCRETE SAMPLE SPECIFICS		
Sample ID	1	**1**
Sample Location	14-UD-A-42-45-107	
Sample Dimensions	12″ × 12″	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	1/8″ Void on left side, no voids in all other areas	
Biological Materials	None	
Wet or Dry	Dry	
Smell	None	
Temperature	76.9	Degrees F
Surface pH	9 to 9.5	
Structure to Electrolyte	-0.252	Volts/CSE
Concrete Resistivity	26.4 Horizontal 31.1 Vertical	k-ohm-cm k-ohm-cm
General Condition	Excellent, sound concrete with some discoloration and no cracks and no delamination	
Concrete behind Coupon 1		

Coupon 1 Backside		

		Wed, 20 Jun 2018, 01:33 PM
COUPON SPECIFICS		
Coupon ID	1	**1**
Coupon Location	14-UD-A-42-45-107	
Coupon Dimensions	12” × 12”	
Coupon Thickness	¼” (NDE: minimum 0.147”)	Prove-up: minimum 0.112”
Locations of Welds	None	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Interior
Deposits, Coatings, Debris	Deposits	Standard coating with paint
Scale	None	None
Observed Biological Material	None	None
Wet or Dry	Wet	Dry
Smell	Damp, burnt	Burnt
Presence of petroleum product between steel and concrete surface	No	No
Presence of corrosion	Yes	No
Isolated pitting	No	No
Isolated pitting within areas of general corrosion	No	No
Linked pitting within areas of general corrosion	No	No
Identify color of corrosion products	Brown	N/A
Identify if selected attack at welds	N/A	N/A

3.1.2 Destructive Testing Laboratory Evaluation of Coupon 1

- Detailed results of the Destructive Testing Laboratory analysis of Coupon 1 are contained in Appendix A.
- The thinnest measured location was 207.9 mils (5.28 mm).
- Assuming a nominal wall thickness of 250 mils, the remaining wall thickness at the thinnest location was 83.1%.
- Coupon 1 exhibited backside corrosion as was predicted.
- A cross-section view of Coupon 1 is shown in Figure 3-2.

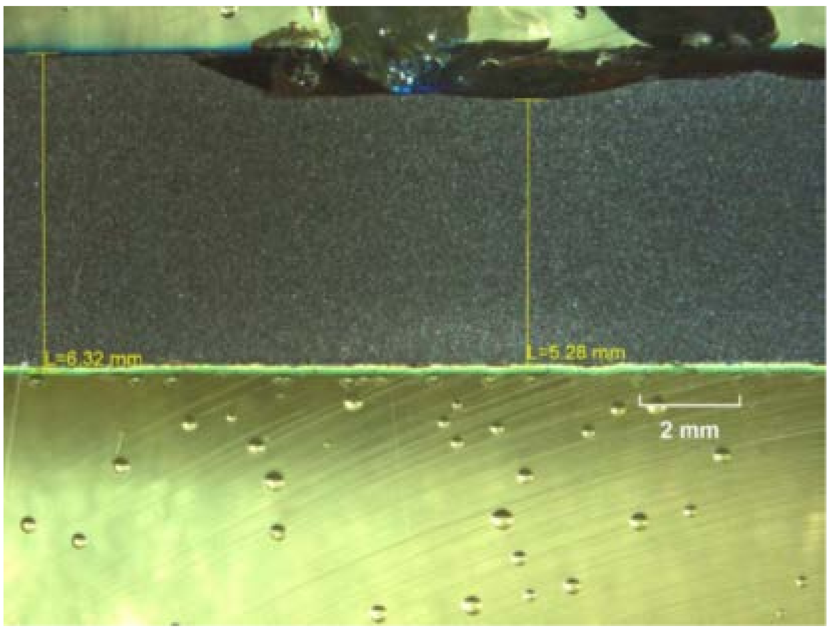


Figure 3-2 Cross Section of Coupon 1 at Area of Maximum Wall Loss

3.2 Coupon 2

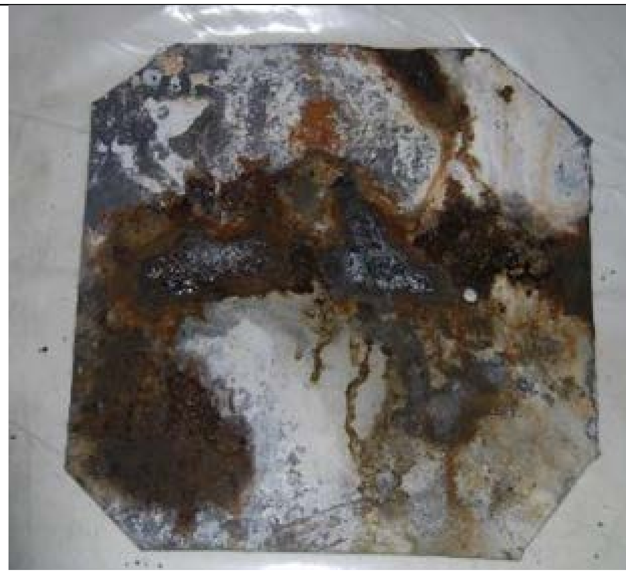
Coupon 2 was located in the extension ring at location 14-ER-E3-12-33-40. Backside corrosion was identified by LFET with a minimum wall thickness of 0.157 inch. Prove-up measurement using phased array ultrasonic testing (PAUT) indicated a minimum wall thickness of 0.150 inch.

3.2.1 On-Site Evaluation of Coupon 2

The concrete behind Coupon 2 was sound concrete with no cracks or delaminations. There was a 1/8-inch void between the steel and concrete identified. Table 3-2 contains the on-site concrete observations and test results.

Table 3-2 Coupon 2 On-Site Condition Assessment

		6/19/2018: 0930
CONCRETE SAMPLE SPECIFICS		
Sample ID	2	**2**
Sample Location	14-ER-E3-12-33-40	
Sample Dimensions	12” × 12”	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	1/8” void at upper left side. Otherwise no voids.	
Biological Materials	None	
Wet or Dry	Slightly damp	
Smell	Musty, no fuel	
Temperature	80.0	Degrees F
Surface pH	10-11 corroded area 11-12 non-corroded area	
Structure to Electrolyte	-0.380	Volts/CSE
Concrete Resistivity	19.0 Horizontal 17.5 Vertical	k-ohm-cm k-ohm-cm
General Condition	Good sound condition with some minor spalling and corrosion product. Coupon took some hammering to remove.	
Concrete behind Coupon 2		

Coupon 2 backside		

		Tue, 19 Jun 2018, 10:46 AM
COUPON SPECIFICS		
Coupon ID	2	**2**
Coupon Location	14-ER-E3-12-33-40	
Coupon Dimensions	12” × 12”	
Coupon Thickness	¼” (NDE: minimum 0.157”)	Prove-up: minimum 0.150”
Locations of Welds	None	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Interior
Deposits, Coatings, Debris	Lots of deposits and concrete	Regular coating
Scale	None	None
Observed Biological Material	None	None
Wet or Dry	damp	Dry
Smell	burnt, musty, muddy	Burnt but less intense than exterior
Presence of petroleum product between steel and concrete surface.	No	No
Presence of corrosion	Yes	Yes
Isolated pitting	Yes	Yes
Isolated pitting within areas of general corrosion	Yes	No
Linked pitting within areas of general corrosion	No	No
Identify color of corrosion products	Brown, black, gray	Brown
Identify if selected attack at welds	N/A	N/A

3.2.2 Destructive Testing Laboratory Evaluation of Coupon 2

- Detailed results of the Destructive Testing Laboratory analysis of Coupon 2 are contained in Appendix A.
- The thinnest measured location was 152.4 mils (3.87 mm).
- Assuming a nominal wall thickness of 250 mils, the remaining wall thickness at the thinnest location was 60.9%.

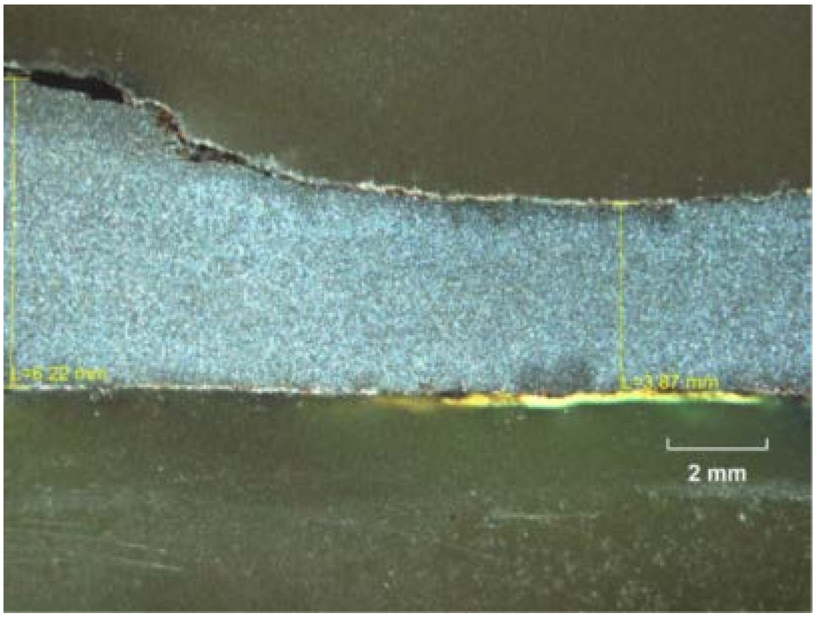


Figure 3-3 Cross Section of Coupon 2 at area of Maximum Wall Loss

3.3 Coupon 3

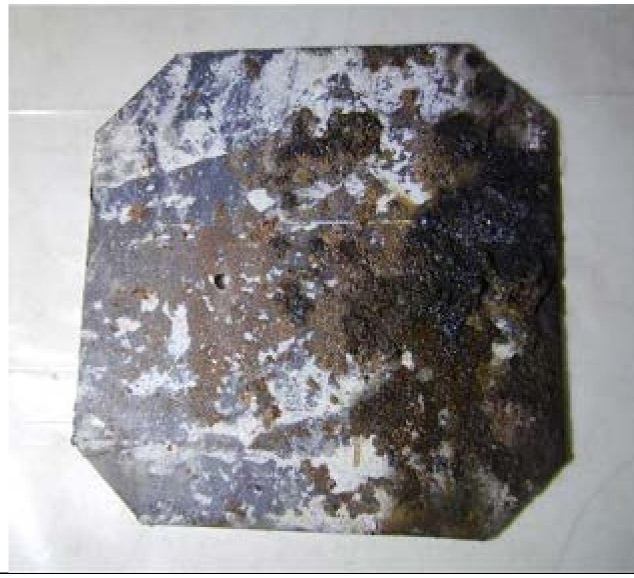
Coupon 3 was located in the extension ring at location 14-ER-E3-13-9-18. Prove-up measurement data was not available.

3.3.1 On-Site Evaluation of Coupon 3

The concrete behind Coupon 3 was sound concrete with no cracks or delaminations. Table 3-3 contains the on-site concrete observations and test results.

Table 3-3 Coupon 3 On-Site Condition Assessment

		6/19/2018: 14:00
CONCRETE SAMPLE SPECIFICS		
Sample ID	3	**3**
Sample Location	14-ER-E3-13-7-18	
Sample Dimensions	12” × 12”	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	On left side, uneven corrosion product and a 1/16-inch void. Otherwise, no voids.	
Biological Materials	None	
Wet or Dry	Mostly dry, with some damp spots	
Smell	None	
Temperature	79.3	F
Surface pH	11-12 dry areas, 7-8 in areas with corrosion product	
Structure to Electrolyte	-0.488	Volts/CSE
Concrete Resistivity	27.8 Horizontal 31.2 Vertical	K-Ohm-cm
General Condition	Good, with some corrosion products. Corrosion product was black on the left side, and brown in some other areas. Concrete was hard and difficult to drill for powder samples. Coupons required some hammering and prying to remove after cutting.	
Concrete behind Coupon 3		

Backside of Coupon 3		

		Tue, 19 Jun 2018, 3:00 PM
COUPON SPECIFICS		
Coupon ID	3	**3**
Coupon Location	14-ER-E3-13-9-18	
Coupon Dimensions	12" × 12"	
Coupon Thickness	¼" (NDE: minimum 0.033")	(No prove-up-phase thickness)
Locations of Welds	None	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Interior
Deposits, Coatings, Debris	Thick, brown, grey deposits	Standard coating with paint
Scale	None	None
Observed Biological Material	None	None
Wet or Dry	Wet	Dry
Smell	Burnt, like wax	None
Presence of petroleum product between steel and concrete surface	Yes	No
Presence of corrosion	Yes	Yes
Isolated pitting	Yes	Yes
Isolated pitting within areas of general corrosion	Yes	No
Linked pitting within areas of general corrosion	No	No
Identify color of corrosion products	White, brown	Brown
Identify if selected attack at welds	N/A	N/A

Coupon 3 exhibited backside corrosion that was not predicted. However, it must be noted that layout work to finalize sizing and location of a repair adjacent to Coupon 3 had not taken place prior to removal of the coupon. This corrosion was noted on the Spreadsheet that was reviewed by the Regulators, and one of the reasons why this coupon location was selected.

3.3.2 Destructive Testing Laboratory Evaluation of Coupon 3

- Detailed results of the Destructive Testing Laboratory analysis of Coupon 3 are contained in Appendix A.
- The thinnest measured location was 131.5 mils (3.34 mm).
- Assuming a nominal wall thickness of 250 mils, the remaining wall thickness at the thinnest location was 52.6%.
- A cross-section view of Coupon 3 is shown in Figure 3-4.

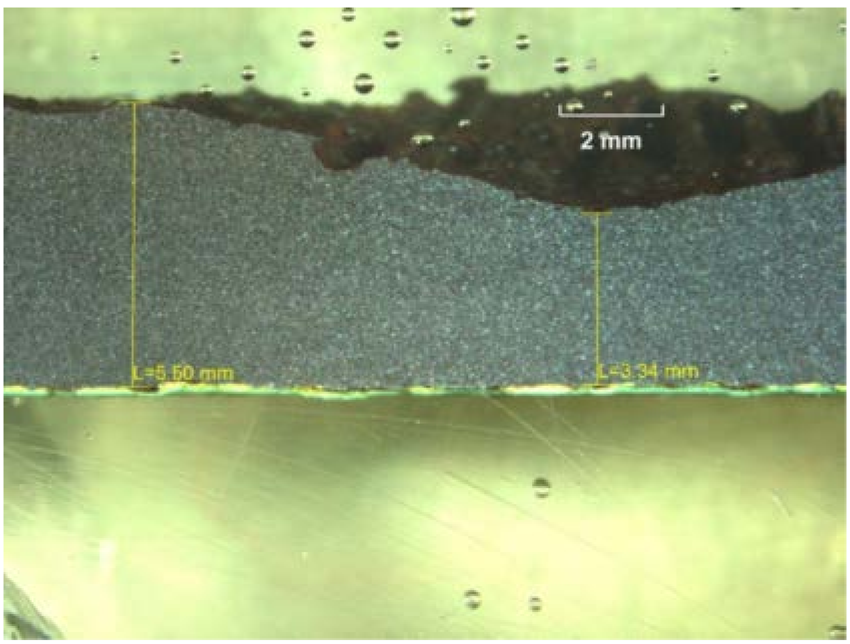


Figure 3-4 Cross Section of Coupon 3 at Area of Maximum Wall Loss

3.4 Coupon 5

Coupon 5 was located in barrel at location 14-BA-26-15-15-8. No significant backside corrosion was identified by LFET. A minimum wall thickness of 0.224 inch was indicated. Prove-up measurement data was not obtained because LFET wall thickness measurements were greater than 200 mils.

3.4.1 On-Site Evaluation of Coupon 5

The concrete behind Coupon 5 was sound concrete with no cracks or delaminations. A 1/16" void was observed on site. Table 3-4 contains the on-site concrete observations and test results.

Table 3-4 Coupon 5 On-Site Condition Assessment

		6/20/2018: 0800
CONCRETE SAMPLE SPECIFICS		
Sample ID	5	**5**
Sample Location	14-BA-26-15-15-8	
Sample Dimensions	12” × 12”	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	1/16” Void on top right side, no voids in all other areas	
Biological Materials	None	
Wet or Dry	Dry	
Smell	None	
Temperature	78.5	F
Surface pH	11-12	
Structure to Electrolyte	-0.220	Volts/CSE
Concrete Resistivity	19.1 Horizontal 22.0 Vertical	k-ohm-cm k-ohm-cm
General Condition	Excellent, sound concrete	
Concrete behind Coupon 5		

Backside of Coupon 5		

		Wed, 20 Jun 2018, 08:20 AM
COUPON SPECIFICS		
Coupon ID	5	**5**
Coupon Location	14-BA-26-15-15-8	
Coupon Dimensions	12” × 12”	
Coupon Thickness	¼” (NDE: minimum 0.047”)	(No prove-up-phase thickness)
Locations of Welds	None	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Interior
Deposits, Coatings, Debris	Concrete layer, thin	Standard coating
Scale	None	None
Observed Biological Material	None	None
Wet or Dry	Dry	Dry
Smell	Burnt	Burnt
Presence of petroleum product between steel and concrete surface	No	No
Presence of corrosion	Yes	No
Isolated pitting	No	No
Isolated pitting within areas of general corrosion	No	No
Linked pitting within areas of general corrosion	No	No
Identify color of corrosion products	Brown	N/A
Identify if selected attack at welds	N/A	N/A

3.3.3 Destructive Testing Laboratory Evaluation of Coupon 5

- Detailed results of the Destructive Testing Laboratory analysis of Coupon 5 are contained in Appendix A.
- The thinnest measured location was 224.0 mils (5.69 mm).
- Assuming a nominal wall thickness of 250 mils, the remaining wall thickness at the thinnest location was 89.6%.
- A cross-section view of Coupon 5 is shown in Figure 3-5.

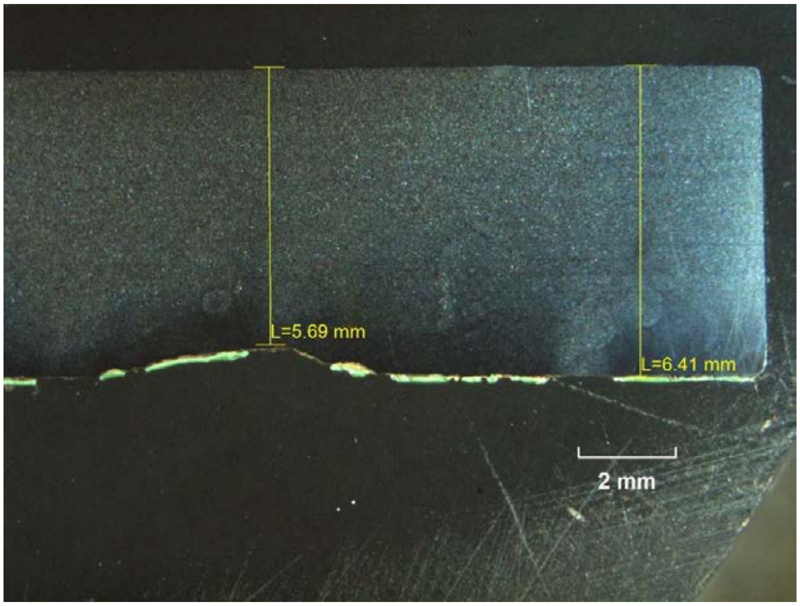


Figure 3-5 Cross Section of Coupon 5 at Area of Maximum Wall Loss

3.5 Coupon 6

Coupon 6 was located in barrel at location 14-BA-24-8-36-30. No significant backside corrosion was identified by LFET. Prove-up measurement data was not obtained because LFET wall thickness measurements were greater than 200 mils.

3.5.1 On-Site Evaluation of Coupon 6

The concrete behind Coupon 6 was sound concrete with no cracks or delaminations. Table 3-5 contains the on-site concrete observations and test results.

Table 3-5 Coupon 6 On-Site Condition Assessment

		6/21/2018: 1100
CONCRETE SAMPLE SPECIFICS		
Sample ID	6	**6**
Sample Location	14-BA-24-8-36-30	
Sample Dimensions	12” × 12”	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	None, however some loose adhering grout present	
Biological Materials	None	
Wet or Dry	Dry	
Smell	None	
Temperature	77.4	F
Surface pH	12.5	
Structure to Electrolyte	-0.387	Volts/CSE
Concrete Resistivity	Horizontal = 10.1 Vertical = 18.2	k-ohm-cm k-ohm-cm
General Condition	Concrete is sound, no delamination. There is loose adhering grout on left side and middle	
Concrete behind Coupon 6		

Backside of Coupon 6		

		Thu, 21 Jun 2018, 11:05 AM
COUPON SPECIFICS		
Coupon ID	6	**6**
Coupon Location	14-BA-24-8-36-30	
Coupon Dimensions	12” × 12”	
Coupon Thickness	¼” (NDE: No reported thickness; greater than 0.200”)	(No prove-up-phase thickness)
Locations of Welds	None	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Interior
Deposits, Coatings, Debris	Scrapes	Standard coating
Scale	Concrete	None
Observed Biological Material	None	None
Wet or Dry	Dry	Dry
Smell	Burnt	Burnt
Presence of petroleum product between steel and concrete surface	No	No
Presence of corrosion	Yes, small	Yes, tiny
Isolated pitting	No	No
Isolated pitting within areas of general corrosion	No	No
Linked pitting within areas of general corrosion	No	No
Identify color of corrosion products	Brown	Brown
Identify if selected attack at welds	N/A	N/A

3.5.2 Destructive Testing Laboratory Evaluation of Coupon 6

- Detailed results of the Destructive Testing Laboratory analysis of Coupon 6 are contained in Appendix A.
- The thinnest measured location was 157.9 mils (4.01 mm).
- Assuming a nominal wall thickness of 250 mils, the remaining wall thickness at the thinnest location was 63.1%.
- A cross-section view of Coupon 6 is shown in Figure 3-6.

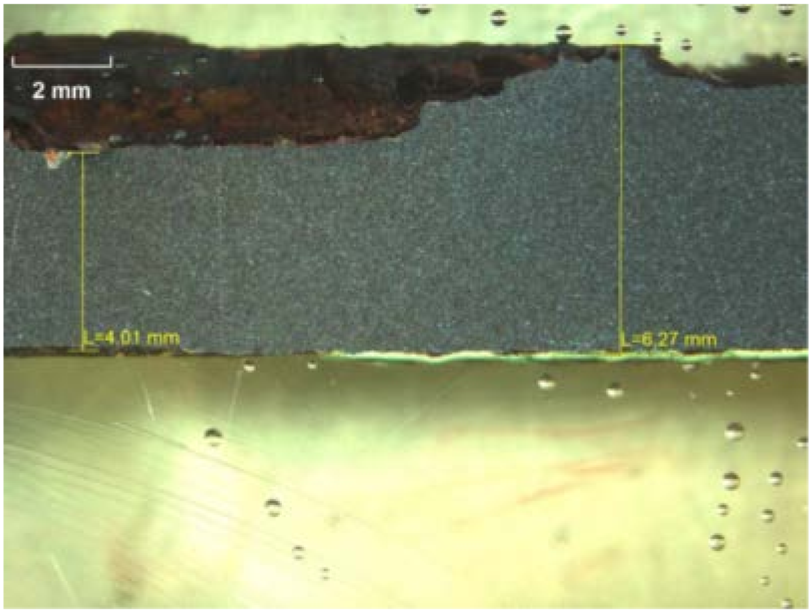


Figure 3-6 Cross Section of Coupon 6 at Area of Maximum Wall Loss

3.6 Coupon 7

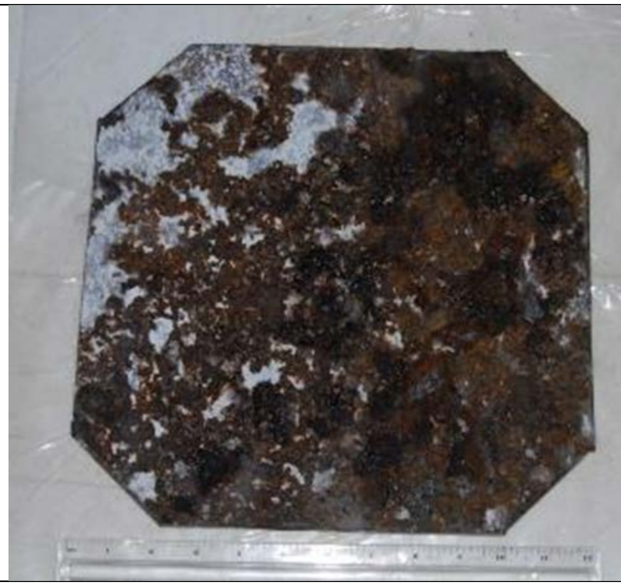
Coupon 7 was located in barrel at location 14-BA-23-7-38-49. Backside corrosion and pitting corrosion was identified by LFET. Prove-up measurement data indicated a minimum wall thickness of 0.135 inch.

3.6.1 On-Site Evaluation of Coupon 7

The concrete behind Coupon 7 was sound concrete with no cracks or delaminations. There was a 3/8" void between the concrete and steel on the left side and 1/16" void on the top right. Table 3-6 contains the on-site concrete observations and test results.

Table 3-6 Coupon 7 On-Site Condition Assessment

		6/21/2018: 1030
CONCRETE SAMPLE SPECIFICS		
Sample ID	7	**7**
Sample Location	14-BA-23-7-38-49	
Sample Dimensions	12” × 12”	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	3/8” void on left side. 1/16” void on top right otherwise no voids	
Biological Materials	None	
Wet or Dry		
Smell	none	
Temperature	77.5	F
Surface pH	9-10	
Structure to Electrolyte	-0.276	Volts/CSE
Concrete Resistivity	Horizontal = 39.3 Vertical = 42.4	k-ohm-cm k-ohm-cm
General Condition	Concrete is sound with no delamination or cracks. Some brown and black corrosion products on concrete	
Concrete behind Coupon 7		

Backside of Coupon 7		

		Thu, 21 Jun 2018, 10:35 AM
COUPON SPECIFICS		
Coupon ID	7	**7**
Coupon Location	14-BA-23-7-38-49	
Coupon Dimensions	12” × 12”	
Coupon Thickness	¼” (NDE: minimum 0.157”)	Prove-up: minimum 0.135”
Locations of Welds	None	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Interior
Deposits, Coatings, Debris	Lots of general corrosion	Standard coating
Scale	Yes, thick, varied	None
Observed Biological Material	None	None
Wet or Dry	Wet	Dry
Smell	Burnt, damp	Burnt
Presence of petroleum product between steel and concrete surface,	No	No
Presence of corrosion	Yes	Yes
Isolated pitting	Yes	No
Isolated pitting within areas of general corrosion	Yes	No
Linked pitting within areas of general corrosion	No	No
Identify color of corrosion products	Brown, black	Brown
Identify if selected attack at welds	N/A	N/A

3.6.2 Destructive Testing Laboratory Evaluation of Coupon 7

- Detailed results of the Destructive Testing Laboratory analysis of Coupon 7 are contained in Appendix A.
- The thinnest measured location was 163.8 mils (4.16 mm).
- Assuming a nominal wall thickness of 250 mils, the remaining wall thickness at the thinnest location was 66.5%.
- A cross-section view of Coupon 7 is shown in Figure 3-7.

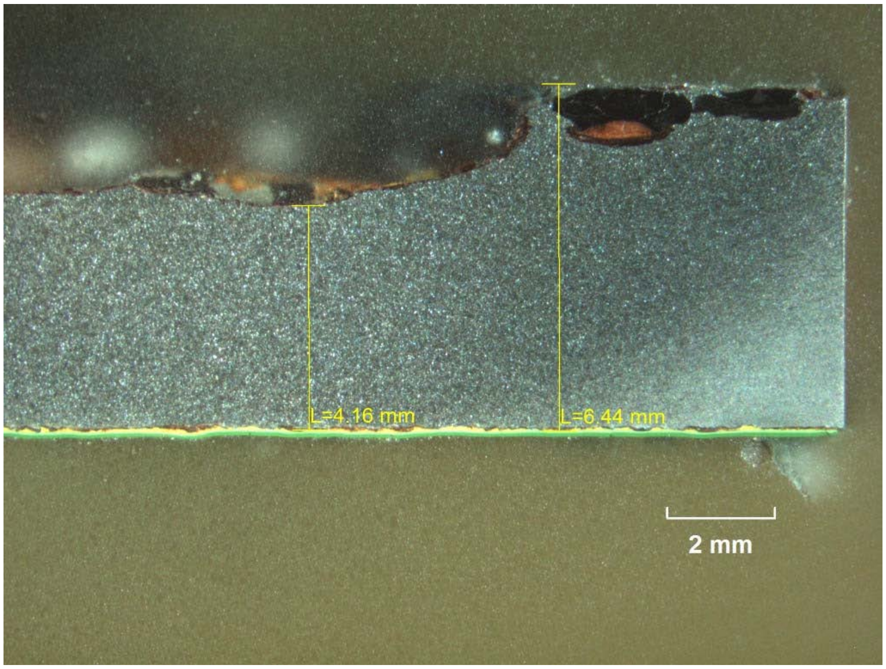


Figure 3-7 Cross Section of Coupon 7 at Area of Maximum Wall Loss

3.7 Coupon 8

Coupon 8 was located in barrel at location 14-BA-20-13-236-43. Backside corrosion was not identified by prove-up PAUT. (Remaining wall thickness greater than 0.200 inch)

3.7.1 On-site Evaluation of Coupon 8

The concrete behind Coupon 8 was sound concrete with no cracks or delaminations. There was a 1/16 inch void between the concrete and steel on the left side. Table 3-7 contains the on-site concrete observations and test results.

Table 3-7 Coupon 8 On-Site Condition Assessment

		6/20/2018: 1400
CONCRETE SAMPLE SPECIFICS		
Sample ID	8	**8**
Sample Location	14-BA-20-13-236-43	
Sample Dimensions	12” × 12”	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	1/16” Void on left side, no voids in all other areas	
Biological Materials	None	
Wet or Dry	Dry	
Smell	None	
Temperature	80.0	F
Surface pH	11-12	
Structure to Electrolyte	-0.248	Volts/CSE
Concrete Resistivity	30.9 Horizontal 27.5 Vertical	k-ohm-cm k-ohm-cm
General Condition	Excellent, sound concrete with no cracks or delamination. Coupon had steel backing plate	
Concrete behind Coupon 8		
Backside of Coupon 8		

		Wed, 20 Jun 2018, 09:40 AM
COUPON SPECIFICS		
Coupon ID	8	**8**
Coupon Location	14-BA-20-13-236-43	
Coupon Dimensions	12” × 12”	
Coupon Thickness	¼” (NDE: minimum 0.069”)	Prove-up: minimum 0.200”
Locations of Welds	About 2” from right edge of front face (exterior face)	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Interior
Deposits, Coatings, Debris	White coating	Standard coating with pink, white paint
Scale	None	None
Observed Biological Material	None	None
Wet or Dry	Dry	Dry
Smell	Burnt metal	Fuel-like
Presence of petroleum product between steel and concrete surface	No	No
Presence of corrosion	Yes	No
Isolated pitting	Yes (Pit 1: 5” from left, 2” from top) (Pit 2: 7” from left, 5” from top)	No
Isolated pitting within areas of general corrosion	Yes	No
Linked pitting within areas of general corrosion	No	No
Identify color of corrosion products	Brown	No
Identify if selected attack at welds	Yes	N/A

3.7.2 Destructive Testing Laboratory Evaluation of Coupon 8

- Detailed results of the Destructive Testing Laboratory analysis of Coupon 8 are contained in Appendix A.
- The thinnest measured location was 205.9 mils (5.23 mm).
- Assuming a nominal wall thickness of 250 mils, the remaining wall thickness at the thinnest location was 82.4%.
- A cross-section view of Coupon 8 is shown in Figure 3-8.

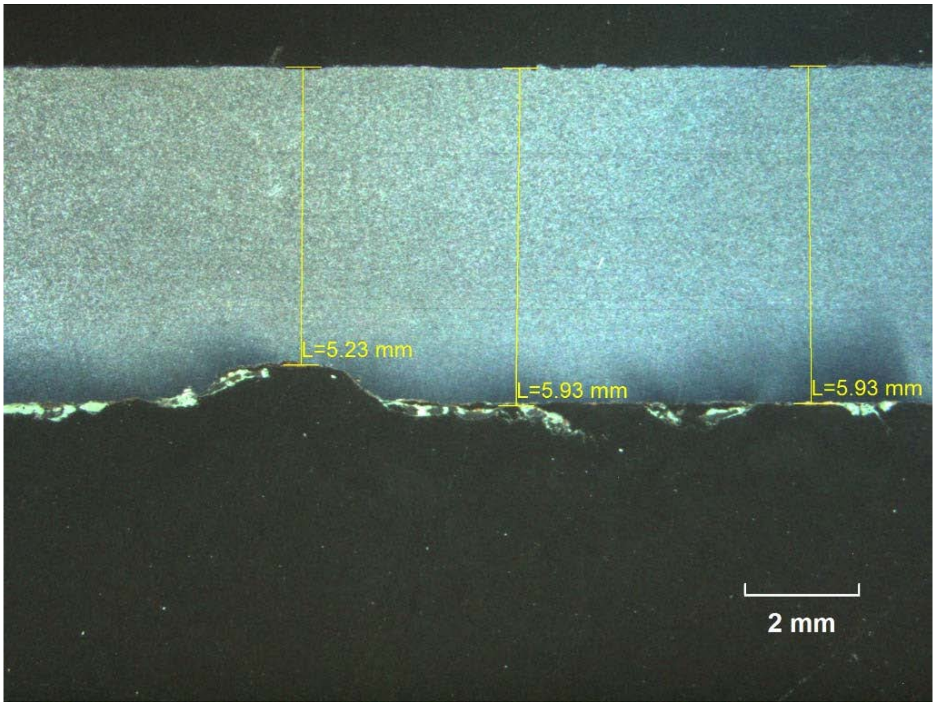


Figure 3-8 Cross Section of Coupon 8 at Area of Maximum Wall Loss

3.8 Coupon 10

Coupon 10 was located in lower dome at location 14-LD-3-9-24-215. Backside corrosion was not identified by LFET. (Remaining wall thickness greater than 0.200 inch)

3.8.1 On-site Evaluation of Coupon 10

The concrete behind Coupon 10 was sound concrete with no cracks or delaminations. There was a 1/16 inch void between the concrete and steel on the left side. Table 3-8 contains the on-site concrete observations and test results.

Table 3-8 Coupon 10 On-Site Condition Assessment

<table>
<tr><td colspan="3" align="right">6/21/2018: 0930</td></tr>
<tr><td colspan="3" align="center">CONCRETE SAMPLE SPECIFICS</td></tr>
<tr><td>Sample ID</td><td>10</td><td rowspan="3">10</td></tr>
<tr><td>Sample Location</td><td>14-LD-3-9-24-215</td></tr>
<tr><td>Sample Dimensions</td><td>12” × 12”</td></tr>
<tr><td colspan="3" align="center">ON SITE VISUAL EXAMINATION</td></tr>
<tr><td rowspan="2">Checks</td><td colspan="2">Observations</td></tr>
<tr><td>Exterior</td><td>Units</td></tr>
<tr><td>Void space between concrete and liner (if any)</td><td>None</td><td></td></tr>
<tr><td>Biological Materials</td><td>None</td><td></td></tr>
<tr><td>Wet or Dry</td><td>Dry</td><td></td></tr>
<tr><td>Smell</td><td>like coal tar</td><td></td></tr>
<tr><td>Temperature</td><td>77.6</td><td>F</td></tr>
<tr><td>Surface pH</td><td>12-12.5</td><td></td></tr>
<tr><td>Structure to Electrolyte</td><td>-0.181</td><td>Volts/CSE</td></tr>
<tr><td>Concrete Resistivity</td><td>27.3 Horizontal
38.1 Vertical</td><td>k-ohm-cm
k-ohm-cm</td></tr>
<tr><td>General Condition</td><td>Excellent, sound concrete with no cracks or delamination. Coupon had to be cut into two pieces to remove. What appears to be coal tar coating present on backside of coupon and concrete.</td><td></td></tr>
<tr><td>Concrete behind Coupon 10</td><td></td><td></td></tr>
</table>

Backside of Coupon 10		

		Thu, 21 Jun 2018, 10:30 AM
COUPON SPECIFICS		
Coupon ID	10	**10**
Coupon Location	14-LD-3-9-24-215	
Coupon Dimensions	12” × 12”	
Coupon Thickness	¼” (NDE: minimum 0.198”)	Prove-up: minimum 0.200”
Locations of Welds	None	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Interior
Deposits, Coatings, Debris	Coal-tar-like	Lots of surface debris
Scale	None	None
Observed Biological Material	None	None
Wet or Dry	Wet	Dry
Smell	Coal-tar-like	None
Presence of petroleum product between steel and concrete surface	No	No
Presence of corrosion	Yes (small)	Yes
Isolated pitting	No	Yes
Isolated pitting within areas of general corrosion	No	No
Linked pitting within areas of general corrosion	No	No
Identify color of corrosion products	Brown	Brown
Identify if selected attack at welds	N/A	N/A

3.8.2 Destructive Testing Laboratory Evaluation of Coupon 10

- Detailed results of the Destructive Testing Laboratory analysis of Coupon 10 are contained in Appendix A.
- The thinnest measured location was 241.7 mils (6.14 mm).
- Assuming a nominal wall thickness of 250 mils, the remaining wall thickness at the thinnest location was 96.7%.
- A cross-section view of Coupon 10 is shown in Figure 3-9.

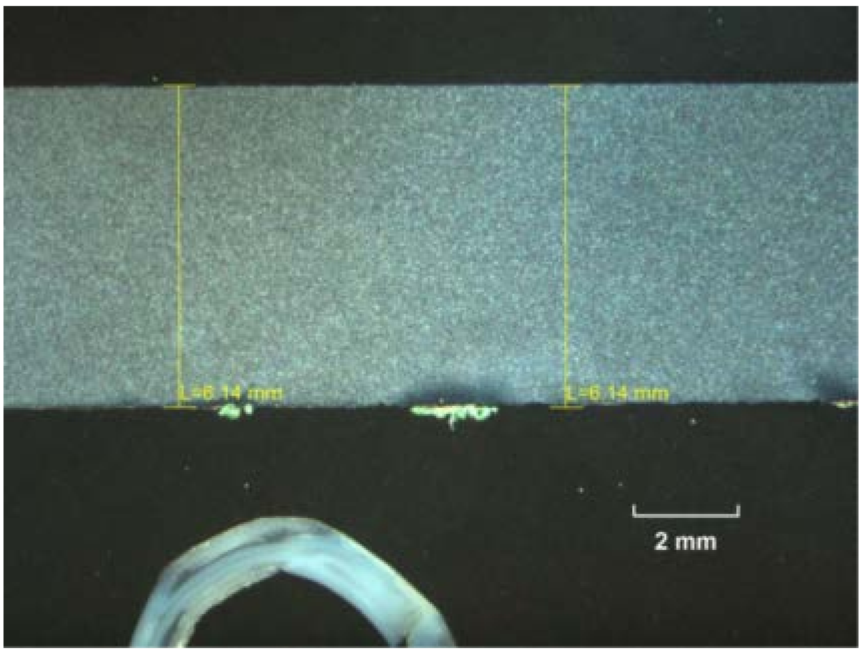


Figure 3-9 Cross Section of Coupon 10 at Area of Maximum Wall Loss

3.9 Coupon A1

Coupon A1 was located in the barrel at location 14-BA-23-9-95-50. Backside corrosion was identified by LFET with minimum remaining wall thickness less than 0.160 inch.

3.9.1 On-site Evaluation of Coupon A1

The concrete behind Coupon A1 was sound concrete with no cracks or delaminations. There was a 1/8 inch void between the concrete and steel on the left side. Table 3-9 contains the on-site concrete observations and test results.

Table 3-9 Coupon A1 On-Site Condition Assessment

		6/20/2018: 1100
CONCRETE SAMPLE SPECIFICS		
Sample ID	A1	**A1**
Sample Location	14-BA-23-9-95-50	
Sample Dimensions	12” × 12”	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	1/8” Void on left side, no voids in all other areas	
Biological Materials	None	
Wet or Dry	Mostly dry with damp areas around corrosion product	
Smell	None	
Temperature	77.5	Degrees F
Surface pH	11-12 in dry areas, 7-8 in corroded area	
Structure to Electrolyte	-0.448 (dry area) -0.432 (damp area w. corrosion products)	Volts/CSE
Concrete Resistivity	32.9 Horizontal 37.0 Vertical	k-ohm-cm
General Condition	Good condition with sound concrete, no cracks or delamination. Corrosion products are present on concrete.	
Concrete behind Coupon A1		

Backside of Coupon A1		

		Wed, 20 Jun 2018, 10:55 AM
COUPON SPECIFICS		
Coupon ID	A1	**A1**
Coupon Location	14-BA-23-9-95-50	
Coupon Dimensions	12” × 12”	
Coupon Thickness	¼” (NDE: minimum 0.134”)	(no prove-up-phase thickness)
Locations of Welds	None	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Interior
Deposits, Coatings, Debris	Abundant corrosion product	Standard coating
Scale	None	None
Observed Biological Material	None	None
Wet or Dry	Dry	Dry
Smell	Burnt, musty	Burnt
Presence of petroleum product between steel and concrete surface, and on or above the leg of the angle backer bar embedded in the concrete	No	No
Presence of corrosion	Yes	Yes
Isolated pitting	Yes (Pit: 7.5” from left, 2.5” from top)	No
Isolated pitting within areas of general corrosion	Yes	No
Linked pitting within areas of general corrosion	Yes	No
Identify color of corrosion products	Dark brown	Brown
Identify if selected attack at welds	Yes	N/A

3.9.2 Destructive Testing Laboratory Evaluation of Coupon A1

- Detailed results of the Destructive Testing Laboratory analysis of Coupon A1 are contained in Appendix A.
- The thinnest measured location 122.4 mils (3.11 mm).
- Assuming a nominal wall thickness of 250 mils, the remaining wall thickness at the thinnest location was 48.5%.
- A cross-section view of Coupon A1 is shown in Figure 3-10.

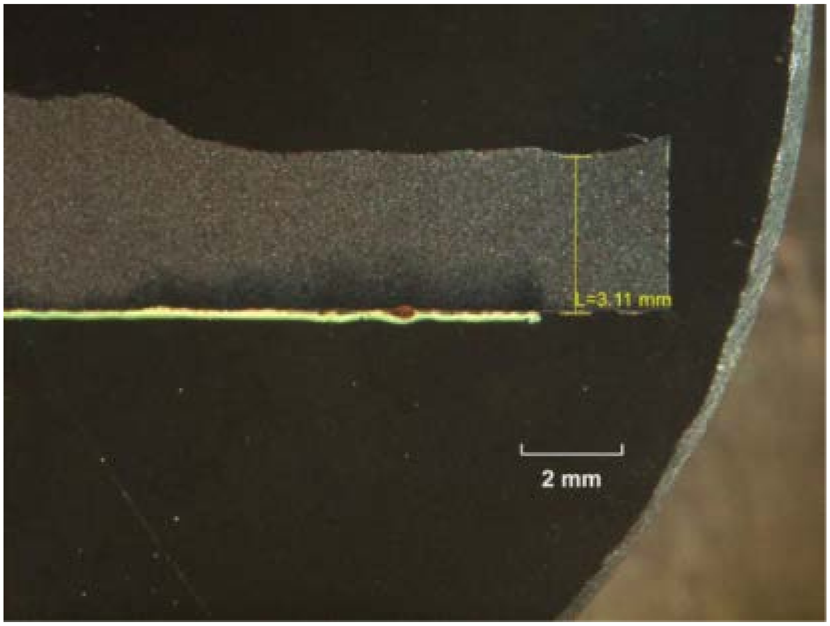


Figure 3-10 Cross Section of Coupon A1 at Area of Maximum Wall Loss

3.10 Coupon A2

Coupon A2 was located in the barrel at location 14-BA-11-4-226-50. Backside corrosion was not identified by LFET with minimum remaining wall thickness greater than 0.200 inch.

3.10.1 On-site Evaluation at Coupon A2

The concrete behind Coupon A2 was sound concrete with no cracks or delaminations. Table 3-10 contains the on-site concrete observations and test results.

Table 3-10 Coupon A2 On-Site Condition Assessment

		6/20/2018: 1530
CONCRETE SAMPLE SPECIFICS		
Sample ID	A2	**A2**
Sample Location	14-BA-11-4-226-50	
Sample Dimensions	12” × 12”	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	1/2” Void on left and bottom side. ¼”void on the right side	
Biological Materials	None	
Wet or Dry	Dry	
Smell	None	
Temperature	78.4	Degrees F
Surface pH	11-12	
Structure to Electrolyte	-0.226 (middle) -0.230 (right side)	Volts/CSE
Concrete Resistivity	35.8 Horizontal 36.1 Vertical	k-ohm-cm
General Condition	Good condition with sound concrete, no cracks or delamination. There is a layer of concrete that appears to have come off. Below that layer is sound concrete.	
Concrete behind Coupon A2		

Backside of Coupon A2		

		Thu, 21 Jun 2018, 10:30 PM
COUPON SPECIFICS		
Coupon ID	A2	**A2**
Coupon Location	14-BA-11-4-226-50	
Coupon Dimensions	12” × 12”	
Coupon Thickness	¼” (NDE: minimum 0.161”)	(no prove-up-phase thickness)
Locations of Welds	None	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Interior
Deposits, Coatings, Debris	Thin concrete film on 50% of surface	Standard coating
Scale	None	None
Observed Biological Material	None	None
Wet or Dry	Dry	Dry
Smell	None	None
Presence of petroleum product between steel and concrete surface	No	No
Presence of corrosion	Yes, general	No
Isolated pitting	No	No
Isolated pitting within areas of general corrosion	No	No
Linked pitting within areas of general corrosion	No	No
Identify color of corrosion products	Brown	N/A
Identify if selected attack at welds	N/A	N/A

3.10.3 Destructive Testing Laboratory Evaluation of Coupon A2

- Detailed results of the Destructive Testing Laboratory analysis of Coupon A2 are contained in Appendix A.
- The thinnest measured location was 247.6 mils (6.29 mm).
- Assuming a nominal wall thickness of 250 mils, the remaining wall thickness at the thinnest location was 97.5%.
- A cross-section view of Coupon A2 is shown in Figure 3-11.

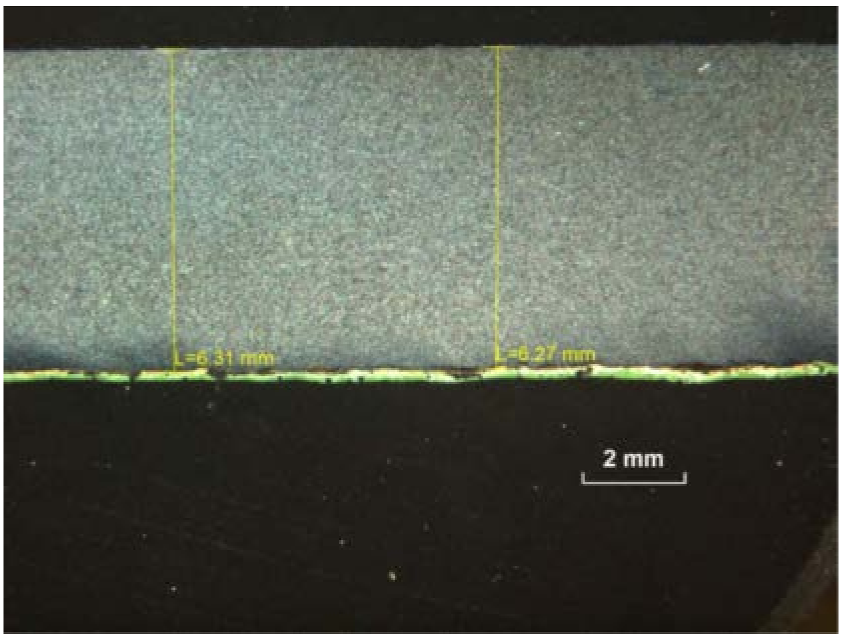


Figure 3-11 Cross Section of Coupon A2 at Area of Maximum Wall Loss

3.11 Metallurgical Characterization of Steel Coupons

3.11.1 Chemical Composition

Optical emission spectroscopy was performed on the steel coupons by the laboratory. The steel chemical composition was consistent for the ten coupons. All but one coupon met the chemical composition requirements stated in ASTM A36 "Standard Specification for Carbon Structural Steel". Coupon 10 had 0.010 weight percent more sulfur than what is allowed by the specification. This is an insignificant deviation especially since ASTM A36 was established in 1960 after Red Hill was built.

3.11.2 Mechanical Properties

The Laboratory performed tensile testing on tensile specimens cut from all ten coupons.

Tensile strength values were consistent and ranged from 61,500 psi to 68,500 psi.

Yield strength values ranged from 38,900 psi to 46,300 psi. Percent elongation ranged from 23 percent to 36 percent elongation. These values meet the mechanical property requirements stated in ASTM A36.

3.12 Characterization of Concrete from Field Test and Powder Samples Analysis

3.12.1 Concrete Field Testing

Table 3-11 summarizes the concrete field-testing data.

Table 3-11 Summary of Concrete Field Testing

Coupon	pH	Structure-to-electrolyte potential (volts vs. copper/copper-sulfate electrode)	Resistivity (kΩ-cm)
Coupon 1	9–9.5	-0.252	26.4
Coupon 2	10-12	-0.380	17.5
Coupon 3	11-12, 7-8 corroded area	-0.488	27.8
Coupon 5	11-12	-0.220	19.1
Coupon 6	12.5	-0.387	10.1
Coupon 7	9-10	-0.276	39.3
Coupon 8	11-12	-0.248	27.5
Coupon 10	12-12.5	-0.181	27.3
Coupon A1	11-12, 7-8 corroded area	-0.448	32.9
Coupon A2	11-12	-0.230	35.8

Surface contamination, especially in locations with corrosion products, may have contributed to lower pH values.

Structure-to-electrolyte (S/E) potential testing was done using a high-impedance voltmeter and a copper/copper-sulfate electrode (CSE). Values ranged from passive to active. Note that these potentials do not indicate that corrosion is occurring in the active areas, only that there is the potential for corrosion.

The potentials can approximately be interpreted as follows:

- More positive than -0.20 volts: Passive
- -0.20 to -0.35 volts: Active or passive
- More negative than -0.35 volts: Active

Resistivity values of the concrete are in the expected range for sound concrete.

3.12.2 Laboratory Concrete Powder Sample Analysis

Laboratory measured values of concrete pH measured from concrete powder extracted from the concrete behind each coupon ranged from 9.86 to 11.79. Some surface contamination, especially in powder specimens with corrosion products, may have given lower than actual pH values. However, all specimens tested in the alkaline range, with a pH of 7 or higher.

Chloride content of the powder samples ranges from 50 ppm (0.005 weight percent) in Coupon 3 to 171 ppm (0.017 weight percent) in Coupon 8. The average chloride content was 80 ppm (0.008 weight percent). NACE SP0308-2008 “Standard Practice Inspection Methods for Corrosion Evaluation of Conventionally Reinforced Concrete Structures” states that the generally applicable threshold for chloride-induced corrosion of steel in concrete is 0.2 weight percent. Measured chloride levels at the ten coupon sites are well below this threshold.

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4.0 CORRELATION OF NDE EXPECTED OUTCOME WITH DESTRUCTIVE TESTING DATA AND FIELD OBSERVATIONS

Table 4-1 summarizes the correlation between the NDE expected outcomes and the results of the visual inspection of the backside of the coupons.

Table 4-1 NDE Expected Outcome Compared to Visual Inspection of Coupons

Coupon #	Expected Features from NDE	Actual Features from Visual Inspection
1	One or more backside-corrosion (BC) pits in central part of coupon	Corrosion on many parts of coupon, mostly on right half. Pitting present
2	One or more BC pits in most of top half of coupon	Corrosion mostly concentrated in a 2" horizontal band. Pitting present. Portions adhered to concrete.
3	Horizontal plate manufacturing flaw† running through middle of coupon, but no backside corrosion	Visible backside corrosion scattered throughout coupon. Pitting present.
5	Horizontal laminar-type manufacturing flaw† all over coupon, but no BC pits expected	Slight corrosion on several isolated parts of coupon surface. Most of coupon was adhered to concrete.
6	No indications, including BC pits thinner than 200 mils, expected	Slight corrosion on several isolated parts of coupon surface. Most of coupon was adhered to concrete. Pitting present.
7	One or more BC pits expected throughout coupon	Thick corrosion product on about 90% of coupon. Pitting present
8	At center, an inclusion, or an original manufacturing flaw†, expected, with a minimum thickness of 69 mils	Slight corrosion on about 40% of coupon surface. Pitting present
10	No indications, including BC pits thinner than 200 mils, expected. If any BC is present, it would be general metal loss	No significant metal loss found. Black surface throughout coupon area.
A1	One or more BC pits expected throughout whole coupon, except for left-most 1"	Concrete adhesion on top 2/3 of coupon; concrete on about 60% of bottom 1/3 of coupon. Pitting present
A2	At center, a thickness greater than 160 mils expected, otherwise, no indications. If any BC is present, it would be general metal loss	On most of coupon, from 1" from the top all the way down, slight corrosion scattered throughout surface, with concrete adhesion as well.
† Manufacturing or lamination flaw not be expected to be observed on the surface of the metal		

4.1 Coupon 1

The LFET minimum screening thickness found was 0.112 inch. Therefore, a repair was specified in this area. Backside pitting corrosion expected. Later prove-up with PAUT indicated an expected minimum remaining wall thickness of 0.112 inch.

Destructive testing found pitting and minimum wall thickness of 0.208 inch. Remaining wall thickness greater than expected (208 mils vs. 112 mils). This deviation exceeded the 20 mils accuracy range for pitting.

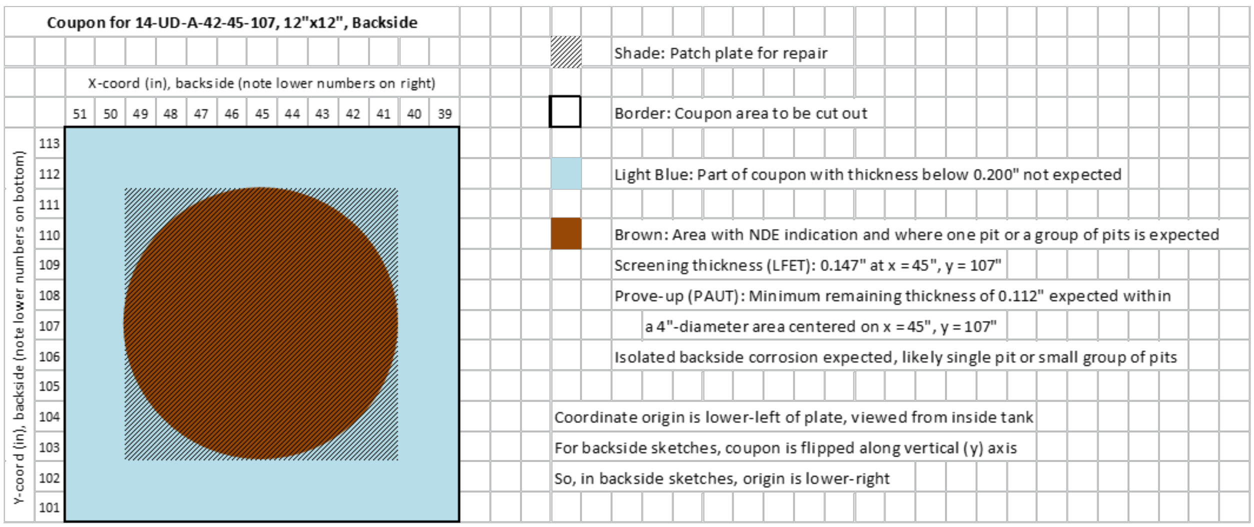

Figure 4-1 Expected Results from NDE Spreadsheet Data, Coupon 1

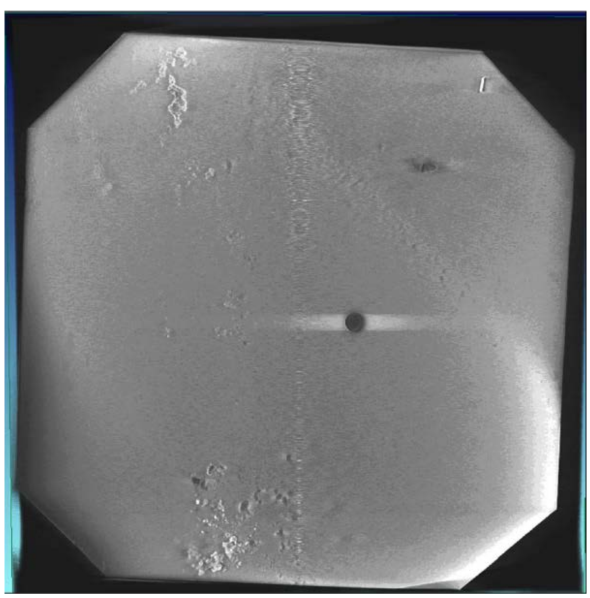

Figure 4-2 CT Scan Image from Destructive Testing Lab Report, Coupon 1

4.2 Coupon 2

The LFET minimum screening thickness found was 0.157 inch. Therefore, a repair was specified in this area. Backside pitting corrosion expected. Later prove-up with PAUT indicated an expected minimum remaining wall thickness of 0.150 inch.

Destructive testing found pitting and minimum wall thickness of 0.152 inch.
Remaining wall thickness as expected (152 mils vs. 150 mils). The LFET result fell within the 20 mils accuracy range for pitting.

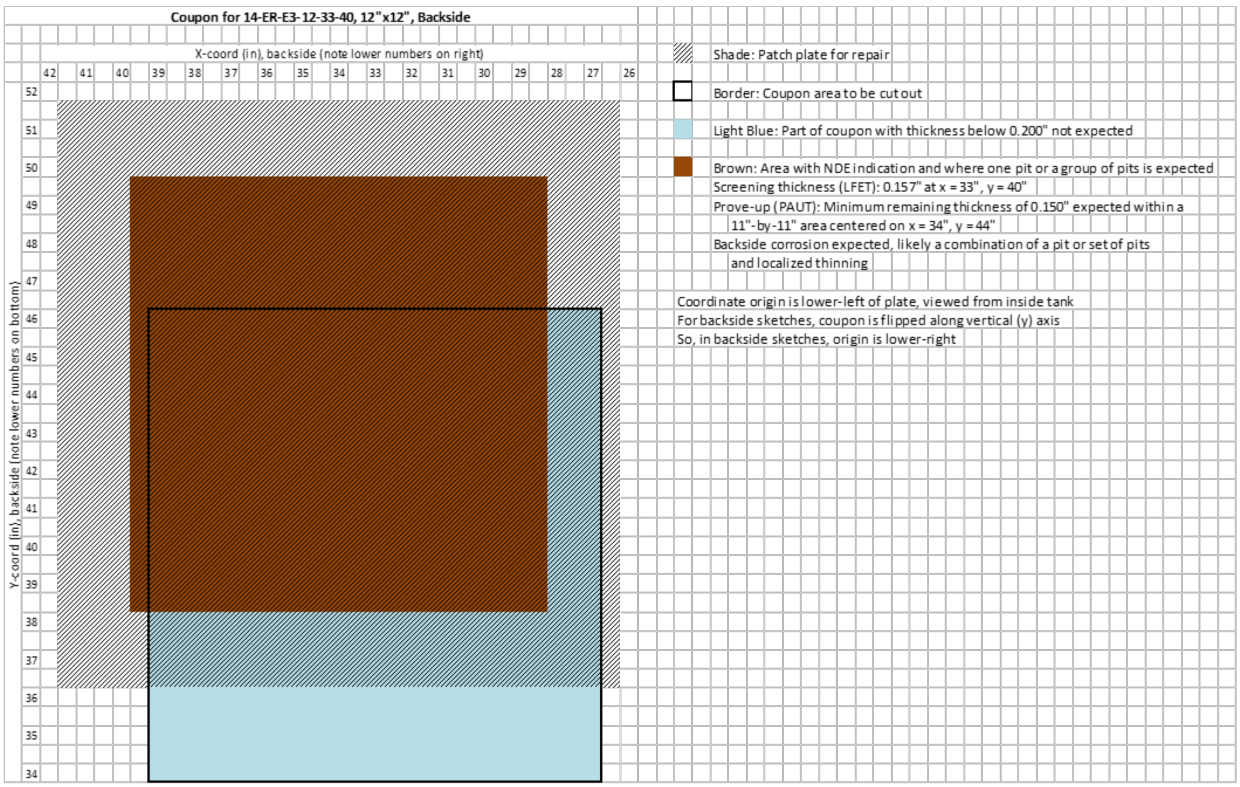

Figure 4-3 Expected Results from NDE Spreadsheet Data, Coupon 2

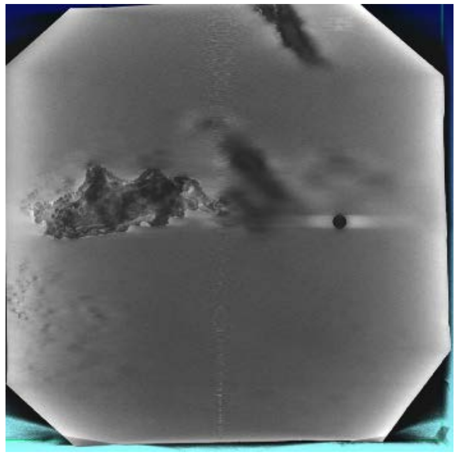

Figure 4-4 CT Scan Image from Destructive Testing Lab Report, Coupon 2

4.3 Coupon 3

The LFET minimum screening thickness was 0.033 inch. During the PAUT prove-up, the 33-mil thickness was identified not to be metal loss but instead was a non-actionable lamination. Therefore, a repair was not initially specified in this area. Backside corrosion was not expected.

Destructive testing found pitting and minimum wall thickness of 0.132 inch. The remaining wall thickness, 132 mils, was less than expected (greater than 200 mils). The LFET value did not fall within the 20-mil accuracy range for pitting.

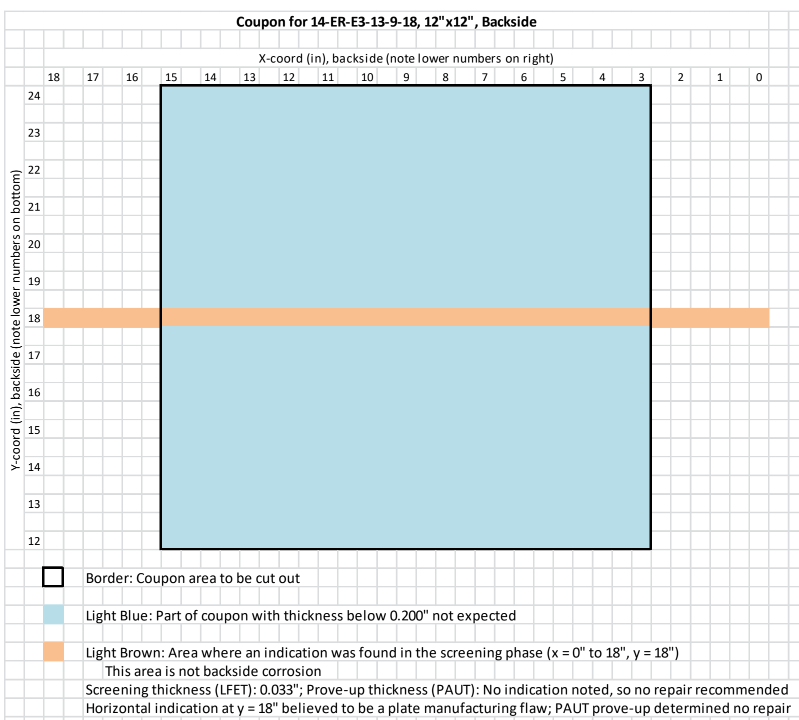

Figure 4-5 Expected Results from NDE Spreadsheet Data, Coupon 3

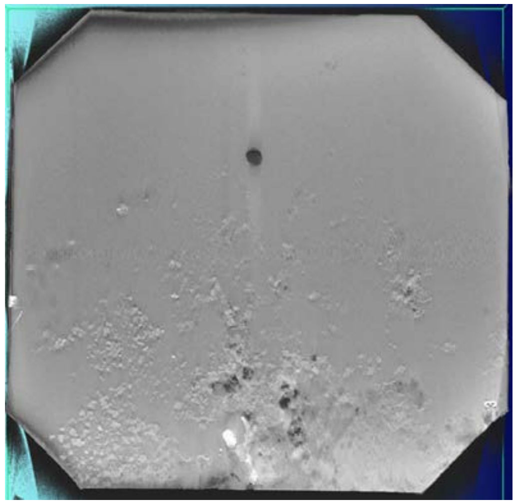

Figure 4-6 CT Scan Image from Destructive Testing Lab Report, Coupon 3

Tank 14 Coupon 3 was located at Indication 14-ER-E3-13-9-18 (here referred to as Indication A). It was selected because the area of the nearby repair at 14-ER-E3-13-7-5-2 (here, Indication B) appeared to miss Indication A.

During the tank-scan phase of the inspection, an LFET indication was noted at Indication A with a remaining thickness of 33 mils. The technician marked a boot-shaped area (Figure 4-7), noted the indication in the database, and left the location for the prove-up phase.

The PAUT technician was unable to locate the 33-mil indication at Indication A. However, during prove-up, PAUT identified an indication within the LFET marking that was actionable and noted it in the database as a repair at Indication B. Instead of entering a new line in the database for Indication B, the technician entered the repair on the same line as Indication A, which was not proved up, as shown in Figure 4-7). The PAUT technician did not continue to search for actionable indications because once a repair had been identified the depth of adjacent indications at the same site was irrelevant.

There is another action required prior to repair at Indication B. In preparation for the repair, the contractor is required to perform UT to ensure adequate thickness exists that is compliant with API Standard (Std) 653, paragraph 9.3.1.9. This step lays out each repair, marks it on the tank shell, and finalizes the size and location of each repair. Due to geometry and API Std 653 compliance, it is normal for some repairs to change in size and center coordinates. At the time that the indications database was provided in February 2018 to the regulators for the destructive testing plan, the layout of repairs in Tank 14 had not started. The fact that the layout of the repairs in Tank 14 had not been performed was stated to the AOC stakeholders on 2 March 2018 when the indications database was delivered and at the 12 March 2018 meeting. Both times it was stated the repair information in the database was draft because work was ongoing.

When NAVFAC issued the RFP to remove ten coupons on 20 March 2018, the specific locations became known to the contractor. Instructions were given to the contractor to refrain from proving up the coupon sites in order to preserve the integrity of the destructive testing plan. The contractor was prevented from finishing the NDE process by being unable to layout the repair at Indication B. Instead of performing a layout at Indication B, the contractor was asked to layout repairs for Coupon 3 (Indication A). Figure 4-8 depicts the location after the coupon was removed.

The two-step NDE process worked. In the first step LFET identified there were indications at Coupon 3 site and marked a general area where there was actionable corrosion. In the second step, PAUT identified a repair. The Government stopped the repair layout because of the destructive testing plan to remove a coupon from the site.

Laboratory results from Coupon 3 showed an area of remaining thickness of 131 mils, which is actionable. This thickness is within the layout area of Indication B.

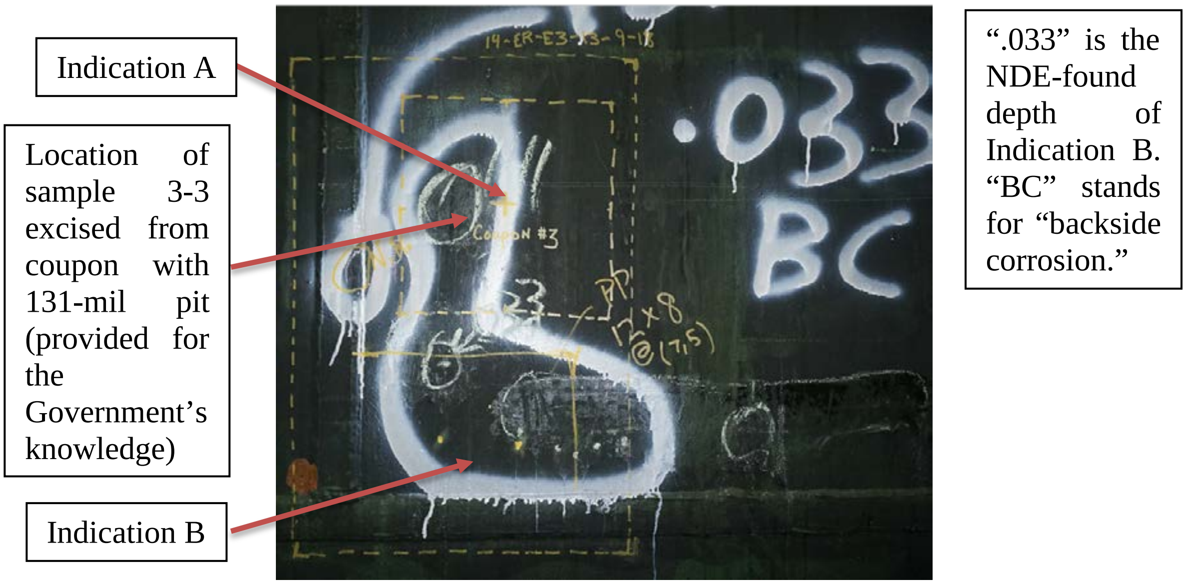

Figure 4-7 Location of Coupon 3 Prior to Removal

Inner square indicates boundary of Coupon 3. Outer rectangle indicates boundary of patch plate for repair.

Figure 4-8 Location of Coupon 3 after Removal

4.4 Coupon 5

The LFET minimum screening thickness was 0.047 inch. A prove-up thickness greater than 0.160 inch was expected. Therefore, a repair was not specified in this area. A flaw, not backside corrosion, was expected.

Destructive testing found pitting and minimum wall thickness of 0.224 inch. The remaining wall thickness was as expected.

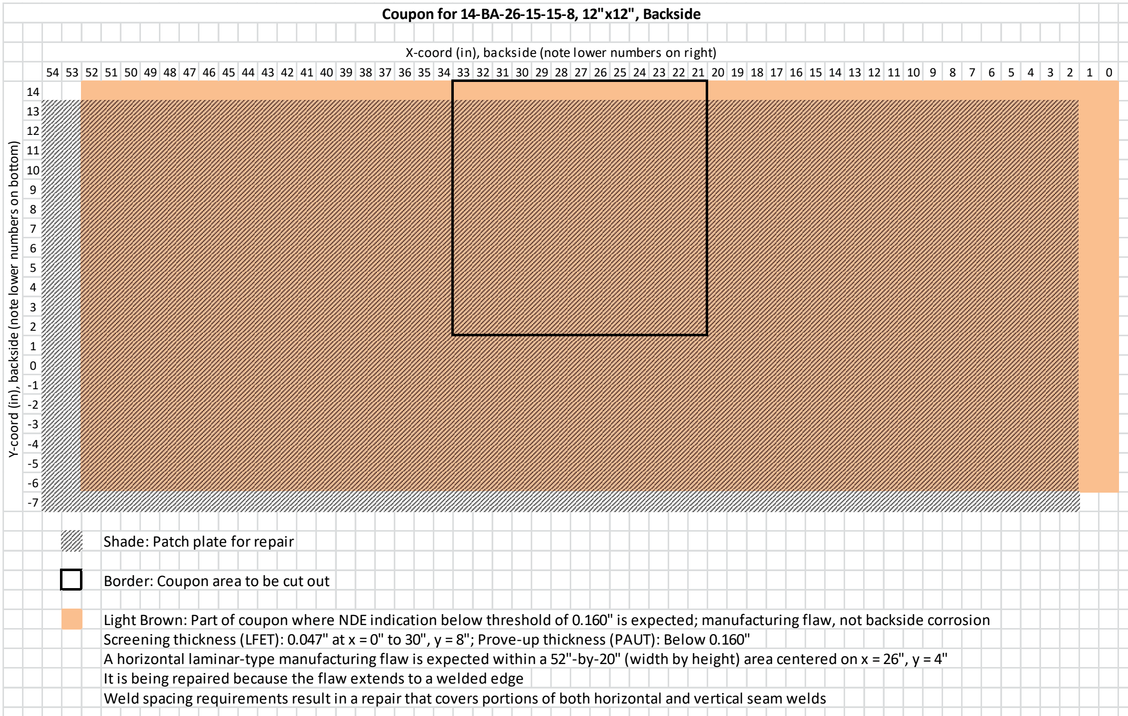

Figure 4-9 Expected Results from NDE Spreadsheet Data, Coupon 5

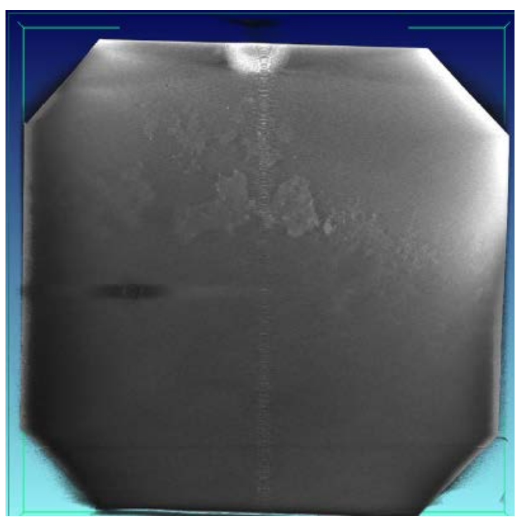

Figure 4-10 CT Scan Image from Destructive Testing Lab Report, Coupon 5

4.5 Coupon 6

The LFET screening found no indications. Therefore, a repair was not specified in this area.

Destructive testing found pitting and minimum wall thickness of 0.158 inch. The remaining wall thickness was thinner than expected in the isolated pit.

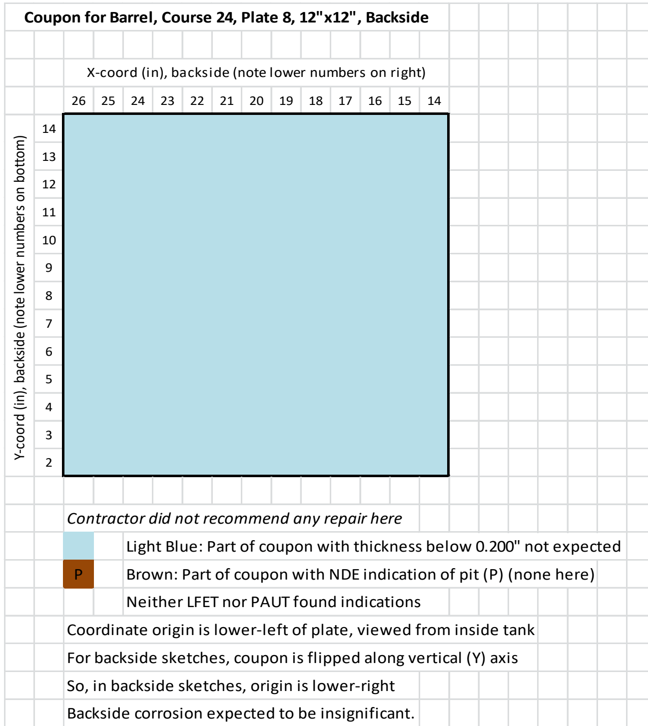

Figure 4-11 Expected Results from NDE Spreadsheet Data, Coupon 6

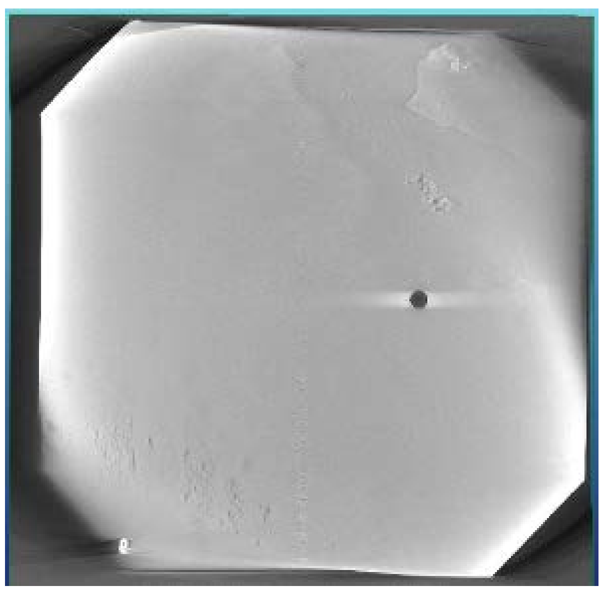

Figure 4-12 CT Scan Image from Destructive Testing Lab Report, Coupon 6

LFET does not always detect metal loss of very small volume with narrow and non-uniform characteristics. The likelihood this single small pit, smaller than what the equipment could detect with more than 64% metal thickness remaining after 75 years in service, would form into a thru-hole before the next inspection, is extremely low. Given the steel plate's original thickness of 250 mils and the metal thickness of 158 mils upon removal (a loss of 92 mils), and assuming a constant rate of corrosion between the tank's construction in 1943 and coupon removal in 2018 (75 years), the maximum corrosion rate at Coupon 6 is 1.23 mils per year (mpy). No conditions were evident that would support accelerated corrosion at Coupon 6.

4.6 Coupon 7

The LFET minimum screening thickness was 0.157 inch. The prove-up thickness was 0.135 inch. Therefore, a repair was specified in this area.

Destructive testing found pitting and a minimum wall thickness of 0.164 inch. The remaining wall thickness was within the 20-mil range for pitting but thicker than expected for the prove-up testing (164 mils vs. 135 mils).

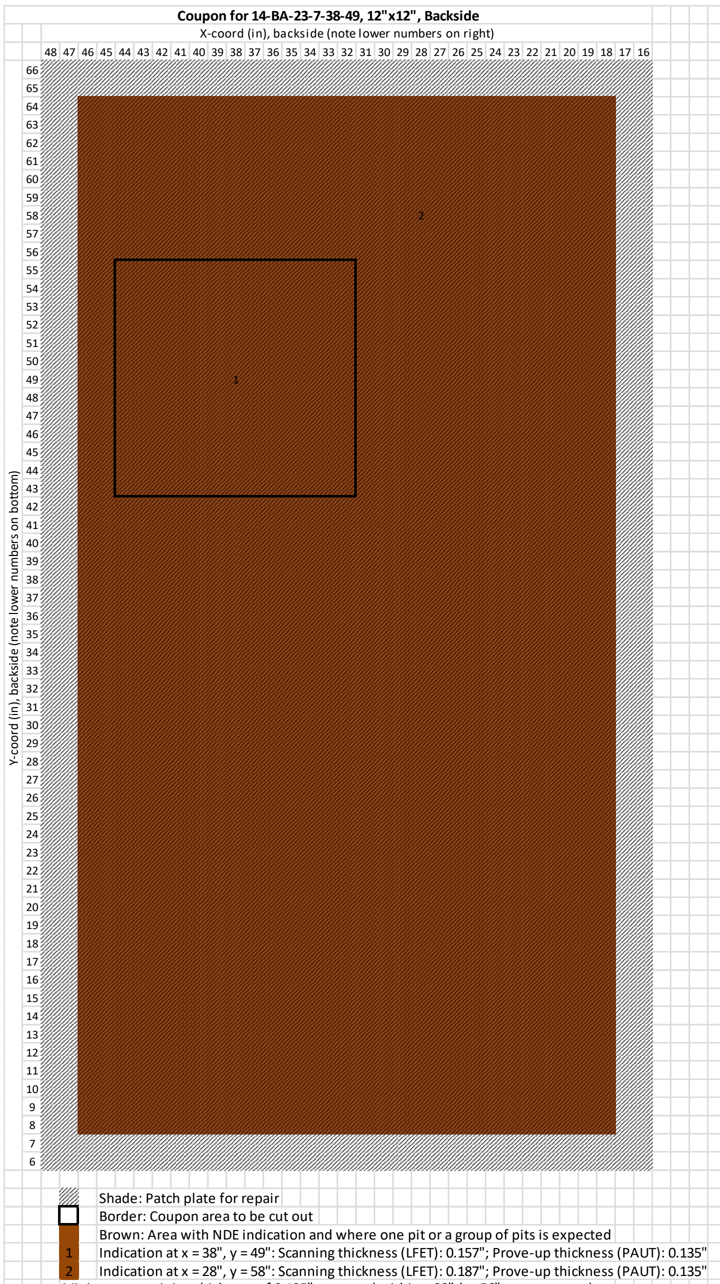

Figure 4-13 Expected Results from NDE Spreadsheet Data, Coupon 7

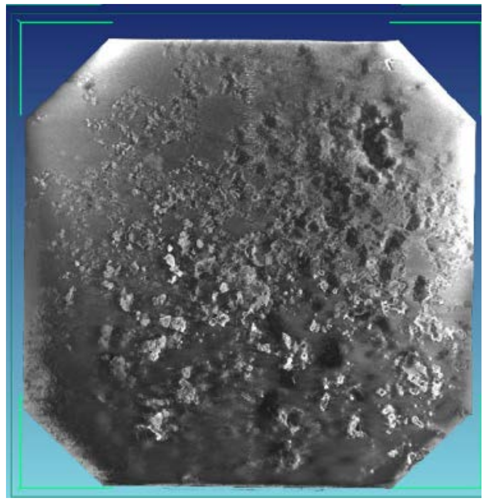

Figure 4-14 CT Scan Image from Destructive Testing Lab Report, Coupon 7

4.7 Coupon 8

The LFET minimum screening thickness was 0.069 inch. The prove-up thickness was greater than 0.200 inch. Therefore, no repair was specified in this area.

Destructive testing found pitting and minimum wall thickness of 0.206 inch. Remaining wall thickness was as expected.

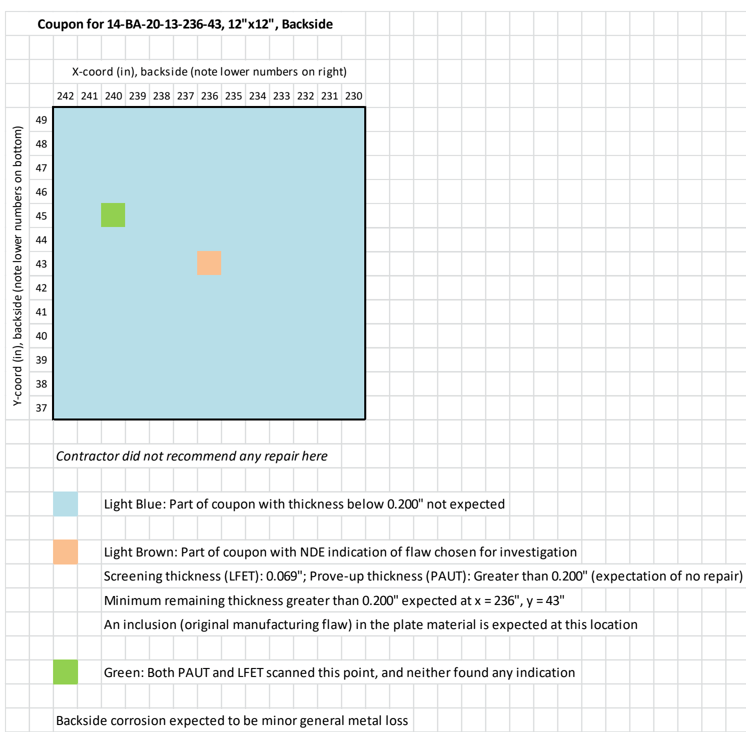

Figure 4-15 Expected Results from NDE Spreadsheet Data, Coupon 8

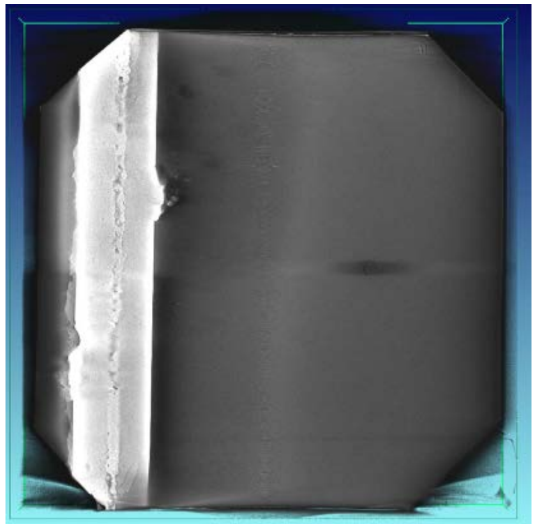

Figure 4-16 CT Scan Image from Destructive Testing Lab Report, Coupon 8

4.8 Coupon 10

The LFET screening found no indications. Therefore, no repair was specified in this area.

Destructive testing found a minimum wall thickness of 0.242 inch. Remaining wall thickness was as expected.

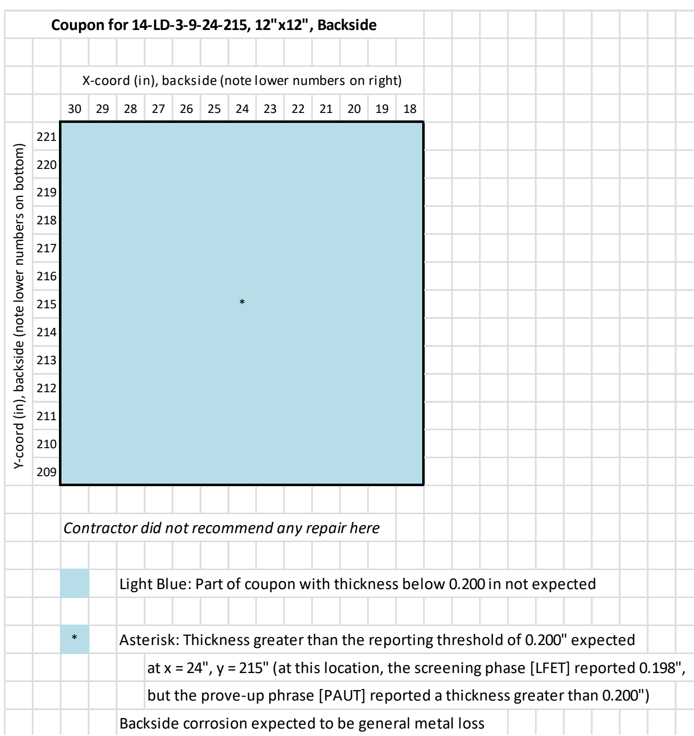

Figure 4-17 Expected Results From NDE Spreadsheet Data, Coupon 10

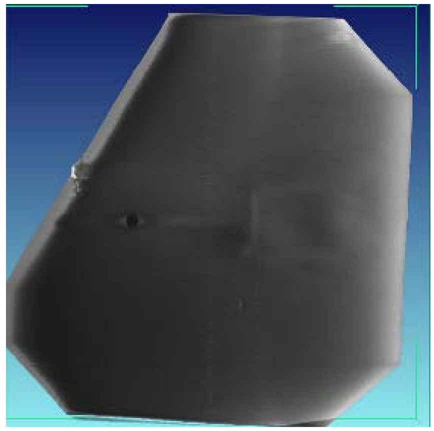

Figure 4-18 CT Scan Image from Destructive Testing Lab Report, Coupon 10

4.9 Coupon A1

The LFET minimum screening thickness was 0.134 inch. No prove-up measurements were done in this location because a weld repair was indicated. A repair was specified in this area.

Destructive testing found pitting and minimum wall thickness of 0.122 inch. The remaining wall thickness was as expected. The LFET thickness fell within the 20-mil accuracy range.

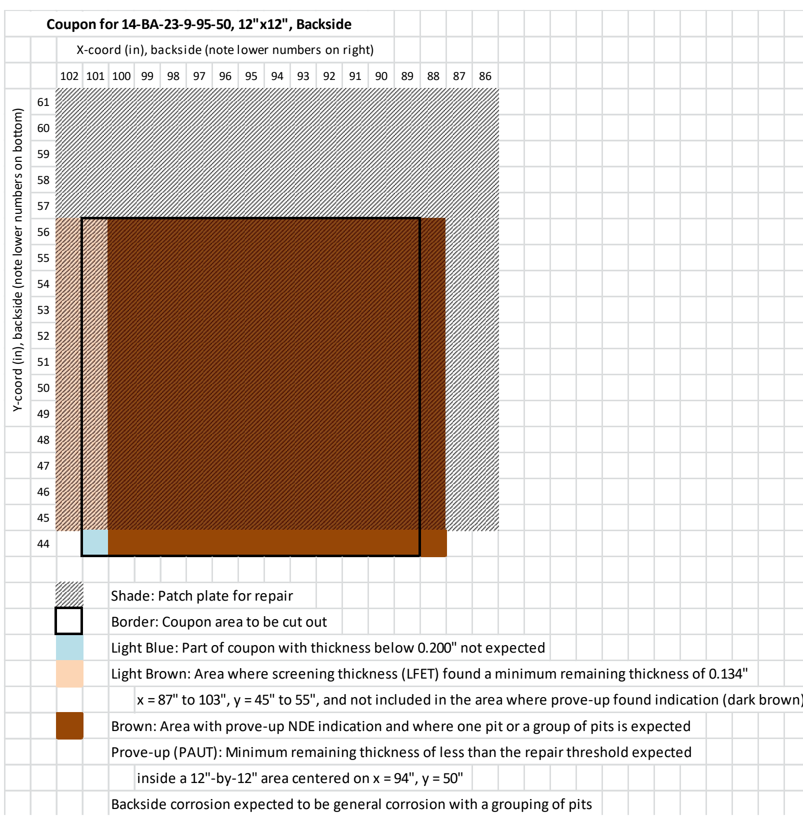

Figure 4-19 Expected Results from NDE Spreadsheet Data, Coupon A1

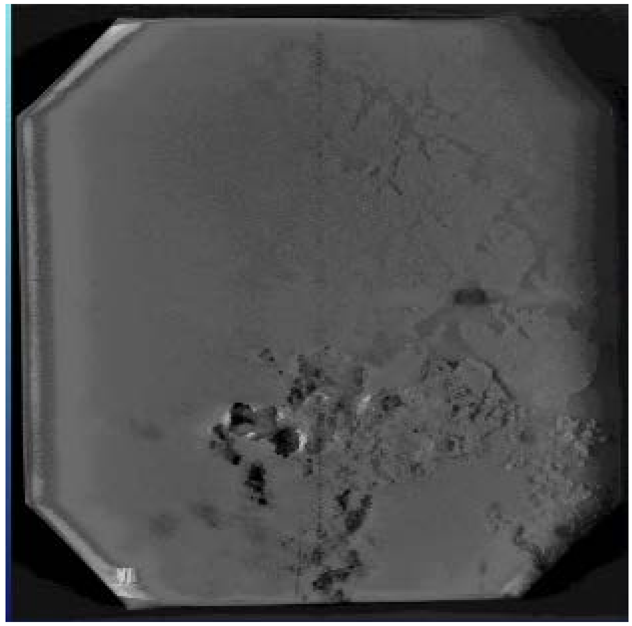

Figure 4-20 CT Scan Image from Destructive Testing Lab Report, Coupon A1

4.10 Coupon A2

The LFET screening found no indications. Therefore, no repair was specified in this area.

Destructive testing found a minimum wall thickness of 0.248 inch. The remaining wall thickness was as expected.

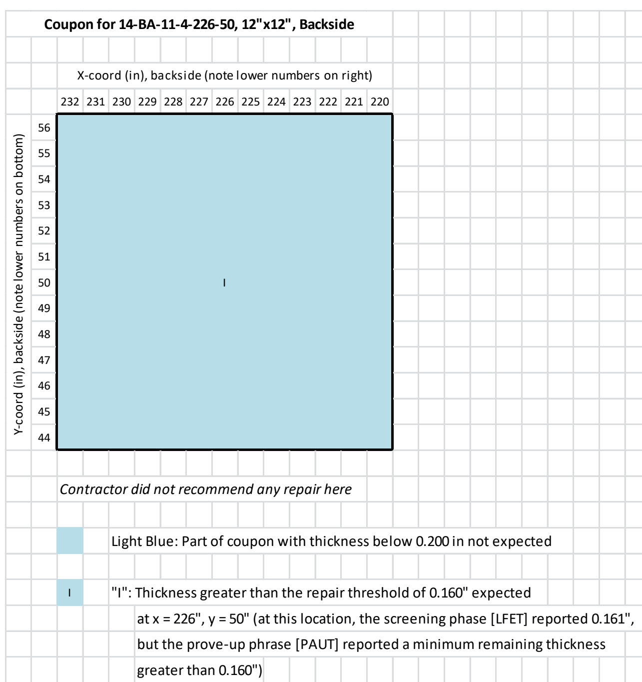

Figure 4-21 Expected Results from NDE Spreadsheet Data, Coupon A2

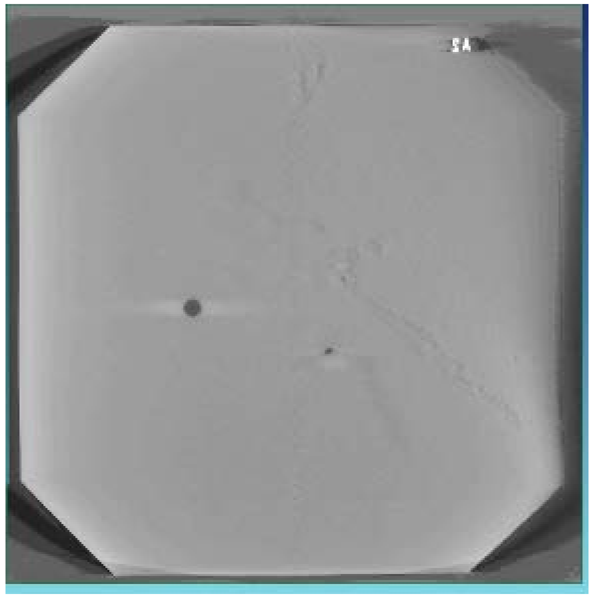

Figure 4-22 CT Scan Image from Destructive Testing Lab Report, Coupon A2

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5.0 SCIENTIFIC DISCUSSIONS

5.1 Origin of Backside Corrosion on Red Hill Tanks

The cause of backside corrosion, as observed on most of the coupons, is a worthwhile topic of discussion. For metals, corrosion is an electrochemical reaction in which metal atoms receive electrons and become ions in an oxide. Corrosion requires four components, to occur: an anode (made of metal atoms receiving electrons, thereby corroding), a cathode (made of metal atoms losing electrons, thereby not corroding), a metallic path, and an electrolyte. The metallic path and electrolyte must be in contact with both the anode and cathode for a corrosion cell to form. If even one of these components is absent, a corrosion cell does not form, and therefore, corrosion does not happen (Ref 8).

In theory, the steel tank liners at Red Hill should be adhered to the concrete substrate behind it. In practice, some gaps between the steel liners and the concrete have been found. Some of the coupons removed from Tank 14 were observed to be well-adhered to the concrete substrate. Past inspections of other Red Hill tanks have anecdotally identified locations of small gaps between the steel liners and concrete (Ref 1).

Water is an electrolyte, and parts of a body of metal can act as a cathode in a corrosion cell while other parts of that same metal can act as a cathode, and the metal itself is the metallic path between the cathode and anode (as indicated in Ref 8's passages on corrosion science). Therefore, because all four elements of a corrosion cell were present on the back side of the steel tank liners, corrosion cells were able to occur there.

There have been instances where dampness was detected behind the steel liners. However, the majority of the coupons from Tank 14 found dry concrete. Since the likely mechanism for the corrosion cells observed on some of the coupons depends on water as the electrolyte—water that was not observed—several questions arise. First, what was the source of the water that was present when the corrosion was formed? Second, are the corrosion cells observed dormant? Water moving through the subsurface at Red Hill does not affect the reinforced concrete structures because the concrete is high above the groundwater table and the surrounding geology contains many vertical passages for water drainage.

Great care was taken during construction at Red Hill to ensure the reinforced concrete was of good quality, tight, and appropriately prestressed to avoid strain concentrations. More than 15,000 cubic yards of reinforced concrete were placed around each tank liner. Tens of thousands of sacks of cementitious grout were pumped under pressure into native rock surrounding each tank structure in order to consolidate the material. Based on analysis of the concrete, it is expected to be reasonably tight and prevent vadose zone ground water from reaching the back surface of the steel liner.

The Tank Inspection, Repair, and Maintenance Report for the AOC SOW Section 2.2 (Ref 9) mentions, on page 1-2:

> To recheck for leaks in joints and to verify the shell plates were tight, each tank was filled with water in 5-foot increments. The tell-tale pipes were used to detect any water leaking through the shell plates and welds. If water appeared in the tell-tales, low pressure air was again introduced via the tell-tales behind the tank shell plates into the interstitial space between the back side of the shell plates and the reinforced concrete.

Thus, it is known that during leak testing circa 1942, water was introduced into interstitial spaces behind the steel liner. It is possible that water from the leak testing initiated the corrosion cells that were observed on the Tank 14 coupons. Once the water was absorbed by the concrete matrix or evaporated and available oxygen was consumed, conditions conducive to corrosion were diminished. Under dry and oxygen-deficient conditions, the corrosion cells observed on the Tank 14 coupons could have remained dormant for many years.

5.2 Absence of Metal Fatigue

The Red Hill AOC SOW Section 5.3.2 Destructive Testing Scope of Work (DT SOW, Ref 2, p. 9) states:

> To date, there has been no inspection data that suggest any metal fatigue issues in the tanks. If under certain rare operational circumstances where the steel plates experience cyclic loads or stresses, fatigue would be expected to culminate in cracks in the tank steel plate welds. Destructive testing of weld linear indications will be conducted only when NDE results indicate a need for such investigation.

The NDE results did not find linear indications on any of the welds on the coupons. The third-party laboratory (Ref 4) found that only two of the coupons contained welds, namely, Coupons 8 and 10. Coupon 8 had a weld line from one edge to the other, and Coupon 10 had a weld nugget on the back side. The laboratory did not observe cracks on either of the welds.

The laboratory findings are consistent with weld examination results for the entirety of Tank 14 in that linear indications were not found. Beyond Tank 14, linear weld indications have not been found during any Red Hill tank inspection conducted in recent years. Therefore, metal fatigue is not an issue in the steel tank liners at Red Hill.

6.0 SUMMARY AND RECOMMENDATIONS

Chemical analysis indicated that the steel tank liner was made from steel that generally conformed to ASTM A36 specification. That grade of carbon steel is commonly used and is an appropriate application for use as a steel fuel storage tank.

Coupon 1 was found to have significantly less metal loss than what was identified by the NDE. Coupon 7 had less metal loss than what was predicted by NDE. Coupons 2, 5, 8, 10, A1 and A2 all had measured thicknesses consistent to what was found with the NDE. Coupon 3 destructive testing showed actionable metal loss whereas the NDE did not identify any in this exact location. An actionable indication was found adjacent to where Coupon 3 was cut out. During the follow-on repair process, however, the metal loss at the Coupon 3 location would have been detected. Coupon 6 showed more metal loss than was predicted by the NDE and was just below the repair threshold. The destructive testing identified this to be a pit of very small volume. The NDE method used (LFET) does not always detect metal losses of very small volume.

The Navy identified two unavoidable shortfalls in the execution of the destructive testing plan. Contracting and negotiating processes for Tank 14 prevented having a complete repair plan available from which to base the selection of coupons. (At the time of this report, the contracting process is still ongoing for Tank 14.) At the time coupon sites were selected, the Navy had obtained initial scan and prove-up data from the contractor, but the final phase of laying out repairs in the tank had yet to be performed. This process involves conducting additional UT scans to ensure the boundary of each repair site is adequate to address the areas in need of repair and that the repair sites are properly laid out. Also, it needs to be recognized that the TIRM objective when scanning the tank is to identify areas in need of repair. This objective does not require or justify the need to record the exact location and depth of every pit or thinned area so long as the damage is properly repaired. As a result, no attempt was made to assess the minute accuracy of the locational coordinates of pits or areas of wall thinning. For this reason, it should not be expected that the maximum pit depth was recorded for any given area.

The Navy holds that the analysis of coupons in this study is an effective means of validating NDE findings. As discussed in the Red Hill AOC SOW Deliverable 5.3.2 Destructive Testing Scope of Work, a representative sample of coupons was selected from multiple regions of Tank 14. Coupons with backside corrosion of multiple depths, coupons with manufacturing flaws, and coupons with no flaws as found through NDE were chosen from the upper dome, extension ring, barrel, and lower dome. Every coupon area at which the contractor did not recommend repair (Coupons 6, 8, 10, and A2) was found through DT and through additional analysis not to require repair after all. Every coupon area at which the contractor did recommend repair (Coupons 1, 2, 5, 7, 9, and A1), as well as the one coupon area near which the contractor found an indication of excessive backside corrosion (Indication B near Coupon 3) that warranted repair, was indeed found by DT to be thin enough require repair. Therefore, the NDE results are validated, both by DT and thorough, case-by-case analysis.

On-site testing and laboratory testing of concrete powder samples indicated that the concrete behind the steel tank liner is alkaline and in sound condition. Alkaline concrete is necessary to avoid corrosion. No cracks or spalling was detected, and the concrete is in good condition.

6.1 Impacts to Current Clean, Inspect, Repair (CIR) Process

There is an ongoing integrity management program to clean, inspect and repair the Red Hill tanks to be fit for 20-year service intervals. The standard of care used to assess integrity on the tanks is modified from and consistent with API Standard 653, Tank Inspection, Repair, Alteration, and Reconstruction (Ref 5). The AOC Section 2.2 Tank Inspection, Repair, and Maintenance (TIRM) Report (Ref 9) contains details about the integrity management program.

Improvements to TIRM procedures are continuous. For example, according to the Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document (Ref 7), the TIRM process had previously involved a single individual being responsible for quality assurance (QA) in design management, construction management, and project management during CIR at Red Hill. After investigating the root causes of the release at Tank 5, the Navy updated its TIRM procedure so that three different individuals are responsible for each type of QA, and in turn, more-thorough QA is conducted in future CIR processes at Red Hill.

NAVFAC EXWC is undertaking a study to evaluate the reliability of some NDE methods, with a goal of establishing the Probability of Detection (POD) of at least one NDE technology. POD is the likelihood of detecting a defect given its existence. Some of the data from the study could be applicable to TIRM processes at Red Hill. Should the study yield information or refined techniques, which improve the TIRM integrity assessment program, it will be implemented as part of NAVFAC continuous improvement.

6.2 Analysis of Procedures for Calculating Corrosion Rates and Recommendations for Improvement

The TIRM report includes details about how the corrosion rate assessment in the modified API Standard 653 inspection is performed. Coupon 3 contained the most unexpected metal loss at an average rate of 1.57 mpy, based on a loss of 118 mils over 75 years (from 250 mils in 1943 to 132 mils in 2018). Since the TIRM process used in Tank 14 assumed a rate of 2.96 mpy, the results of the destructive testing validate that the assessment is conservative. No changes to the corrosion rate assessment are recommended.

6.3 Recommendations for Additional Destructive Testing

During the meeting on 12-14 March 2019, the concept of removing additional coupons was discussed. The benefit to destructive testing at Red Hill in order to validate NDE technology is far outweighed by numerous detriments. These detriments include introducing unnecessary damage to the tanks wall, increasing the amount of weld repairs, and delaying the return to service of the tank and subsequently delaying the CIR process on other tanks at Red Hill. The removal of additional coupons from a Red Hill tank to validate NDE is counterproductive and would not provide new information. Further destructive testing at Red Hill is neither recommended nor planned.

7.0 REFERENCES

1. T. Tehada, *Red Hill Facility Corrosion and Metal Fatigue Practices Report Administrative Order on Consent (AOC) and Statement of Work (SOW) Section 5.2.4*, Naval Facilities Engineering and Expeditionary Warfare Center, 4 April 2016.

2. T. Tehada, *Red Hill Bulk Fuel Storage Facility Scope of Work for Destructive Testing Administrative Order on Consent (AOC) and Statement of Work (SOW) Section 5.3.2*, Naval Facilities Engineering and Expeditionary Warfare Center, 30 May 2017.

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5. *API Standard 653 Tank Inspection, Repair, Alteration, and Reconstruction*, Fifth Edition, American Petroleum Institute, April 2018.

6. *NACE SP0308 – 2008 Standard Practice Inspection Methods for Corrosion Evaluation of Conventionally Reinforced Concrete Structures*, NACE International, 2008.

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10. R. Pallarino, United States Environmental Protection Agency, and S. Chang, State of Hawaii Department of Health. "Conditional Approval of Scope of Work for Destructive Testing Dated May 30, 2017 Submitted to the Regulatory Agencies Pursuant to Section 5.3.2 of the Red Hill Administrative Order on Consent." 7 July 2017.

11. R. Pallarino, United States Environmental Protection Agency, and S. Chang, State of Hawaii Department of Health. "Revision to Conditional Approval of Scope of Work

for Destructive Testing Dated May 30, 2017 Submitted to the Regulatory Agencies Pursuant to Section 5.3.2 of the Red Hill Administrative Order on Consent." 7 July 2017.

APPENDIX A

Destructive Testing Laboratory Report

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IMR TEST LABS
A Curtiss-Wright Business Unit
www.imrlouisville.com

4510 Robards Lane
Louisville, KY 40218
T: 1.502.810.9007 | **F**: 1.502.810.0380

Destructive Analysis of 10 Steel Coupons Removed from Red Hill Fuel Storage Tank #14

Solomon Resources, LLC
1001 Kamokila Blvd., Suite 125 Kapolei Bldg.
Kapolei, HI 96707

Attention: Michelle Mercado

REPORT No. 201801967 Revision 2

Original Date: December 17, 2018
Revised Date: June 3, 2019

Report By:

Thomas N. Ackerson, P.E. and
Jennifer Breetz

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Solomon Resources, LLC
1001 Kamokila Blvd., Suite 125 Kapolei Bldg.
Kapolei, HI 96707

Attention: Michelle Mercado

Original Date: December 17, 2018
Revised Date: June 3, 2019

Report No. 201801967 Revision 2

Destructive Analysis of 10 Steel Coupons Removed from Red Hill Fuel Storage Tank #14

INTRODUCTION

The United States Navy maintains a set of underground fuel storage tanks at Red Hill approximately five miles northwest of Honolulu, Hawaii. To ensure tank integrity, the Navy has contractors perform non-destructive evaluation (NDE) on the operational tanks at periodic intervals. NDE processes include identifying locations of possible excessive back-side thinning, back-side pitting, and weld defects, as well as the minimum wall thickness of each section of the tank walls.

The primary purpose of this study was to provide in-depth chemical and physical analysis of coupon samples provided by the customer from Red Hill Tank #14, in an effort to assist them in validating NDE results. Ten coupons removed from the tank were submitted for analysis, and were approximately 12” X 12” in size. They were labeled as 1, 2, 3, 5, 6, 7, 8, 10, A1 and A2 (there was no Sample #4 or #9). Poly bags of concrete powder samples and corrosion product were also submitted with the coupons. The coupons and bagged samples were evaluated using a combination of laboratory techniques. It was reported that the specified tank wall thickness was 250 mils.

An initial evaluation was performed on the coupons in the as-received condition (i.e., prior to the removal of loose corrosion product), which included visual inspection and computerized tomography scans. This was followed by a step-wise process of excising corrosion product for analysis, CO_2 blast cleaning, and determining microstructural, chemical and mechanical properties.

The work was performed over a 4-month period, from August to November 2018. All analytical work was performed by IMR Test Labs – Louisville, under the direction of the authors, unless otherwise indicated. IMR Test Labs – Louisville is accredited to ISO 17025 by the American Association for Laboratory Accreditation (A2LA), Certificate #1140-03 and 1140-04.

Revision 2 Notes:

- Modified Table 23 to add notes about figures provided in Appendix B (footnote #7).
- Added Appendix B, which provides photographs showing location of additional samples that were removed from the coupons. These are referenced in Table 23 and throughout metallographic cross-section figures.

ANALYTICAL PROCEDURES

I. Visual Examination and Optical Microscopic Examination
- A. Visual Observations
- B. Photography (digital)
- C. Digital Optical Microscopy
- D. Dimensional Measurements

II. Non-Destructive Inspection
- A. Computer Tomography (CT), subcontracted to an approved vendor using personnel certified and qualified in accordance with ASNT Recommended Practice No. SNT-TC-1A: *Personnel Qualification and Certification in Nondestructive Testing*.

III. Chemical Analysis: Base Metal
- A. Optical Emission Spectroscopy, ASTM E415-17
- B. Carbon and Sulfur Content by Combustion Analysis, ASTM E1019-18

IV. Scanning Electron Microscopic Examination
- A. Scanning Electron Microscopy (SEM)

V. Microanalysis: Deposits, Corrosion Products, etc.
- A. Energy Dispersive X-ray Spectroscopy (EDS) in conjunction with SEM, permits detection and quantification of all elements greater than beryllium in atomic weight, ASTM E1508-12a.
- B. Ion Chromatography for water soluble anions (IC), ASTM D4327-17 and pH measurement per ASTM D1293-18
- C. Fourier Transform Infrared Spectroscopy (FTIR) – FTIR is a nondestructive microanalytical spectroscopic technique that involves the study of molecular vibrations. Reference ASTM E1252-98(13)e1
- D. X-Ray Diffraction Spectroscopy Analysis (XRD) – This technique generates a diffraction pattern and matches unique peaks using a computer-based library in order to identify compounds by their crystalline structure, CLP-056A

VI. Mechanical Testing
- A. Tensile Testing, ASTM E8-16a
- B. Rockwell Hardness Testing, ASTM E18-17e1

VII. Metallography
- A. Microstructural Analysis using a Light Metallurgical Microscope, specimen preparation in accordance with ASTM E3-11 (17)
- B. Pit Depth Measurement per ASTM G46-94 (2005), as referenced by ASTM G1 - 03(2017)e1

RESULTS

VISUAL EXAMINATION

Overall images of the submitted coupons in the as-received condition are provided in Figures 1 through 30.

Computer Tomography (CT) scans were performed on each of the submitted coupons prior to cleaning or sectioning. This task was subcontracted to an accredited partner laboratory. Representative screenshots of the scans are provided in Figures 31 through 40. The full CT scan files and appropriate software will be provided to the customer on a separate disk. The CT scans were used to identify three regions on each coupon that exhibited the most severe wall thinning or any other density-based anomaly. The three regions of severe wall thinning identified were excised from the coupons for further analysis.

CHEMICAL ANALYSIS

Chemical analysis was performed on the base metal of specimens excised from each coupon using optical emission spectroscopy (OES). The results are summarized in Tables 1 through 4. The samples were consistent with ASTM A36 structural steel, or similar. No specification for the steel was provided.

SCANNING ELECTRON MICROSCOPY

The three regions removed from each coupon were examined using a scanning electron microscope (SEM) with imaging in secondary electron mode. Representative images of the features observed are provided as Figures 41 through 70. When no specific pitting was observed, the nominal surface of the specimen was imaged and analyzed.

MICROANALYSIS

The three regions removed from each coupon were analyzed using energy dispersive x-ray spectroscopy (EDS). Summaries of the results are provided in Tables 5 through 14. Representative spectra obtained are provided in Figures 71 through 100.

The concrete samples were analyzed by ion chromatography (IC) for common anions. Tables 15 and 16 summarize the ion chromatography results along with the pH values of the analyzed solution from the samples. The ion chromatograms generated are provided as Figures 101 through 110.

Fourier transform infrared (FTIR) spectroscopy was performed on paint samples removed from each coupon using Attenuated Total Reflectance (ATR) with a diamond crystal. All paint samples were identified as polyurethane enamel. The resulting FTIR spectra of the samples and the best matches from the spectral FTIR library of standards for polyurethane enamel are provided as Figures 111 and 112.

X-Ray Diffraction Spectroscopy (XRD) analysis of the concrete samples revealed the presence of the following crystalline phases: calcium oxide (lime); calcium carbonate (calcite); silicon dioxide (coesite); calcium sulfate; calcium sulfate hydrated (gypsum) and calcium hydroxide (portlandite). The results are summarized in Tables 17 and 18. The XRD diffractograms for the concrete samples are provided as Figures 113 through 122.

X-Ray Diffraction Spectroscopy (XRD) analysis of the corrosion product from the metal panels revealed the presence of the following crystalline phases: iron oxide (magnetite); iron hydroxide (goethite); calcium carbonate (calcite); silicon dioxide and hydrous calcium aluminum sulfate (ettringite). The results are summarized in Tables 19 and 20. The XRD diffractograms for the corrosion samples are provided as Figures 123 through 128.

CLEANING OF COUPONS AND 3-D IMAGING

After analysis of the corrosion product and concrete, both sides of the coupons were cleaned using a CO_2 dry ice blast process by a subcontractor. Cleaning was witnessed by the report authors. The CO_2 technique was selected due to its ability to remove most of the residual concrete on the coupon surface, yet not be so aggressive as to remove base metal. Chemical cleaning as prescribed in ASTM G1-03(2011) would not have adequately cleaned the surfaces for analysis. Representative images of the panels after cleaning are provided as Figures 129 through 148. The majority of the residual concrete and loose corrosion product was removed, however the green paint could not be removed.

Digital optical 3D images acquired of the three specimens removed from each coupon are shown in Figures 149 through 179.

MECHANICAL TESTING

Full size flat tensile specimens were excised from each coupon. It could not be readily determined if the samples were removed from the rolling direction of the steel, or transverse to the rolling direction, as this was not marked on the coupons. The results of the tensile testing are summarized in Table 21.

Rockwell hardness specimens were excised from the coupons and the results are presented in Table 22.

METALLOGRAPHY

A minimum of three metallographic specimens were prepared from each of the 10 coupons and were identified as #-1, #-2 and #-3, where "#" was the original coupon number. In some cases, additional areas of interest were identified during the course of the analysis. When this occurred, those samples were identified as #-4, #-5, etc. Some of these additional samples were determined to be worst-case areas for wall loss and are included in Table 23 as such.

In preparation for mounting and polishing, each specimen was sectioned as necessary using a water-cooled saw. The sectioned specimens were mounted in either glass-filled thermosetting epoxy (compression mount) or 2-part slow-cure epoxy (cold mount), depending on the specimen size. The mounted samples were ground and polished using standard metallographic techniques. The finished specimens were used for determining pitting depth, weld imaging, and paint characterization. All specimens were chemically etched with a 2% Nital solution to reveal the microstructure and facilitate imaging.

Pit Depth Measurement

The area exhibiting the maximum degree of wall thinning was measured for each prepared specimen, then the percent remaining wall thickness was calculated. The specified wall thickness of 250 mils, provided by the customer, was used for percent remaining wall thickness calculations. For additional information, local wall thickness measurements were made in the least observed corroded location for each submitted coupon after the remaining paint was removed by grit-blasting. These readings were made using calibrated digital micrometers. The results are summarized in Table 23. Note that some of the NDE indications were likely due to surface anomalies other than pitting (i.e., welding or mechanical depressions on the painted surface). Representative images with calibrated markers are provided in Figures 180 through 207. Markers on the images are in metric units, but were converted to mils for the purposes of Table 23.

Weld Characterization

Coupon 8 exhibited what is presumed to be a prior weld repair and/or addition of a backing plate, where a patch was made on the tank wall. Representative images of the welds are presented as Figures 208 through 213. A full weld evaluation is outside the scope of this effort. The results are thus provided for information only.

Paint Characterization

A typical paint layer was examined microscopically and was determined to consist of two layers, as shown in Figure 214. This indicates that the exterior tank wall exhibits a primer layer with a top coat. The scraped paint samples that were excised from each coupon previously for FTIR analysis would likely have captured some of both layers. The FTIR results presented previously were a good match for polyurethane, with no observable secondary component. Although this indicates that both the primer and top coat were polyurethane-based, it cannot be ruled out that the primer exhibited a different composition.

ACCREDITED
Testing Cert # 1140.03 & 1140.04

Accredited Nadcap™ Materials Testing Lab

Respectfully submitted

Thomas N. Ackerson PE
Laboratory Director

Concurrence

Jennifer Breetz

Jennifer Breetz
Metallurgy/Corrosion Manager
Materials Engineer/Failure Analyst

TABLE 1 – CHEMICAL ANALYSIS TEST RESULTS, COUPONS 1, 2 AND 3

Element	#1	#2	#3	ASTM A36-14 Plates > 15" width and Plates up to ¾" Thick Requirements
Carbon	0.16	0.16	0.16	0.25 Maximum
Manganese	0.51	0.49	0.48	-----
Silicon	0.06	0.03	0.02	0.40 Maximum
Phosphorus	0.006	0.006	0.006	0.030 Maximum
Sulfur	0.019	0.019	0.019	0.030 Maximum
Chromium	0.04	0.02	0.01	-----
Nickel	0.04	0.01	0.01	-----
Molybdenum	0.01	< 0.01	< 0.01	-----
Aluminum	0.01	0.02	0.02	-----
Cobalt	0.01	0.01	0.01	-----
Copper	0.09	0.03	0.03	0.20 Minimum[1]
Niobium	< 0.01	< 0.01	< 0.01	-----
Titanium	< 0.01	< 0.01	< 0.01	-----
Vanadium	< 0.01	< 0.01	< 0.01	-----
Iron	Remainder	Remainder	Remainder	Remainder

Results in weight percent
[1]Copper minimum when copper steel is specified

METHODS
Optical Emission Spectroscopy, ASTM E415-17

TABLE 2 – CHEMICAL ANALYSIS TEST RESULTS, COUPONS 5, 6 AND 7

Element	#5	#6	#7	ASTM A36-14 Plates > 15” width and Plates up to ¾” Thick Requirements
Carbon	0.11	0.20	0.16	0.25 Maximum
Manganese	0.44	0.49	0.52	-----
Silicon	0.05	0.05	0.06	0.40 Maximum
Phosphorus	0.014	0.007	0.024	0.030 Maximum
Sulfur	0.012	0.017	0.028	0.030 Maximum
Chromium	0.01	0.02	0.02	-----
Nickel	0.01	0.02	0.01	-----
Molybdenum	< 0.01	0.01	< 0.01	-----
Aluminum	0.02	0.01	0.01	-----
Cobalt	0.01	0.01	0.01	-----
Copper	0.03	0.07	0.04	0.20 Minimum[1]
Niobium	< 0.01	< 0.01	< 0.01	-----
Titanium	< 0.01	< 0.01	< 0.01	-----
Vanadium	< 0.01	< 0.01	< 0.01	-----
Iron	Remainder	Remainder	Remainder	Remainder

Results in weight percent
[1]Copper minimum when copper steel is specified

METHODS
Optical Emission Spectroscopy, ASTM E415-17

TABLE 3 – CHEMICAL ANALYSIS TEST RESULTS, COUPONS 8 AND 10

Element	#8	#10	ASTM A36-14 Plates > 15" width and Plates up to ¾" Thick Requirements
Carbon	0.14	0.20	0.25 Maximum
Manganese	0.46	0.47	-----
Silicon	0.06	0.06	0.40 Maximum
Phosphorus	0.018	0.012	0.030 Maximum
Sulfur	0.014	0.040*	0.030 Maximum
Chromium	0.01	0.02	-----
Nickel	0.01	0.01	-----
Molybdenum	< 0.01	< 0.01	-----
Aluminum	0.01	0.01	-----
Cobalt	0.01	0.01	-----
Copper	0.05	0.02	0.20 Minimum[1]
Niobium	< 0.01	< 0.01	-----
Titanium	< 0.01	< 0.01	-----
Vanadium	< 0.01	< 0.01	-----
Iron	Remainder	Remainder	Remainder

Results in weight percent
*Fails to meet requirements of ASTM A36, however, no specification was provided.
[1]Copper minimum when copper steel is specified

METHODS
Optical Emission Spectroscopy, ASTM E415-17
Carbon and Sulfur by Combustion, ASTM E1019-18

TABLE 4 – CHEMICAL ANALYSIS TEST RESULTS, COUPONS A1 AND A2

Element	#A1	#A2	ASTM A36-14 Plates > 15" width and Plates up to ¾" Thick Requirements
Carbon	0.15	0.16	0.25 Maximum
Manganese	0.49	0.46	-----
Silicon	0.06	0.06	0.40 Maximum
Phosphorus	0.013	0.020	0.030 Maximum
Sulfur	0.018	0.022	0.030 Maximum
Chromium	0.01	0.01	-----
Nickel	0.01	0.01	-----
Molybdenum	< 0.01	< 0.01	-----
Aluminum	0.01	0.02	-----
Cobalt	0.01	0.01	-----
Copper	0.04	0.02	0.20 Minimum[1]
Niobium	< 0.01	< 0.01	-----
Titanium	< 0.01	< 0.01	-----
Vanadium	< 0.01	< 0.01	-----
Iron	Remainder	Remainder	Remainder

Results in weight percent
[1]Copper minimum when copper steel is specified

METHODS
Optical Emission Spectroscopy, ASTM E415-17

TABLE 5 – ENERGY DISPERSIVE X-RAY SPECTROMETRY RESULTS, COUPON 1

Element	Location 1-1	Location 1-2	Location 1-3
Carbon	7.1	2.9	17.7
Oxygen	35.2	37.9	37.2
Sodium	1.5	1.2	0.8
Magnesium	-----	-----	-----
Aluminum	0.4	-----	-----
Silicon	1.7	1.5	0.6
Phosphorus	-----	-----	-----
Sulfur	-----	-----	-----
Chlorine	-----	-----	-----
Potassium	-----	-----	-----
Calcium	4.8	-----	12.0
Titanium	-----	-----	-----
Vanadium	-----	-----	-----
Chromium	-----	-----	-----
Manganese	0.3	0.4	0.4
Iron	48.8	55.9	31.3
Nickel	-----	-----	-----
Copper	-----	-----	-----
Zinc	-----	-----	-----

- All reported values are in relative weight percent.
- Only elements present in concentrations ≥ 0.2% are reported.
- Results may not add up to 100%, due to rounding or lesser concentrations not being reported.
- If no pits were present, results are for the nominal surface of the test specimen.

TABLE 6 – ENERGY DISPERSIVE X-RAY SPECTROMETRY RESULTS, COUPON 2

Element	Location 2-1	Location 2-2	Location 2-3
Carbon	6.0	7.1	6.4
Oxygen	37.9	36.6	37.1
Sodium	-----	-----	-----
Magnesium	-----	-----	-----
Aluminum	-----	-----	-----
Silicon	-----	-----	-----
Phosphorus	-----	-----	-----
Sulfur	0.2	-----	-----
Chlorine	0.3	0.6	0.2
Potassium	-----	-----	-----
Calcium	-----	-----	0.8
Titanium	-----	-----	-----
Vanadium	-----	-----	-----
Chromium	-----	-----	-----
Manganese	0.5	0.4	0.7
Iron	54.9	55.1	53.7
Nickel	-----	-----	-----
Copper	-----	-----	-----
Zinc	-----	-----	-----

- All reported values are in relative weight percent.
- Only elements present in concentrations ≥ 0.2% are reported.
- Results may not add up to 100%, due to rounding or lesser concentrations not being reported.
- If no pits were present, results are for the nominal surface of the test specimen.

TABLE 7 – ENERGY DISPERSIVE X-RAY SPECTROMETRY RESULTS, COUPON 3

Element	Location 3-1	Location 3-2	Location 3-3
Carbon	6.8	6.6	3.71
Oxygen	38.5	42.7	37.4
Sodium	-----	0.2	-----
Magnesium	-----	-----	-----
Aluminum	0.2	-----	-----
Silicon	0.2	-----	-----
Phosphorus	-----	-----	-----
Sulfur	-----	-----	0.4
Chlorine	-----	-----	0.3
Potassium	-----	-----	-----
Calcium	6.7	0.6	-----
Titanium	-----	-----	-----
Vanadium	-----	-----	-----
Chromium	-----	-----	-----
Manganese	0.5	0.3	0.4
Iron	46.8	49.4	57.7
Nickel	-----	-----	-----
Copper	-----	-----	-----
Zinc	-----	-----	-----

- All reported values are in relative weight percent.
- Only elements present in concentrations ≥ 0.2% are reported.
- Results may not add up to 100%, due to rounding or lesser concentrations not being reported.
- If no pits were present, results are for the nominal surface of the test specimen.

TABLE 8 – ENERGY DISPERSIVE X-RAY SPECTROMETRY RESULTS, COUPON 5

Element	Location 5-1	Location 5-2	Location 5-3
Carbon	5.8	3.4	17.2
Oxygen	28.4	27.2	35.8
Sodium	0.4	-----	0.5
Magnesium	0.2	-----	0.3
Aluminum	0.3	-----	1.2
Silicon	0.9	-----	3.5
Phosphorus	0.2	-----	-----
Sulfur	-----	-----	0.3
Chlorine	-----	-----	0.3
Potassium	-----	-----	-----
Calcium	2.5	0.6	15.2
Titanium	-----	-----	-----
Vanadium	-----	-----	-----
Chromium	-----	-----	-----
Manganese	0.2	0.3	-----
Iron	61.0	68.4	25.7
Nickel	-----	-----	-----
Copper	-----	-----	-----
Zinc	-----	-----	-----

- All reported values are in relative weight percent.
- Only elements present in concentrations ≥ 0.2% are reported.
- Results may not add up to 100%, due to rounding or lesser concentrations not being reported.
- If no pits were present, results are for the nominal surface of the test specimen.

TABLE 9 – ENERGY DISPERSIVE X-RAY SPECTROMETRY RESULTS, COUPON 6

Element	Location 6-1	Location 6-2	Location 6-3
Carbon	2.1	3.8	3.1
Oxygen	34.1	34.6	33.3
Sodium	-----	-----	-----
Magnesium	-----	-----	-----
Aluminum	-----	2.1	-----
Silicon	-----	4.1	-----
Phosphorus	-----	-----	-----
Sulfur	-----	0.3	0.2
Chlorine	-----	-----	0.3
Potassium	-----	-----	-----
Calcium	1.2	13.9	0.2
Titanium	-----	-----	-----
Vanadium	-----	-----	-----
Chromium	-----	-----	-----
Manganese	0.4	-----	0.4
Iron	61.9	41.3	62.3
Nickel	-----	-----	-----
Copper	-----	-----	-----
Zinc	-----	-----	-----

- All reported values are in relative weight percent.
- Only elements present in concentrations ≥ 0.2% are reported.
- Results may not add up to 100%, due to rounding or lesser concentrations not being reported.
- If no pits were present, results are for the nominal surface of the test specimen.

TABLE 10 – ENERGY DISPERSIVE X-RAY SPECTROMETRY RESULTS, COUPON 7

Element	Location 7-1	Location 7-2	Location 7-3
Carbon	3.6	5.0	3.6
Oxygen	28.5	38.7	28.5
Sodium	0.3	-----	0.3
Magnesium	-----	-----	-----
Aluminum	-----	-----	-----
Silicon	-----	-----	-----
Phosphorus	-----	-----	-----
Sulfur	-----	-----	-----
Chlorine	0.6	0.3	0.6
Potassium	-----	-----	-----
Calcium	0.8	6.1	0.8
Titanium	-----	-----	-----
Vanadium	-----	-----	-----
Chromium	-----	-----	-----
Manganese	1.0	0.4	1.0
Iron	64.7	49.2	64.7
Nickel	-----	-----	-----
Copper	-----	-----	-----
Zinc	-----	-----	-----

- All reported values are in relative weight percent.
- Only elements present in concentrations ≥ 0.2% are reported.
- Results may not add up to 100%, due to rounding or lesser concentrations not being reported.
- If no pits were present, results are for the nominal surface of the test specimen.

TABLE 11 – ENERGY DISPERSIVE X-RAY SPECTROMETRY RESULTS, COUPON 8

Element	Location 8-1	Location 8-2	Location 8-3
Carbon	4.7	4.5	5.1
Oxygen	31.8	33.9	33.2
Sodium	0.5	0.4	0.5
Magnesium	-----	-----	-----
Aluminum	0.3	-----	-----
Silicon	1.0	0.3	0.4
Phosphorus	-----	-----	-----
Sulfur	-----	-----	-----
Chlorine	-----	-----	-----
Potassium	-----	-----	-----
Calcium	2.9	0.8	0.9
Titanium	-----	-----	-----
Vanadium	-----	-----	-----
Chromium	-----	-----	-----
Manganese	0.4	0.3	0.3
Iron	58.2	59.5	59.2
Nickel	-----	-----	-----
Copper	-----	-----	0.3
Zinc	-----	-----	-----

- All reported values are in relative weight percent.
- Only elements present in concentrations ≥ 0.2% are reported.
- Results may not add up to 100%, due to rounding or lesser concentrations not being reported.
- If no pits were present, results are for the nominal surface of the test specimen.

TABLE 12 – ENERGY DISPERSIVE X-RAY SPECTROMETRY RESULTS, COUPON 10

Element	Location 10-1	Location 10-2	Location 10-3
Carbon	34.9	27.6	22.5
Oxygen	20.1	16.5	23.7
Sodium	0.3	0.2	0.3
Magnesium	-----	-----	-----
Aluminum	0.2	1.6	0.5
Silicon	0.5	0.4	0.8
Phosphorus	-----	-----	-----
Sulfur	0.3	0.4	0.4
Chlorine	-----	0.3	-----
Potassium	-----	0.2	-----
Calcium	1.2	0.5	2.2
Titanium	-----	-----	-----
Vanadium	-----	-----	-----
Chromium	-----	-----	-----
Manganese	-----	0.2	-----
Iron	41.9	52.1	49.2
Nickel	-----	-----	-----
Copper	-----	-----	-----
Zinc	-----	-----	-----

- All reported values are in relative weight percent.
- Only elements present in concentrations ≥ 0.2% are reported.
- Results may not add up to 100%, due to rounding or lesser concentrations not being reported.
- If no pits were present, results are for the nominal surface of the test specimen.

TABLE 13 – ENERGY DISPERSIVE X-RAY SPECTROMETRY RESULTS, COUPON A1

Element	Location A1-1	Location A1-2	Location A1-3
Carbon	3.1	3.7	3.4
Oxygen	33.7	31.6	28.2
Sodium	-----	-----	-----
Magnesium	-----	-----	-----
Aluminum	-----	-----	0.3
Silicon	-----	-----	0.6
Phosphorus	-----	-----	-----
Sulfur	-----	0.2	-----
Chlorine	1.7	0.7	0.5
Potassium	-----	-----	-----
Calcium	-----	-----	2.7
Titanium	-----	-----	-----
Vanadium	-----	-----	-----
Chromium	-----	-----	0.2
Manganese	0.4	0.6	0.3
Iron	61.0	63.2	63.6
Nickel	-----	-----	-----
Copper	-----	-----	-----
Zinc	-----	-----	-----

- All reported values are in relative weight percent.
- Only elements present in concentrations ≥ 0.2% are reported.
- Results may not add up to 100%, due to rounding or lesser concentrations not being reported.
- If no pits were present, results are for the nominal surface of the test specimen.

TABLE 14 – ENERGY DISPERSIVE X-RAY SPECTROMETRY RESULTS, COUPON A2

Element	Location A2-1	Location A2-2	Location A2-3
Carbon	2.7	2.3	1.9
Oxygen	32.6	32.9	31.1
Sodium	-----	0.3	-----
Magnesium	0.3	-----	-----
Aluminum	0.3	-----	0.4
Silicon	1.0	0.6	1.4
Phosphorus	-----	-----	-----
Sulfur	-----	-----	-----
Chlorine	-----	-----	-----
Potassium	-----	-----	-----
Calcium	2.3	1.7	2.5
Titanium	-----	-----	-----
Vanadium	-----	-----	-----
Chromium	-----	-----	-----
Manganese	0.3	0.4	0.2
Iron	60.7	61.4	62.4
Nickel	-----	-----	-----
Copper	-----	-----	-----
Zinc	-----	-----	-----

- All reported values are in relative weight percent.
- Only elements present in concentrations ≥ 0.2% are reported.
- Results may not add up to 100%, due to rounding or lesser concentrations not being reported.
- If no pits were present, results are for the nominal surface of the test specimen.

TABLE 15 – ION CHROMATOGRAPHY AND pH TEST RESULTS

Anion	Concrete 1	Concrete 2	Concrete 3	Concrete 5	Concrete 6
Fluoride	11	11	27	13	13
Chloride	82	59	50	80	81
Nitrite	282	595	24	26	17
Nitrate	273	535	15	12	3
Sulfate	1518	684	1501	1979	1660
Mass of Concrete Powder, g	0.1057	0.1010	0.1005	0.1017	0.1049
Volume of extract, ml	10.1058	10.1012	10.3508	10.1783	13.8753
Dilution Factor	95.60	100.01	102.99	100.08	132.27
pH	9.86 (alkaline)	11.79 (alkaline)	11.03 (alkaline)	11.13 (alkaline)	10.27 (alkaline)

Results in parts per million (ppm) unless otherwise indicated
Method(s): Modified ASTM D 4327-11 (IC) and pH measurement per ASTM D1293-12.

TABLE 16 – ION CHROMATOGRAPHY AND pH TEST RESULTS

Anion	Concrete 7	Concrete 8	Concrete 10	Concrete A1	Concrete A2
Fluoride	25	70	10	3	16
Chloride	78	171	62	53	80
Nitrite	20	18	6	15	17
Nitrate	5	4	3	6	8
Sulfate	2190	2392	2092	1266	1754
Mass of Concrete Powder, g	0.1011	0.1053	0.1052	0.1019	0.1039
Volume of extract, ml	10.1468	10.1811	10.5856	10.2430	11.0911
Dilution Factor	100.36	96.69	100.62	100.52	106.75
pH	10.65 (alkaline)	10.55 (alkaline)	10.37 (alkaline)	10.45 (alkaline)	10.10 (alkaline)

Results in parts per million (ppm) unless otherwise indicated
Method(s): Modified ASTM D 4327-11 (IC) and pH measurement per ASTM D1293-12.

TABLE 17 – X-RAY DIFFRACTION ANALYSIS TEST RESULTS FOR CONCRETE

Phase	Concrete 1	Concrete 2	Concrete 3	Concrete 5	Concrete 6
Calcium Oxide (CaO) (Lime)	4 (±0.3)	ND	4 (±0.2)	2 (±0.2)	11 (±1.5)
Calcium Carbonate ($CaCO_3$) (Calcite)	37 (±1.0)	5 (±0.5)	12 (±0.4)	53 (±1.2)	49 (±1.8)
Silicon Dioxide (SiO_2) (Coesite)	22 (±0.4)	8 (±0.5)	41 (±0.6)	10 (±0.3)	37 (±1.3)
Calcium Sulfate ($CaSO_4$)	36 (±1.0)	ND	ND	ND	ND
Calcium Sulfate Hydrated ($CaSO_4$ $2H_2O$) (Gypsum)	1 (±0.8)	ND	16 (±0.2)	27 (±0.3)	3 (±0.4)
Calcium Hydroxide ($Ca(HO)_2$) (Portlandite)	ND	87 (±0.8)	27 (±0.6)	8 (±0.2)	ND

Values in relative weight percent
ND=Not Detected

TABLE 18 – X-RAY DIFFRACTION ANALYSIS TEST RESULTS FOR CONCRETE

Phase	Concrete 7	Concrete 8	Concrete 10	Concrete A1	Concrete A2
Calcium Oxide (CaO) (Lime)	13 (±0.7)	3 (±0.6)	2 (±0.2)	2 (±0.2)	12 (±1.0)
Calcium Carbonate ($CaCO_3$) (Calcite)	49 (±1.3)	32 (±0.2)	55 (±1.2)	69 (±1.1)	39 (±2.7)
Silicon Dioxide (SiO_2)	30 (±1.0)	60 (±0.7)	32 (±0.7)	12 (±0.6)	4 (±0.7)
Calcium Sulfate ($CaSO_4$)	ND	ND	ND	7 (±0.6)	38 (±2.9)
Calcium Sulfate Hydrated ($CaSO_4$ $2H_2O$) (Gypsum)	8 (±1.5)	3 (±0.9)	10 (±0.2)	10 (±0.3)	7 (±0.5)
Calcium Hydroxide ($Ca(HO)_2$) (Portlandite)	ND	2 (±0.4)	1 (±0.3)	ND	ND

Values in relative weight percent
ND=Not Detected

TABLE 19 – X-RAY DIFFRACTION ANALYSIS TEST RESULTS FOR CORROSION PRODUCT

Phase	Corrosion 1	Corrosion 2	Corrosion 3
Iron Oxide (Fe_3O_2)	60 (±0.3)	57 (±0.4)	48 (±1.1)
Iron Hydroxide ($FeHO_2$)	40 (±1.2)	34 (±0.6)	46 (±1.2)
Calcium Carbonate ($CaCO_3$)	ND	6 (±0.5)	6 (±0.6)
Silicon Dioxide (SiO_2)	ND	3 (±0.3)	ND
Hydrous Calcium Aluminum Sulfate ($Ca_6Al_2(SO_4)_3(OH)_{12}$ 26 H_2O)	ND	ND	ND

Values in relative weight percent
ND=Not Detected

TABLE 20 – X-RAY DIFFRACTION ANALYSIS TEST RESULTS FOR CORROSION PRODUCT

Phase	Corrosion 6	Corrosion 7	Corrosion 8
Iron Oxide (Fe3O2)	50 (±4.6)	84(±1.5)	17 (±0.3)
Iron Hydroxide (FeHO2)	33 (±1.3)	16(±0.7)	71 (±1.0)
Calcium Carbonate (CaCO3)	ND	ND	ND
Silicon Dioxide (SiO2)	4 (±0.9)	ND	12 (±1.1)
Hydrous Calcium Aluminum Sulfate ($Ca_6Al_2(SO_4)_3(OH)_{12}$ 26 H_2O)	13 (±1.7)	ND	ND

Values in relative weight percent
ND=Not Detected

TABLE 21 - TENSION TEST RESULTS

Sample Identification	Tensile Strength (ksi)②	Yield Strength (ksi)①②	Elongation (%)②③
1	62.0	38.9	36
2	63.5	39.1	36
3	61.5	40.1	35
5	66.0	44.4	33
6	68.0	42.5	32
7	68.5	46.3	32
8	65.0	45.9	34
10	67.5	45.8	23
A1	66.5	44.8	35
A2	67.5	44.1	30

NOTE: ① Yield strength was determined using the 0.2% offset method.
② Mechanical properties were measured using a standard specimen with nominal gauge dimensions of 0.500” x 2.000”.
③ Elongation was calculated using elongation-after-fracture measurements

METHODS

Tensile Testing, ASTM E8/8M-16a

TABLE 22 - HARDNESS TEST RESULTS

Sample Identification	Rockwell B Hardness, HRBW				
	Reading 1	Reading 2	Reading 3	Reading 4	Average
1	68	68	68	68	68
2	67	66	66	66	66
3	66	66	66	66	66
5	68	68	68	68	68
6	72	73	73	73	73
7	72	72	73	72	72
8	71	71	71	71	71
10	68	69	68	68	68
A1	72	72	72	72	72
A2	72	73	72	72	72

METHODS

Rockwell Hardness, ASTM E18-17$^{\varepsilon 1}$

TABLE 23 – COUPON THICKNESS AND THINNING MEASUREMENT RESULTS

Coupon #	Location	Sample ID	Specified Plate Thickness, mils	Measured Plate Thickness, mil①	Thinnest Measured Location, mil	Remaining Wall Thickness, %②
1	1	1-2	250	250	222.4	89.0
	2	1-3			218.5	87.4
	3	1-4⑦			207.9	83.1
2	1	2-1		261	152.4	60.9
	2	2-2			159.8	63.9
	3	2-3			186.6	74.6
3	1	3-1		250	171.3	68.5
	2	3-2			145.3	58.1
	3	3-3			131.5	52.6
	4	3-4⑦			233.9	93.5
5③	1	5-1		251	247.6	99.1
	2	5-4⑦			225.6	90.2
	3	5-5⑦			224.0	89.6
6	1	6-1		245	157.9	63.1
	2	6-2			206.7	82.7
	3	6-3			224.0	89.6
7	1	7-1		252	163.8	65.5
	2	7-3			172.4	69.0
	3	7-4⑦			166.1	66.5
8④	1	8-1		234	---	---
	2	8-3			205.9	82.4
	3	8-4⑦			---	---
10⑤	1	10-1		245	241.7	96.7
	2	10-2			242.1	96.9
	3	10-4⑦			N/A	N/A
A1	1	A1-1		252	193.7	77.5
	2	A1-4⑦			122.4	49.0
	3	A1-5⑦			192.9	77.2
A2⑥	1	A2-3		254	247.6	99.1
	2	A2-4			250.8	100.3
	3	N/A			N/A	N/A

① Local wall thickness, as measured with calibrated digital micrometers after removing paint layer. Measurement uncertainty available upon request.
② Calculated using specified tank wall thickness (250 mils). Measurement uncertainty available upon request.
③ Suspected NDT inspection indication was a depression on the painted face of Sample 5-4. No pits observed.
④ This is the weld-repaired plate section. Sample 8-3 exhibited a depression or pit on the painted surface.
⑤ No pits observed. Suspected NDT inspection indication was a weld nugget on the interior surface of the coupon (thick area) on Sample 10-4.
⑥ No pits observed. Suspected NDT inspection indications are areas of melting on the painted face, underneath the paint on Sample A2-4. Therefore, only 2 samples examined in cross-section.
⑦ See Appendix B for specimen location.

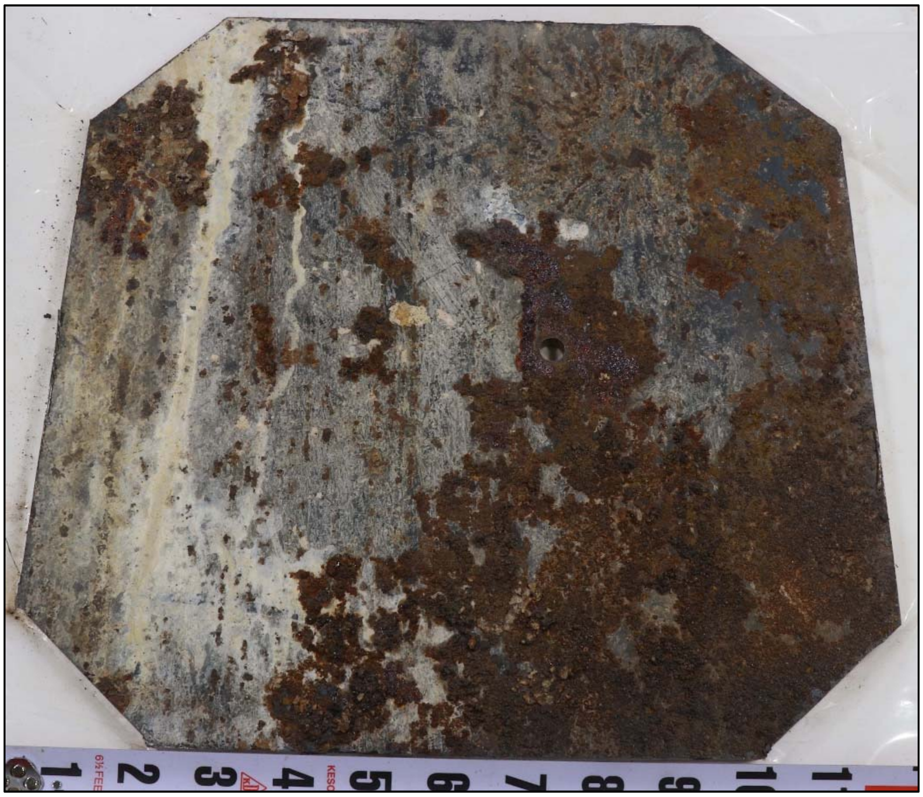


Figure 1. An image of the interior surface of Coupon 1 in the as-received condition.

Figure 2. An image of the exterior surface of Coupon 1 in the as-received condition.

Figure 3. An image of a representative edge of Coupon 1 in the as-received condition.

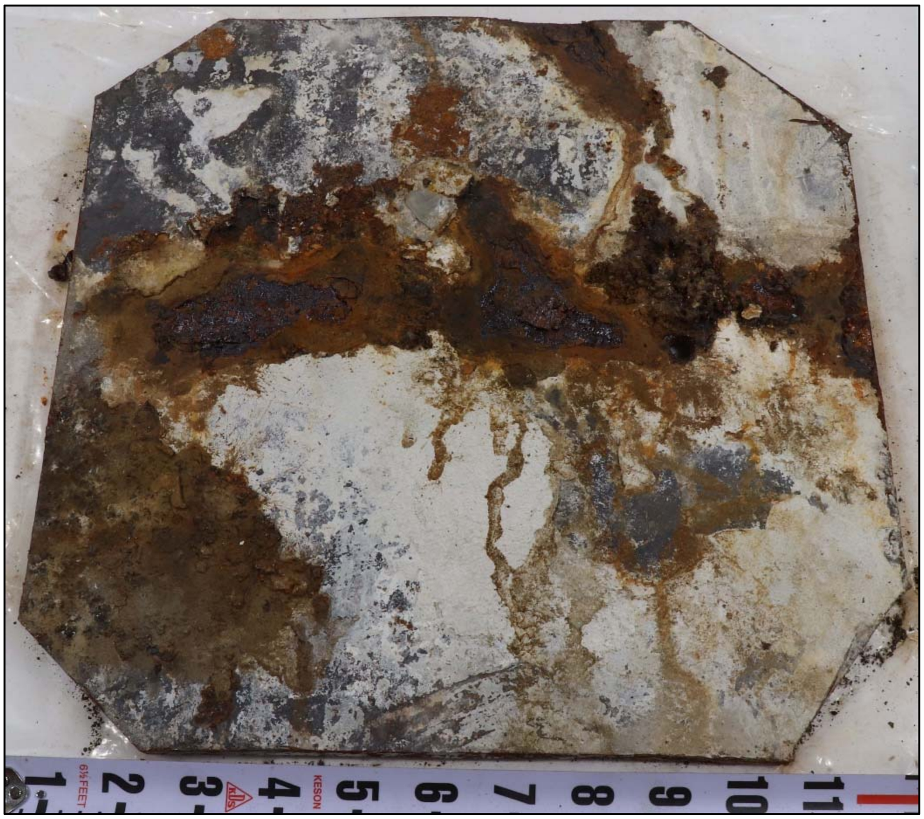


Figure 4. An image of the interior surface of Coupon 2 in the as-received condition.

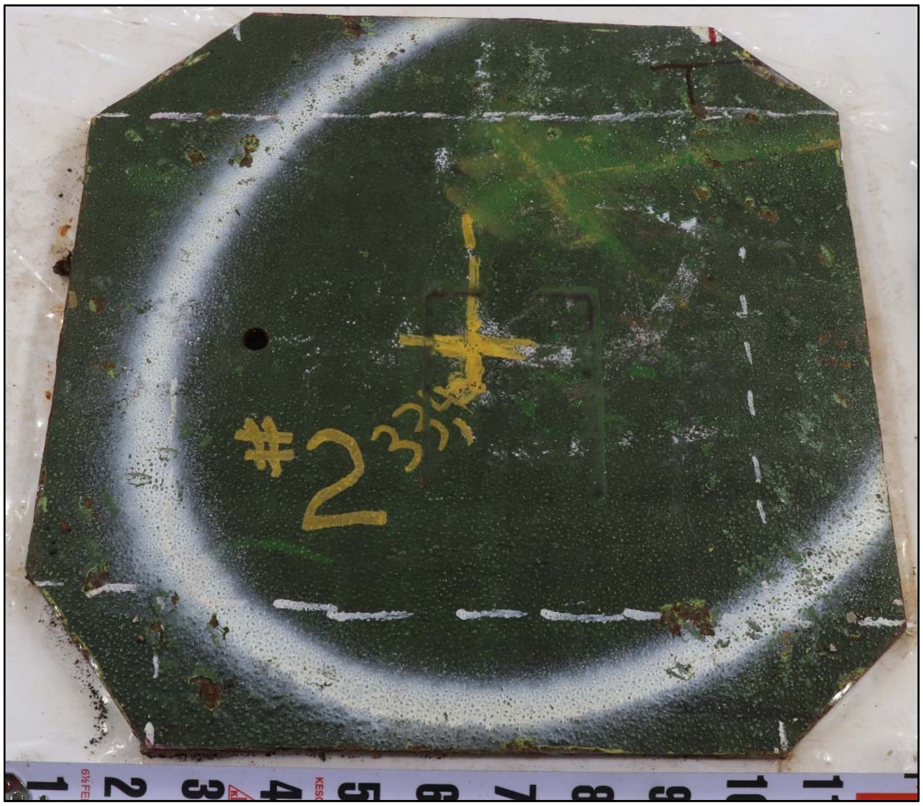


Figure 5. An image of the exterior surface of Coupon 2 in the as-received condition.

Figure 6. An image of a representative edge of Coupon 2 in the as-received condition.

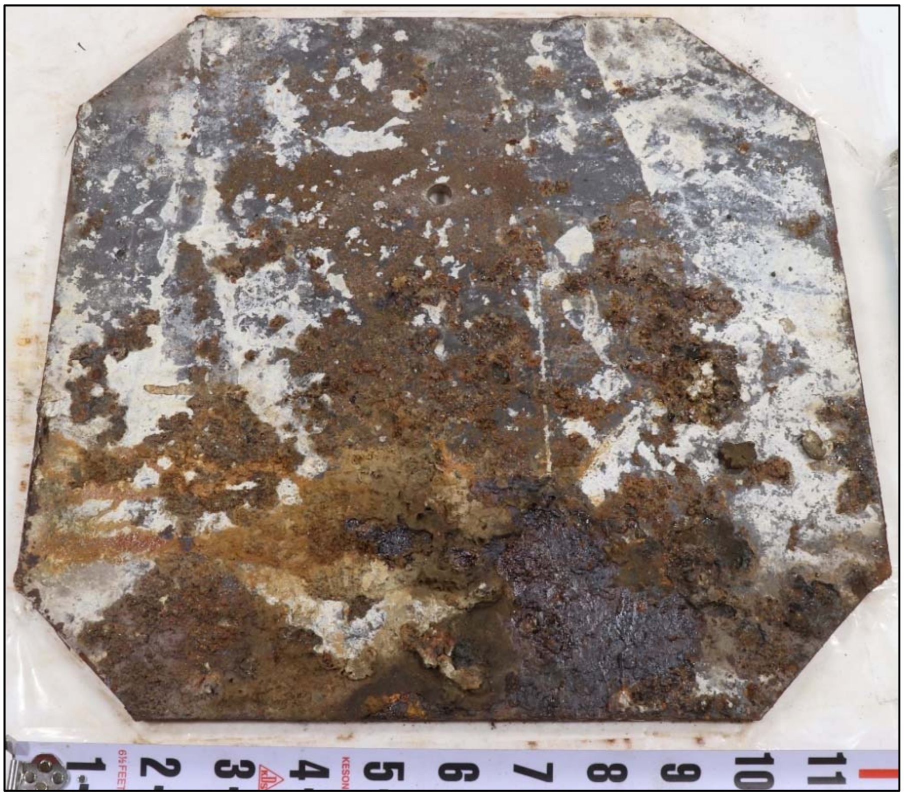


Figure 7. An image of the interior surface of Coupon 3 in the as-received condition.

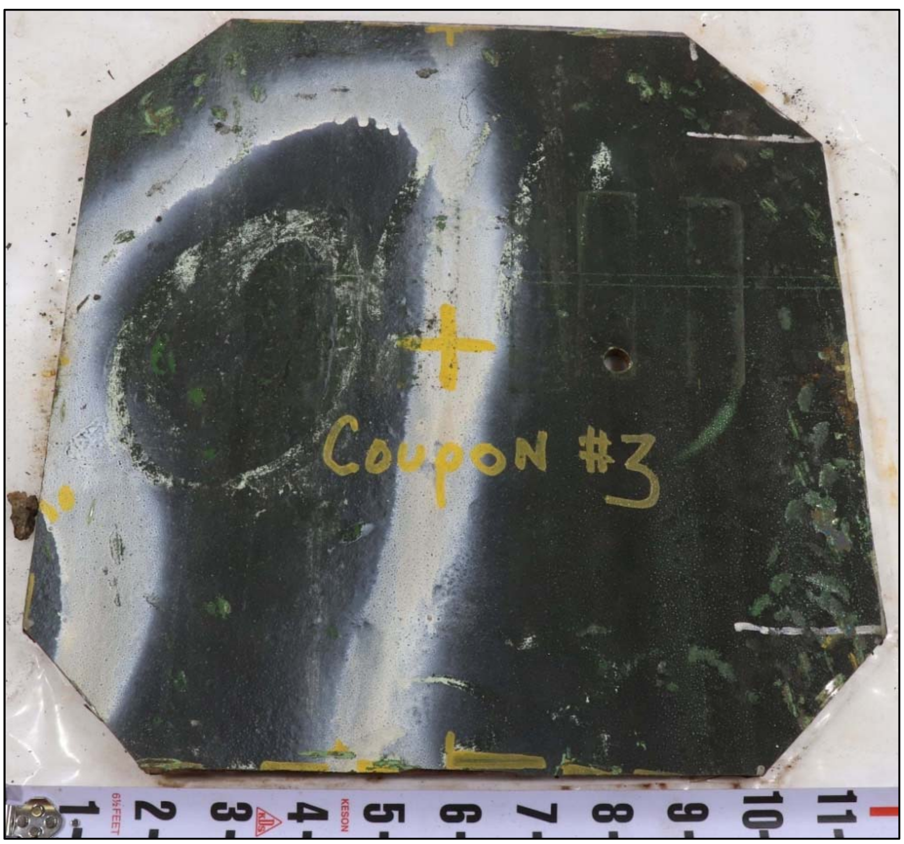


Figure 8. An image of the exterior surface of Coupon 3 in the as-received condition.

Figure 9. An image of a representative edge of Coupon 3 in the as-received condition.

Figure 10. An image of the interior surface of Coupon 5 in the as-received condition.

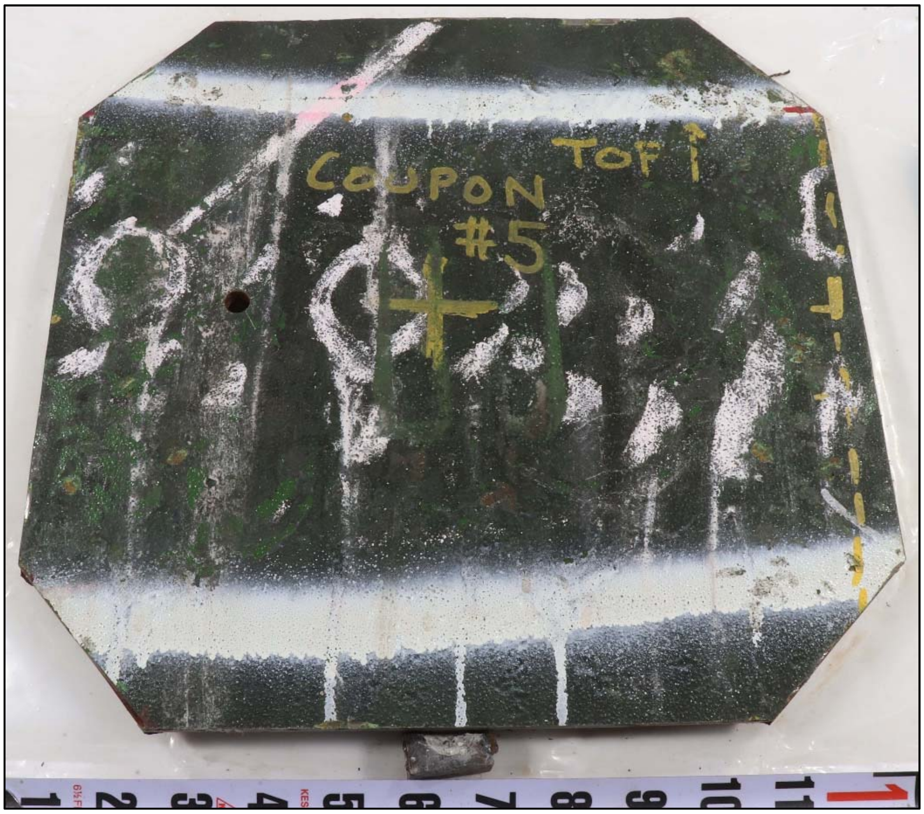


Figure 11. An image of the exterior surface of Coupon 5 in the as-received condition.

Figure 12. An image of a representative edge of Coupon 5 in the as-received condition.

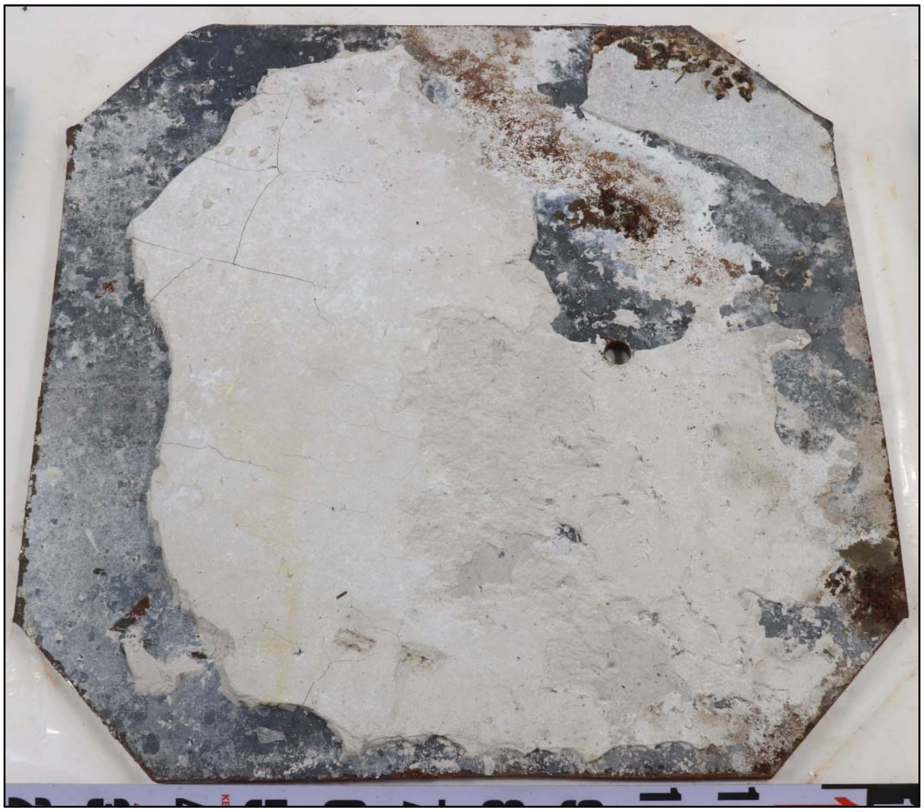


Figure 13. An image of the interior surface of Coupon 6 in the as-received condition.

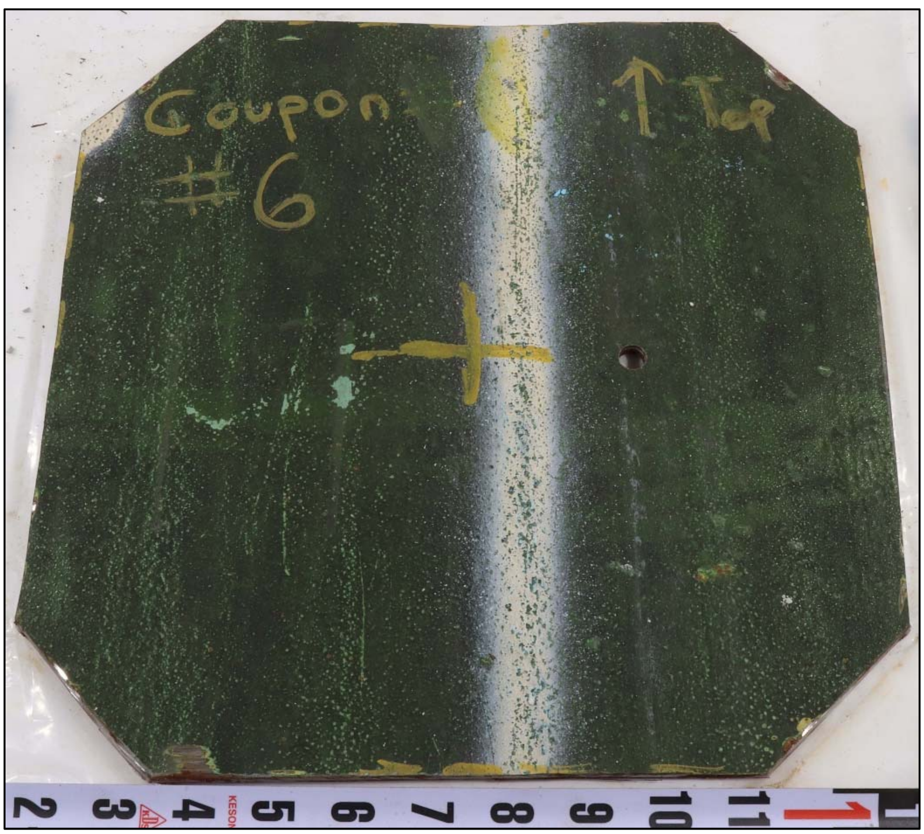


Figure 14. An image of the exterior surface of Coupon 6 in the as-received condition.

Figure 15. An image of a representative edge of Coupon 6 in the as-received condition.

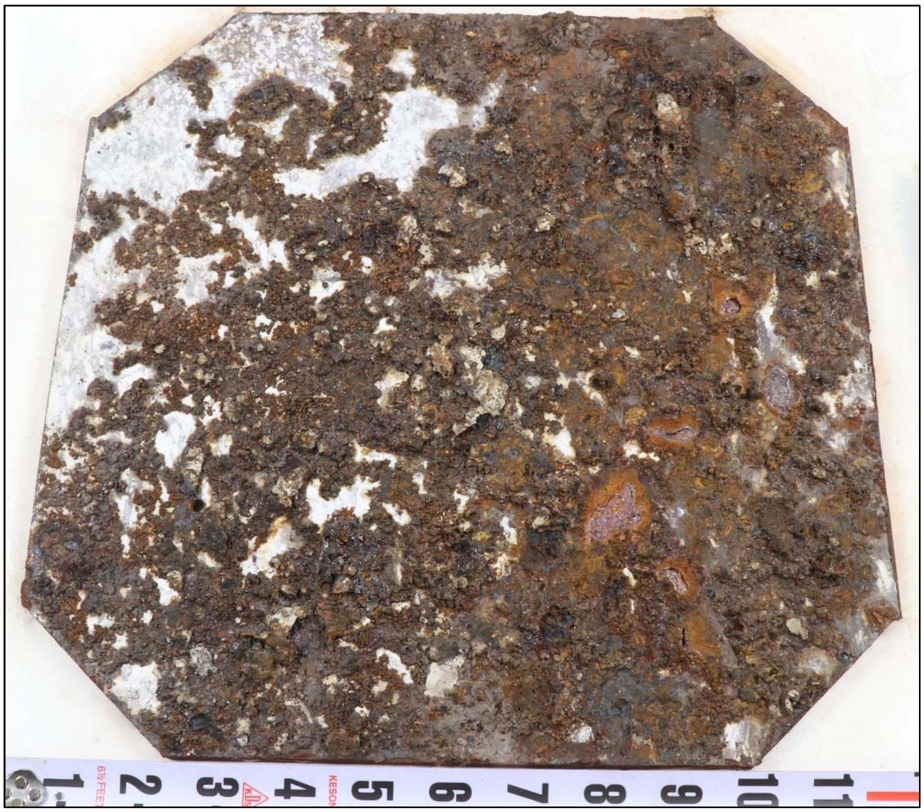


Figure 16. An image of the interior surface of Coupon 7 in the as-received condition.

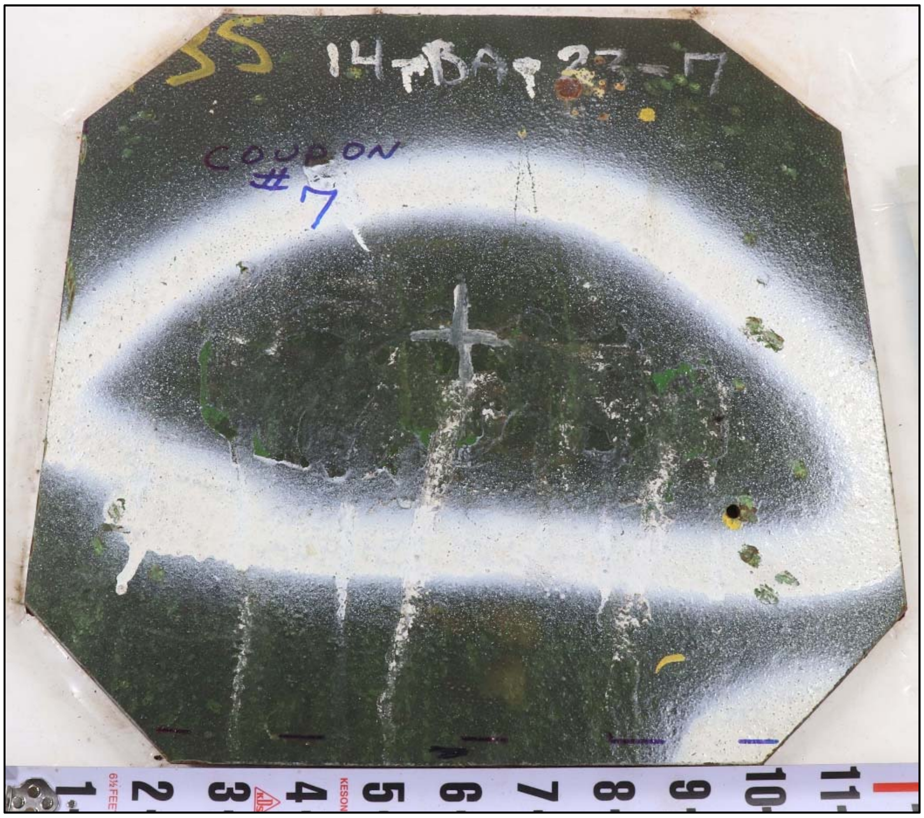


Figure 17. An image of the exterior surface of Coupon 7 in the as-received condition.

Figure 18. An image of a representative edge of Coupon 7 in the as-received condition.

Figure 19. An image of the interior surface of Coupon 8 in the as-received condition.

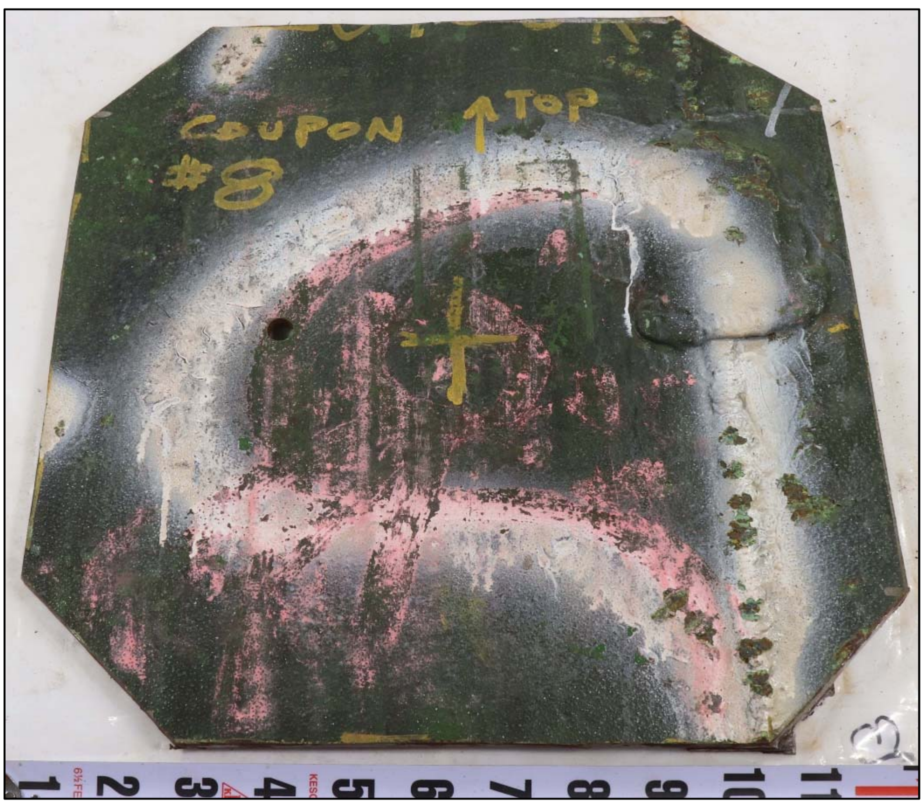


Figure 20. An image of the exterior surface of Coupon 8 in the as-received condition.

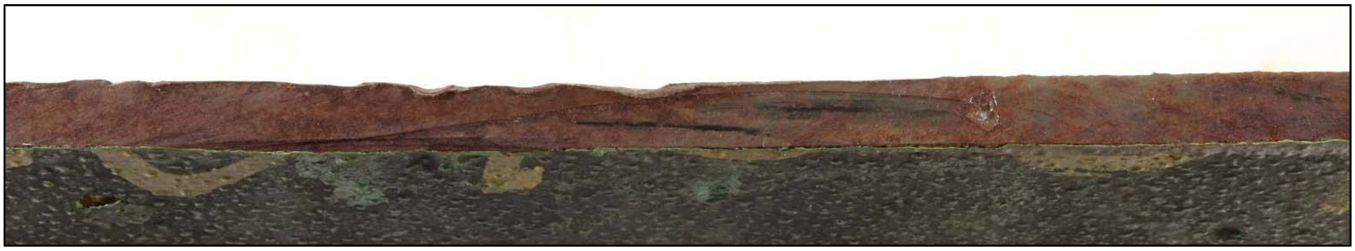


Figure 21. An image of a representative edge of Coupon 8 in the as-received condition.

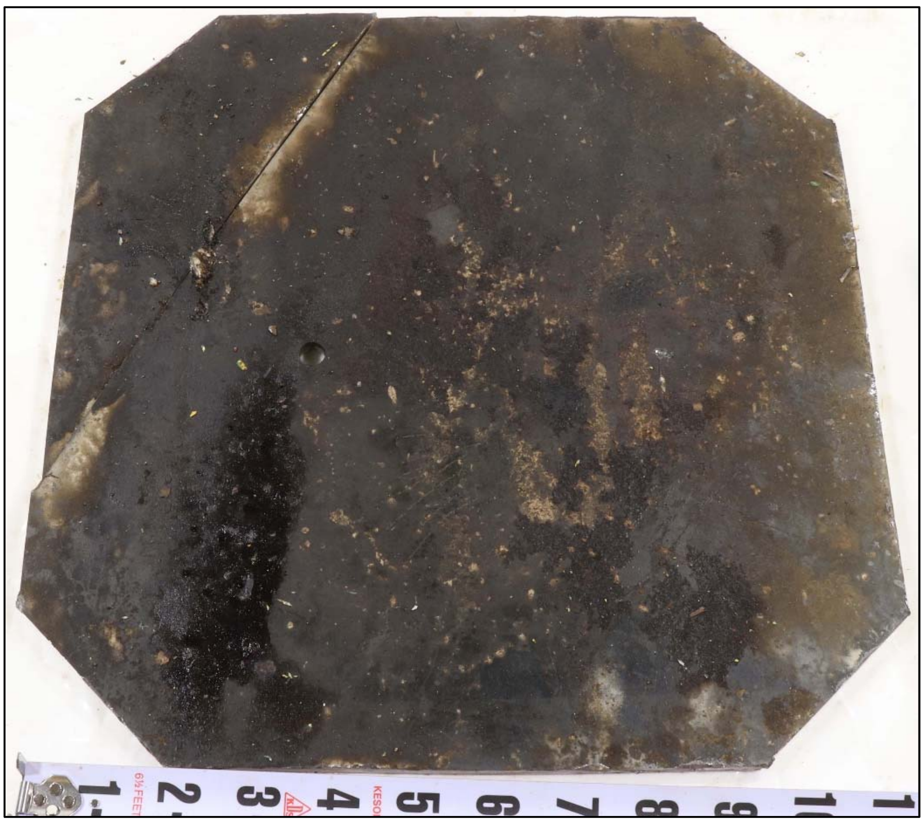


Figure 22. An image of the interior surface of Coupon 10 in the as-received condition.

Figure 23. An image of the exterior surface of Coupon 10 in the as-received condition.

Figure 24. An image of a representative edge of Coupon 10 in the as-received condition.

Figure 25. An image of the interior surface of Coupon A1 in the as-received condition.

Figure 26. An image of the exterior surface of Coupon A1 in the as-received condition.

Figure 27. An image of a representative edge of Coupon A1 in the as-received condition.

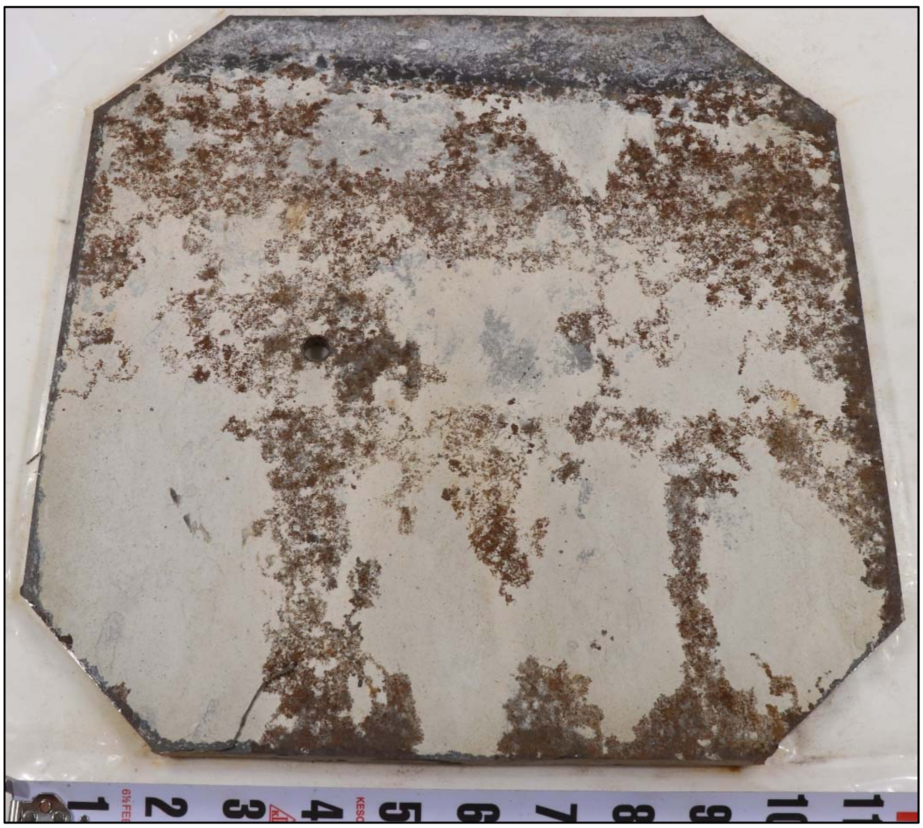


Figure 28. An image of the interior surface of Coupon A2 in the as-received condition.

Figure 29. An image of the exterior surface of Coupon A2 in the as-received condition.

Figure 30. An image of a representative edge of Coupon A2 in the as-received condition.

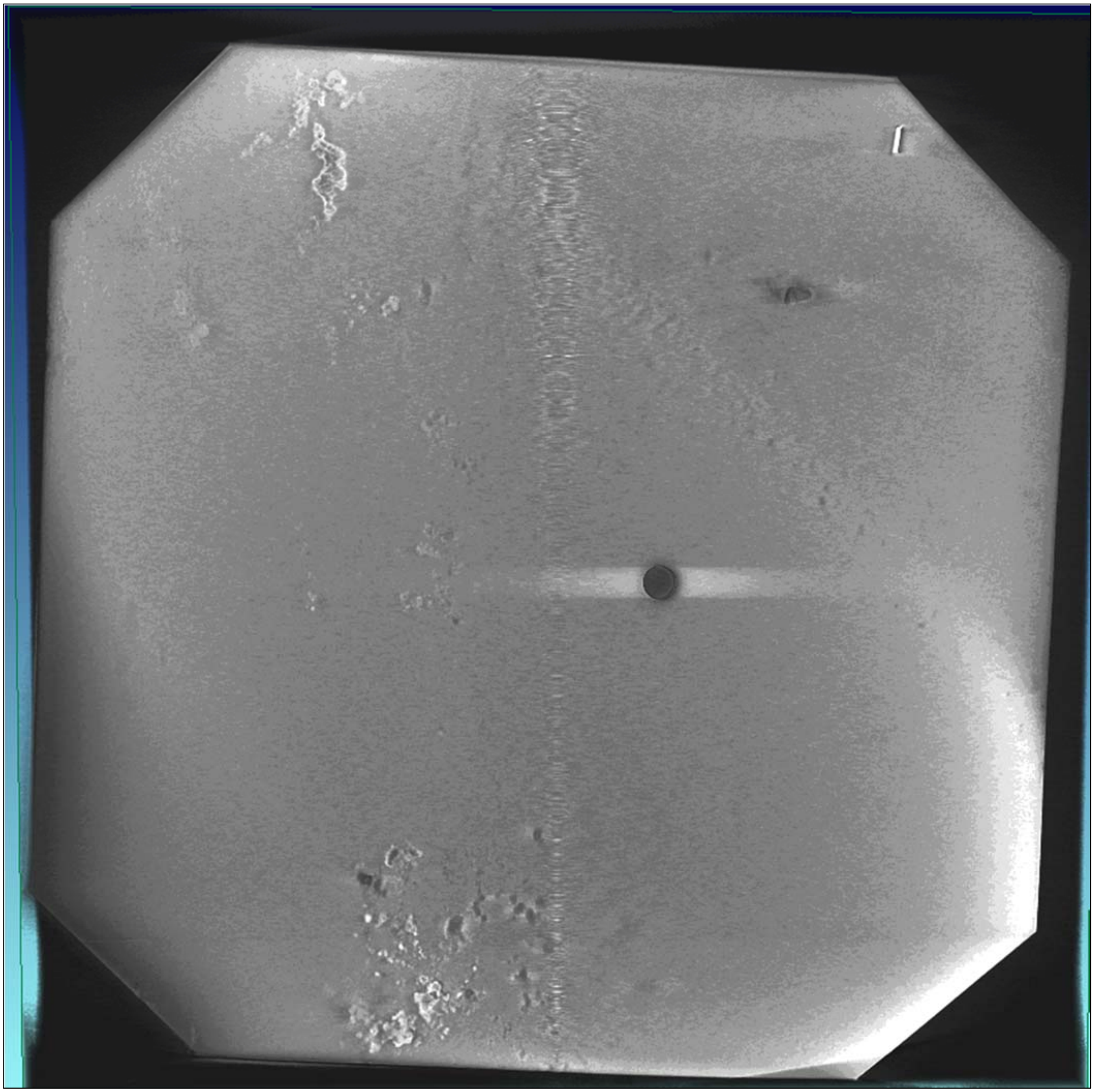


Figure 31. A representative screenshot of the CT scan performed on Coupon 1.

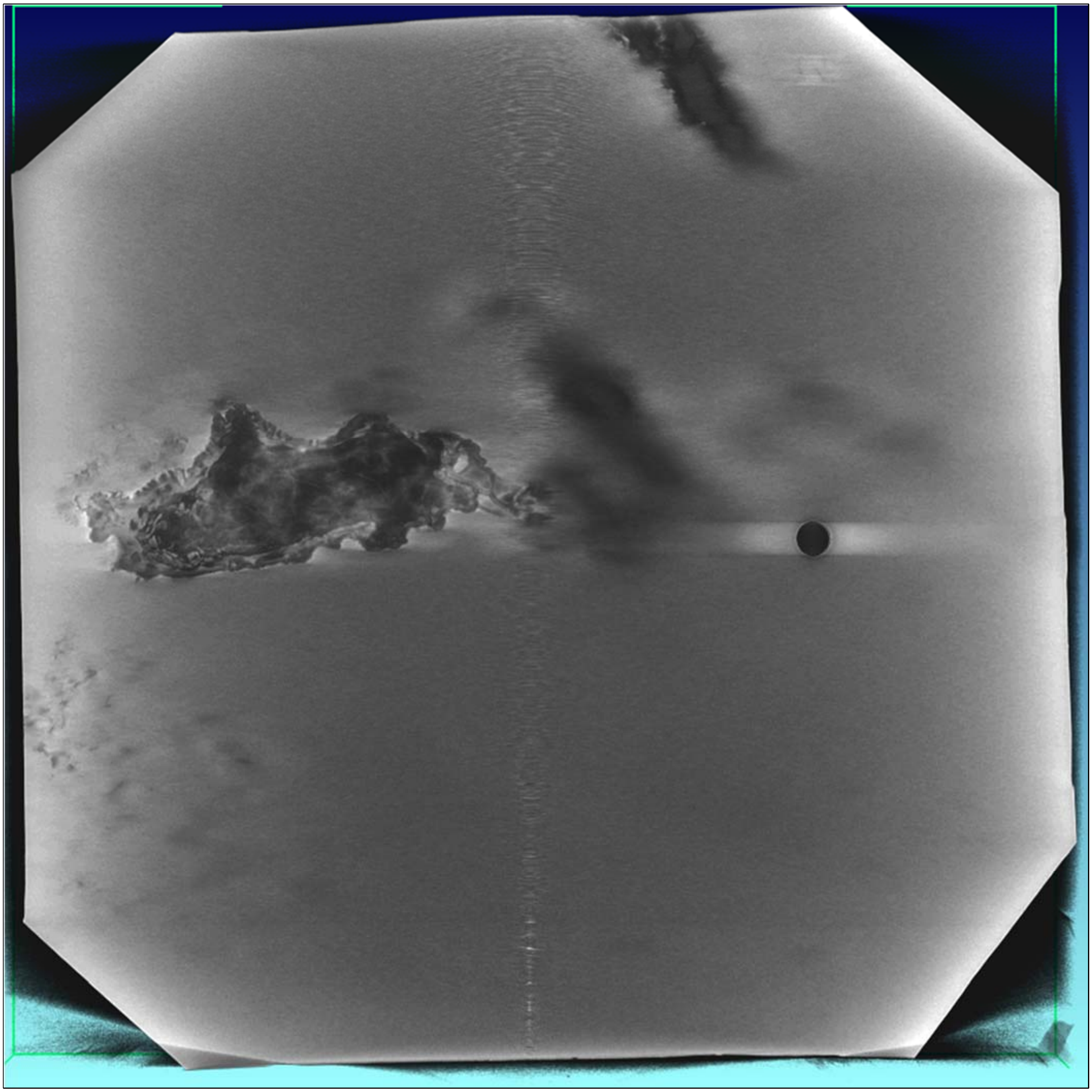


Figure 32. A representative screenshot of the CT scan performed on Coupon 2.

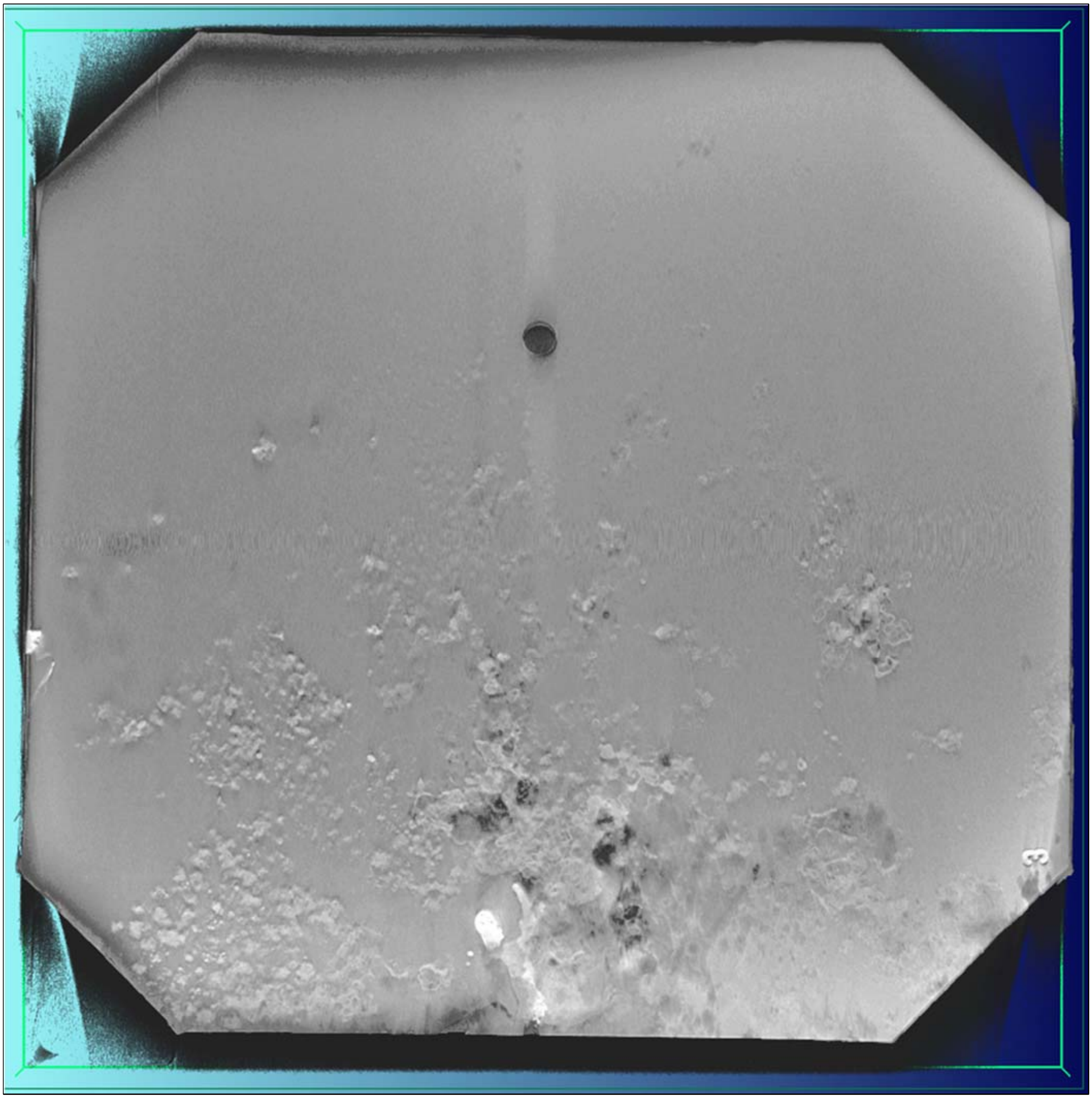


Figure 33. A representative screenshot of the CT scan performed on Coupon 3.

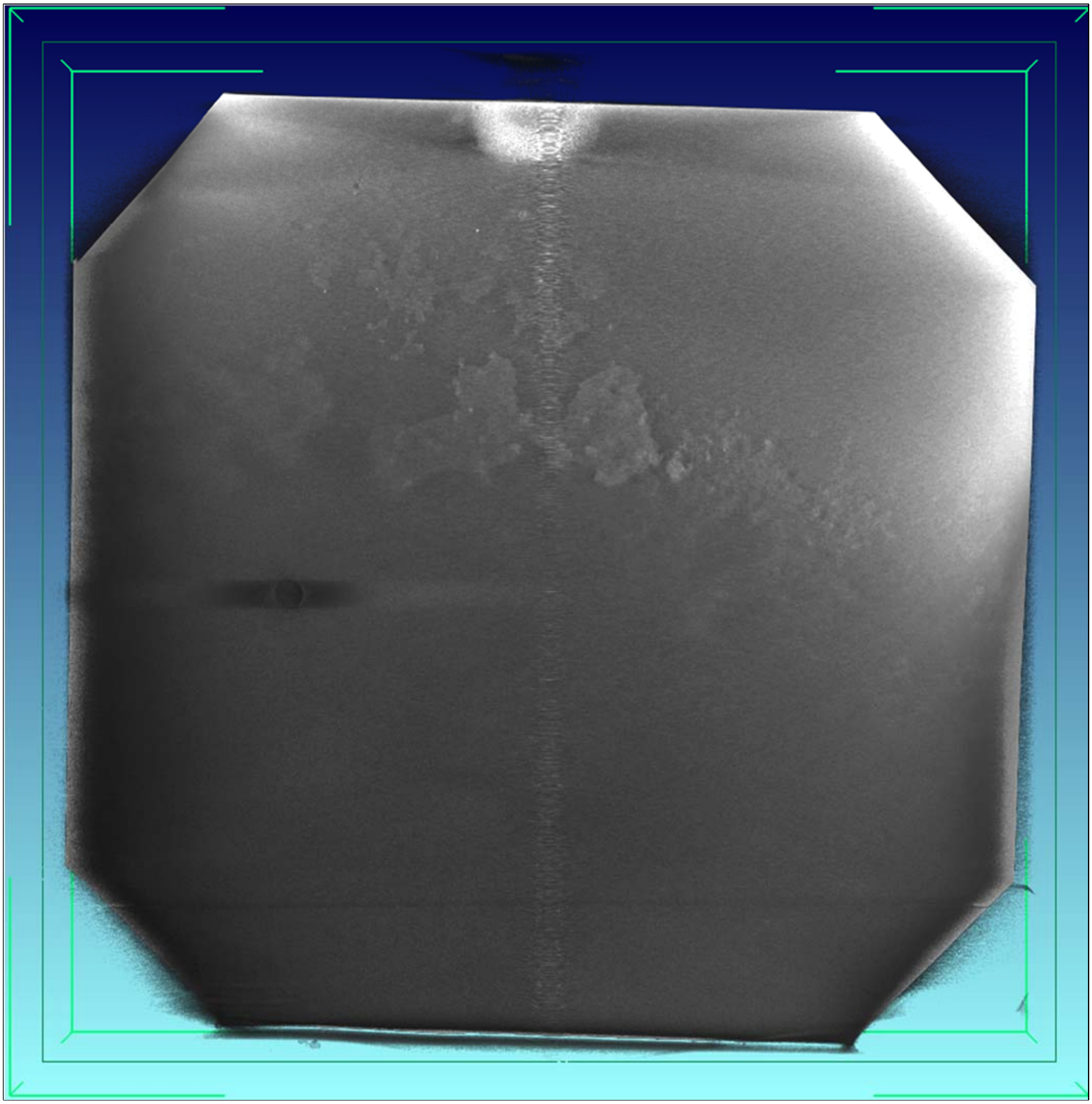


Figure 34. A representative screenshot of the CT scan performed on Coupon 5.

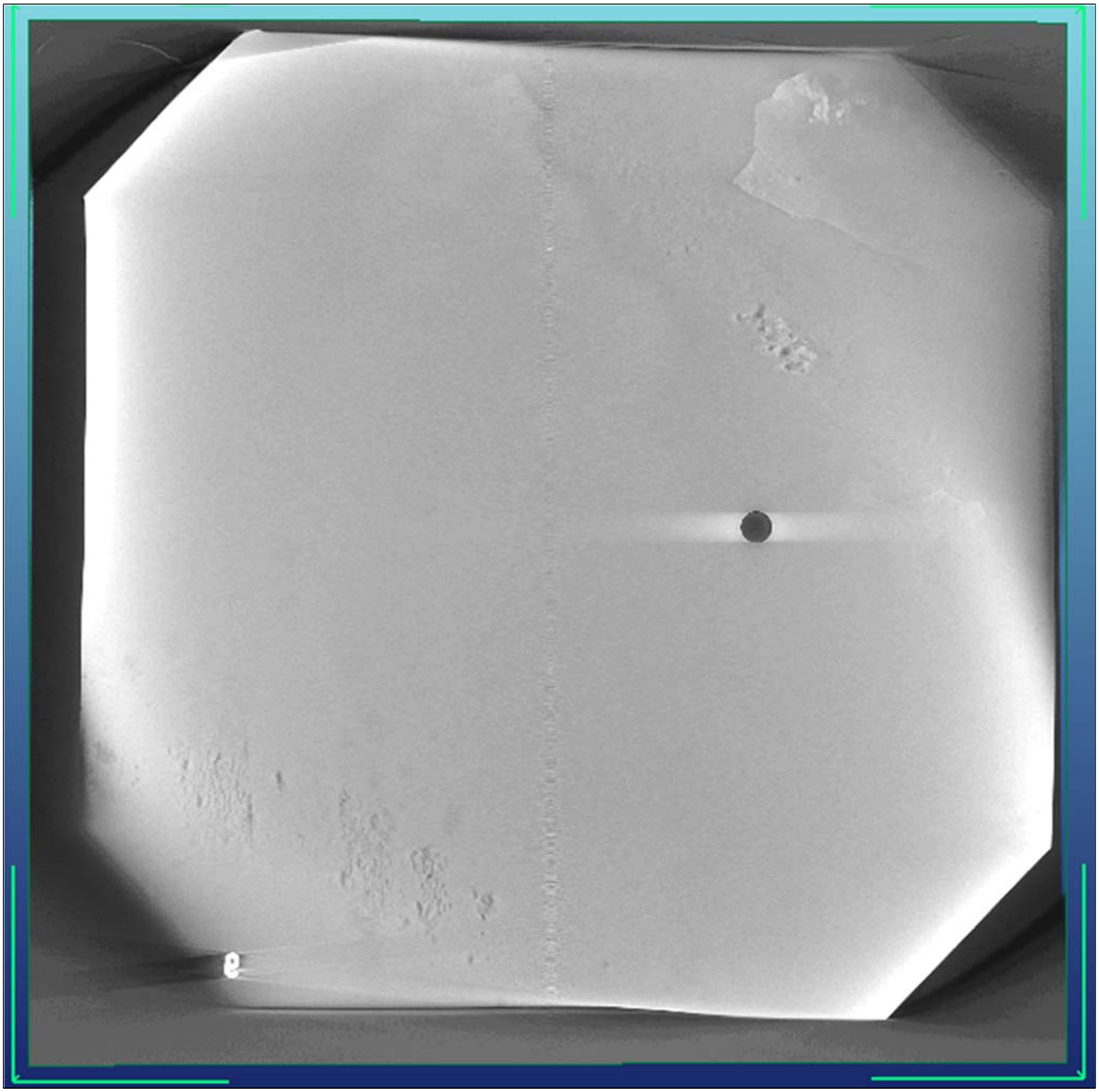


Figure 35. A representative screenshot of the CT scan performed on Coupon 6.

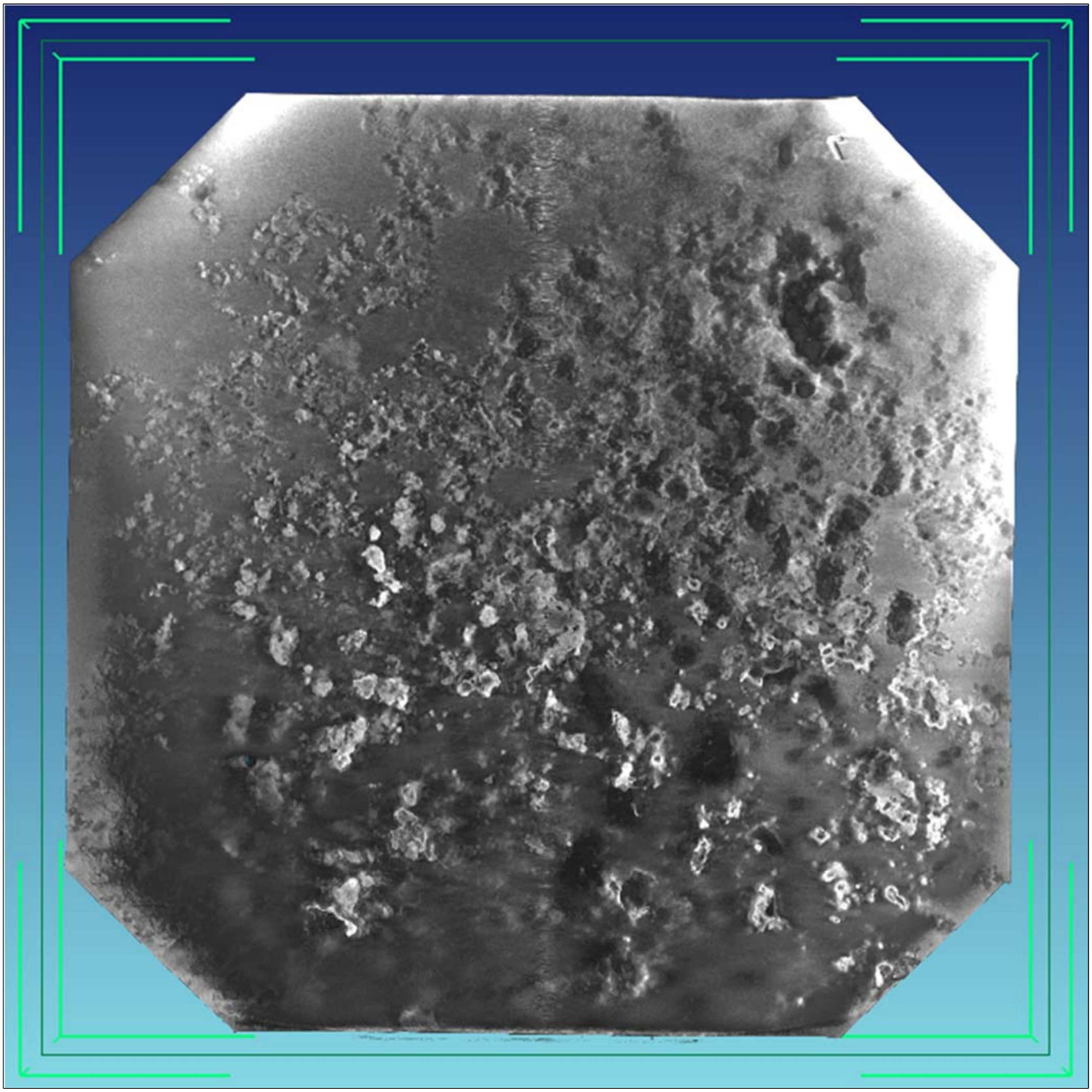


Figure 36. A representative screenshot of the CT scan performed on Coupon 7.

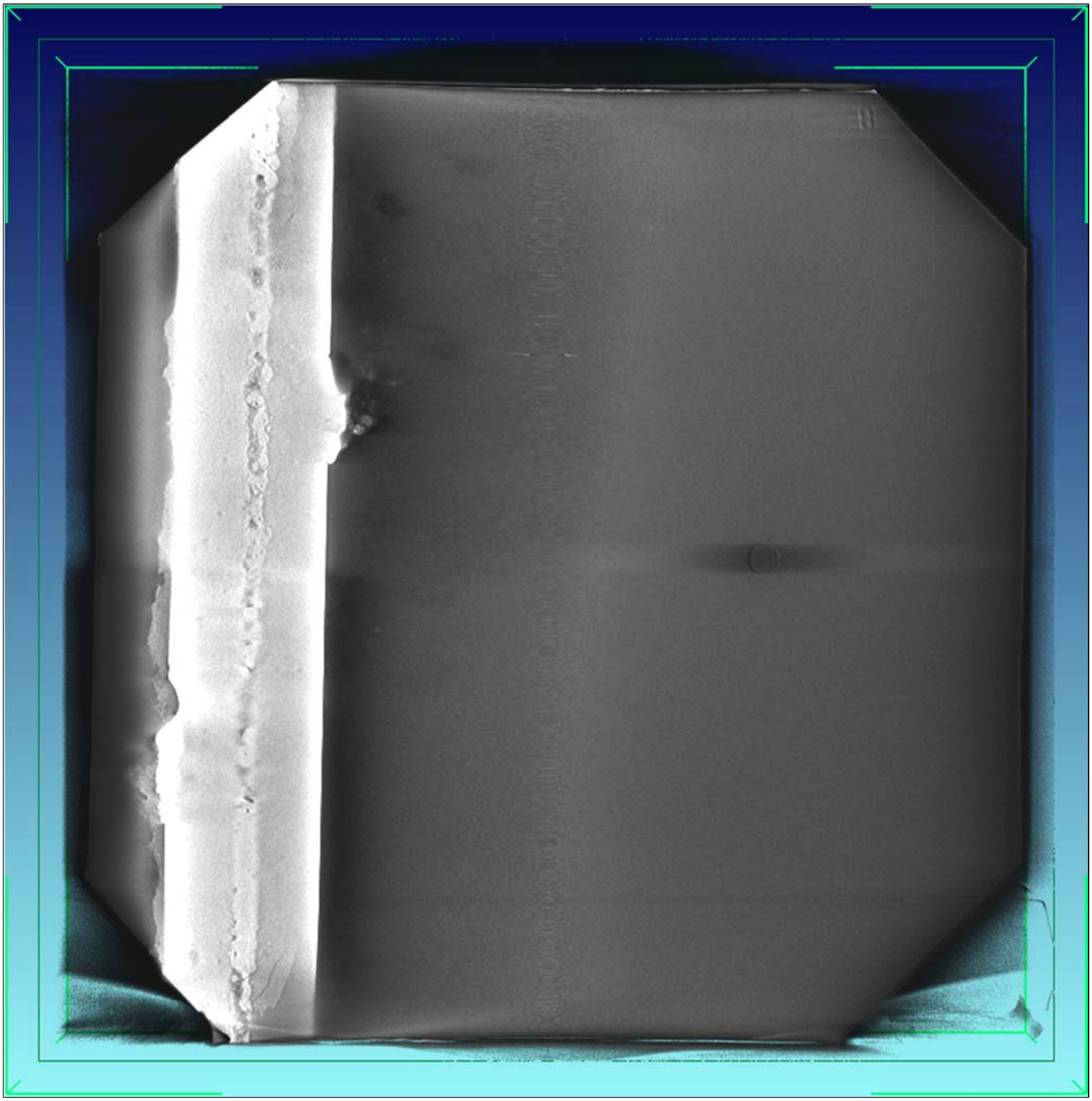


Figure 37. A representative screenshot of the CT scan performed on Coupon 8.

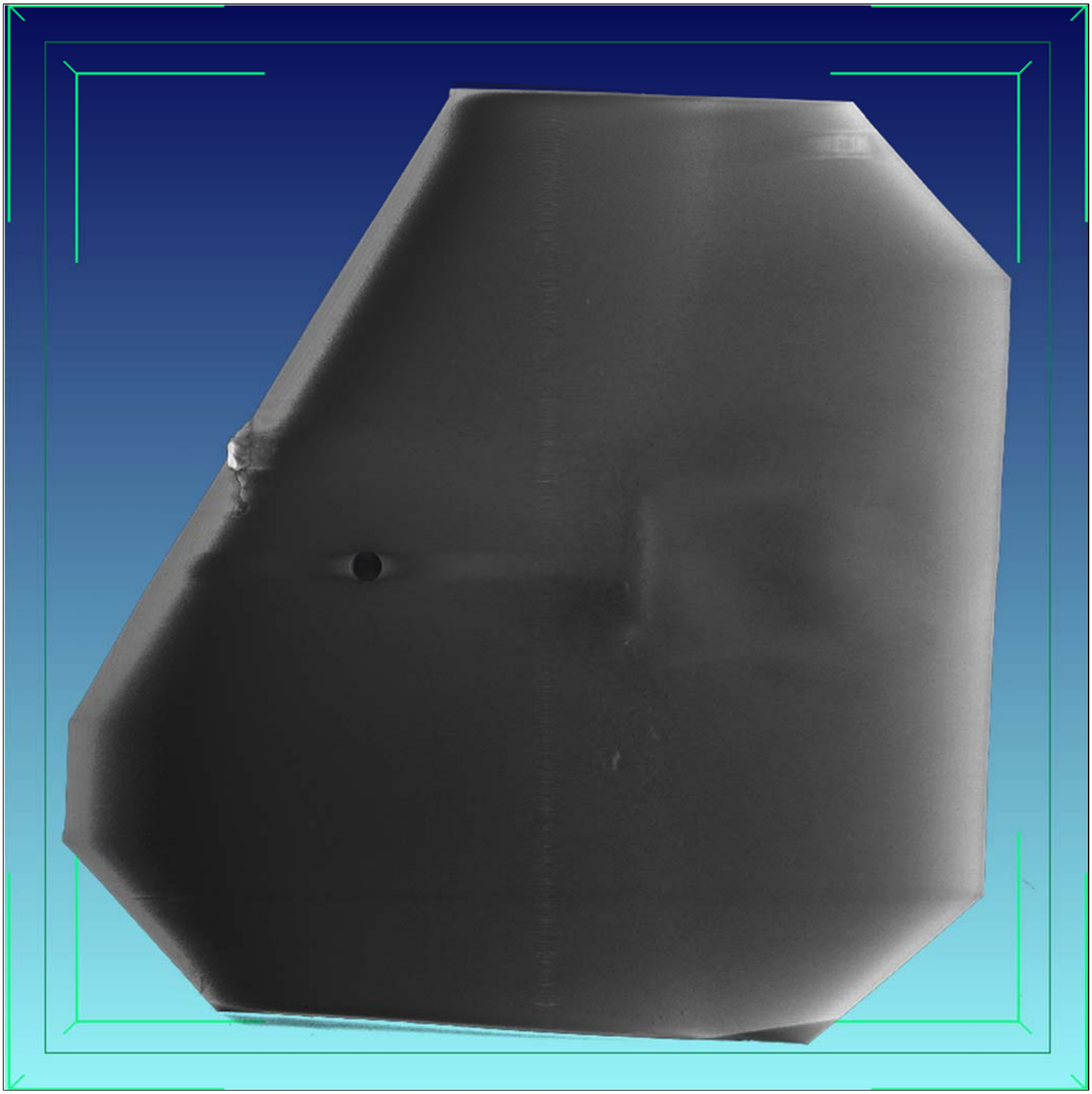


Figure 38. A representative screenshot of the CT scan performed on Coupon 10.

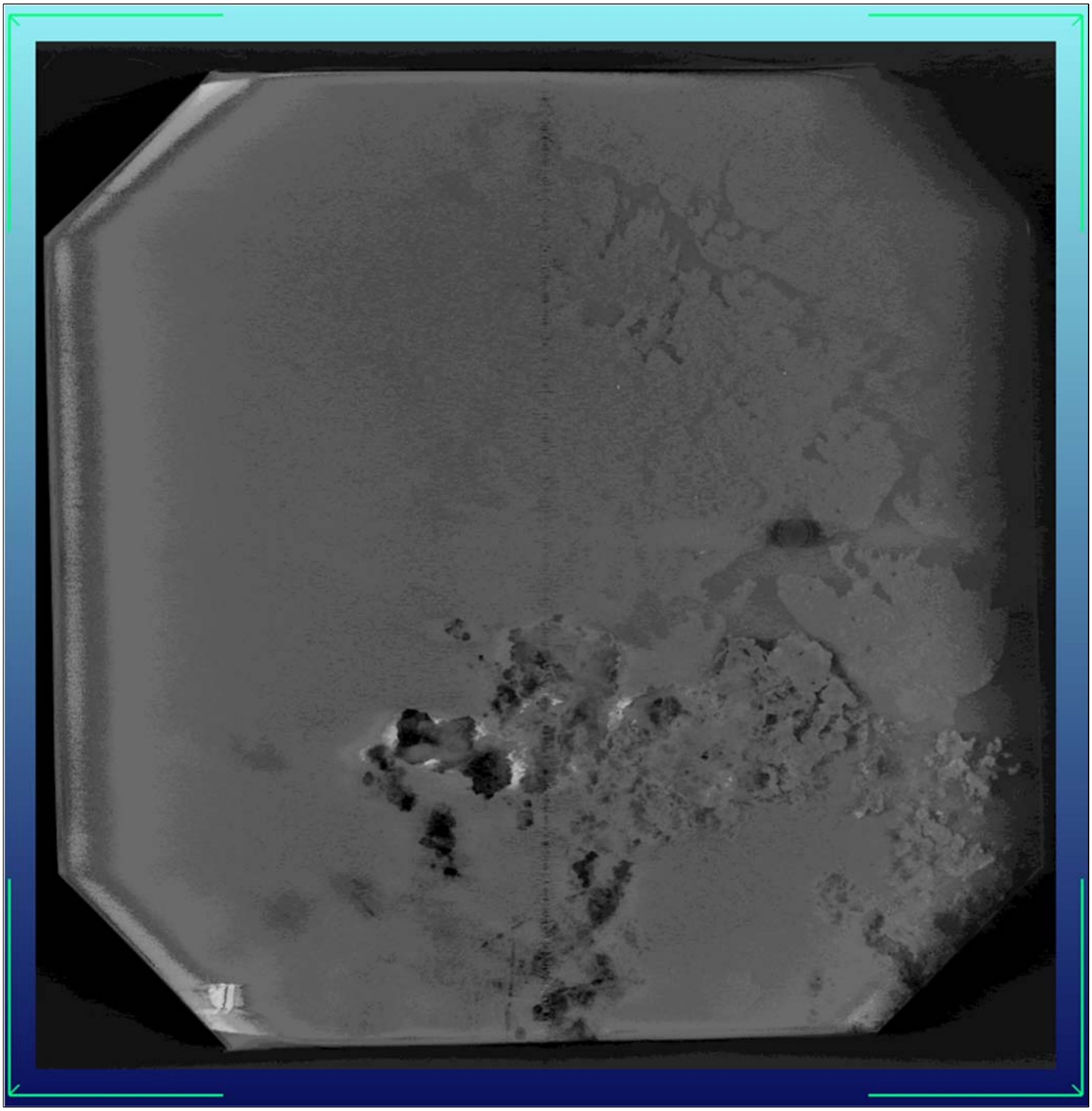


Figure 39. A representative screenshot of the CT scan performed on Coupon A1.

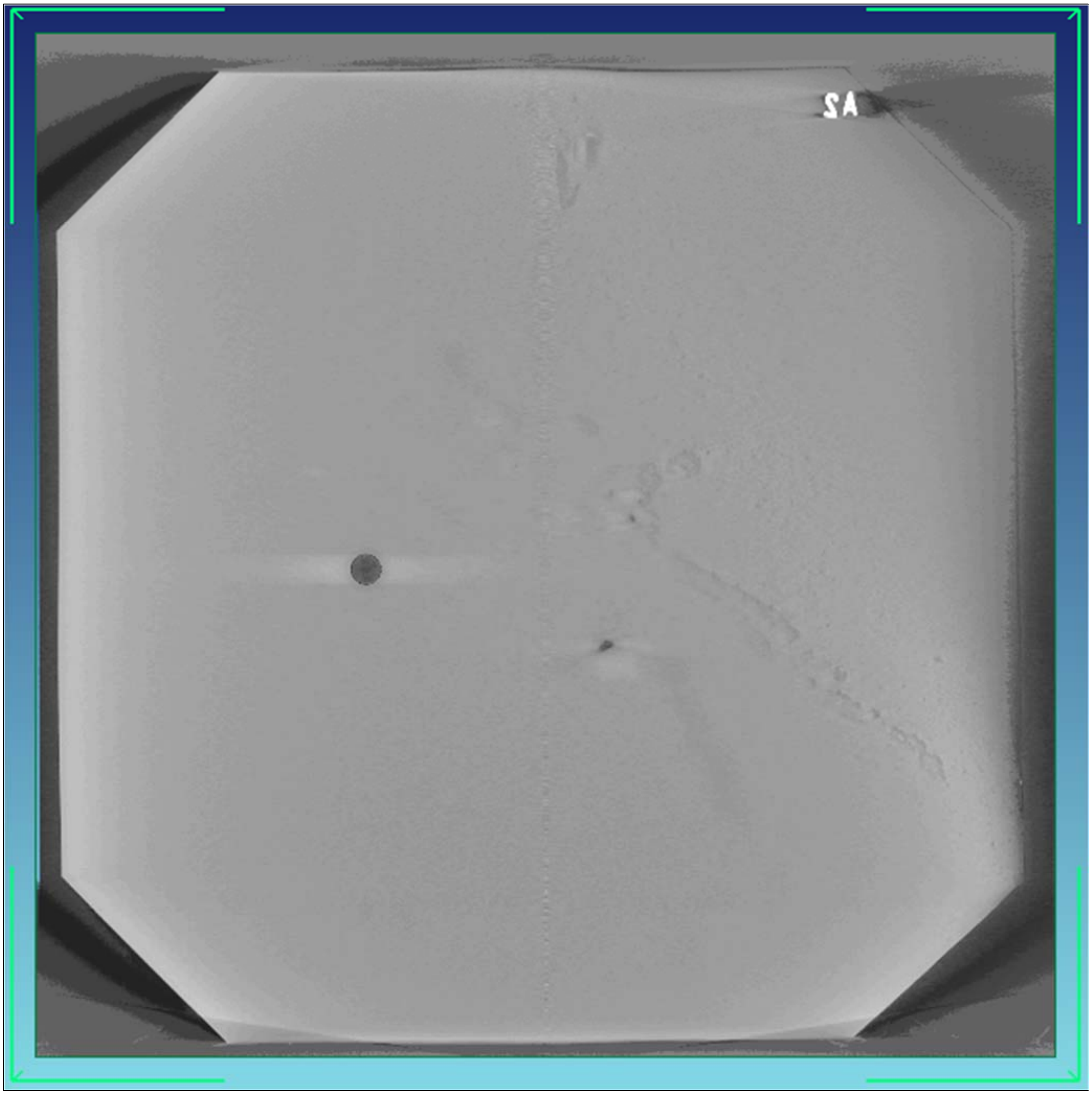


Figure 40. A representative screenshot of the CT scan performed on Coupon A2.

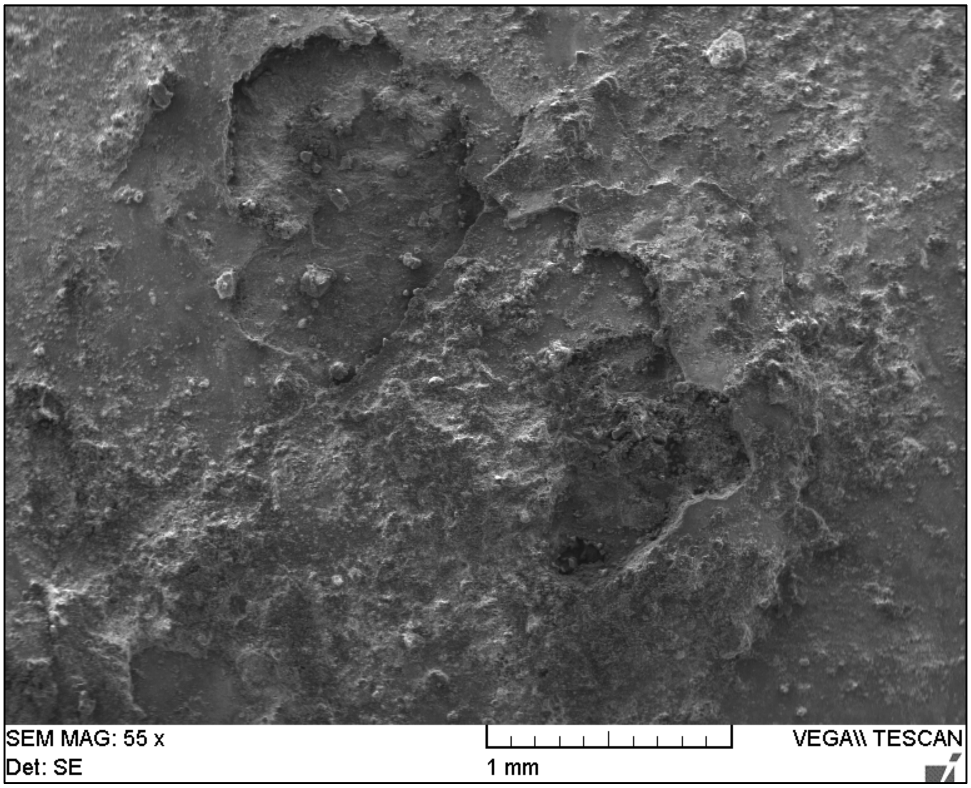


Figure 41. A representative SEM image of a pit on a specimen excised from Coupon 1 labeled as 1-1, prior to cleaning. (SEM, 32X)

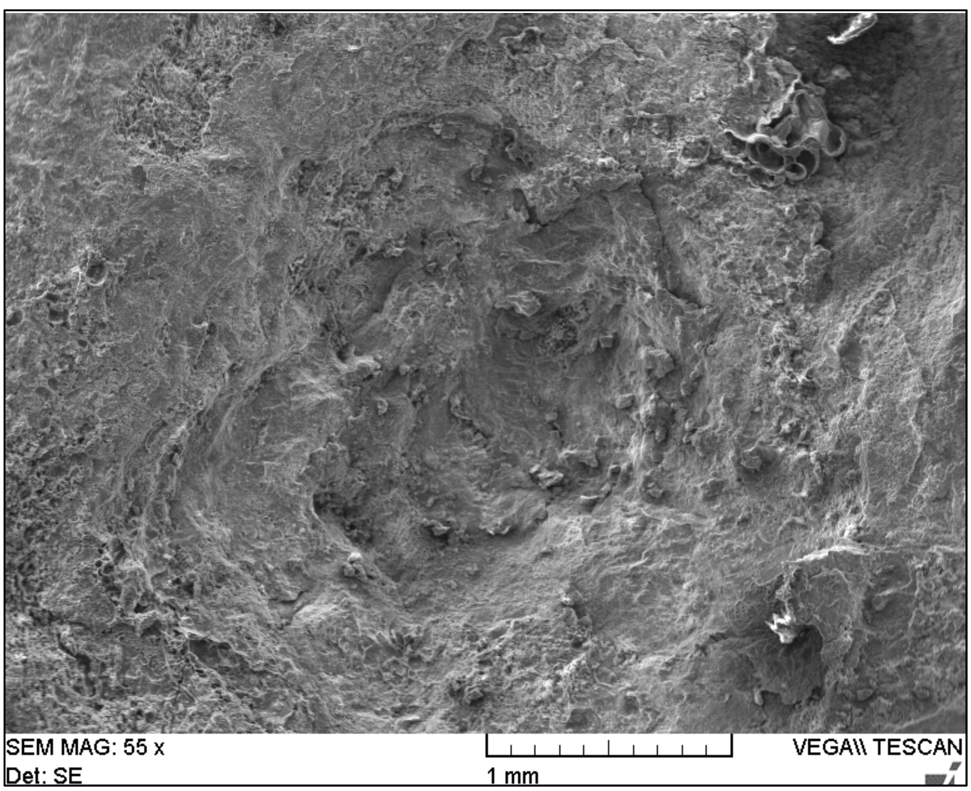


Figure 42. A representative SEM image of a pit on a specimen excised from Coupon 1 labeled as 1-2, prior to cleaning. (SEM, 32X)

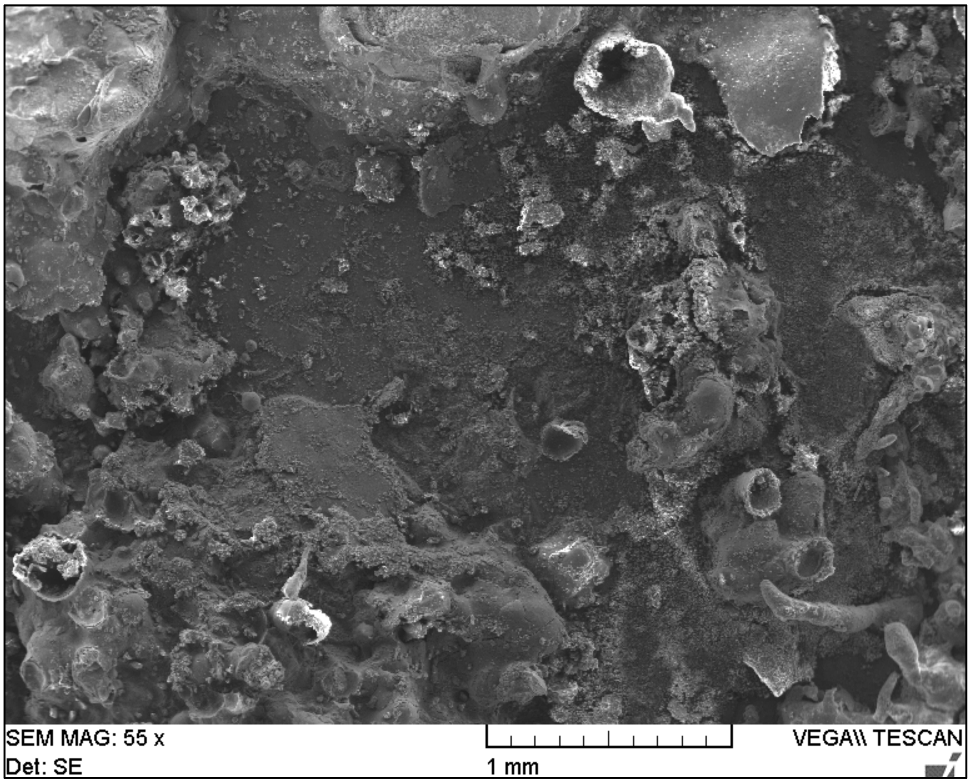


Figure 43. A representative SEM image of a pit on a specimen excised from Coupon 1 labeled as 1-3, prior to cleaning. (SEM, 32X)

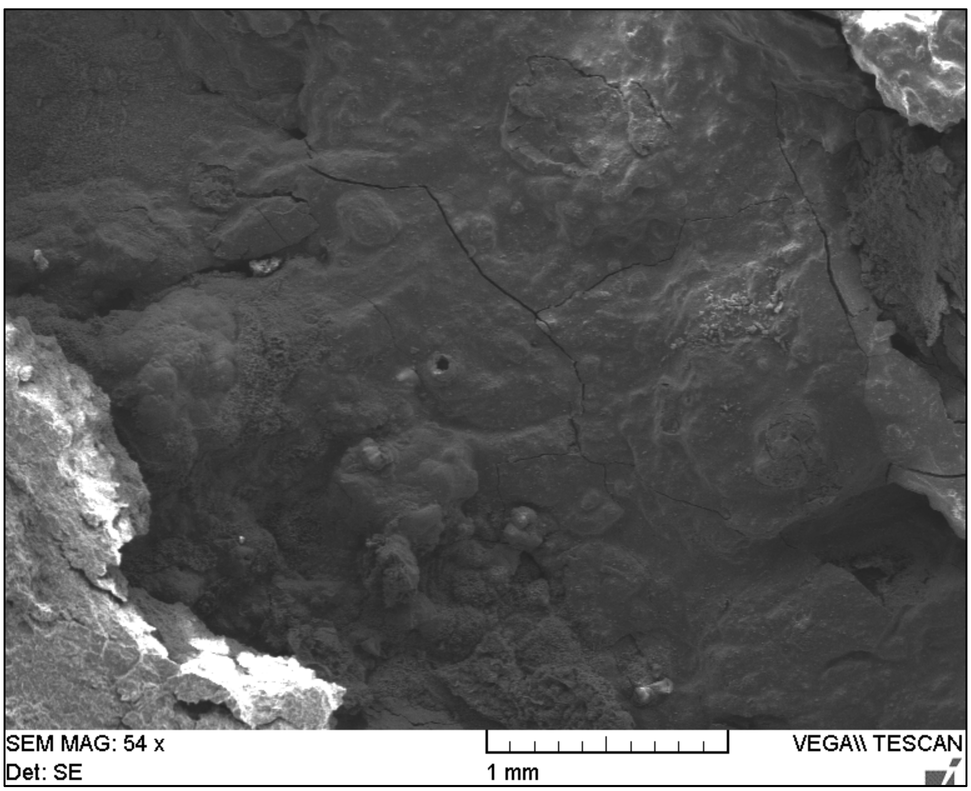


Figure 44. A representative SEM image of a pit on a specimen excised from Coupon 2 labeled as 2-1, prior to cleaning. (SEM, 32X)

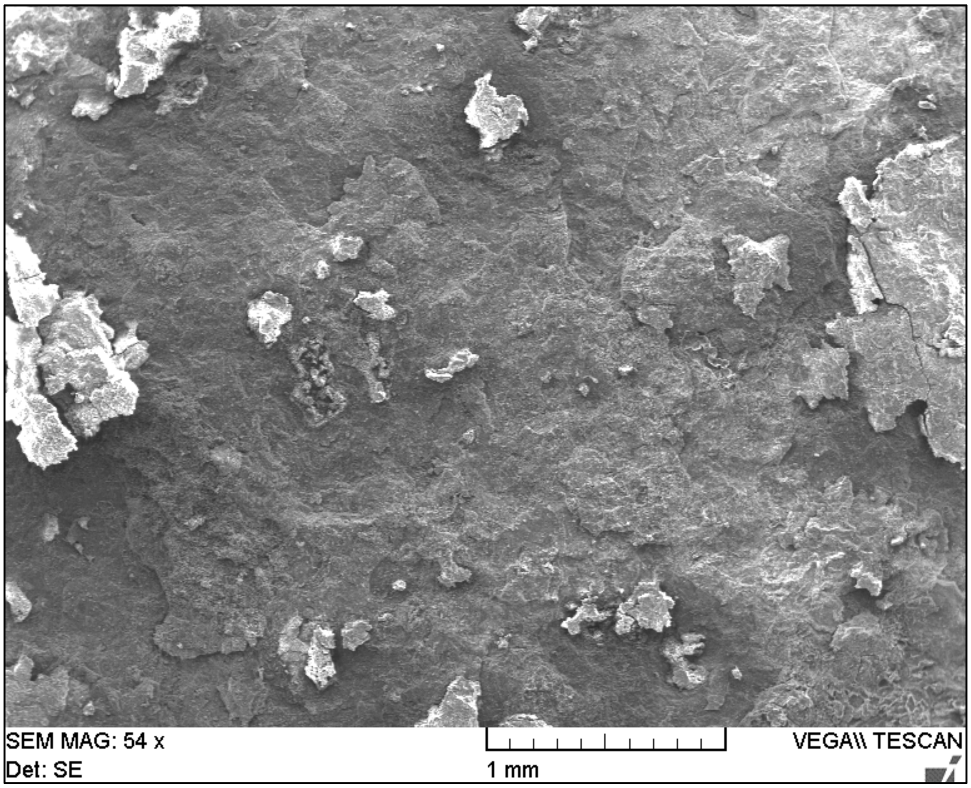


Figure 45. A representative SEM image of a pit on a specimen excised from Coupon 2 labeled as 2-2, prior to cleaning. (SEM, 32X)

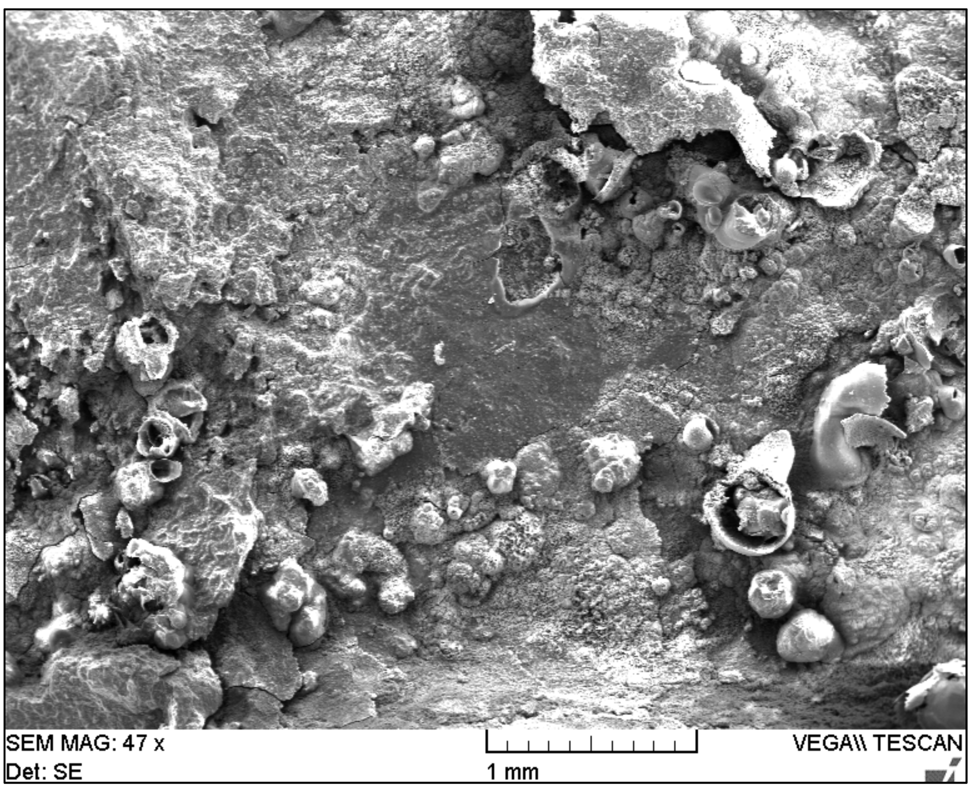


Figure 46. A representative SEM image of a pit on a specimen excised from Coupon 2 labeled as 2-3, prior to cleaning. (SEM, 28X)

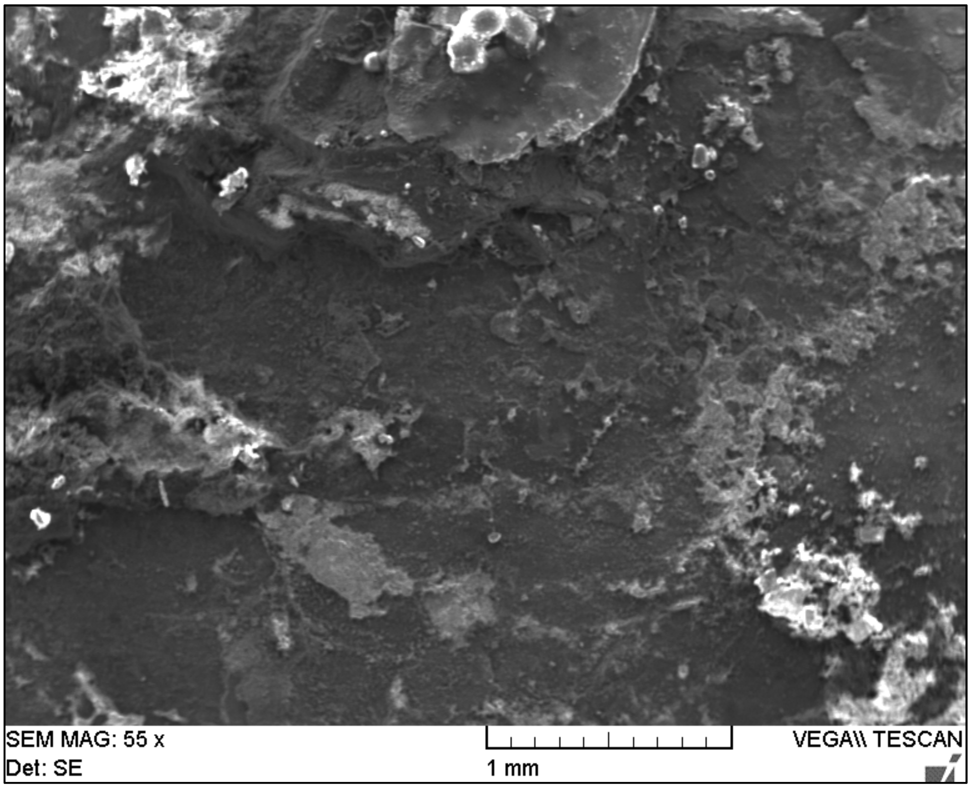


Figure 47. A representative SEM image of a pit on a specimen excised from Coupon 3 labeled as 3-1, prior to cleaning. (SEM, 32X)

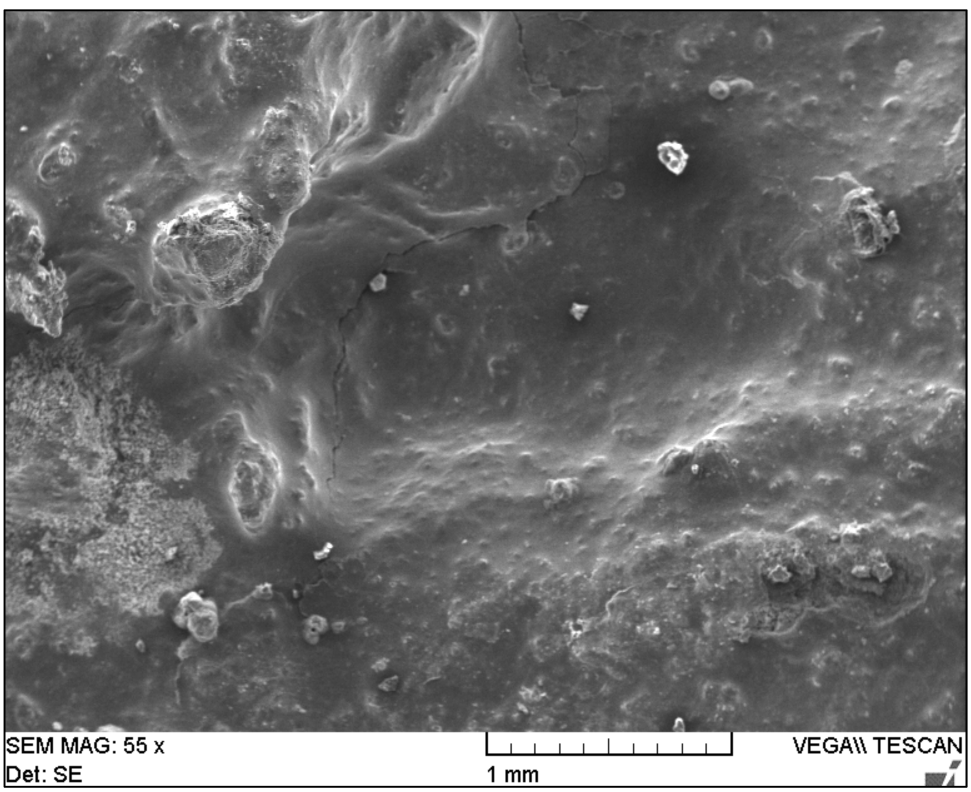


Figure 48. A representative SEM image of a pit on a specimen excised from Coupon 3 labeled as 3-2, prior to cleaning. (SEM, 32X)

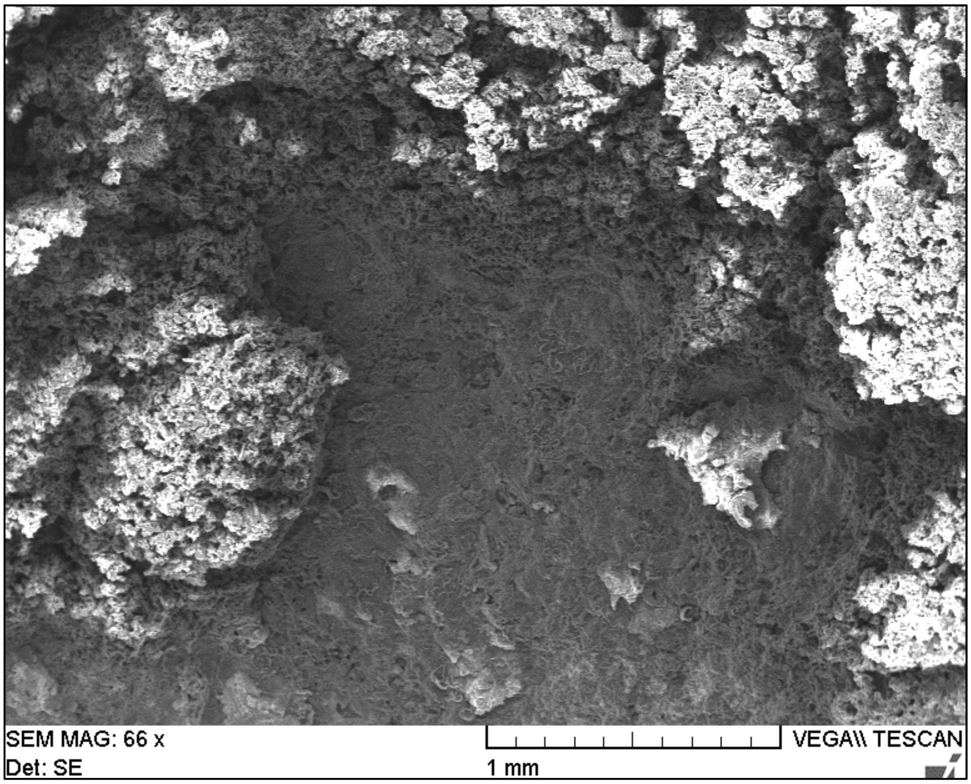


Figure 49. A representative SEM image of a pit on a specimen excised from Coupon 3 labeled as 3-3, prior to cleaning. (SEM, 39X)

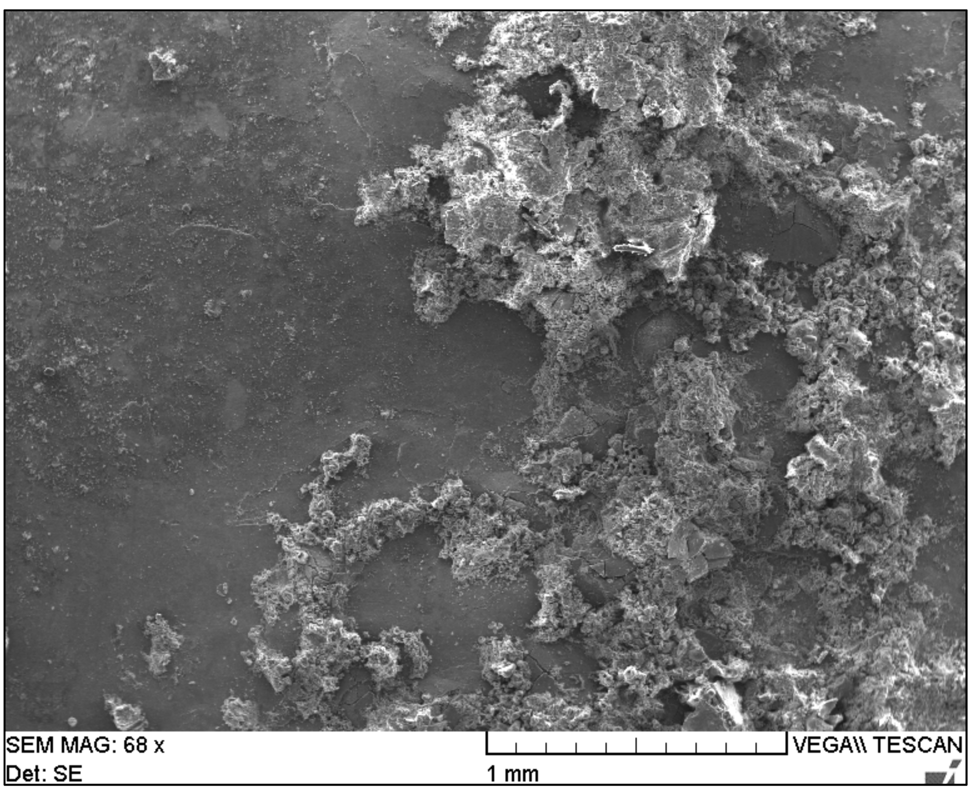


Figure 50. A representative SEM image of the specimen excised from Coupon 5 labeled as 5-1, prior to cleaning. No pits observed. (SEM, 40X)

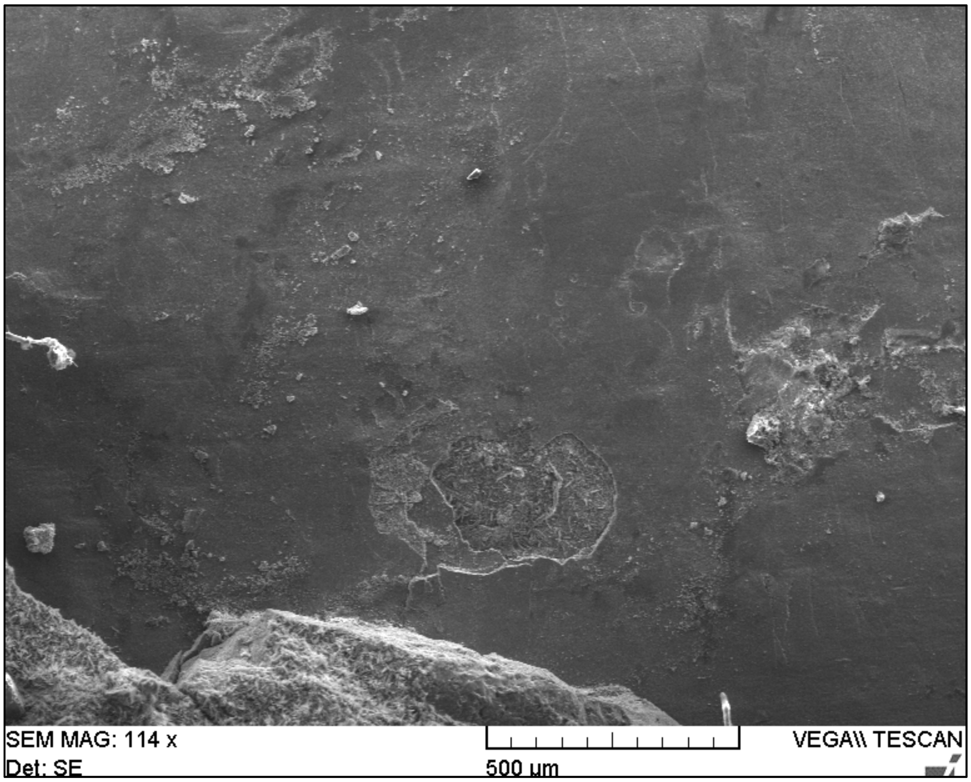


Figure 51. A representative SEM image of a pit on a specimen excised from Coupon 5 labeled as 5-2, prior to cleaning. (SEM, 67X)

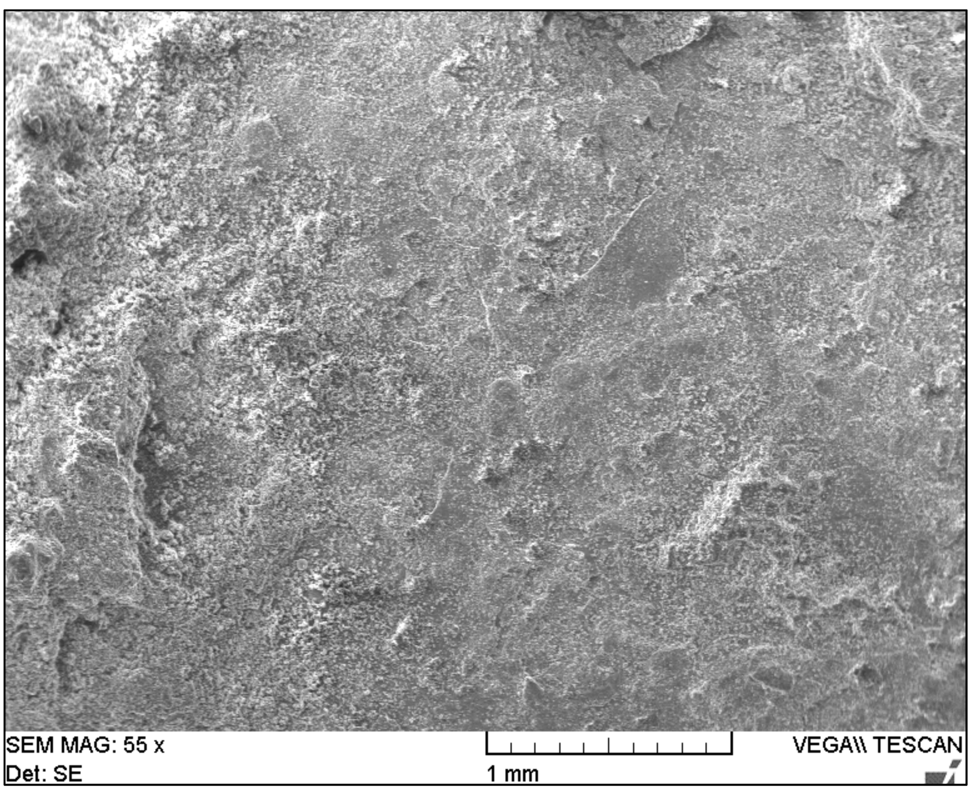


Figure 52. A representative SEM image of a pit on a specimen excised from Coupon 5 labeled as 5-3, prior to cleaning. (SEM, 32X)

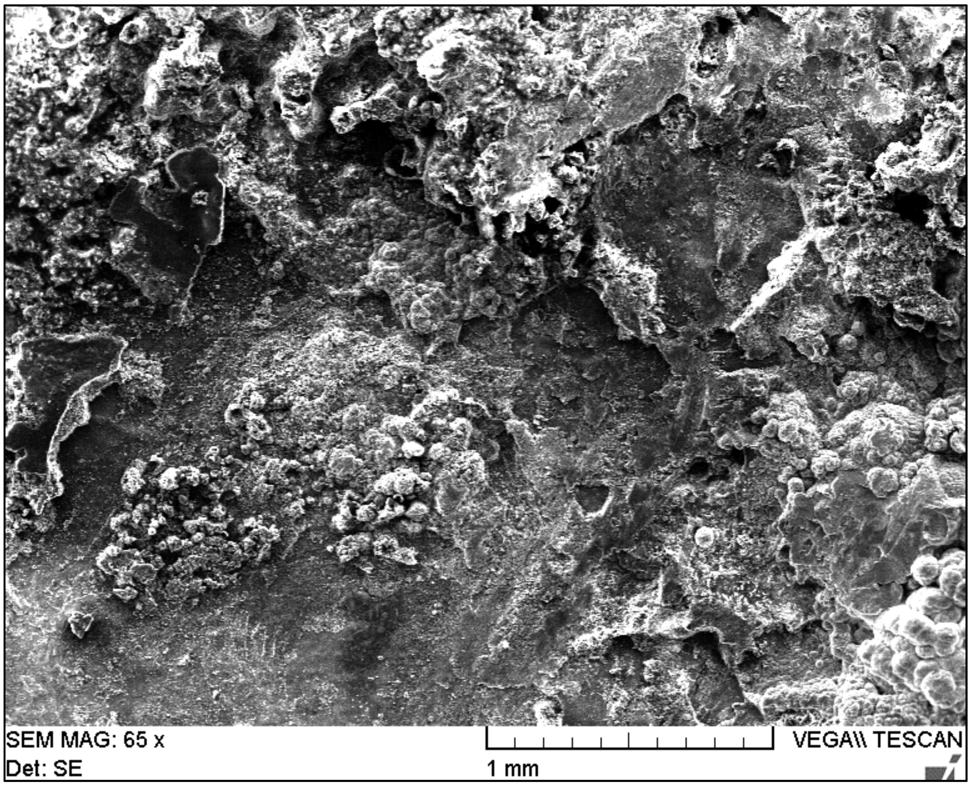


Figure 53. A representative SEM image of a pit on a specimen excised from Coupon 6 labeled as 6-1, prior to cleaning. (SEM, 38X)

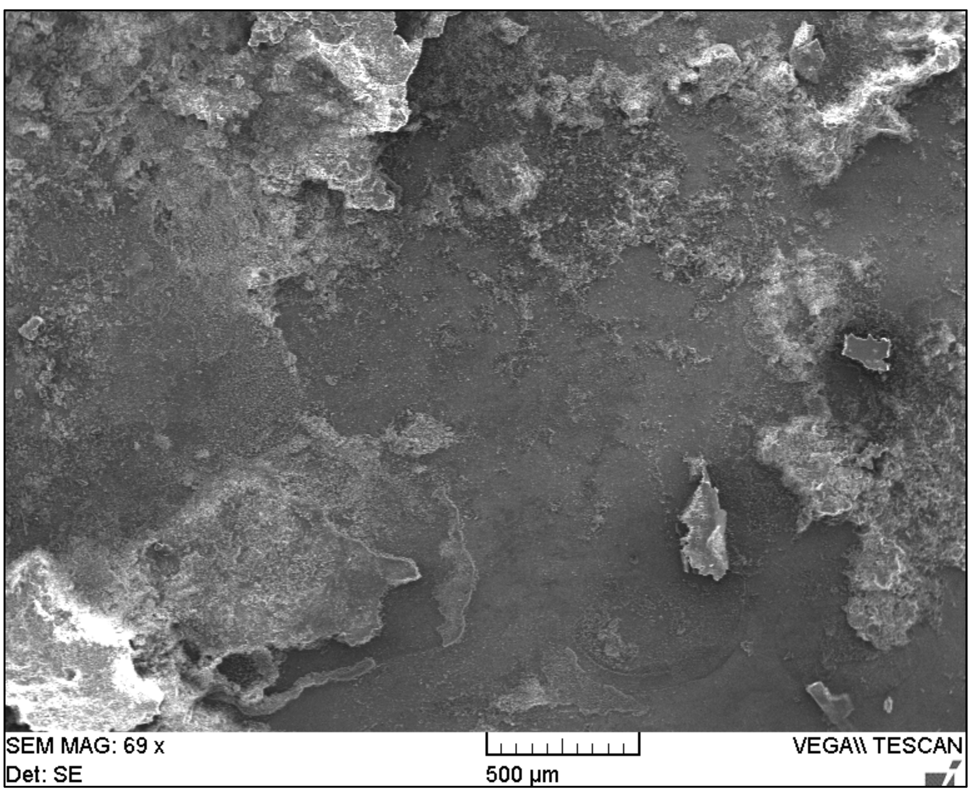


Figure 54. A representative SEM image the surface of a specimen excised from Coupon 6 labeled as 6-2, prior to cleaning. No pit was observed in this location. (SEM, 40X)

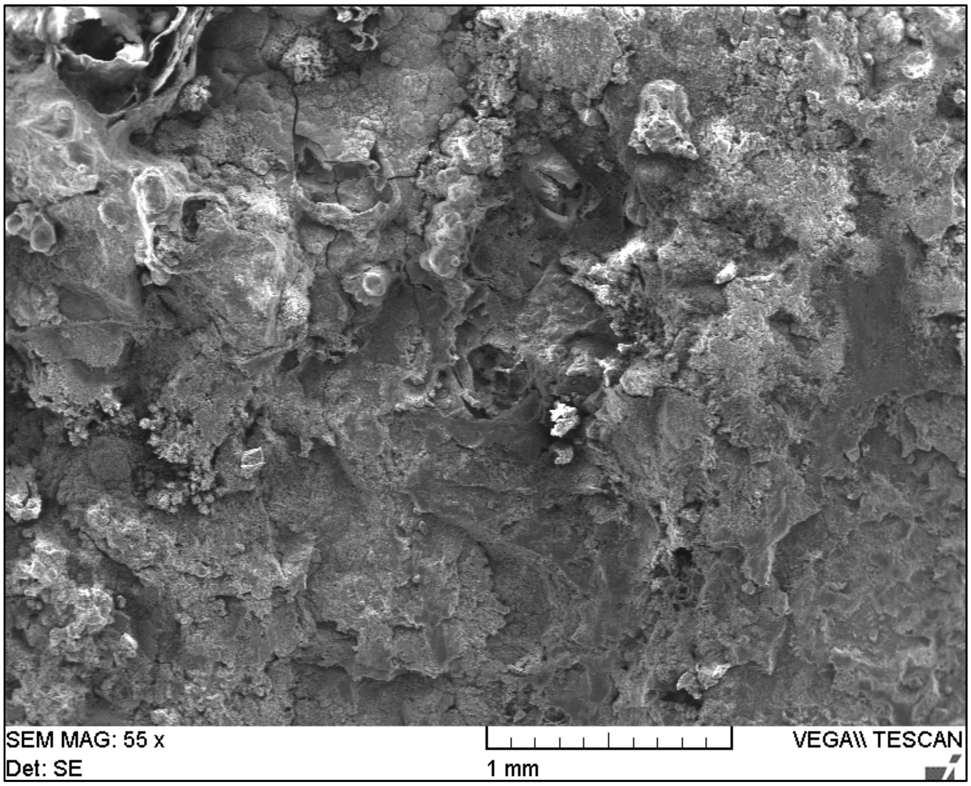


Figure 55. A representative SEM image of a pit on a specimen excised from Coupon 6 labeled as 6-3, prior to cleaning. (SEM, 32X)

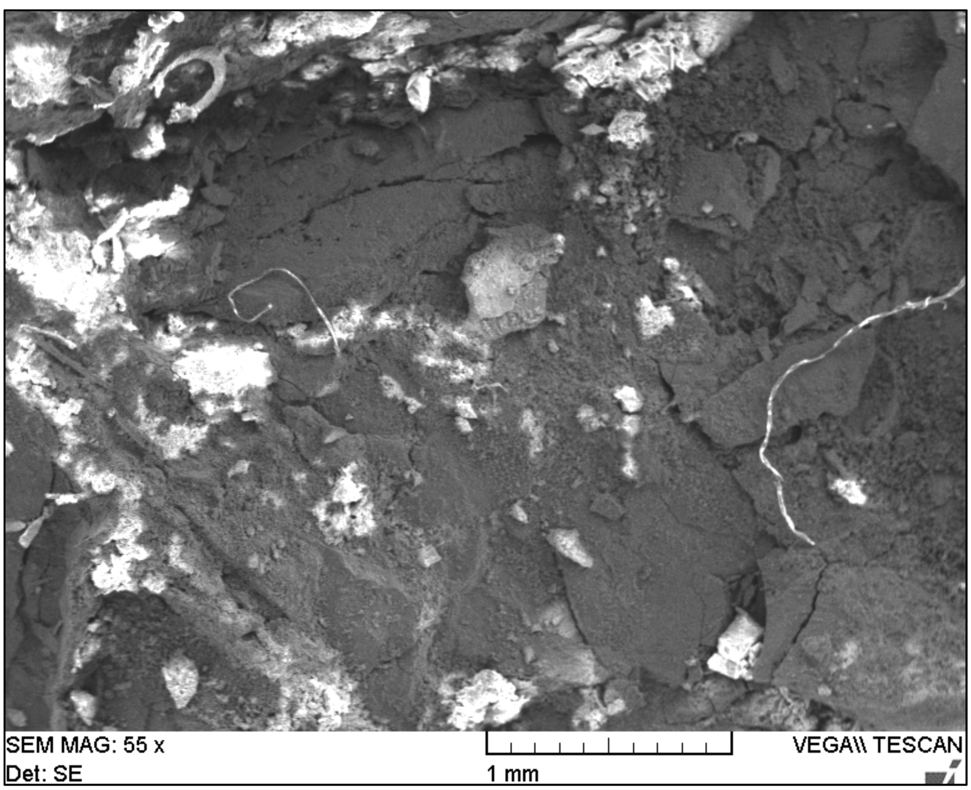


Figure 56. A representative SEM image of a pit on a specimen excised from Coupon 7 labeled as 7-1, prior to cleaning. (SEM, 32X)

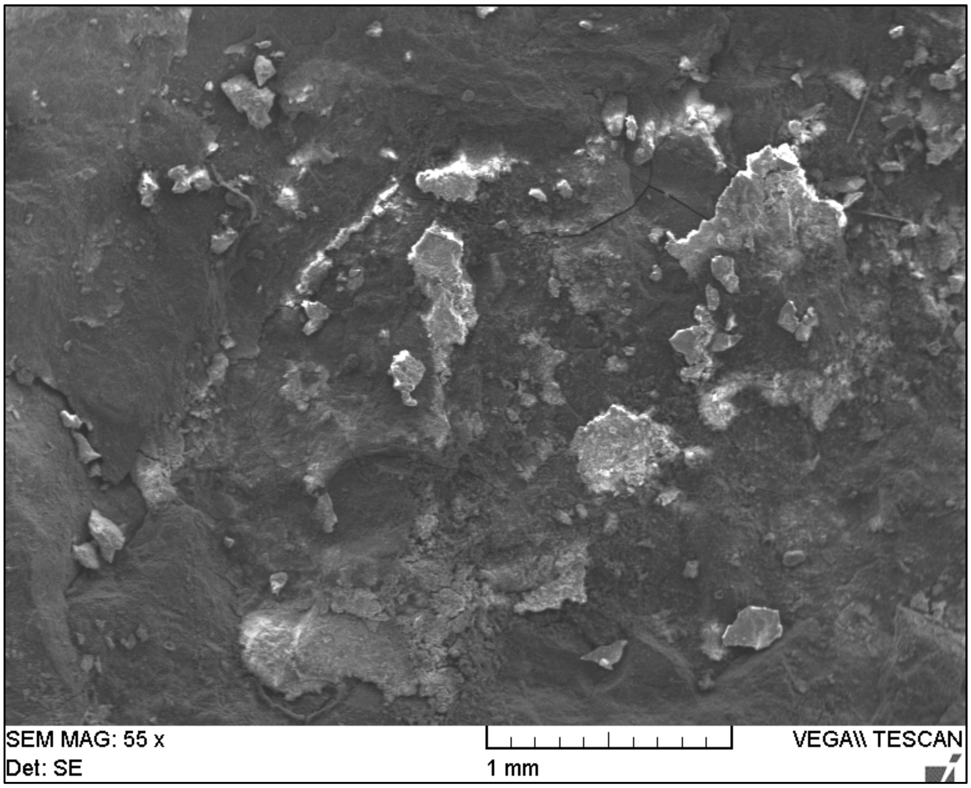


Figure 57. A representative SEM image of a pit on a specimen excised from Coupon 7 labeled as 7-2, prior to cleaning. (SEM, 32X)

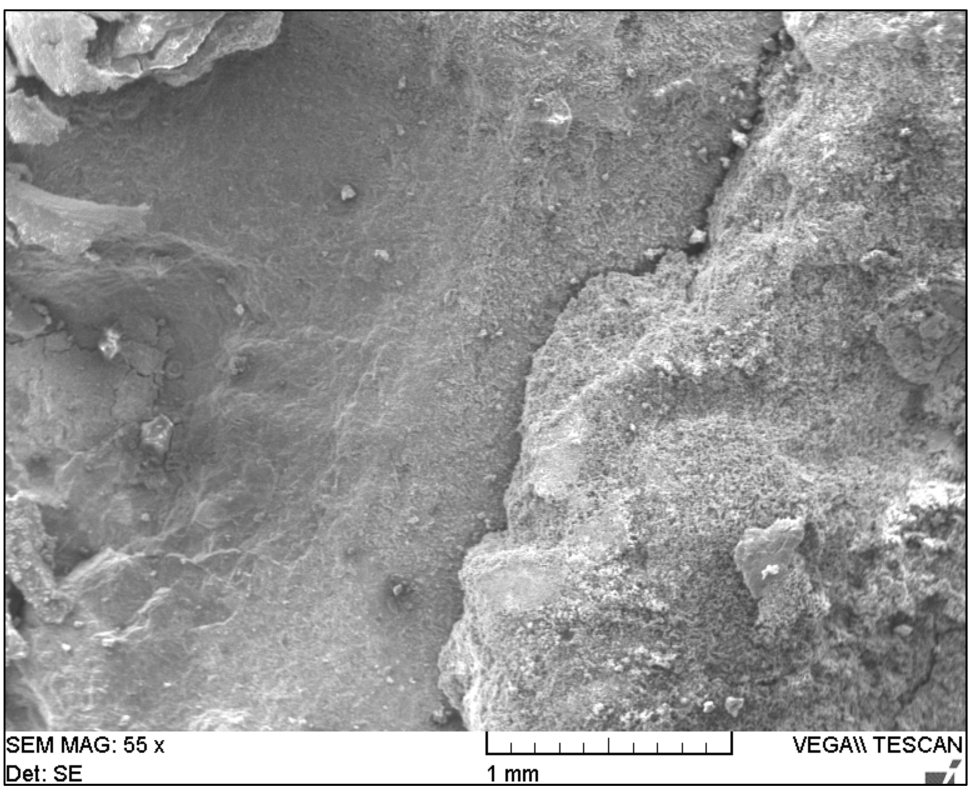


Figure 58. A representative SEM image of a pit on a specimen excised from Coupon 7 labeled as 7-3, prior to cleaning. (SEM, 32X)

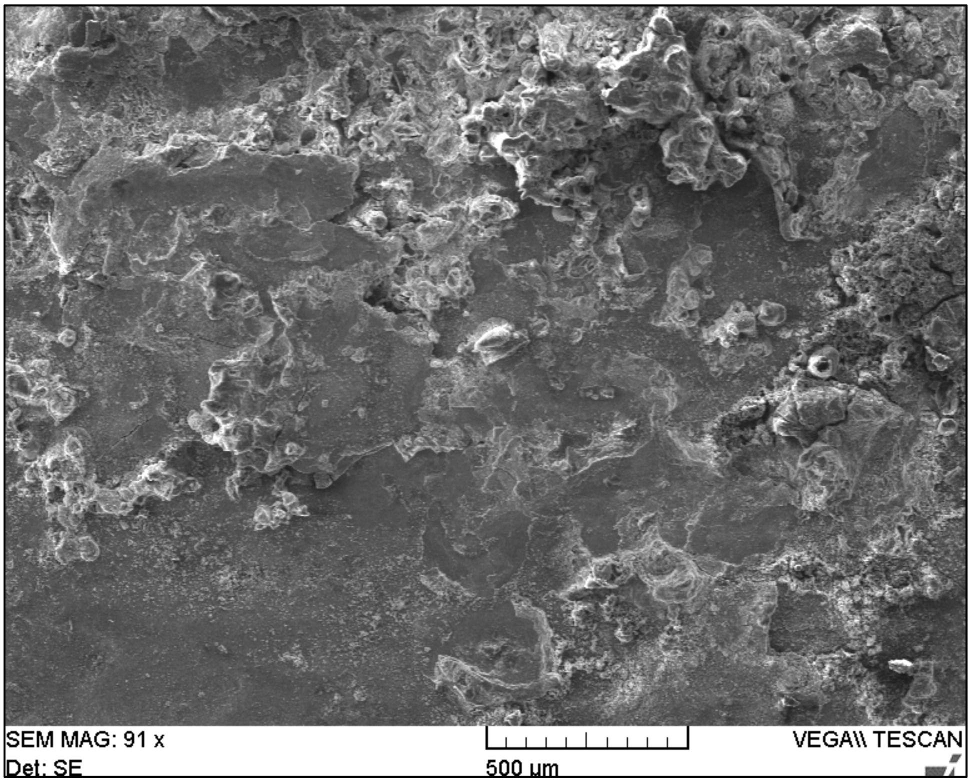


Figure 59. A representative SEM image of a pit on a specimen excised from Coupon 8 labeled as 8-1, prior to cleaning. (SEM, 53X)

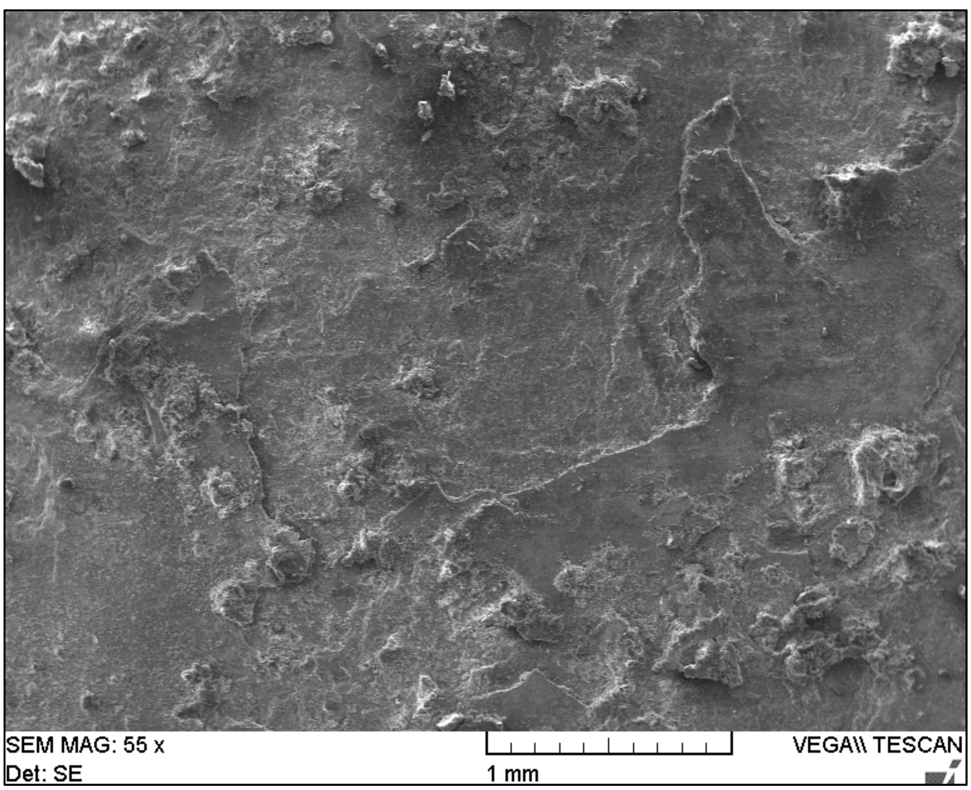


Figure 60. A representative SEM image of a pit on a specimen excised from Coupon 8 labeled as 8-2, prior to cleaning. (SEM, 33X)

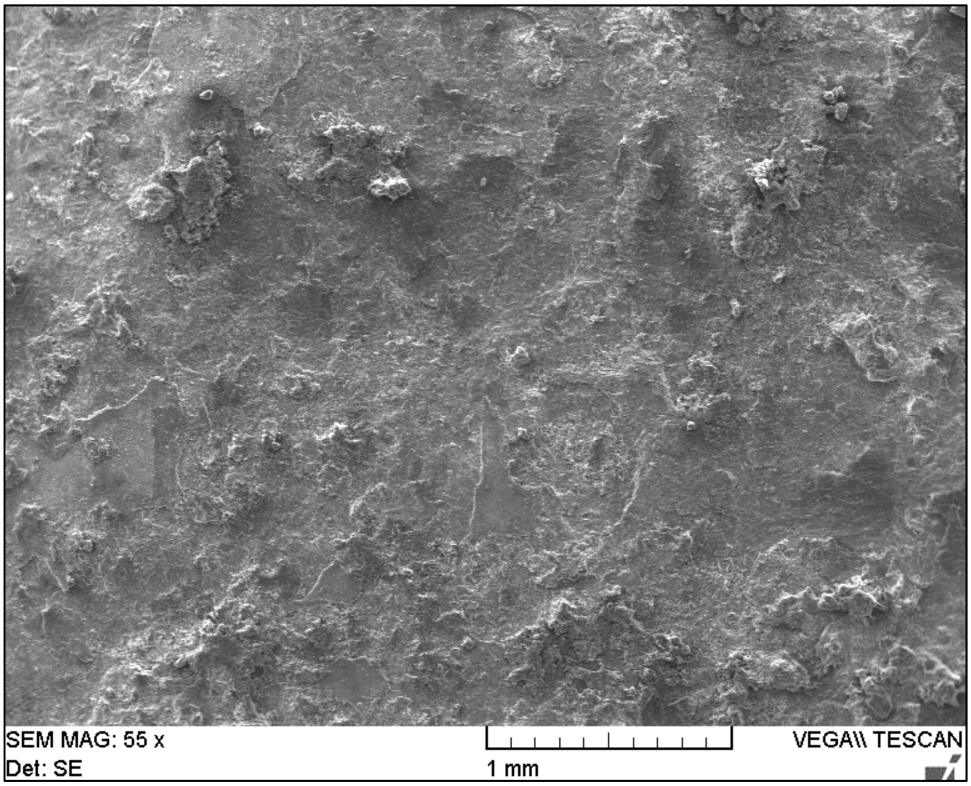


Figure 61. A representative SEM image of a pit on a specimen excised from Coupon 8 labeled as 8-3, prior to cleaning. (SEM, 33X)

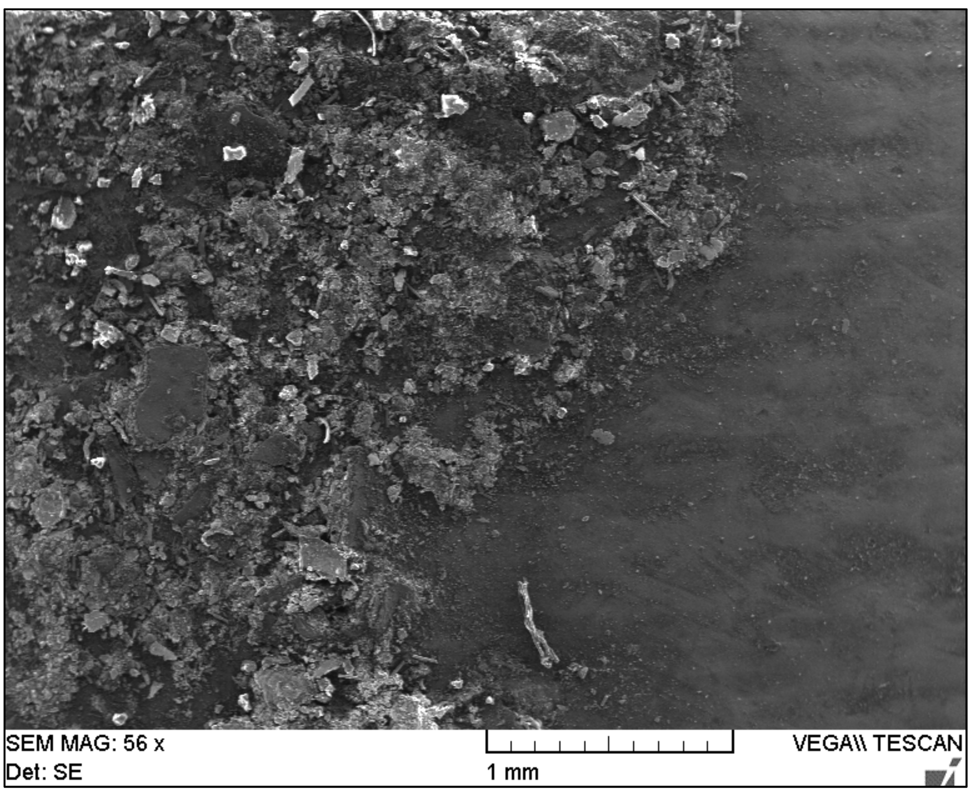


Figure 62. A representative SEM image of the surface of a specimen excised from Coupon 10 labeled as 10-1, prior to cleaning. No pit was observed in this location. (SEM, 33X)

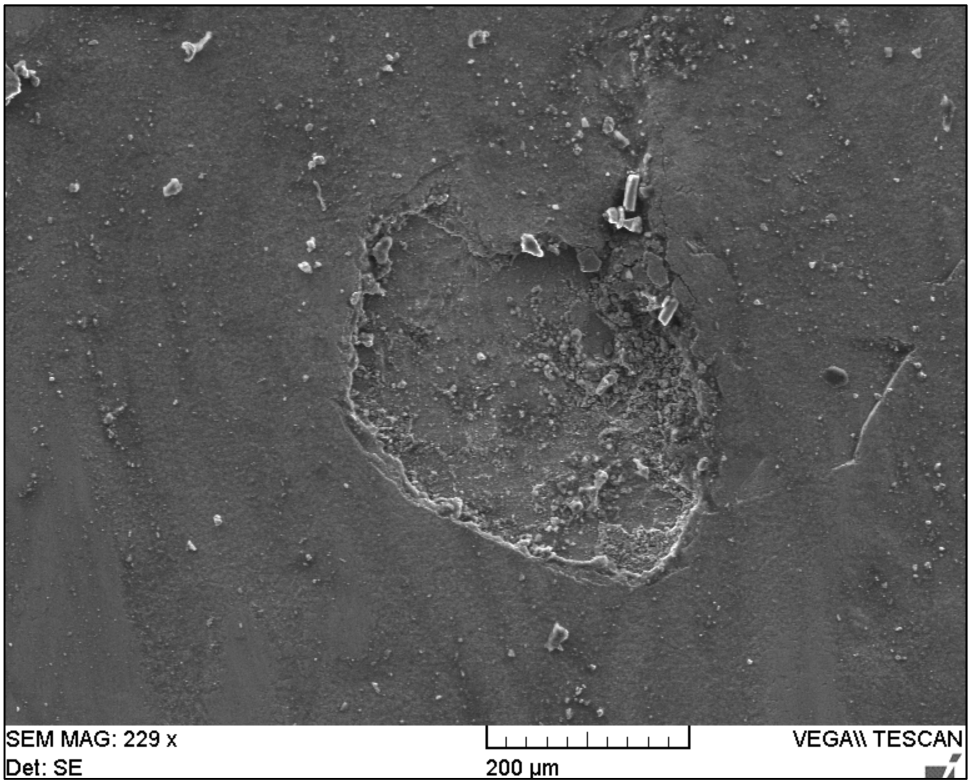


Figure 63. A representative SEM image of a pit on a specimen excised from Coupon 10 labeled as 10-2, prior to cleaning. (SEM, 135X)

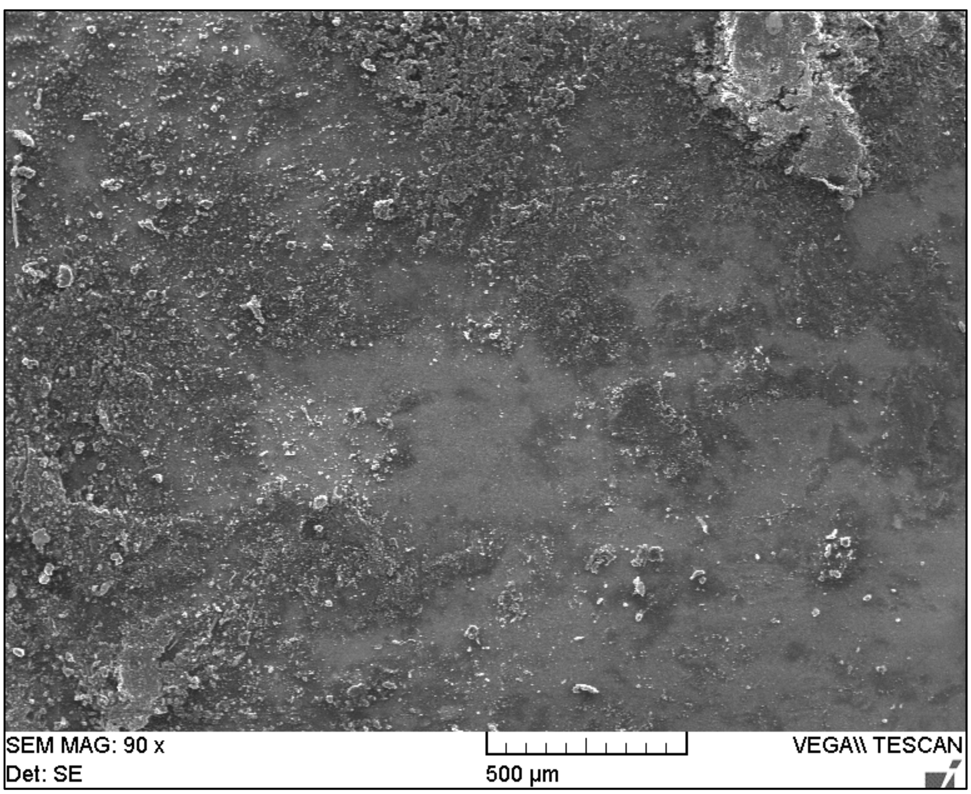


Figure 64. A representative SEM image of the surface on a specimen excised from Coupon 10 labeled as 10-3, prior to cleaning. No pit was observed in this location. (SEM, 53X)

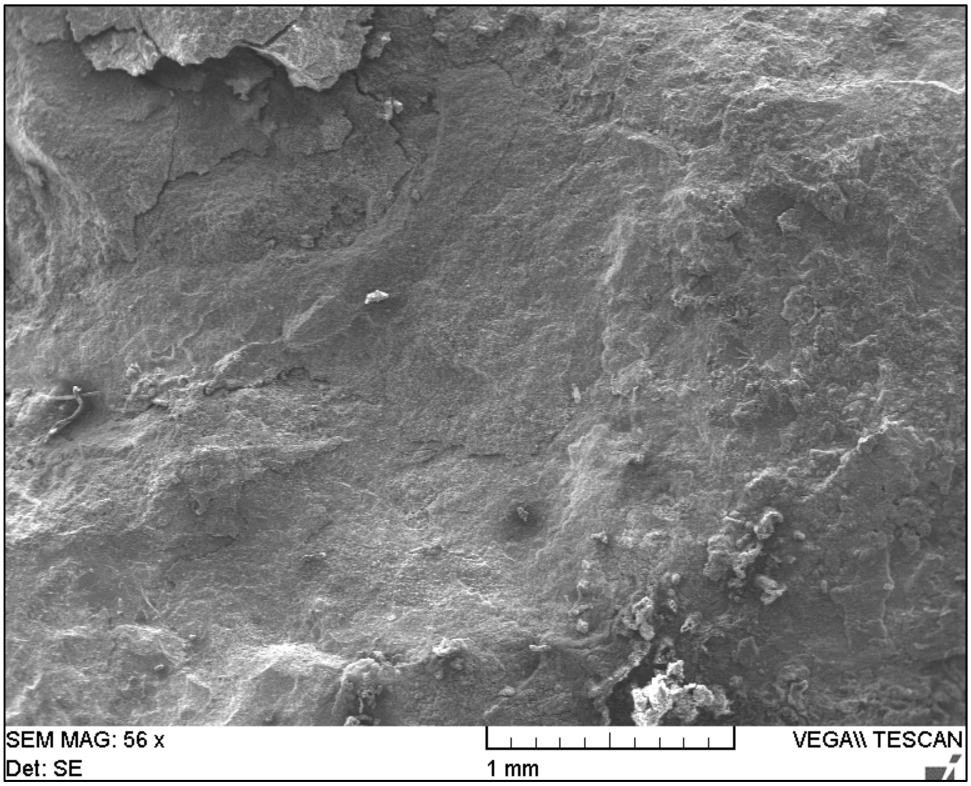


Figure 65. A representative SEM image of a pit on a specimen excised from Coupon A-1 labeled as A1-1, prior to cleaning. (SEM, 33X)

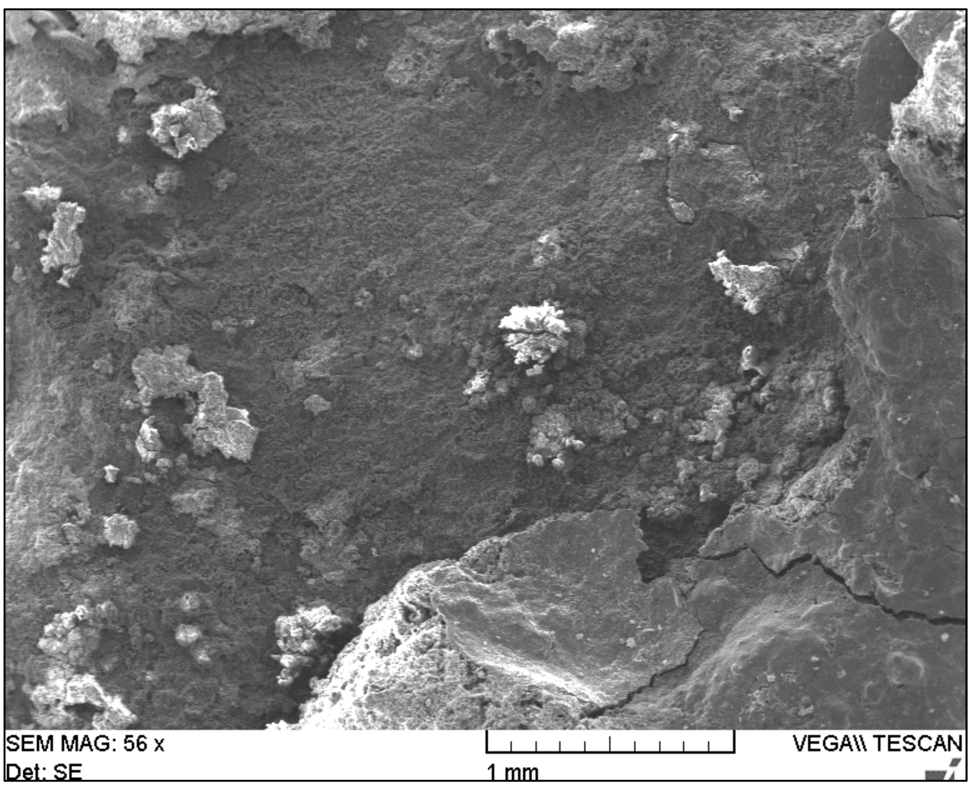


Figure 66. A representative SEM image of a pit on a specimen excised from Coupon A-1 labeled as A1-2, prior to cleaning. (SEM, 33X)

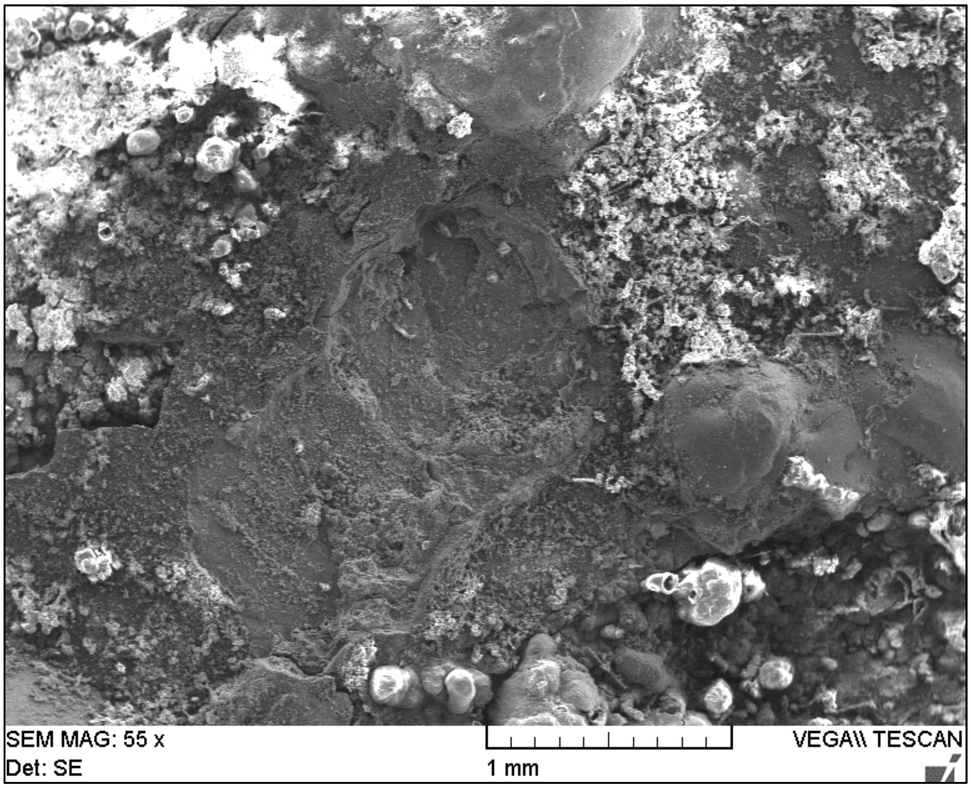


Figure 67. A representative SEM image of a pit on a specimen excised from Coupon A-1 labeled as A1-3, prior to cleaning. (SEM, 32X)

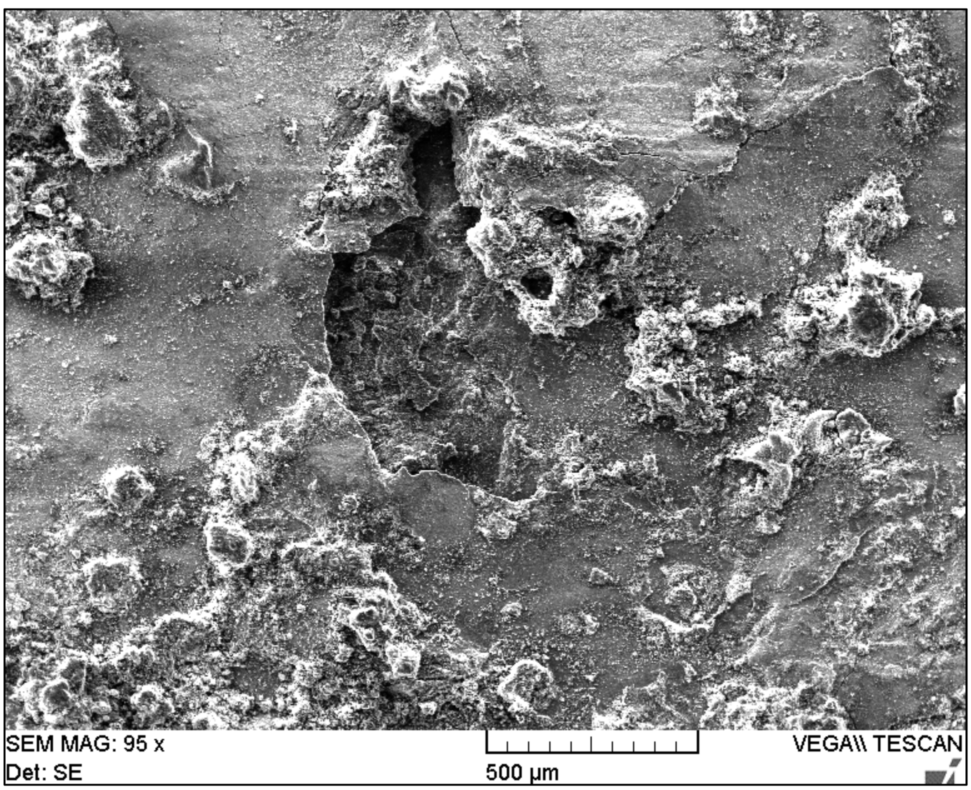


Figure 68. A representative SEM image of a pit on a specimen excised from Coupon A-2 labeled as A2-1, prior to cleaning. (SEM, 56X)

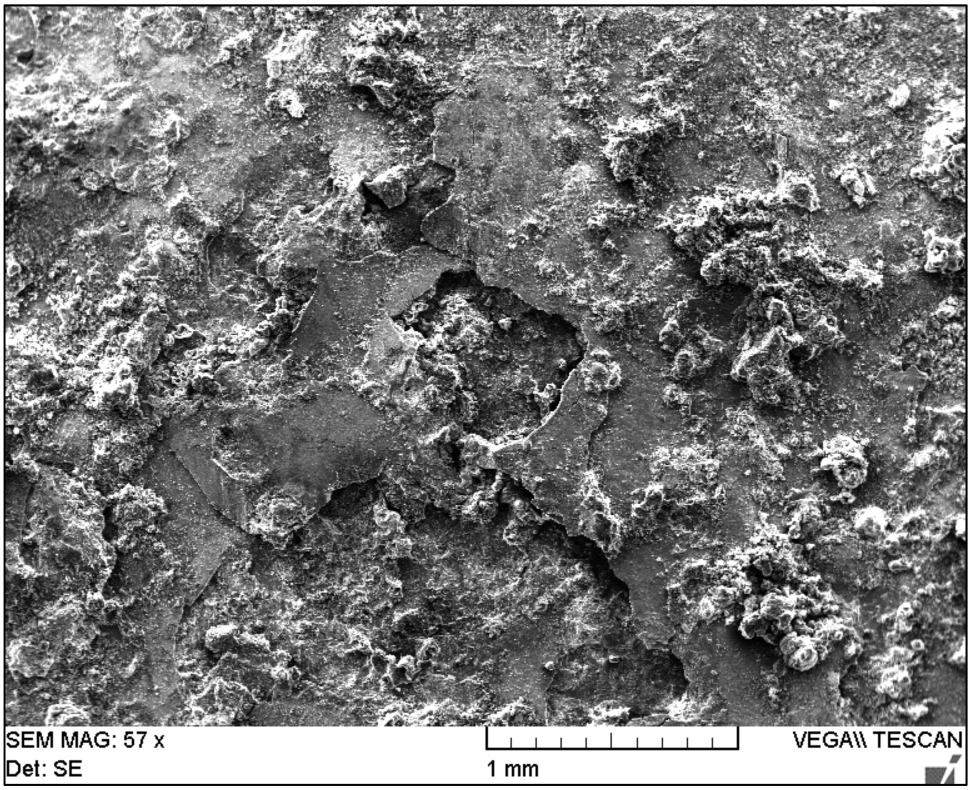


Figure 69. A representative SEM image of a possible pit on a specimen excised from Coupon A-2 labeled as A2-2, prior to cleaning. (SEM, 33X)

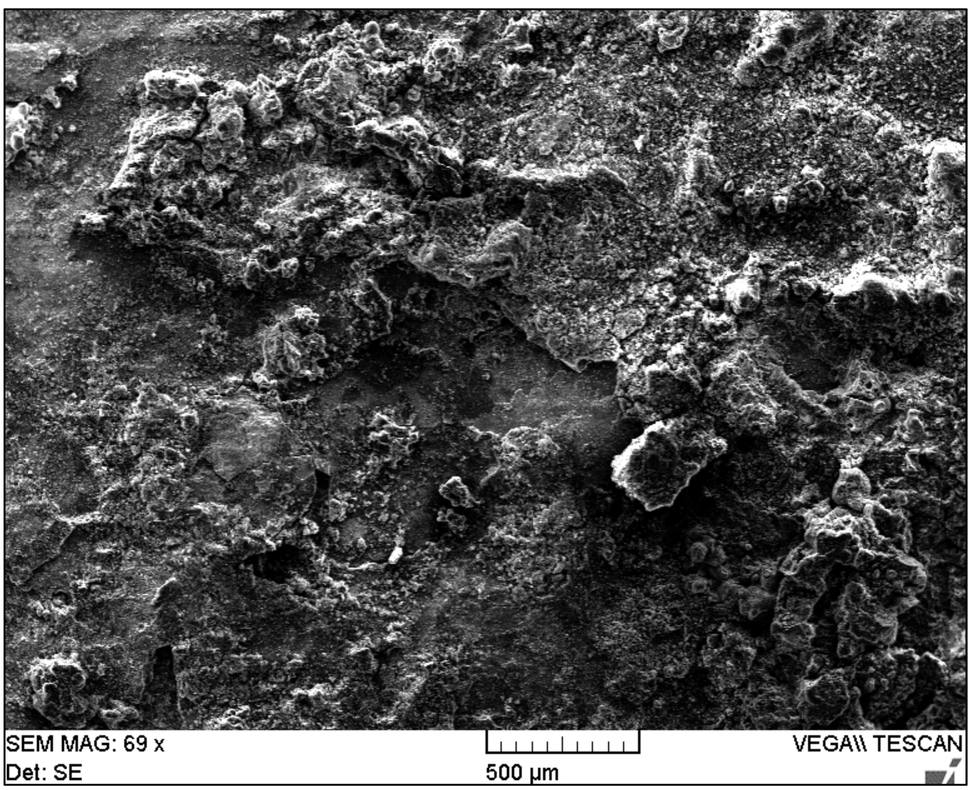
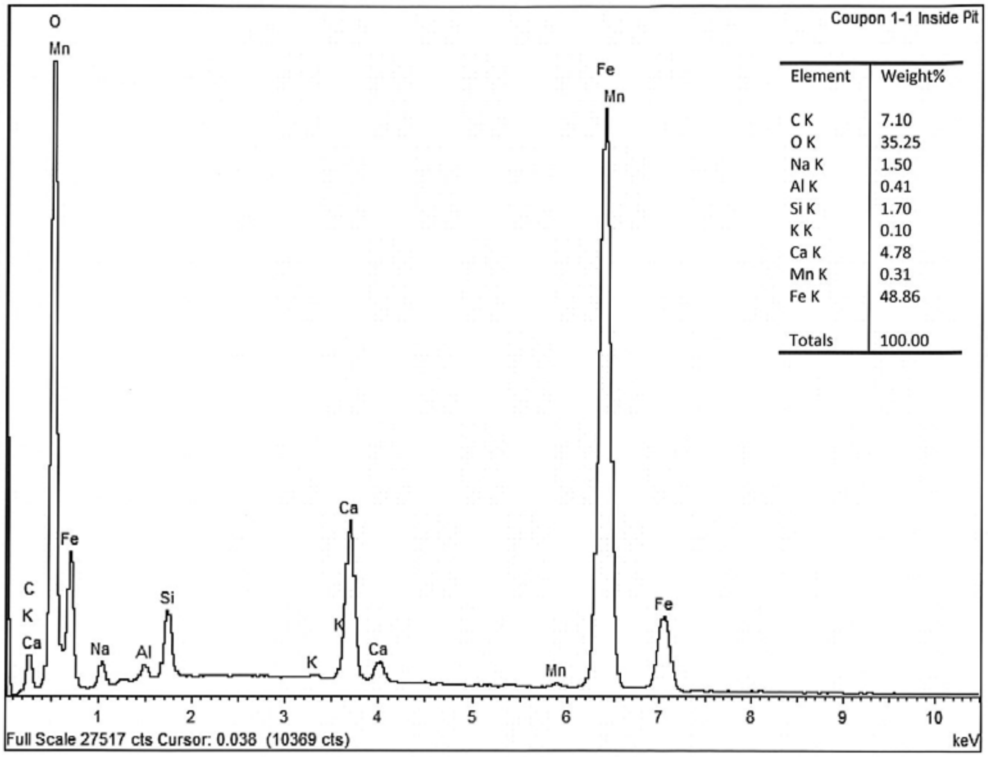
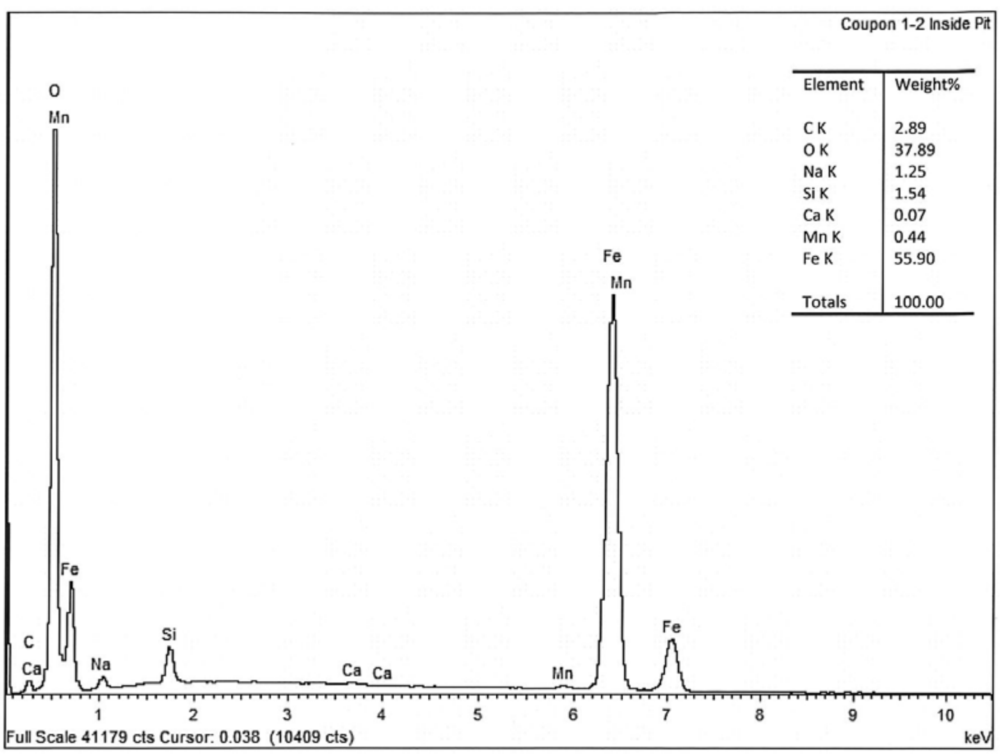


Figure 70. A representative SEM image of a possible pit on a specimen excised from Coupon A-2 labeled as A2-3, prior to cleaning. (SEM, 40X)



Element	Weight%
C K	7.10
O K	35.25
Na K	1.50
Al K	0.41
Si K	1.70
K K	0.10
Ca K	4.78
Mn K	0.31
Fe K	48.86
Totals	100.00

Figure 71. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 1 labeled as 1-1, prior to cleaning.



Element	Weight%
C K	2.89
O K	37.89
Na K	1.25
Si K	1.54
Ca K	0.07
Mn K	0.44
Fe K	55.90
Totals	100.00

Figure 72. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 1 labeled as 1-2, prior to cleaning.

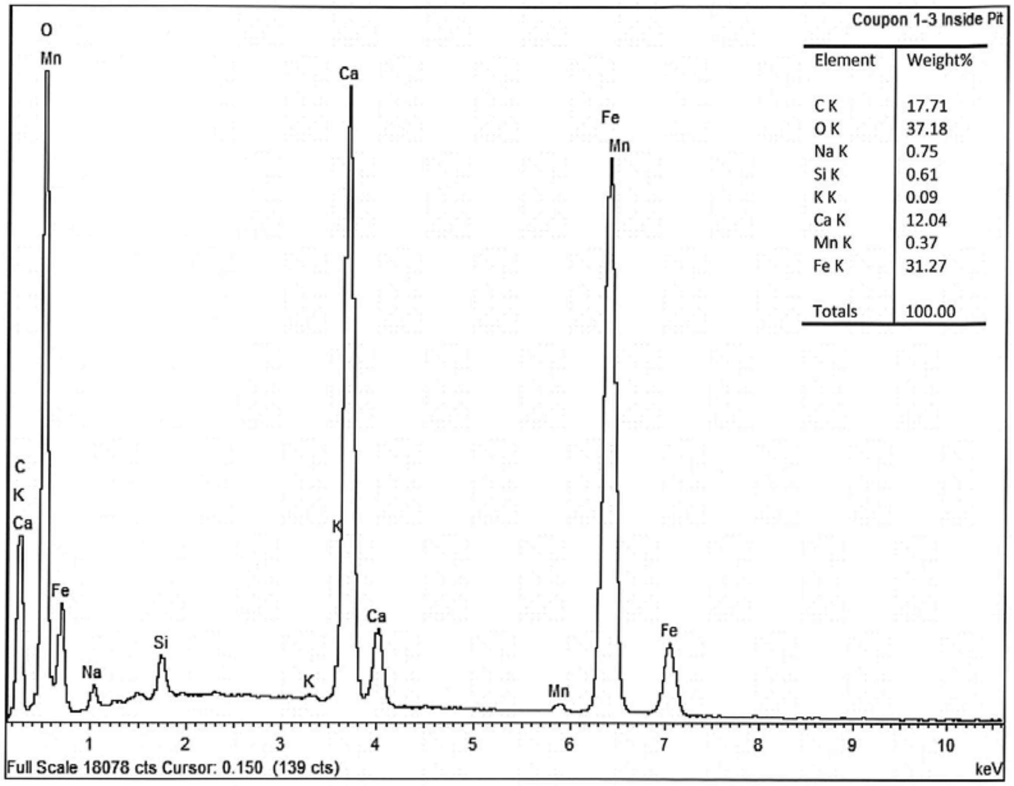


Figure 73. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 1 labeled as 1-3, prior to cleaning.

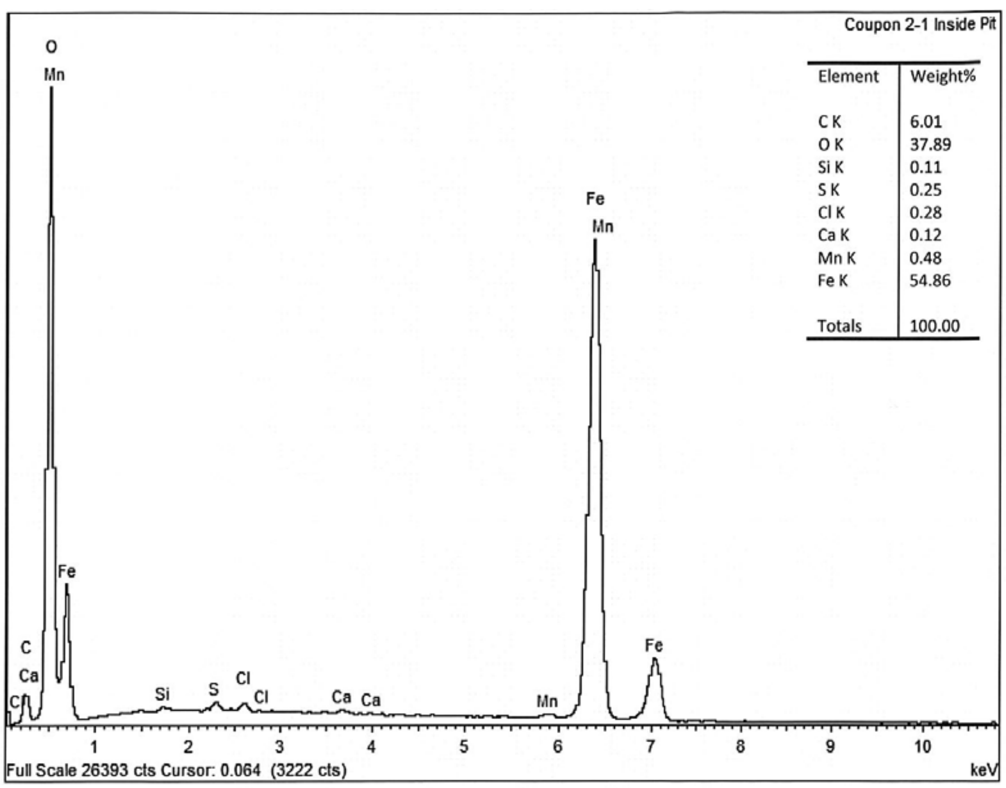


Figure 74. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 2 labeled as 2-1, prior to cleaning.

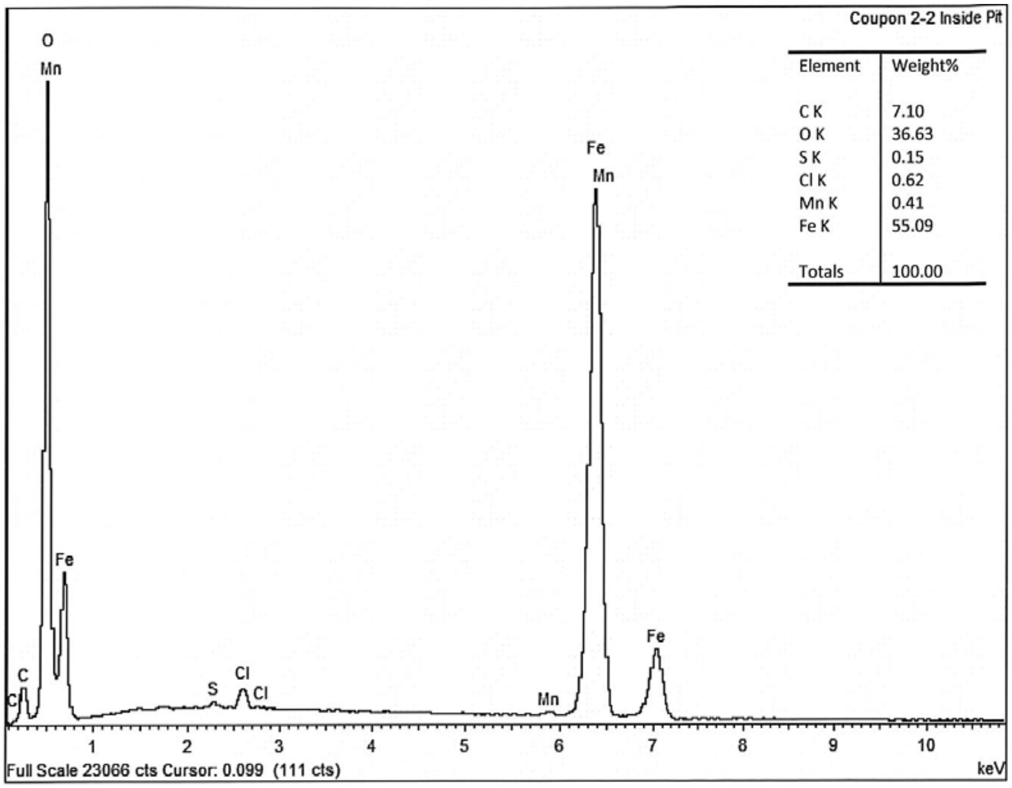


Figure 75. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 2 labeled as 2-2, prior to cleaning.

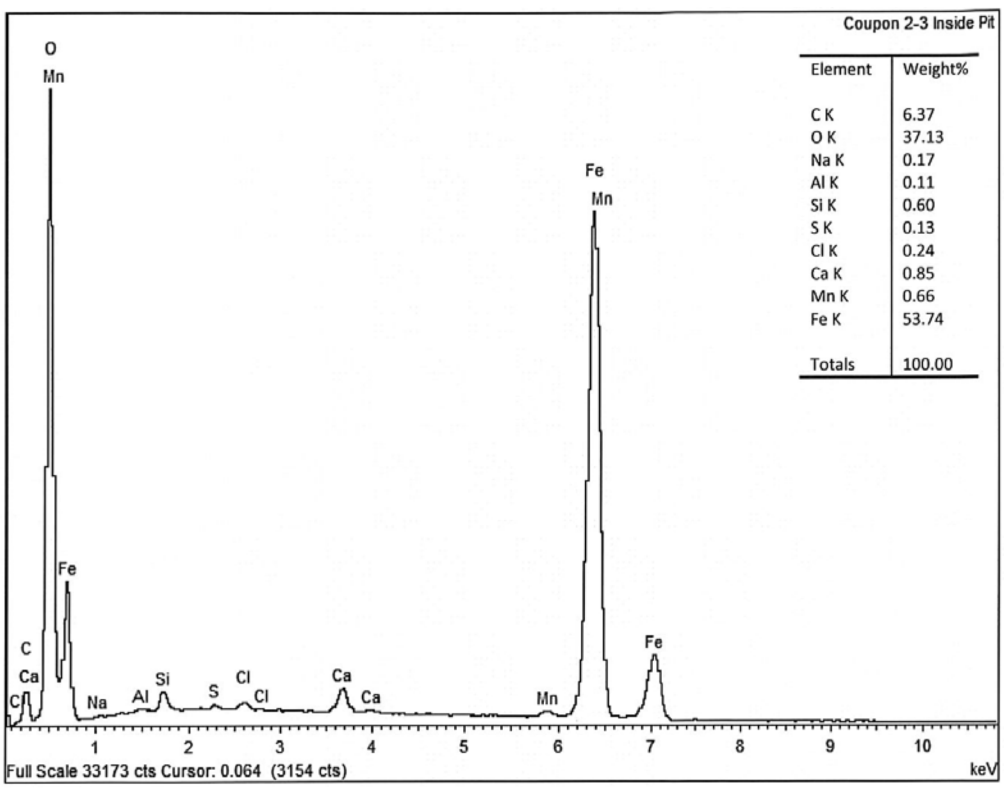
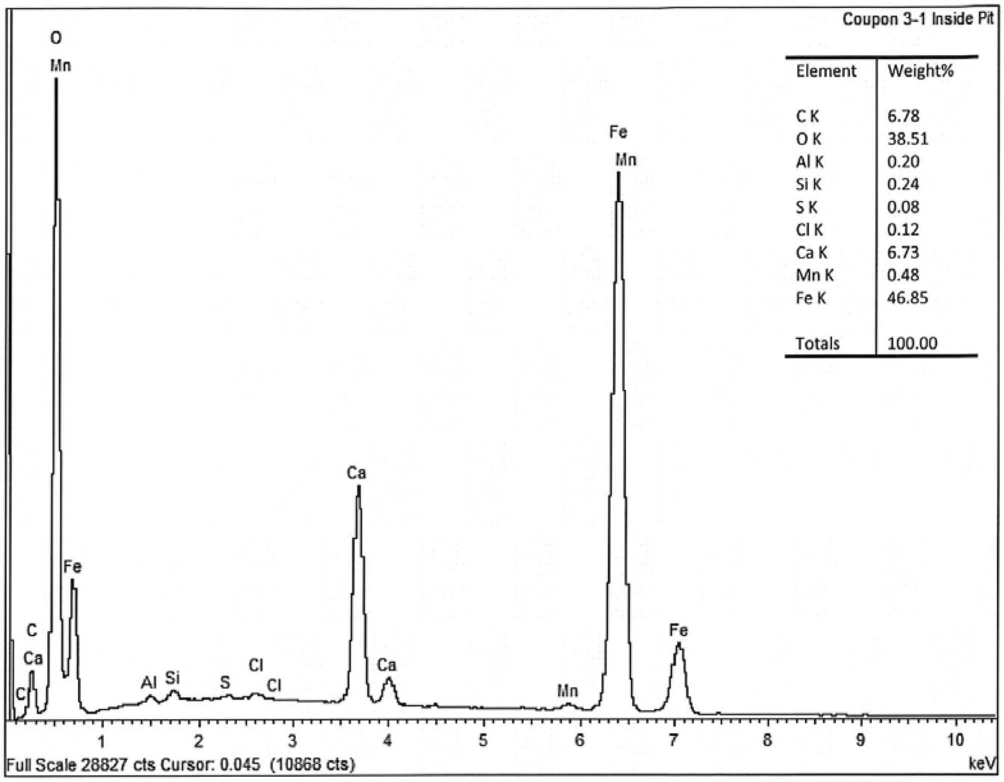
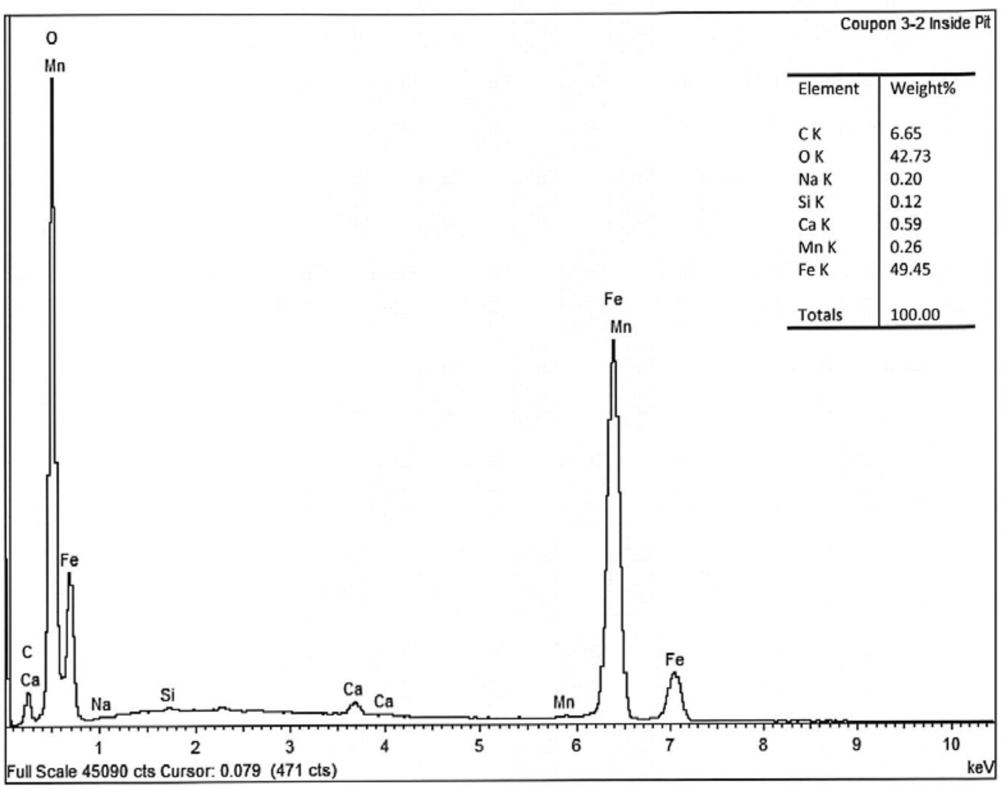


Figure 76. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 2 labeled as 2-3, prior to cleaning.



Element	Weight%
C K	6.78
O K	38.51
Al K	0.20
Si K	0.24
S K	0.08
Cl K	0.12
Ca K	6.73
Mn K	0.48
Fe K	46.85
Totals	100.00

Figure 77. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 3 labeled as 3-1, prior to cleaning.



Element	Weight%
C K	6.65
O K	42.73
Na K	0.20
Si K	0.12
Ca K	0.59
Mn K	0.26
Fe K	49.45
Totals	100.00

Figure 78. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 3 labeled as 3-2, prior to cleaning.

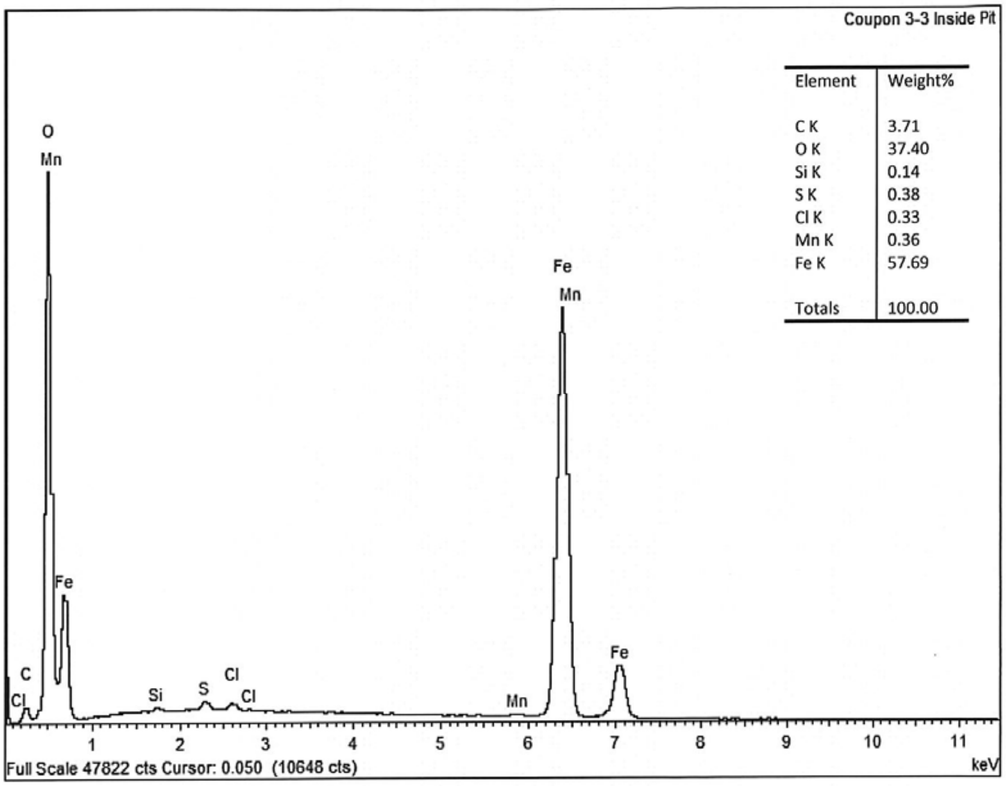


Figure 79. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 3 labeled as 3-3, prior to cleaning.

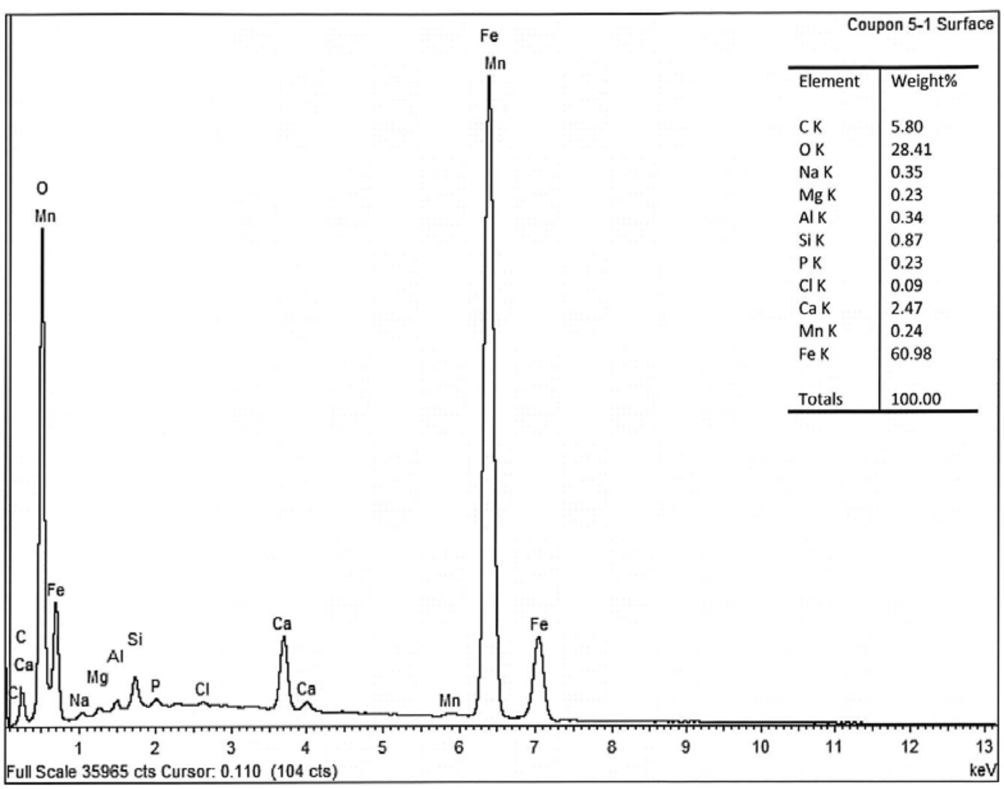


Figure 80. A representative EDS spectrum generated from the nominal surface of a specimen excised from Coupon 5 labeled as 5-1, prior to cleaning. No pit observed.

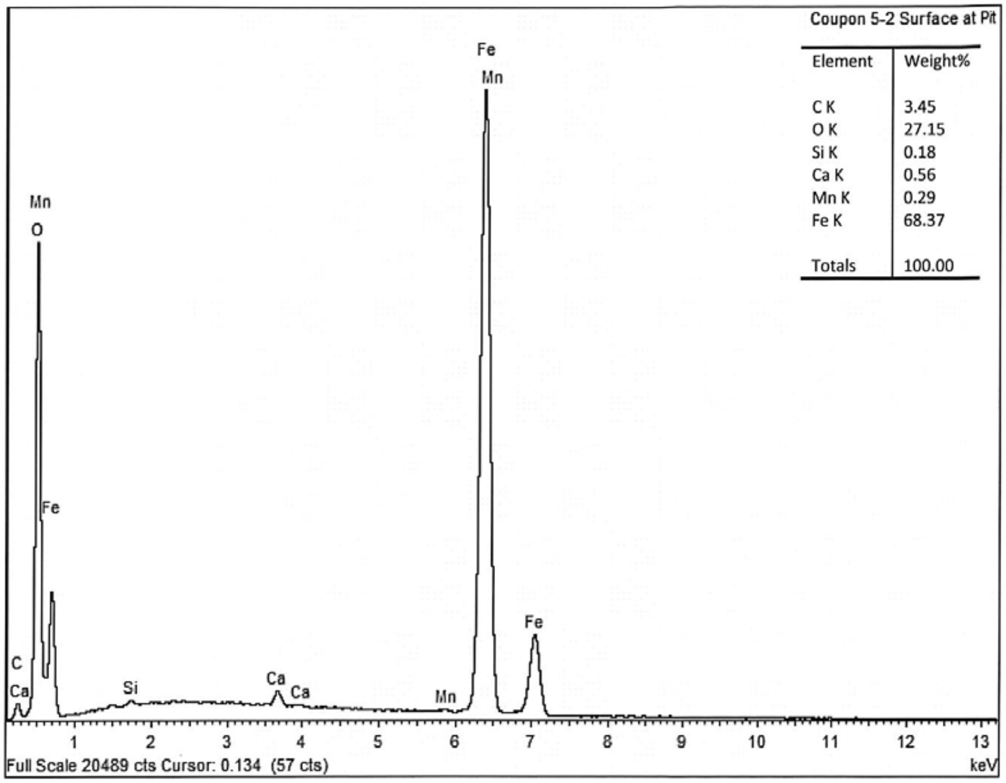


Figure 81. A representative EDS spectrum generated from the surface at a pit on a specimen excised from Coupon 5 labeled as 5-2, prior to cleaning.

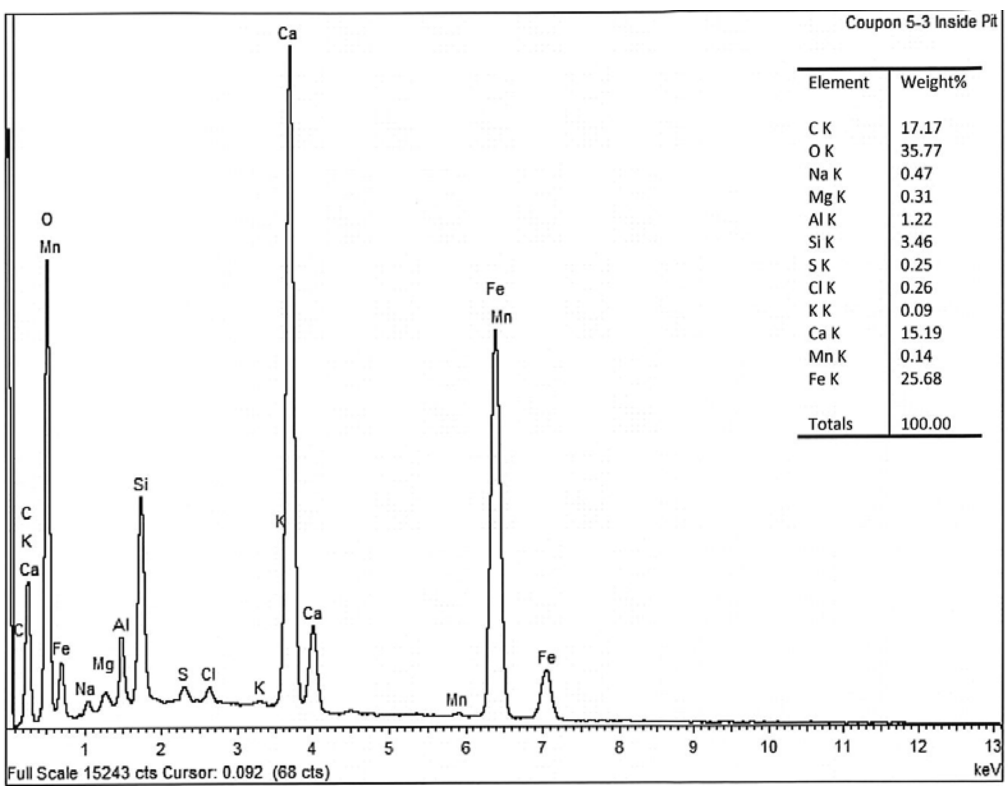


Figure 82. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 5 labeled as 5-3, prior to cleaning.

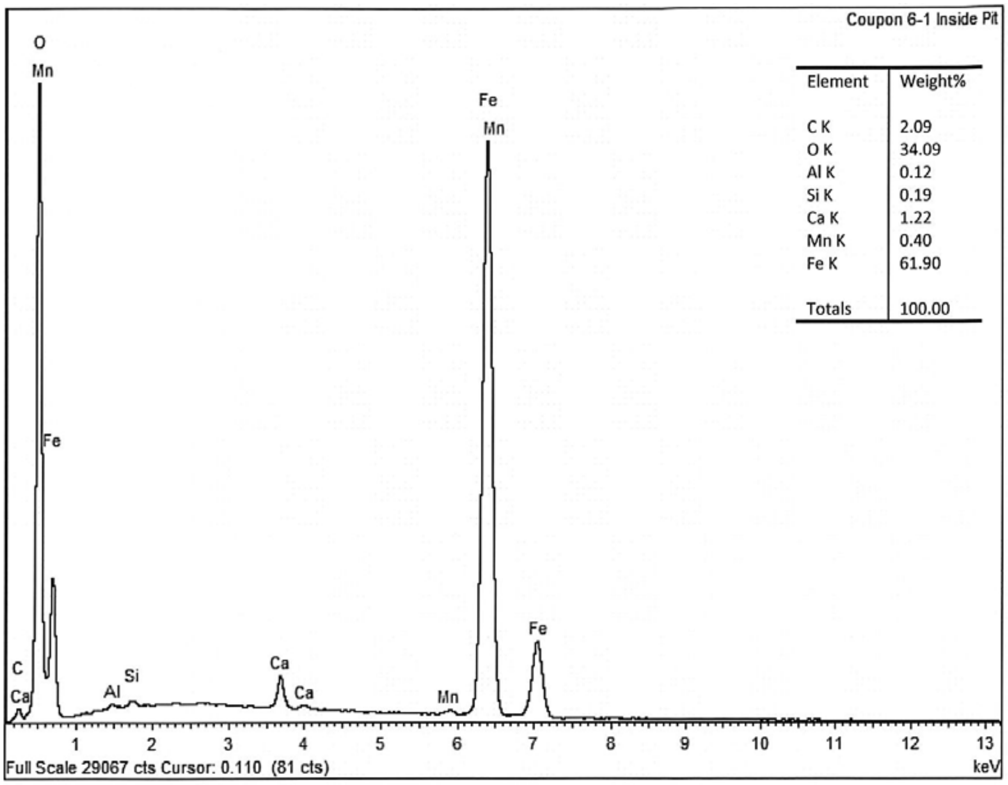


Figure 83. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 6 labeled as 6-1, prior to cleaning.

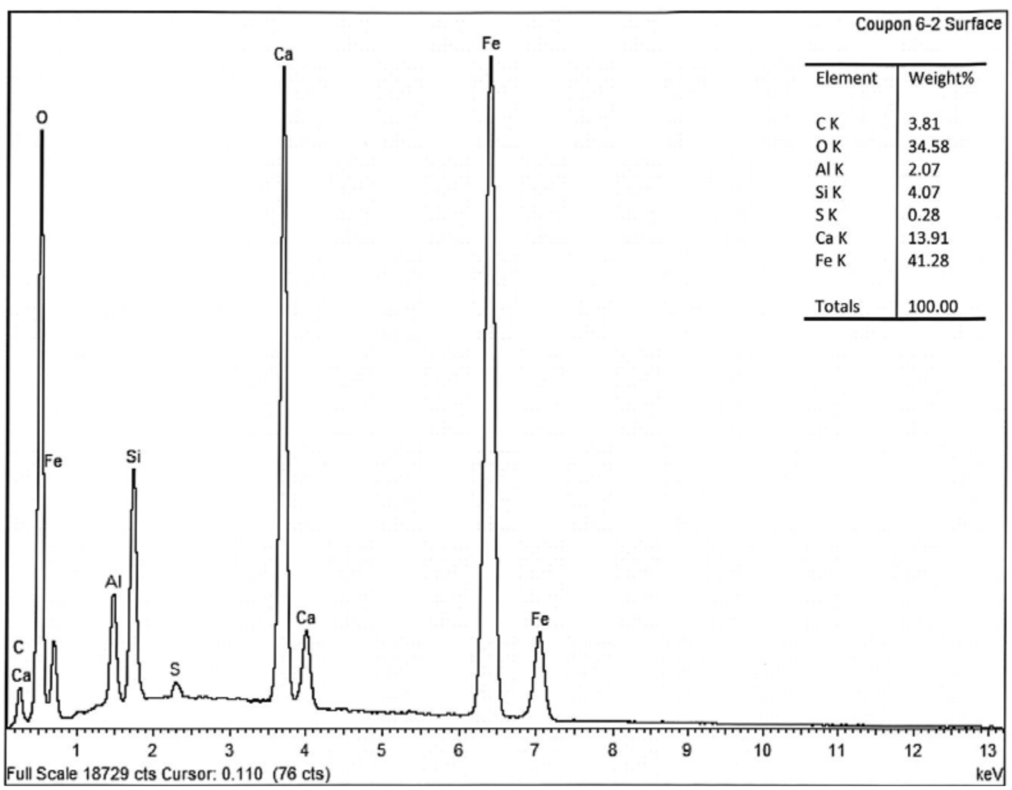


Figure 84. A representative EDS spectrum generated from the surface of a specimen excised from Coupon 6 labeled as 6-2, prior to cleaning.

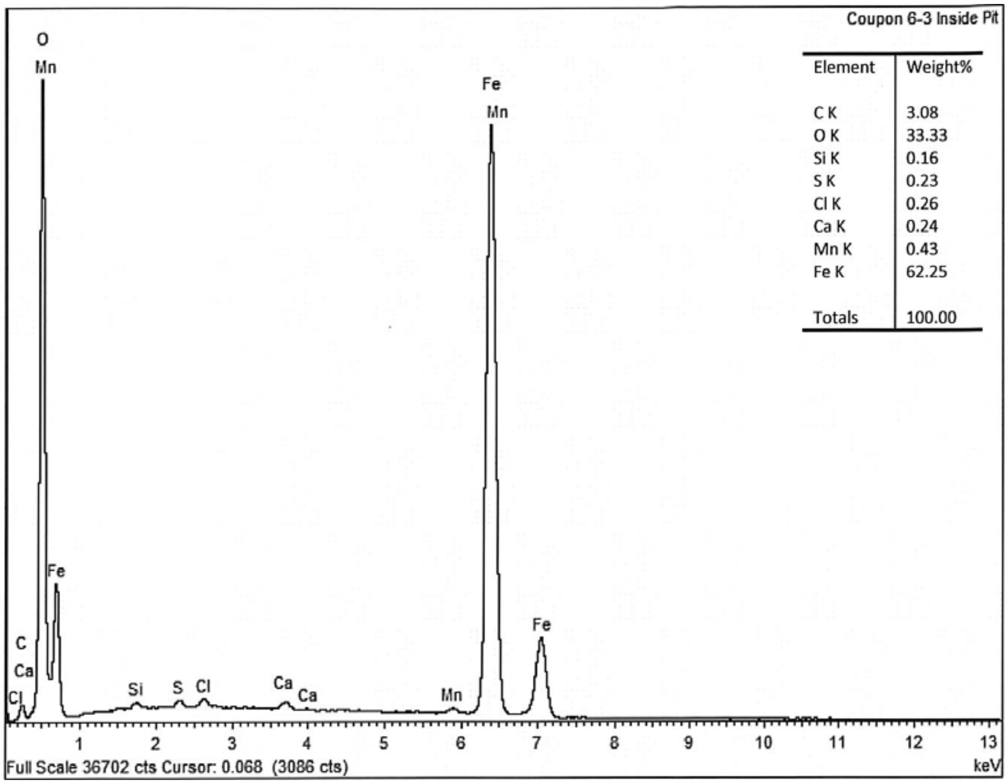


Figure 85. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 6 labeled as 6-3, prior to cleaning.

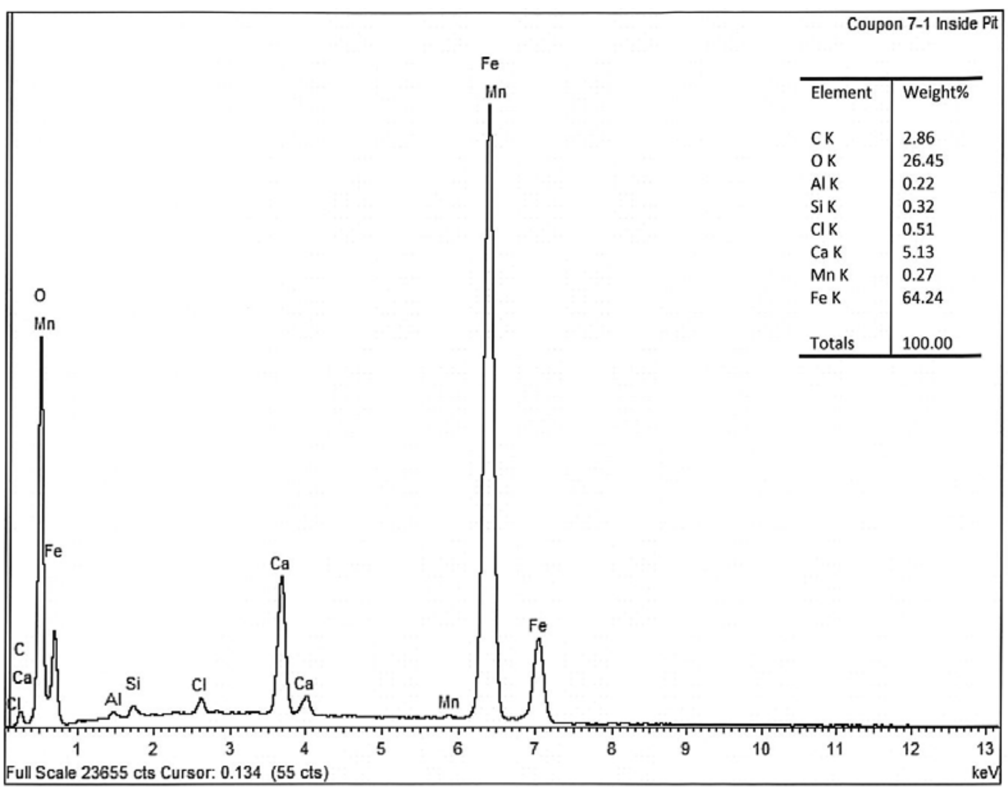


Figure 86. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 7 labeled as 7-1, prior to cleaning.

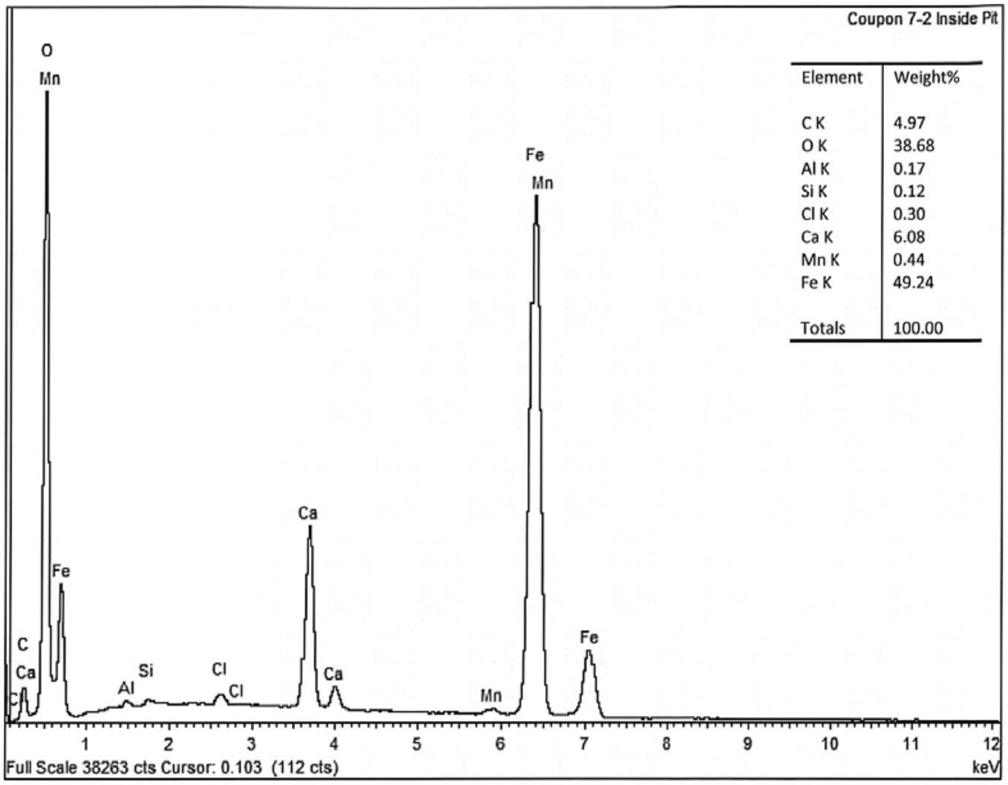


Figure 87. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 7 labeled as 7-2, prior to cleaning.

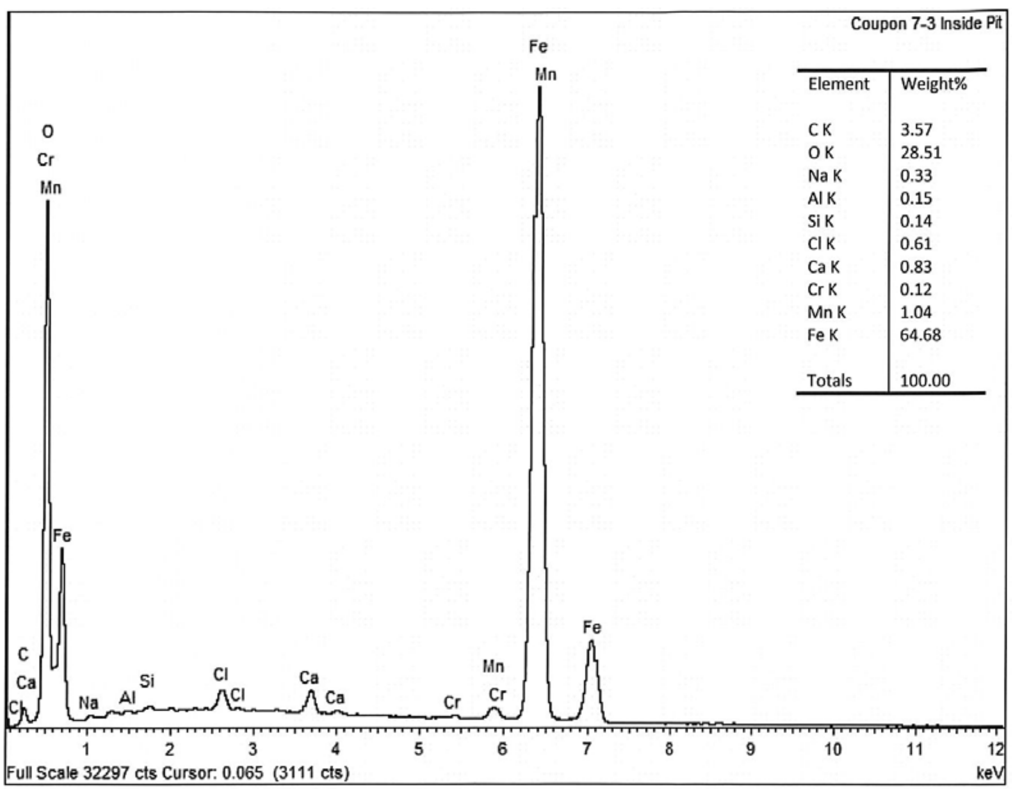
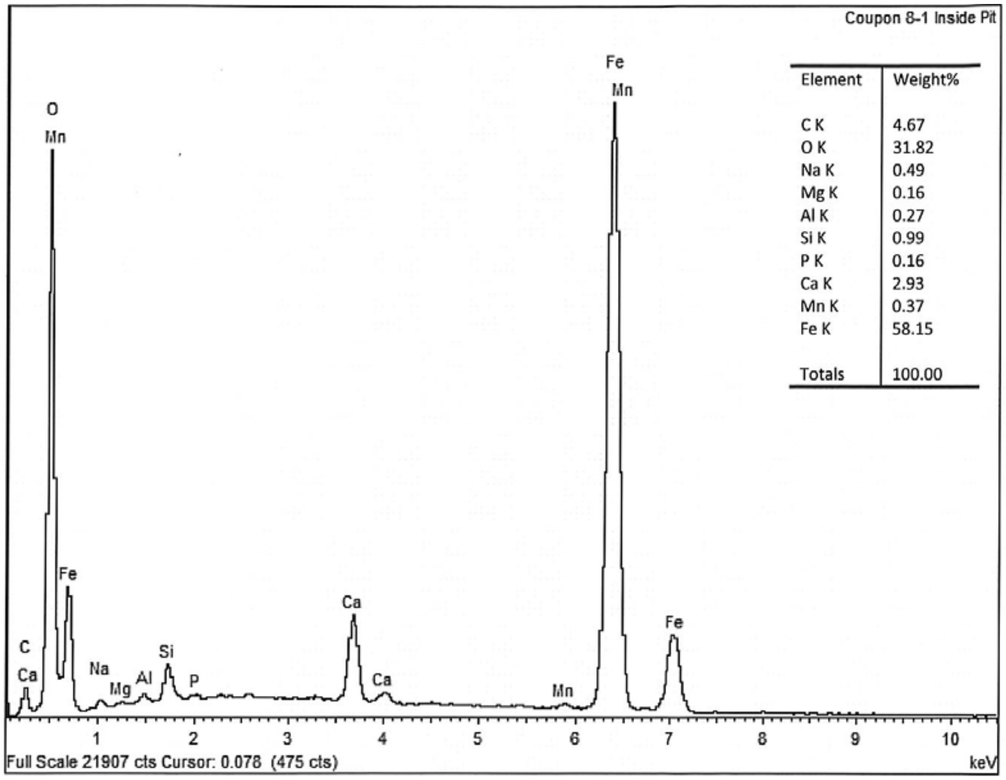
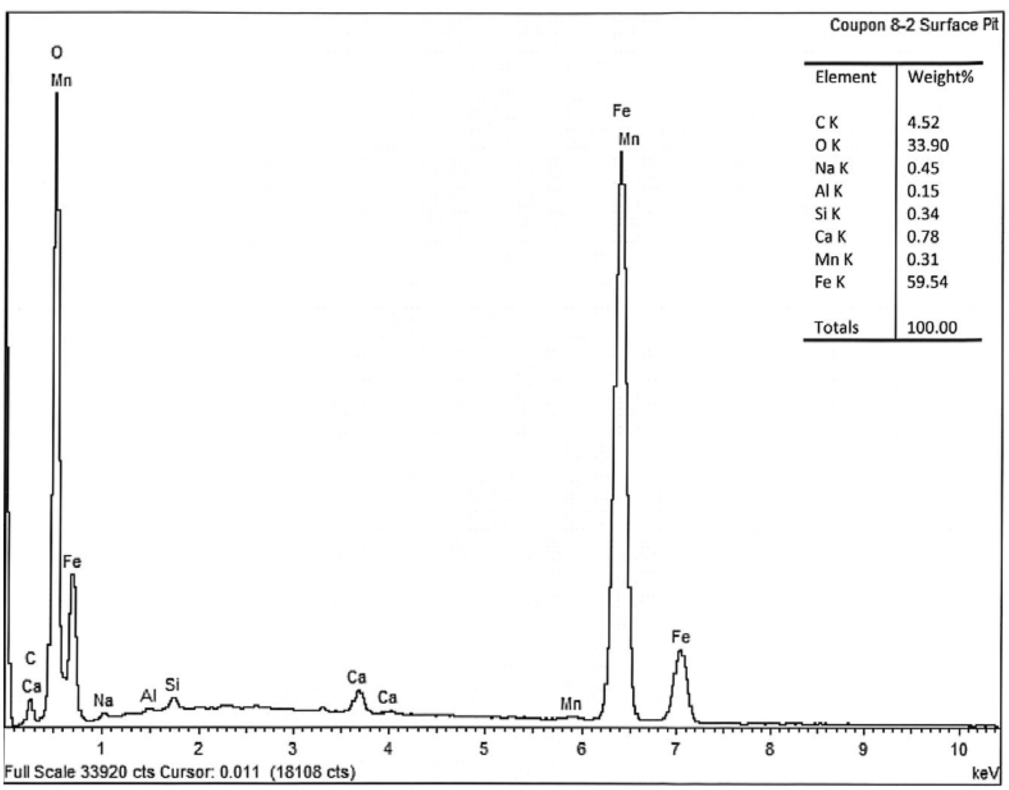


Figure 88. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 7 labeled as 7-3, prior to cleaning.



Element	Weight%
C K	4.67
O K	31.82
Na K	0.49
Mg K	0.16
Al K	0.27
Si K	0.99
P K	0.16
Ca K	2.93
Mn K	0.37
Fe K	58.15
Totals	100.00

Figure 89. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 8 labeled as 8-1, prior to cleaning.



Element	Weight%
C K	4.52
O K	33.90
Na K	0.45
Al K	0.15
Si K	0.34
Ca K	0.78
Mn K	0.31
Fe K	59.54
Totals	100.00

Figure 90. A representative EDS spectrum generated from the surface of a specimen excised from Coupon 8 labeled as 8-2, prior to cleaning.

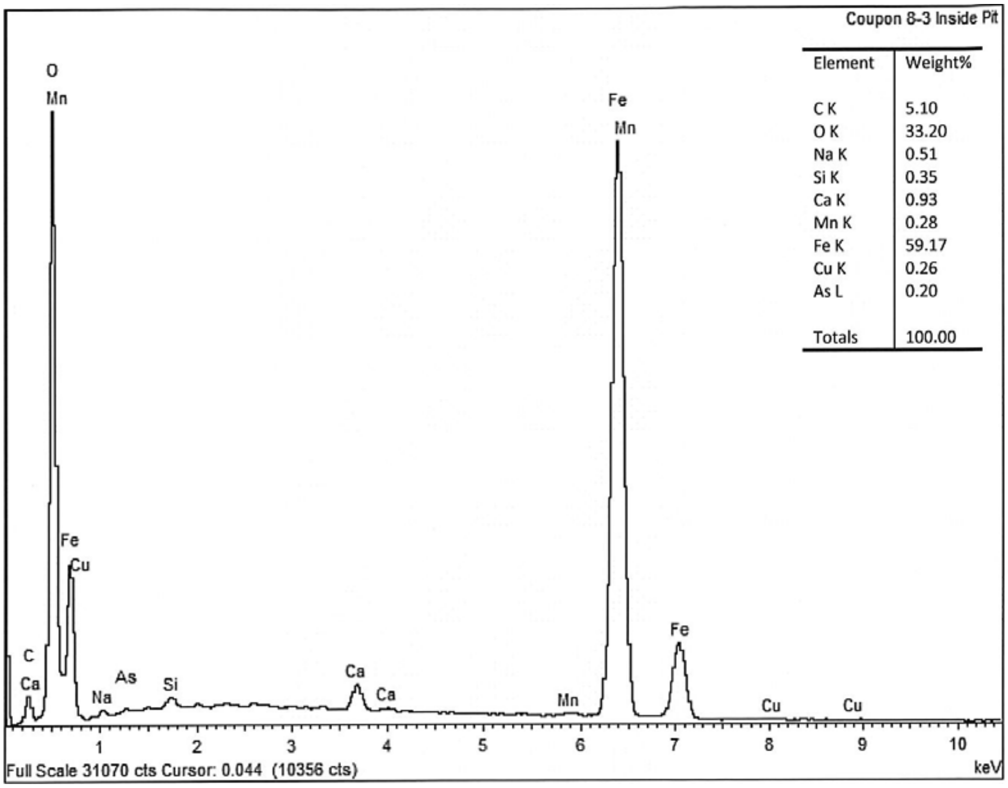


Figure 91. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 8 labeled as 8-3, prior to cleaning.

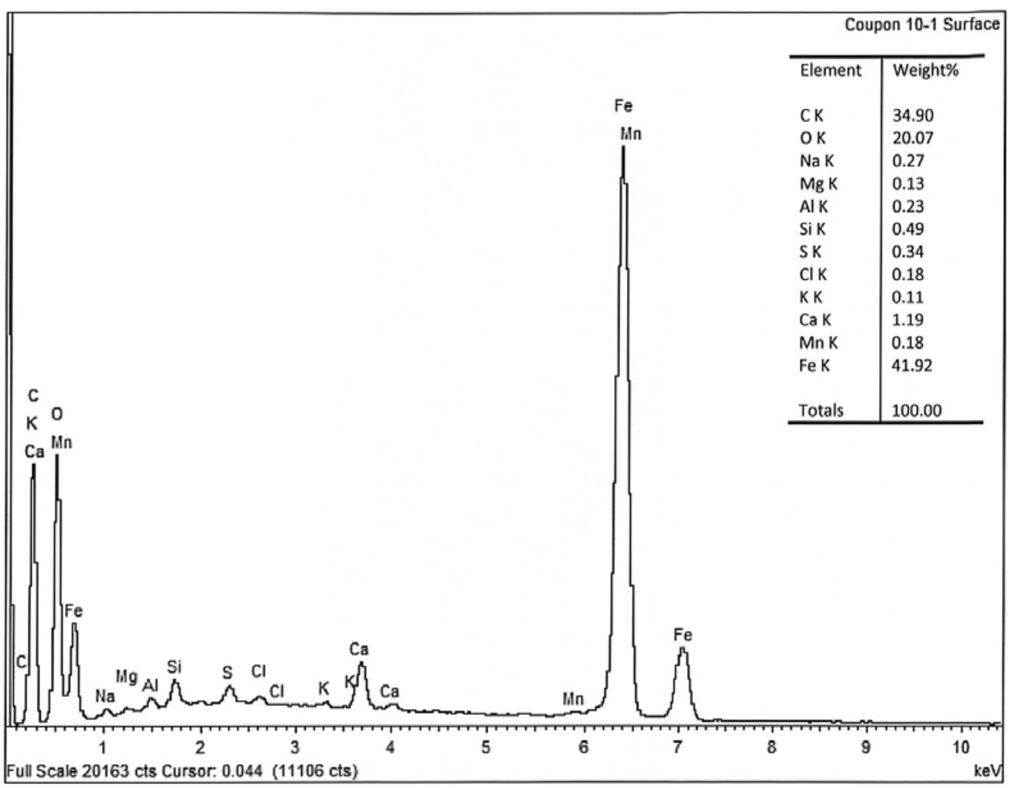


Figure 92. A representative EDS spectrum generated from the surface of a specimen excised from Coupon 10 labeled as 10-1, prior to cleaning.

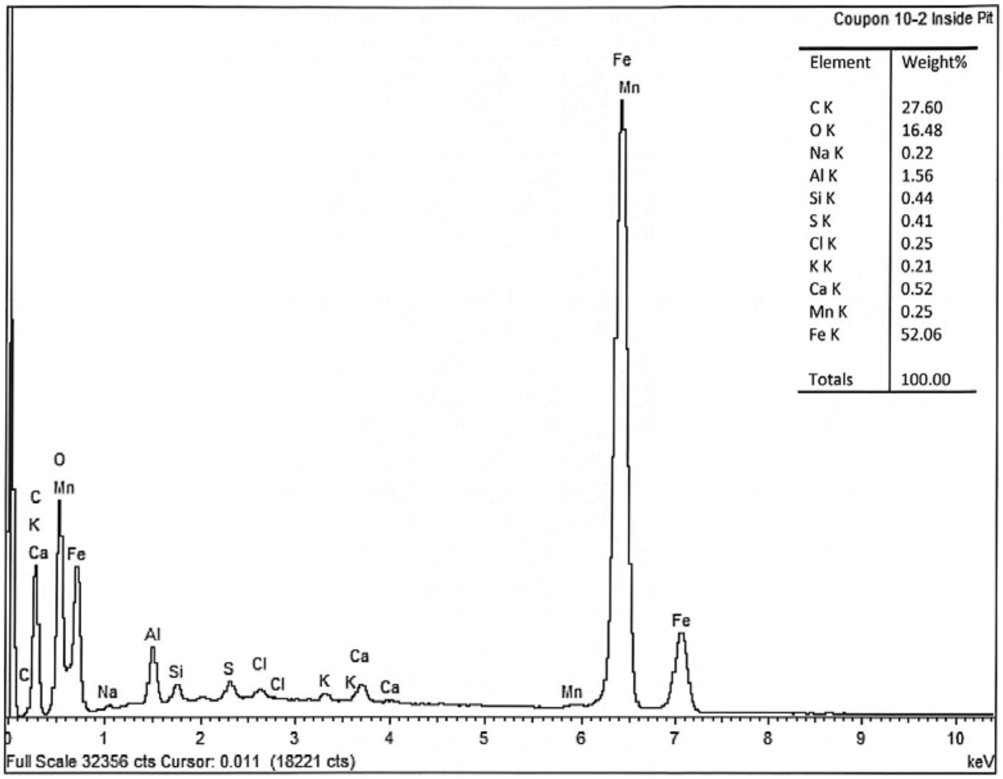


Figure 93. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon 10 labeled as 10-2, prior to cleaning.

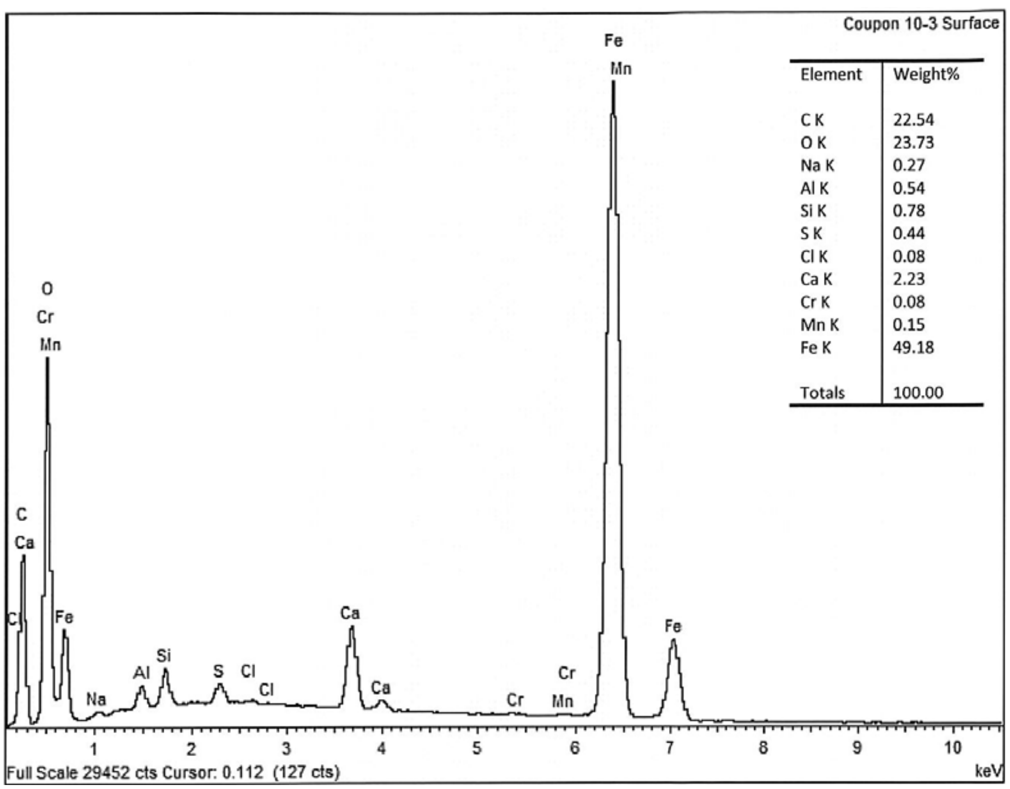


Figure 94. A representative EDS spectrum generated from the surface of a specimen excised from Coupon 10 labeled as 10-3, prior to cleaning.

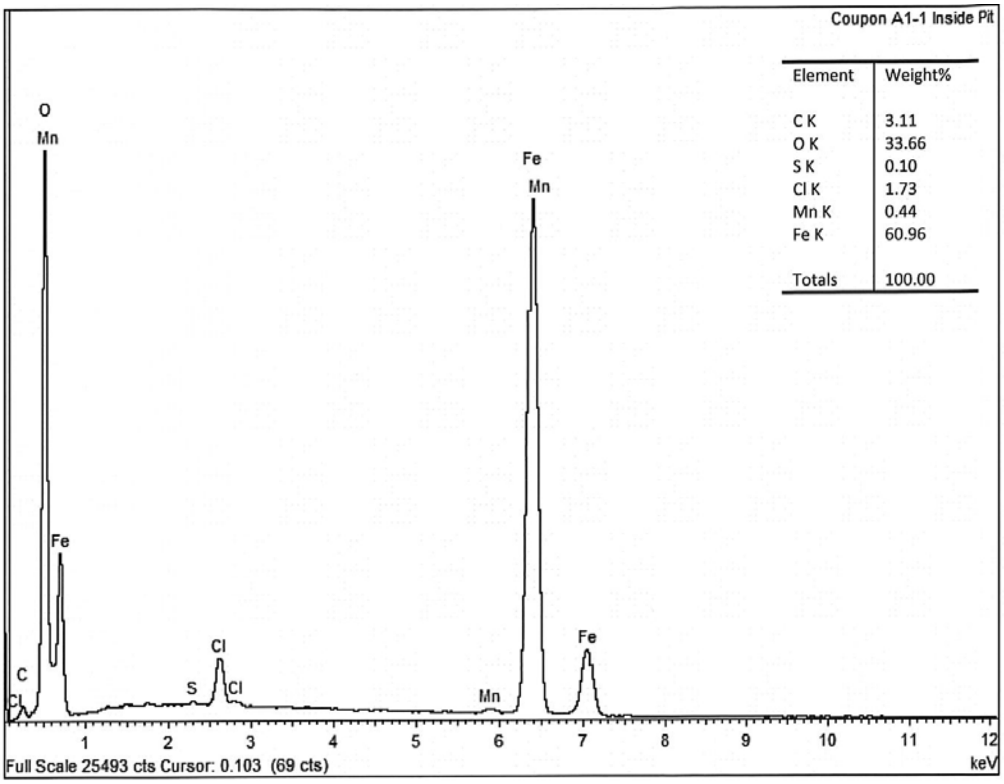


Figure 95. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon A1 labeled as A1-1, prior to cleaning.

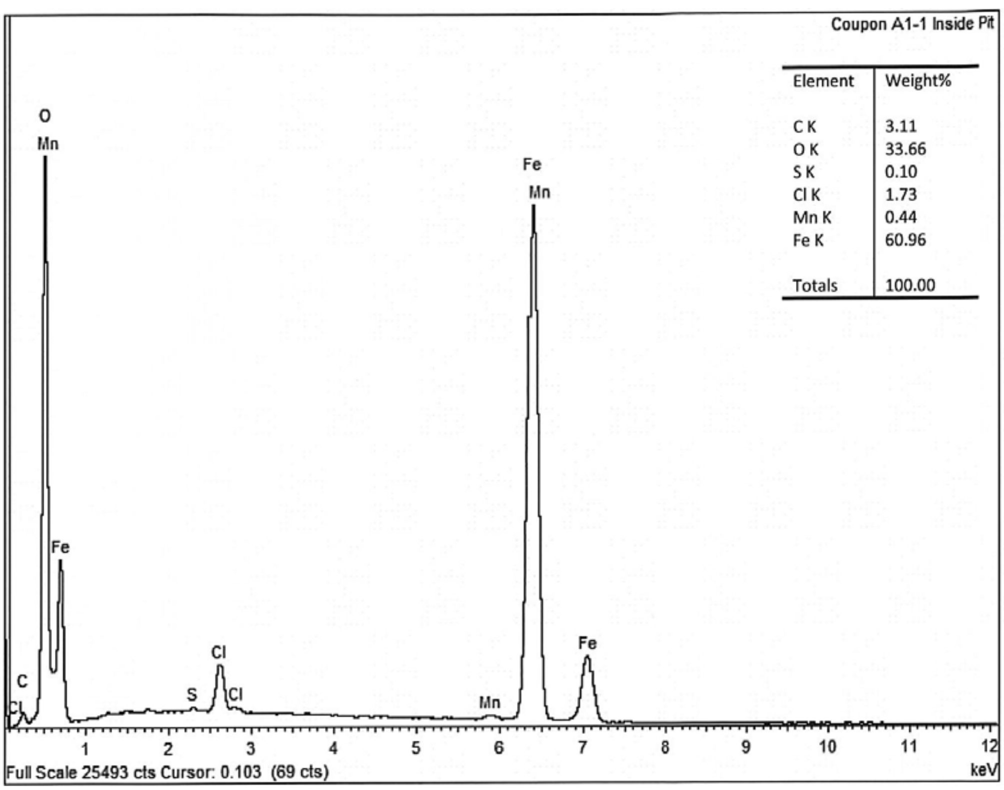


Figure 96. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon A1 labeled as A1-2, prior to cleaning.

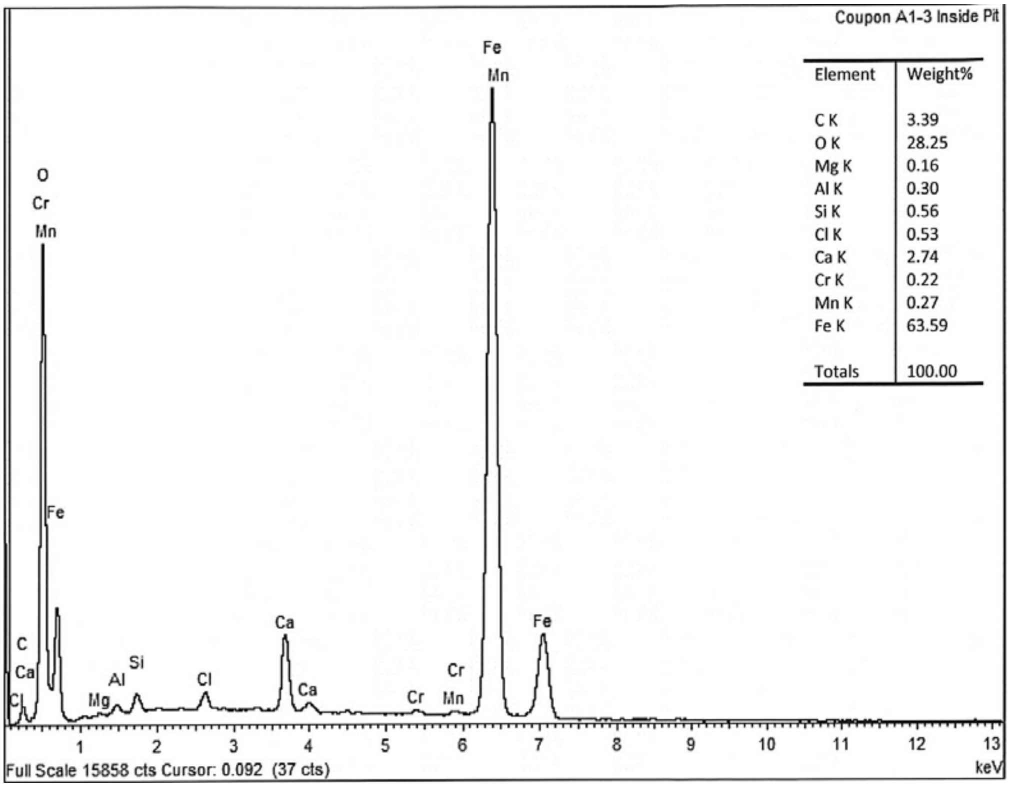


Figure 97. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon A1 labeled as A1-3, prior to cleaning.

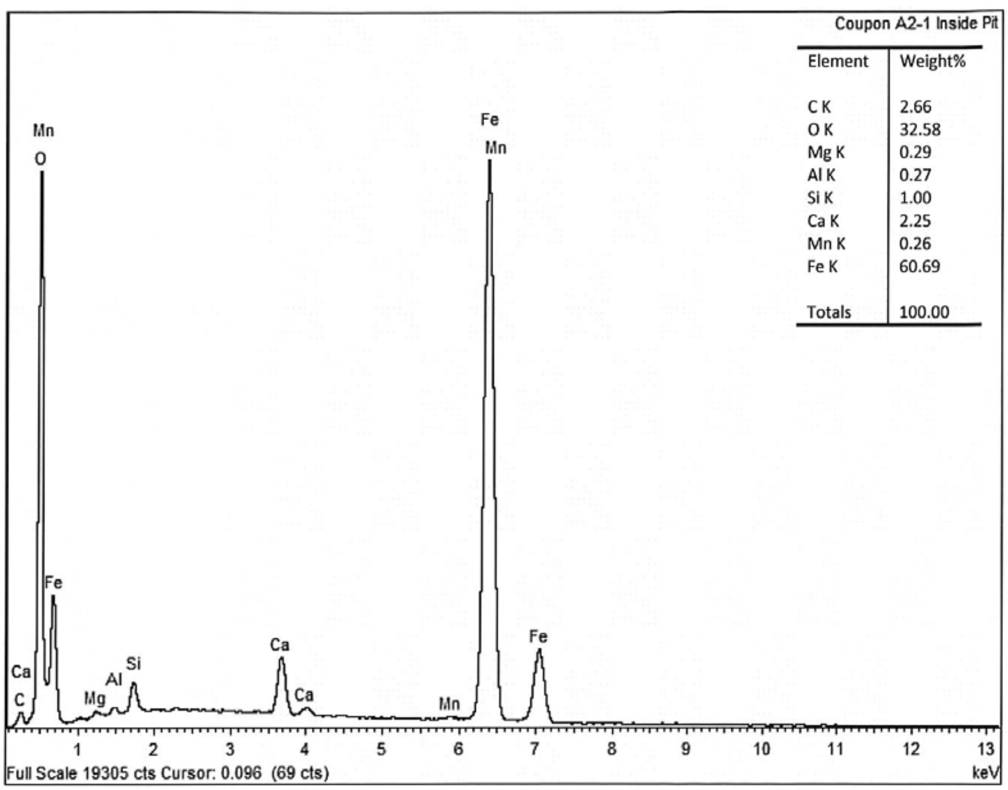


Figure 98. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon A2 labeled as A2-1, prior to cleaning.

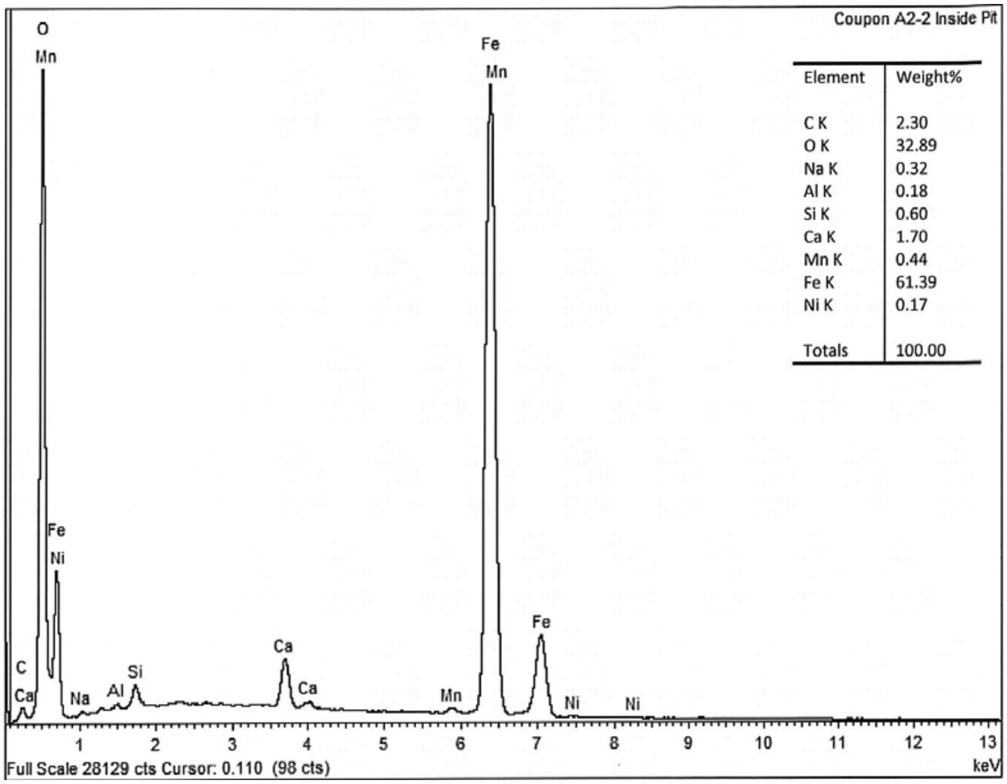


Figure 99. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon A2 labeled as A2-2, prior to cleaning.

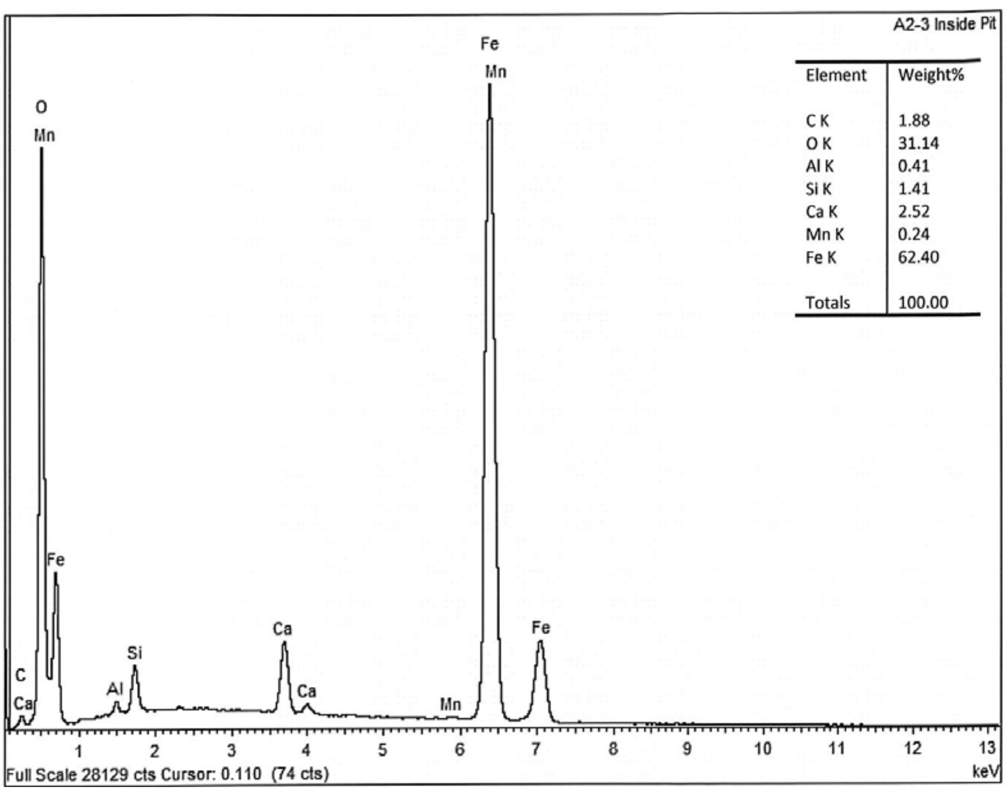
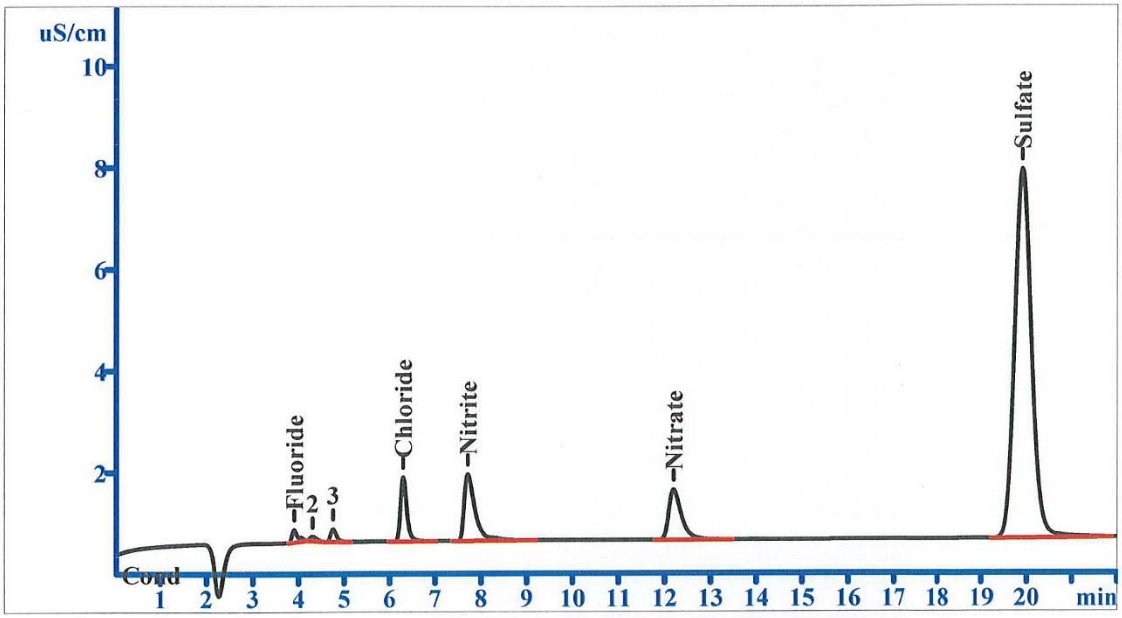


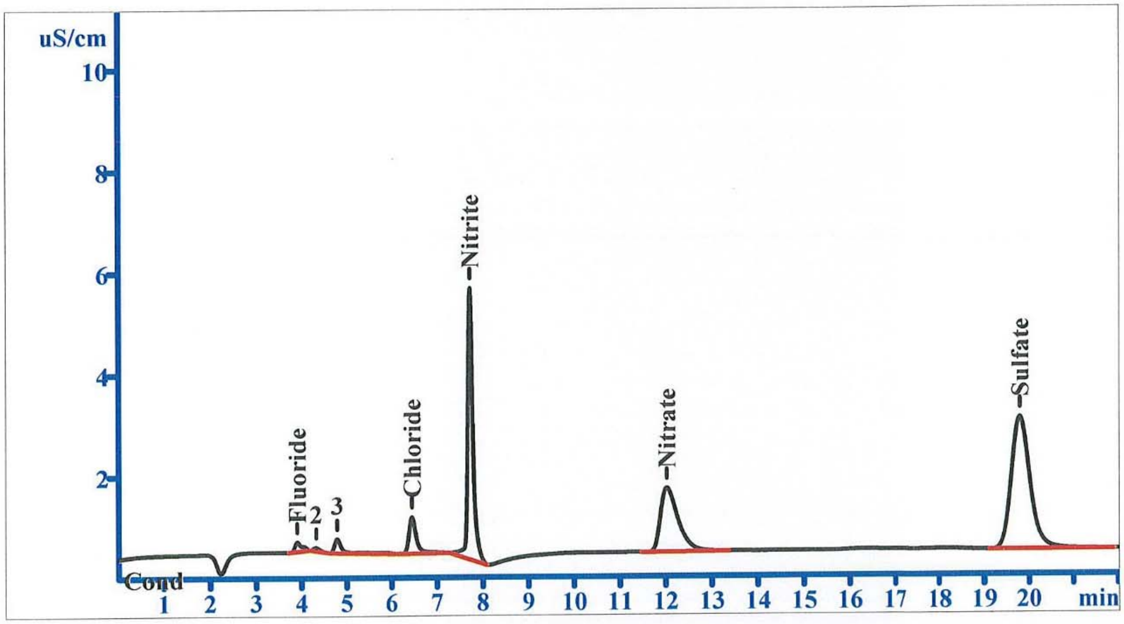
Figure 100. A representative EDS spectrum generated from of a pit on a specimen excised from Coupon A2 labeled as A2-3, prior to cleaning.



Quantitation method: Custom

No	Retention min	Height uS/cm	Area uS/cm*sec	Conc. ppm	Name
1	3.91	0.24	2.148	10.847	Fluoride
4	6.31	1.27	12.457	82.132	Chloride
5	7.74	1.31	22.385	281.793	Nitrite
6	12.22	0.99	19.356	273.382	Nitrate
7	19.92	7.27	188.802	1518.397	Sulfate
5	22.00	11.08	245.149	2166.551	

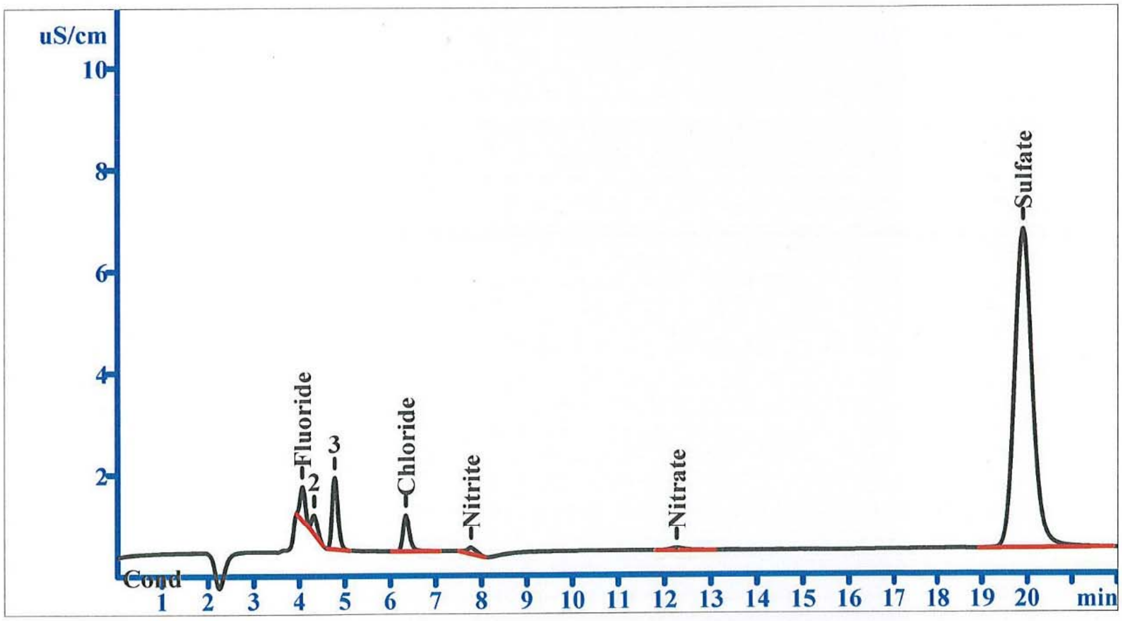
Figure 101. The ion chromatogram generated from a concrete sample removed from Coupon 1.



Quantitation method: Custom

No	Retention min	Height uS/cm	Area uS/cm*sec	Conc. ppm	Name
1	3.91	0.18	2.024	11.408	Fluoride
4	6.44	0.72	7.995	58.860	Chloride
5	7.72	5.34	42.354	595.340	Nitrite
6	12.04	1.26	33.947	535.394	Nitrate
7	19.80	2.61	76.162	683.949	Sulfate
5	22.00	10.11	162.481	1884.952	

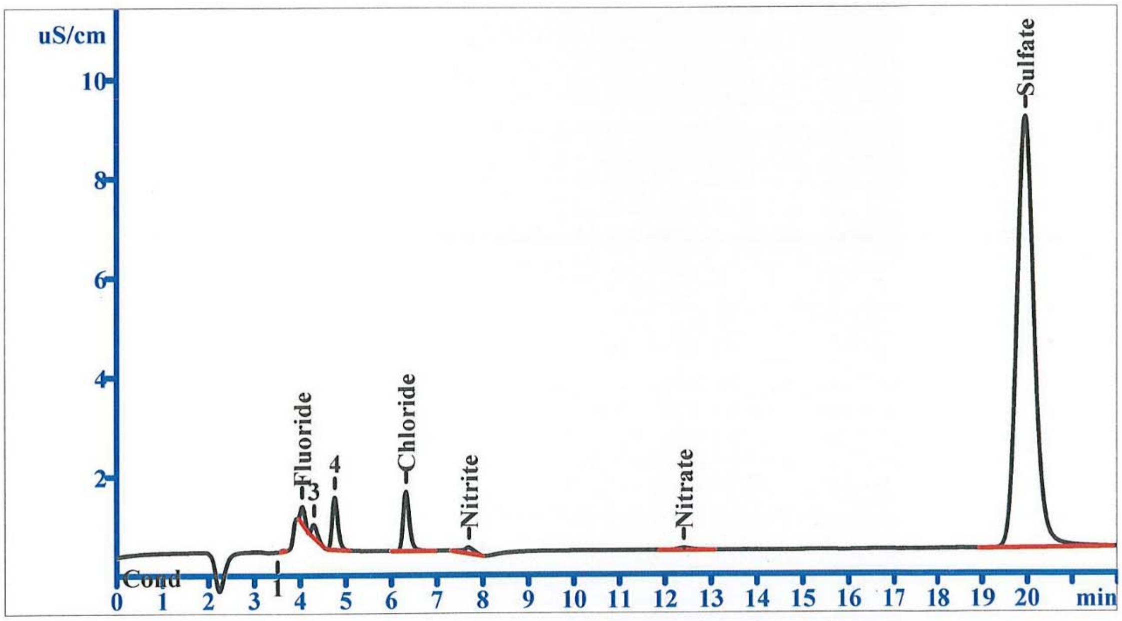
Figure 102. The ion chromatogram generated from a concrete sample removed from Coupon 2.



Quantitation method: Custom

No	Retention min	Height uS/cm	Area uS/cm*sec	Conc. ppm	Name
1	4.07	0.66	5.061	27.530	Fluoride
4	6.34	0.71	7.074	50.245	Chloride
5	7.78	0.12	1.780	24.145	Nitrite
6	12.28	0.05	0.957	14.555	Nitrate
7	19.91	6.28	173.210	1500.682	Sulfate
5	22.00	7.81	188.083	1617.158	

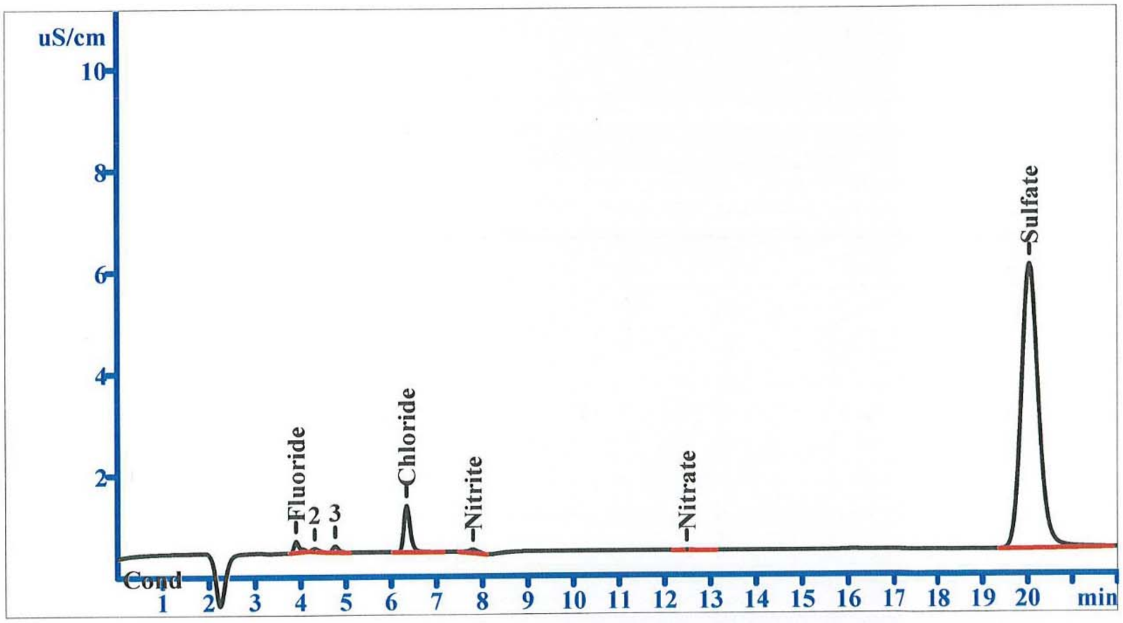
Figure 103. The ion chromatogram generated from a concrete sample removed from Coupon 3.



Quantitation method: Custom

No	Retention min	Height uS/cm	Area uS/cm*sec	Conc. ppm	Name
2	4.06	0.35	2.415	12.764	Fluoride
5	6.35	1.20	11.646	80.382	Chloride
6	7.72	0.12	1.989	26.215	Nitrite
7	12.41	0.04	0.804	11.895	Nitrate
8	19.97	8.69	235.110	1979.422	Sulfate
5	22.00	10.41	251.964	2110.679	

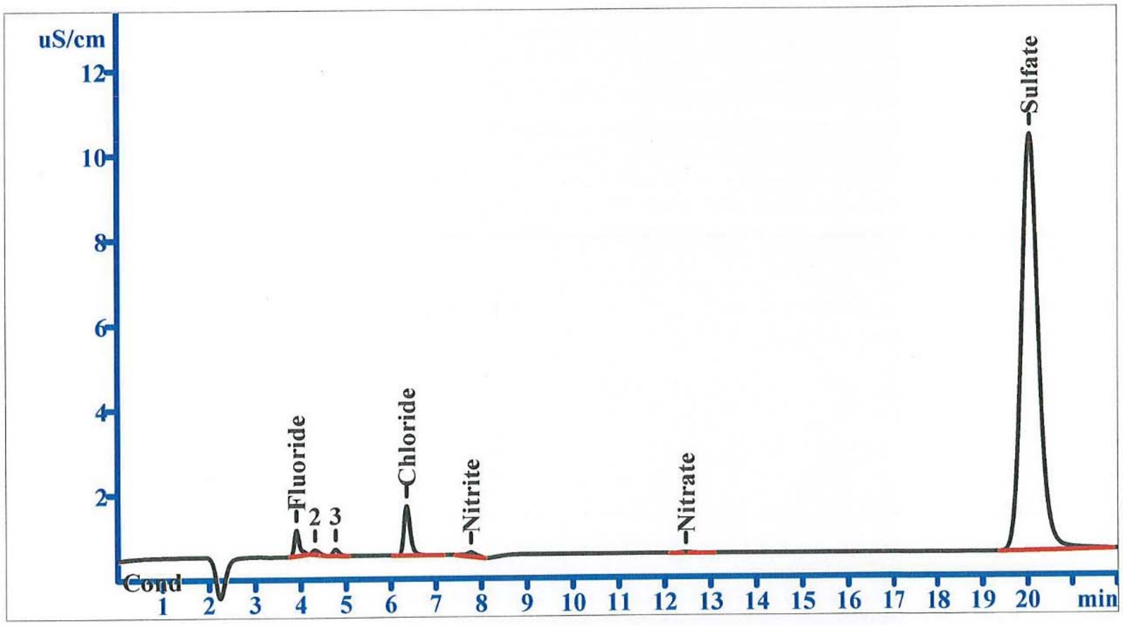
Figure 104. The ion chromatogram generated from a concrete sample removed from Coupon 5.



Quantitation method: Custom

No	Retention min	Height uS/cm	Area uS/cm*sec	Conc. ppm	Name
1	3.92	0.21	1.820	12.711	Fluoride
4	6.35	0.91	8.882	81.024	Chloride
5	7.80	0.07	0.999	17.394	Nitrite
6	12.48	0.01	0.154	3.004	Nitrate
7	20.07	5.59	149.208	1660.246	Sulfate
5	22.00	6.79	161.062	1774.379	

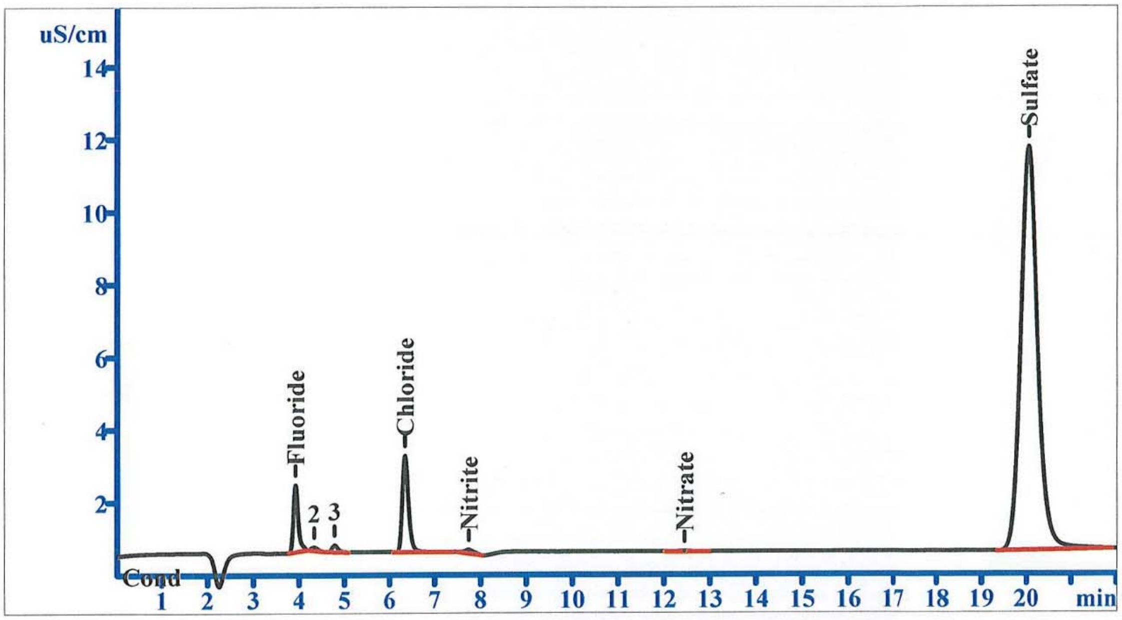
Figure 105. The ion chromatogram generated from a concrete sample removed from Coupon 6.



Quantitation method: Custom

No	Retention min	Height uS/cm	Area uS/cm*sec	Conc. ppm	Name
1	3.92	0.60	4.635	24.567	Fluoride
4	6.35	1.16	11.342	78.508	Chloride
5	7.78	0.10	1.492	19.715	Nitrite
6	12.47	0.02	0.348	5.162	Nitrate
7	20.06	9.81	259.442	2190.390	Sulfate
5	22.00	11.69	277.260	2318.341	

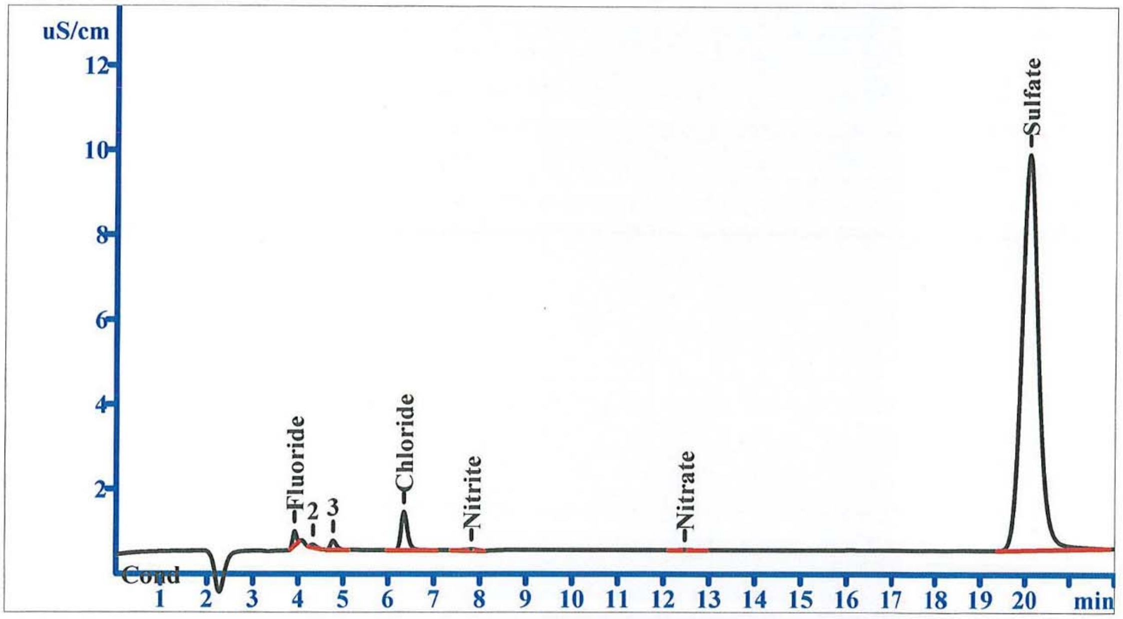
Figure 106. The ion chromatogram generated from a concrete sample removed from Coupon 7.



Quantitation method: Custom

No	Retention min	Height uS/cm	Area uS/cm*sec	Conc. ppm	Name
1	3.92	1.84	13.713	70.024	Fluoride
4	6.34	2.65	25.697	171.359	Chloride
5	7.75	0.10	1.421	18.089	Nitrite
6	12.47	0.02	0.309	4.417	Nitrate
7	20.05	11.12	294.084	2392.060	Sulfate
5	22.00	15.73	335.223	2655.950	

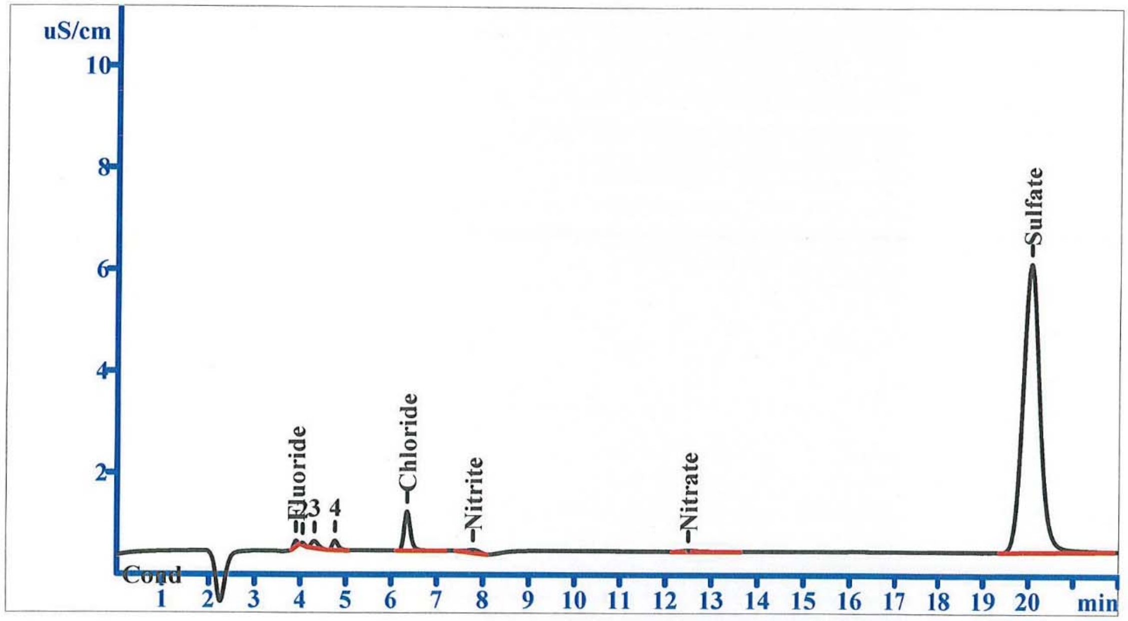
Figure 107. The ion chromatogram generated from a concrete sample removed from Coupon 8.



Quantitation method: Custom

No	Retention min	Height uS/cm	Area uS/cm*sec	Conc. ppm	Name
1	3.92	0.34	1.950	10.365	Fluoride
4	6.35	0.90	8.923	61.921	Chloride
5	7.84	0.03	0.489	6.481	Nitrite
6	12.49	0.01	0.220	3.267	Nitrate
7	20.09	9.33	247.184	2092.300	Sulfate
5	22.00	10.61	258.766	2174.334	

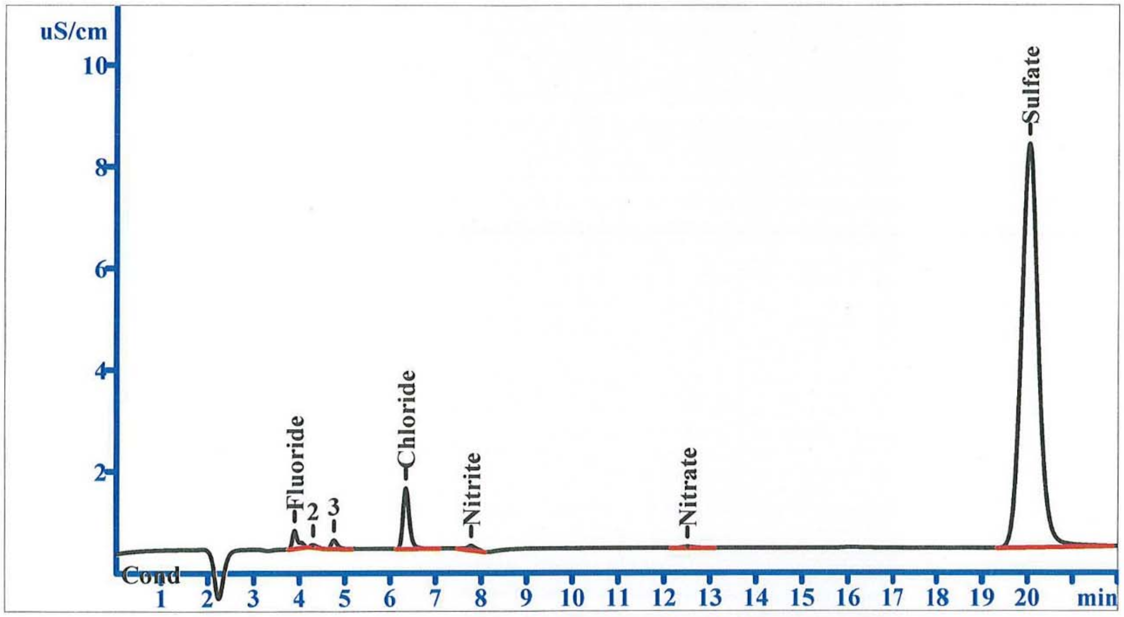
Figure 108. The ion chromatogram generated from a concrete sample removed from Coupon 10.



Quantitation method: Custom

No	Retention min	Height uS/cm	Area uS/cm*sec	Conc. ppm	Name
1	3.91	0.11	0.617	3.277	Fluoride
5	6.36	0.78	7.603	52.710	Chloride
6	7.82	0.06	1.132	14.978	Nitrite
7	12.50	0.02	0.412	6.112	Nitrate
8	20.06	5.68	149.697	1265.856	Sulfate
5	22.00	6.64	159.460	1342.933	

Figure 109. The ion chromatogram generated from a concrete sample removed from Coupon A1.



Quantitation method: Custom

No	Retention min	Height uS/cm	Area uS/cm*sec	Conc. ppm	Name
1	3.92	0.35	3.097	16.357	Fluoride
4	6.36	1.19	11.606	80.052	Chloride
5	7.79	0.09	1.276	16.801	Nitrite
6	12.51	0.03	0.518	7.652	Nitrate
7	20.05	7.94	208.478	1753.979	Sulfate
5	22.00	9.59	224.975	1874.840	

Figure 110. The ion chromatogram generated from a concrete sample removed from Coupon A2.

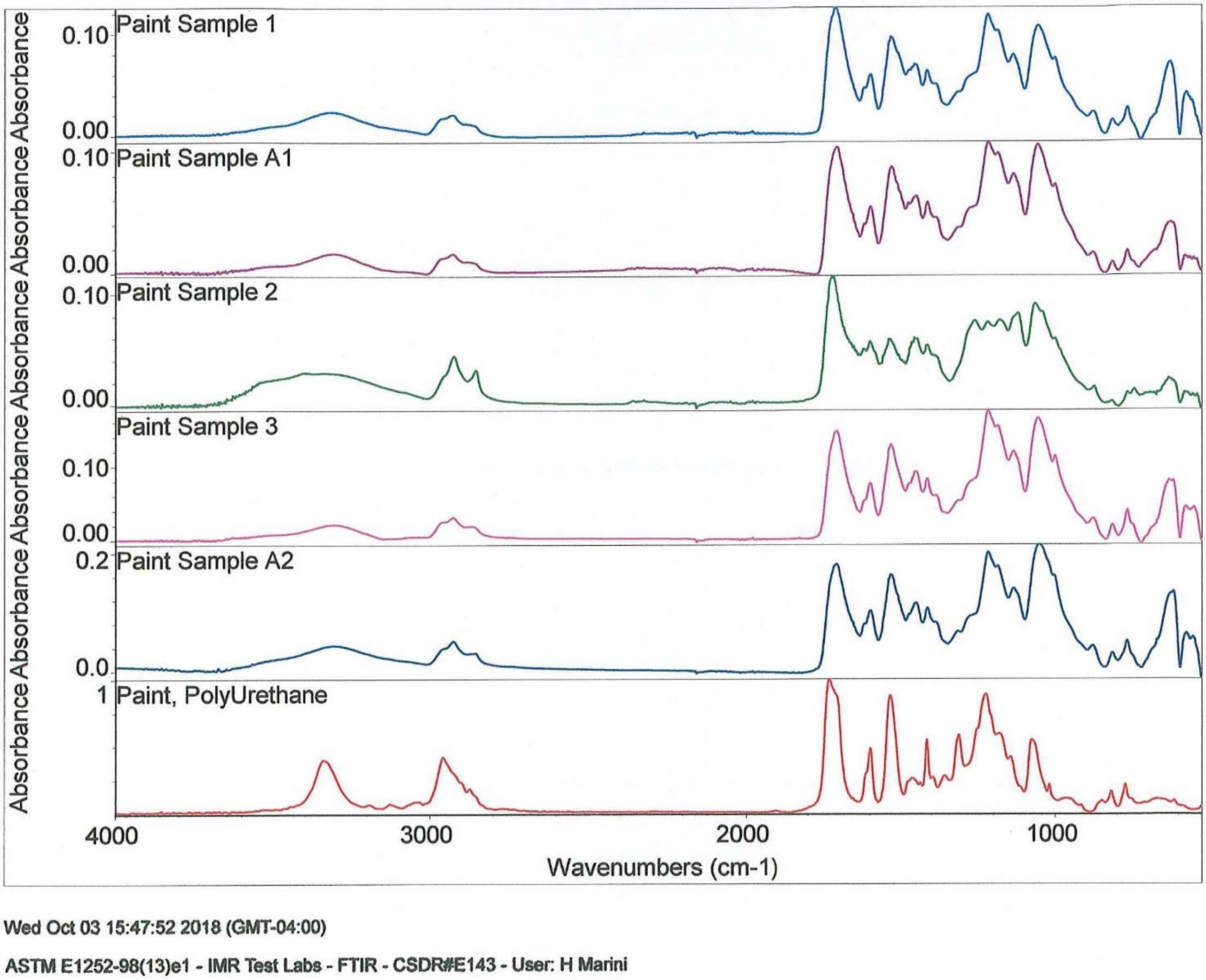


Figure 111. The FTIR spectra generated from a paint samples removed from the exterior surfaces of Coupons 1, A1, 2, A2 and 3 the best matches from the spectral FTIR library of standards for polyurethane enamel.

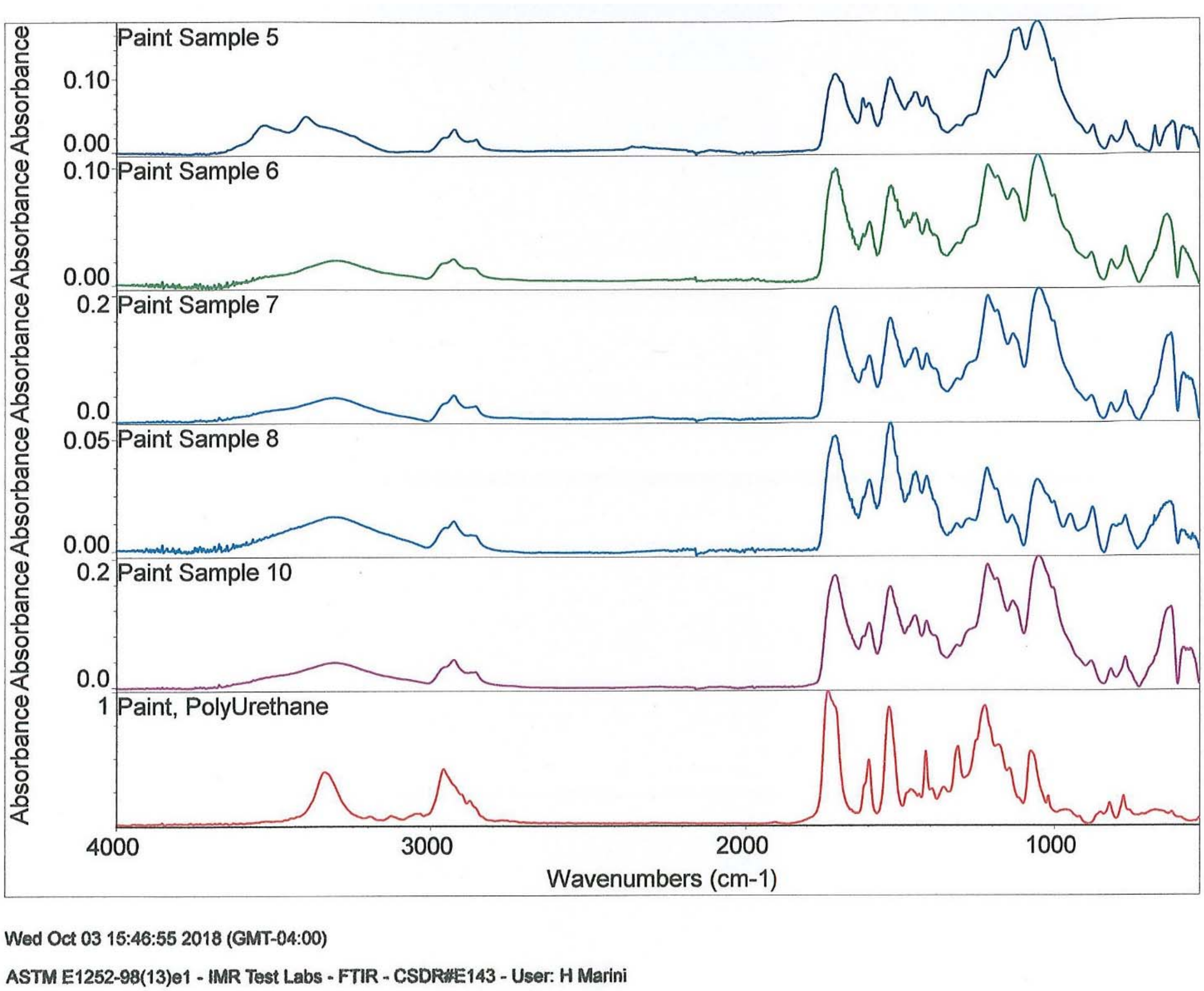


Figure 112. The FTIR spectra generated from a paint samples removed from the exterior surfaces of Coupons 5, 6, 7, 8 and 10 the best matches from the spectral FTIR library of standards for polyurethane enamel.

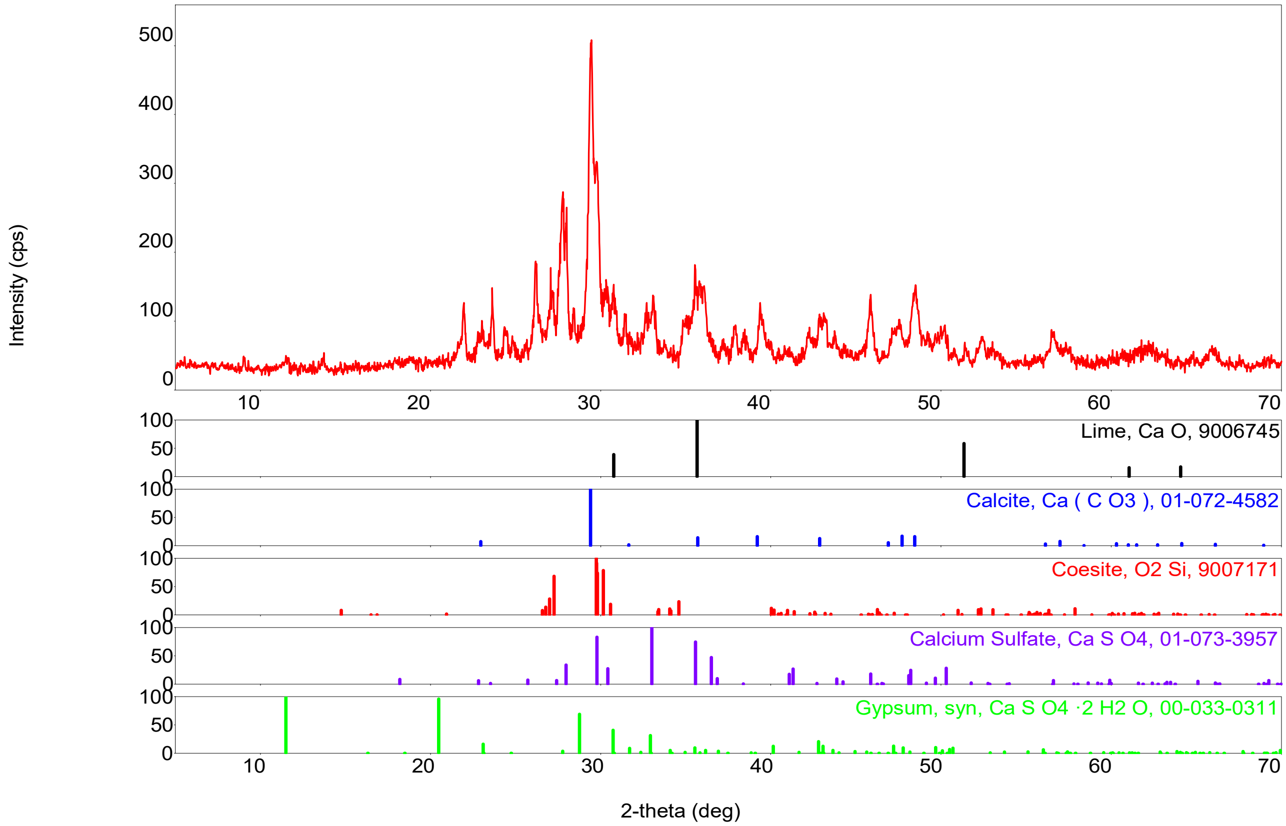


Figure 113. The XRD diffractogram generated from concrete removed Coupon 1.

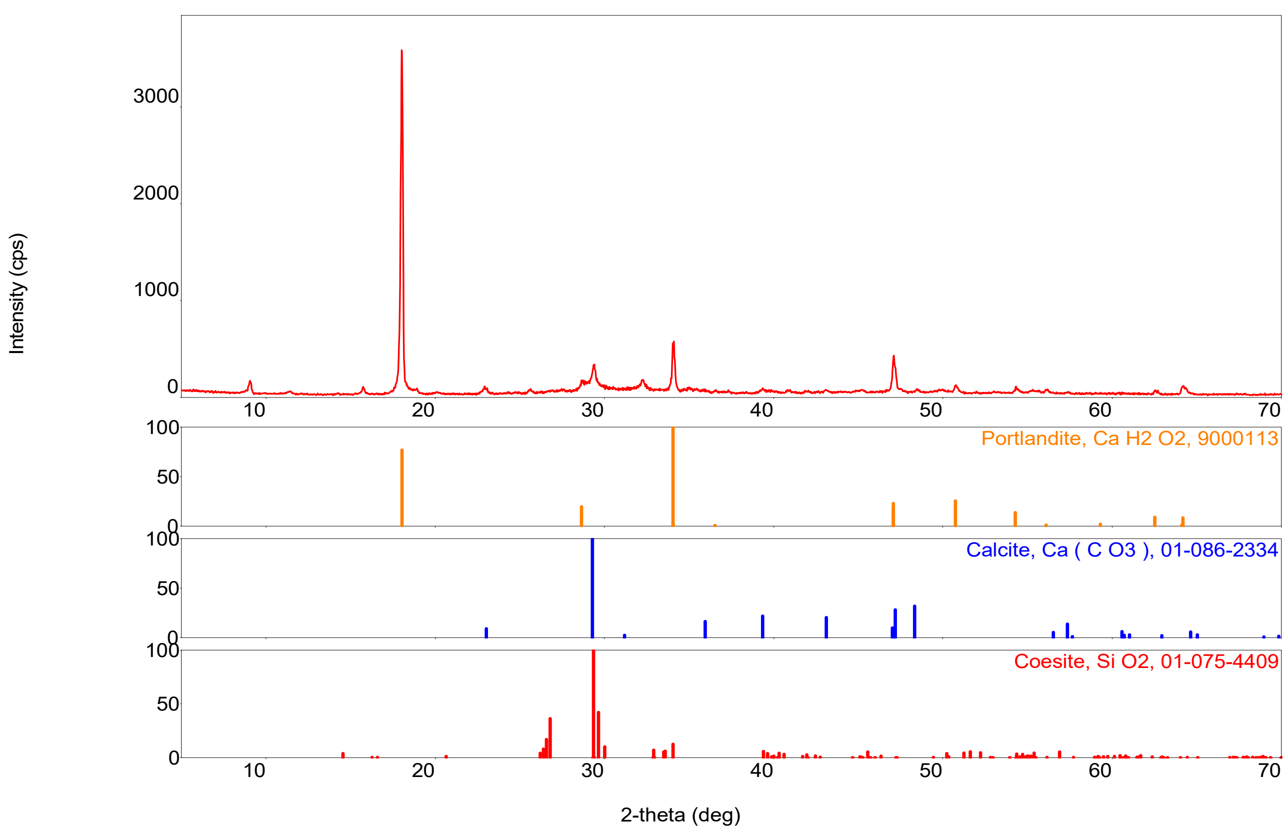


Figure 114. The XRD diffractogram generated from concrete removed Coupon 2.

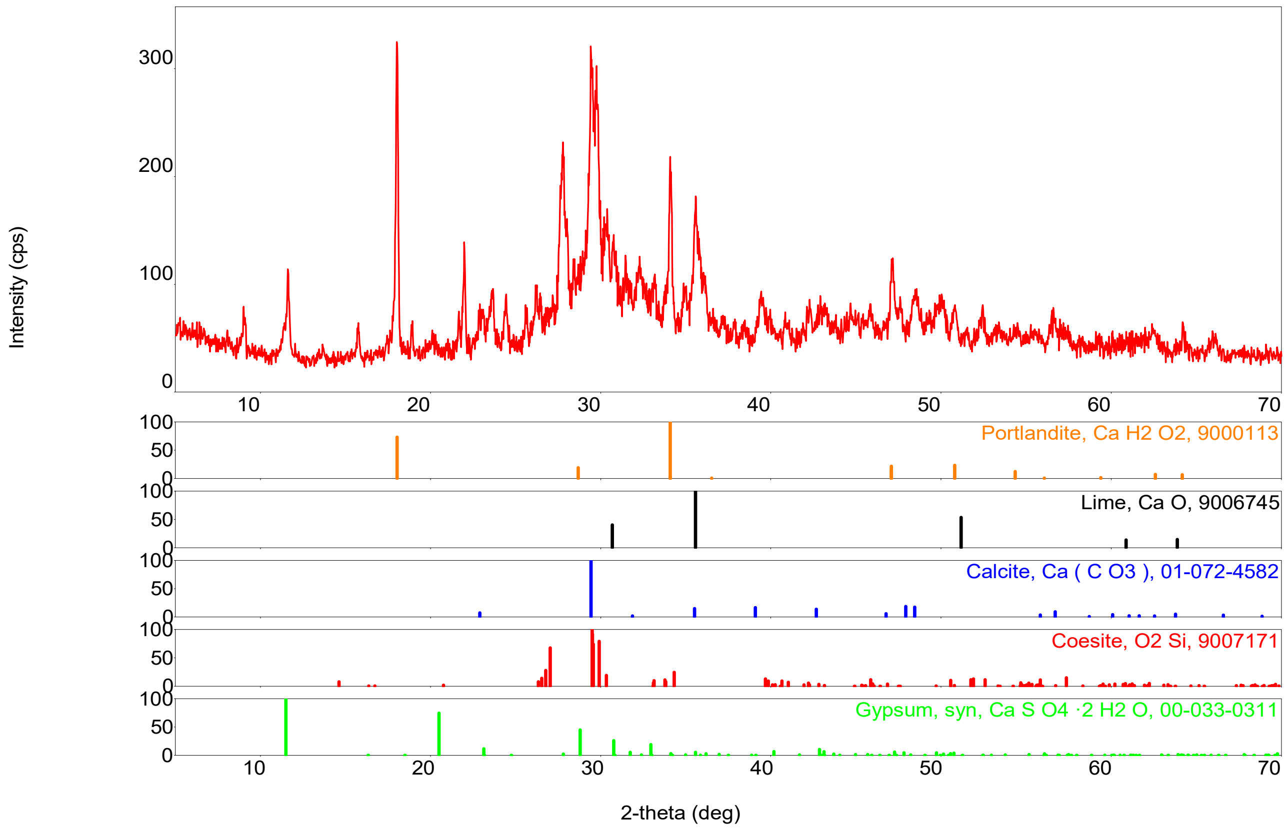


Figure 115. The XRD diffractogram generated from concrete removed Coupon 3.

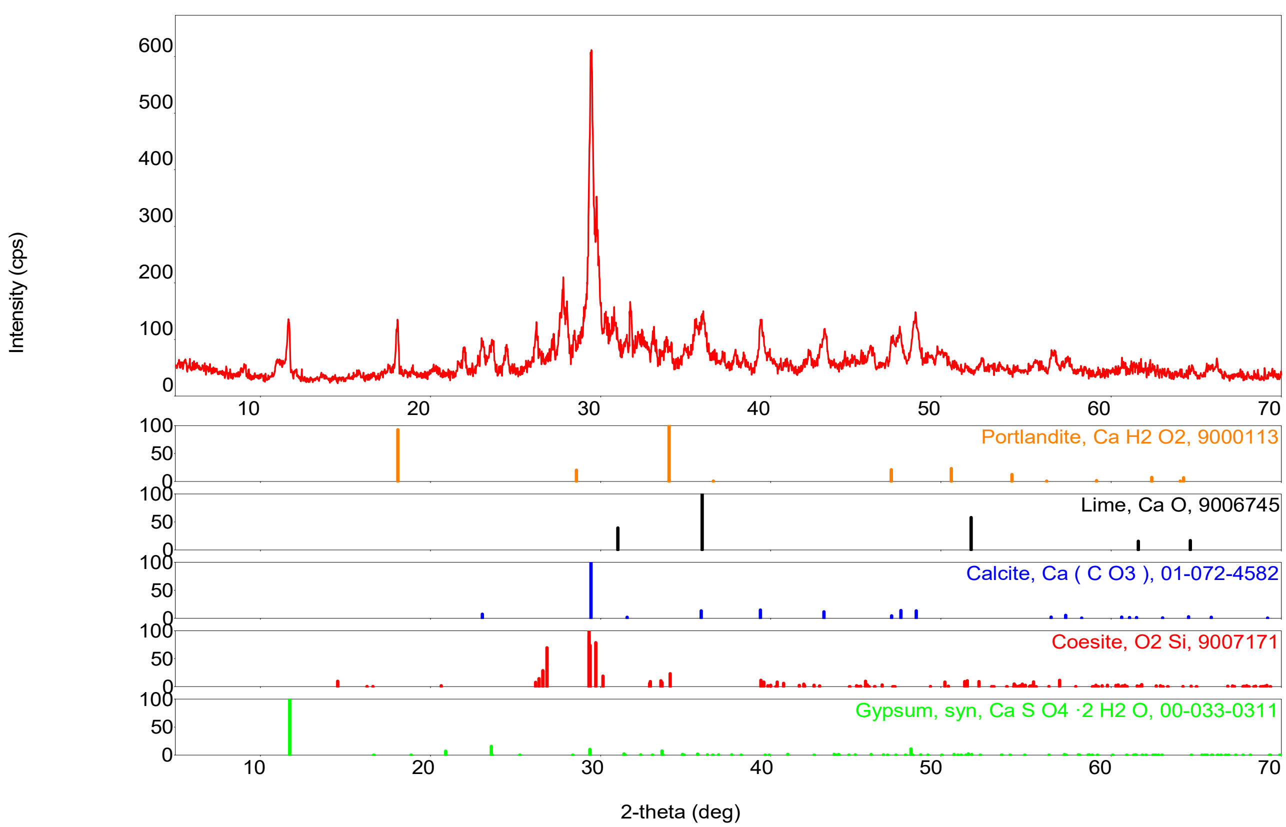


Figure 116. The XRD diffractogram generated from concrete removed Coupon 5.

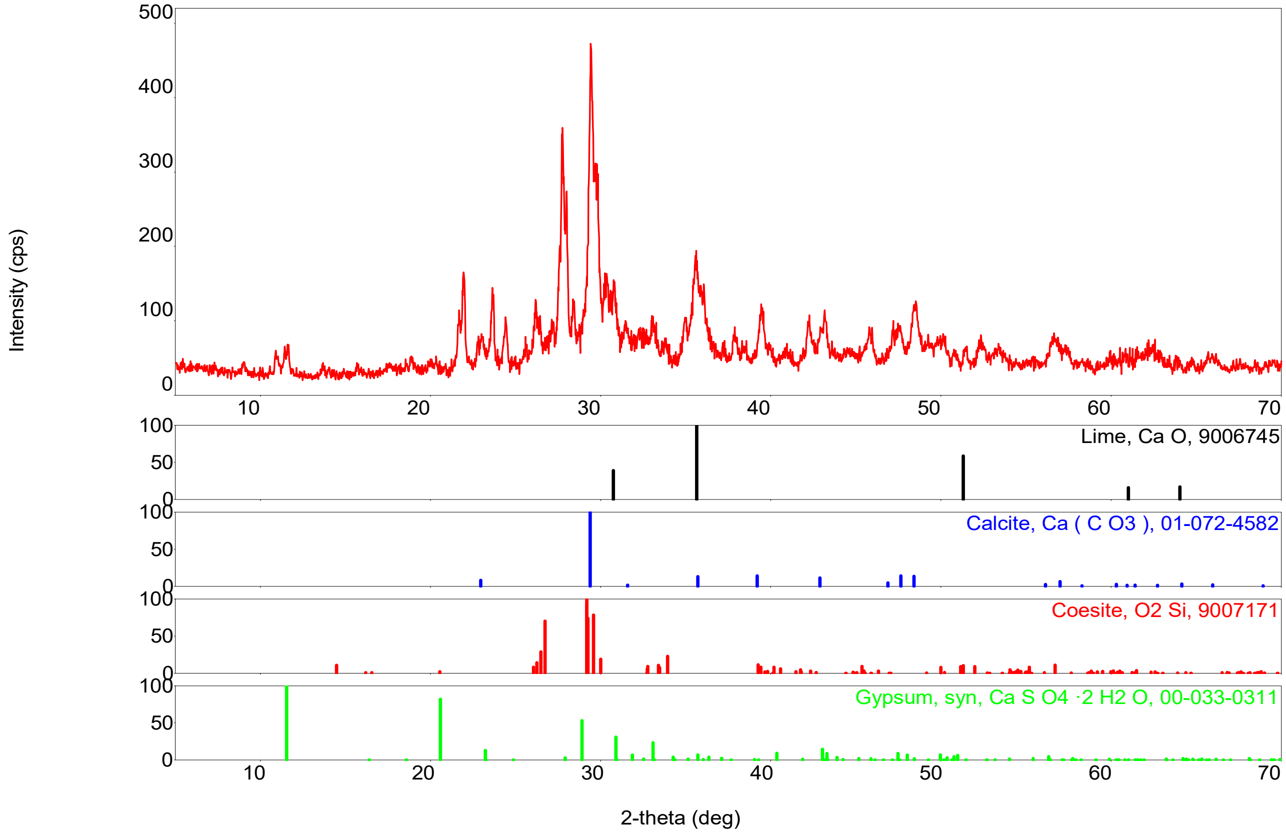


Figure 117. The XRD diffractogram generated from concrete removed Coupon 6.

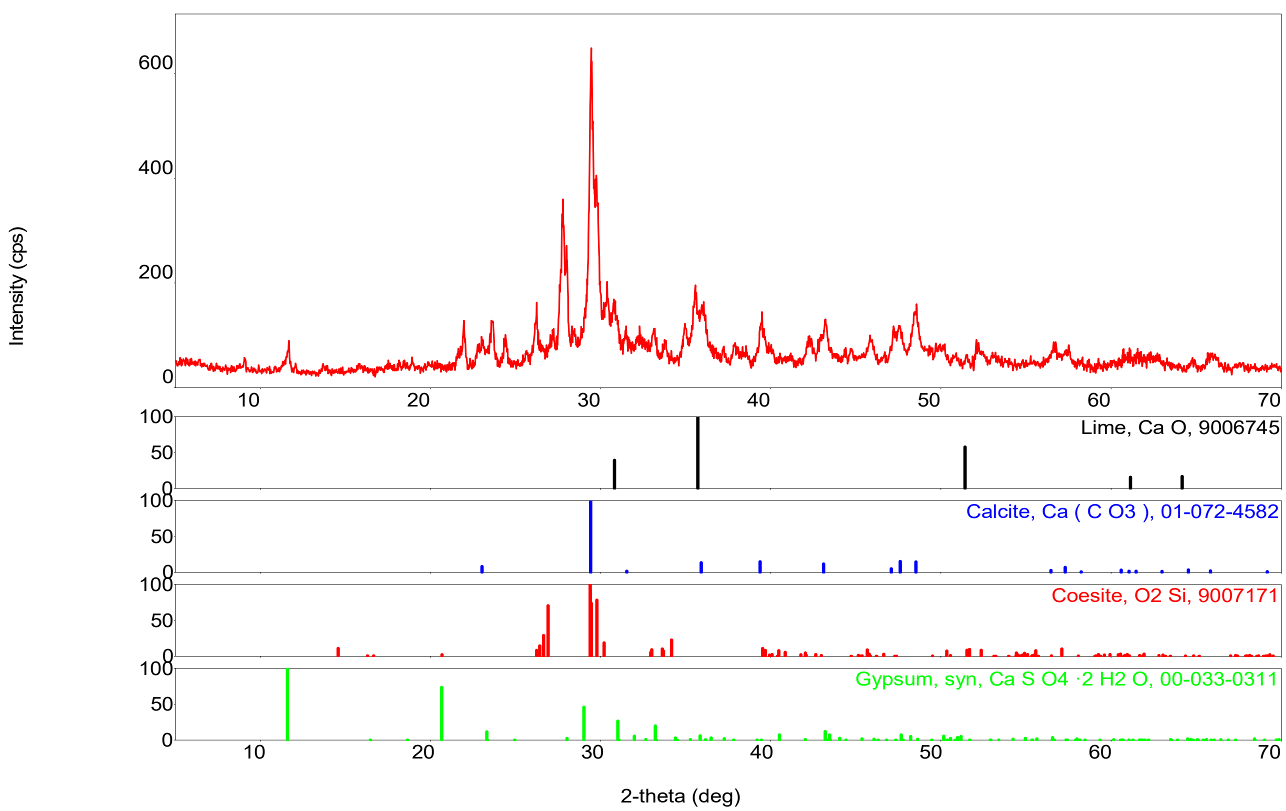


Figure 118. The XRD diffractogram generated from concrete removed Coupon 7.

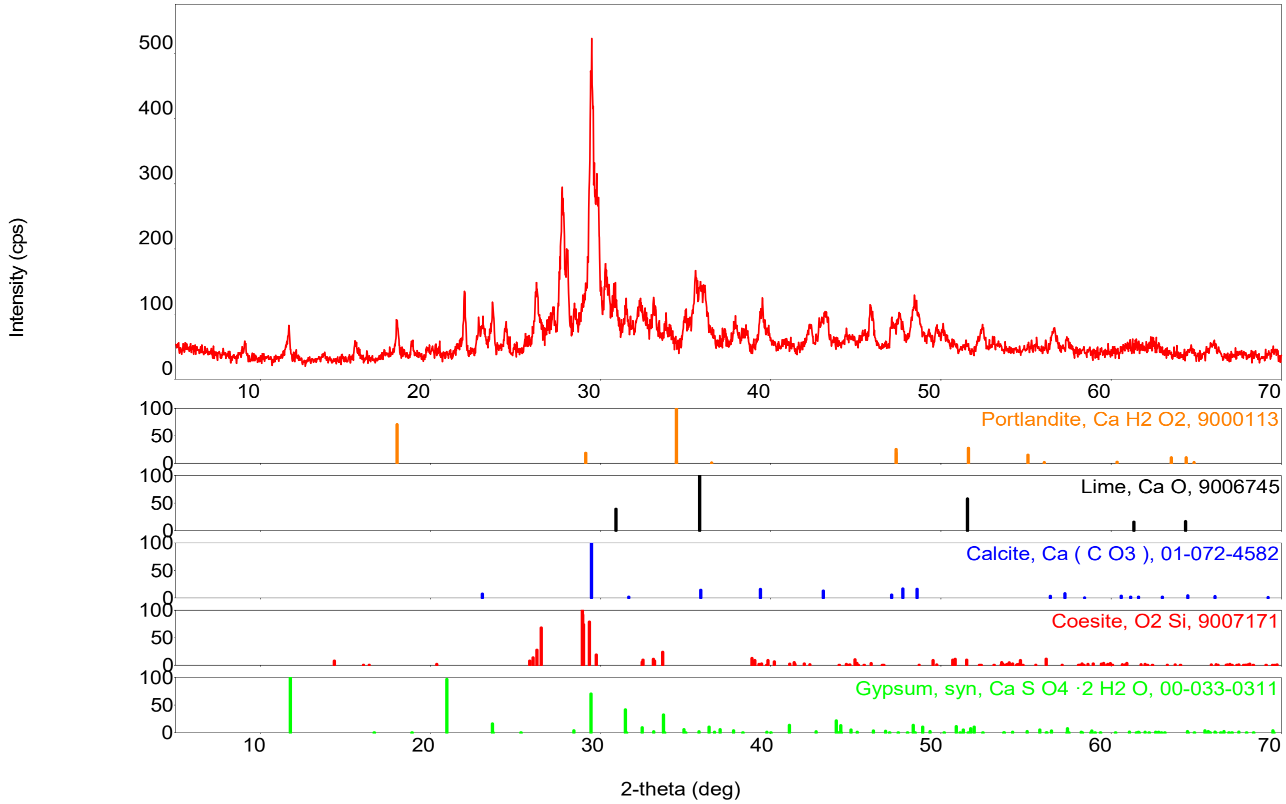


Figure 119. The XRD diffractogram generated from concrete removed Coupon 8.

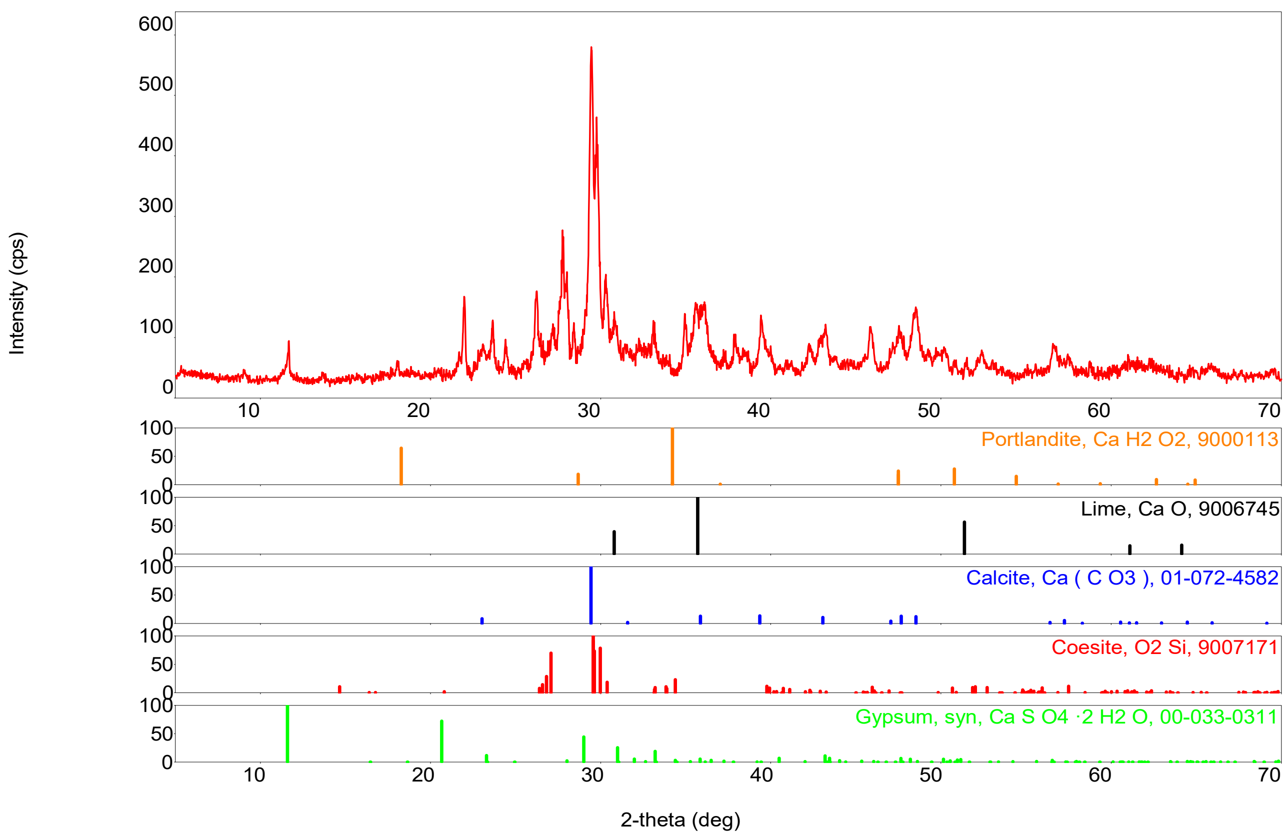


Figure 120. The XRD diffractogram generated from concrete removed Coupon 10.

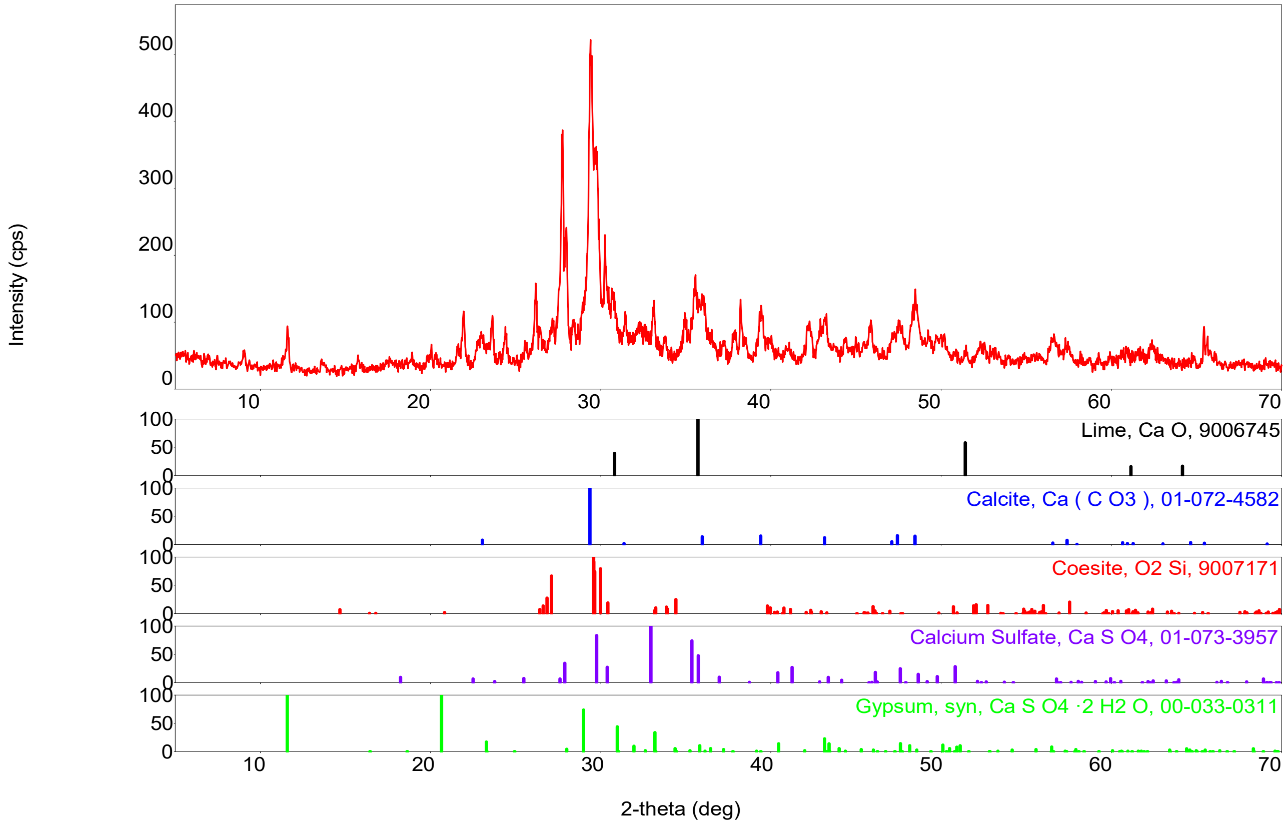


Figure 121. The XRD diffractogram generated from concrete removed Coupon A1.

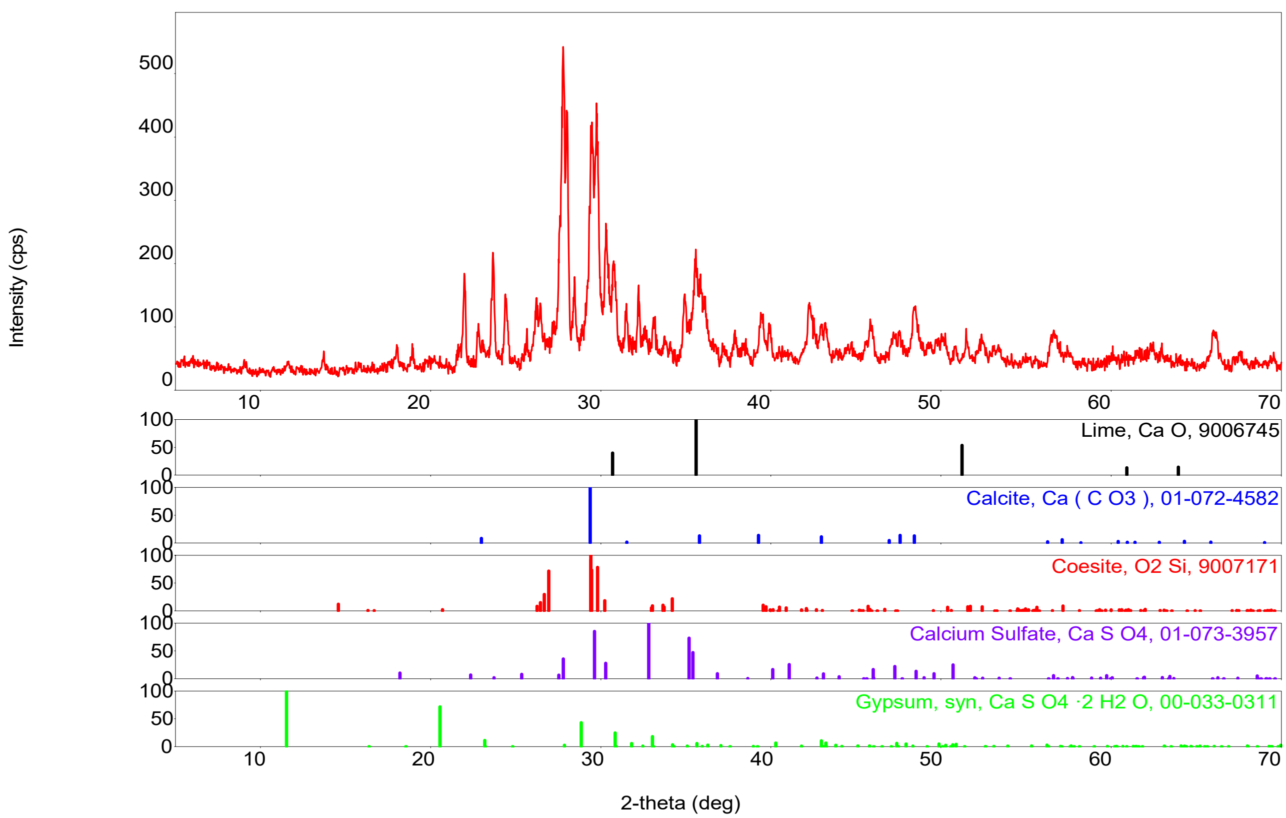


Figure 122. The XRD diffractogram generated from concrete removed Coupon A2.

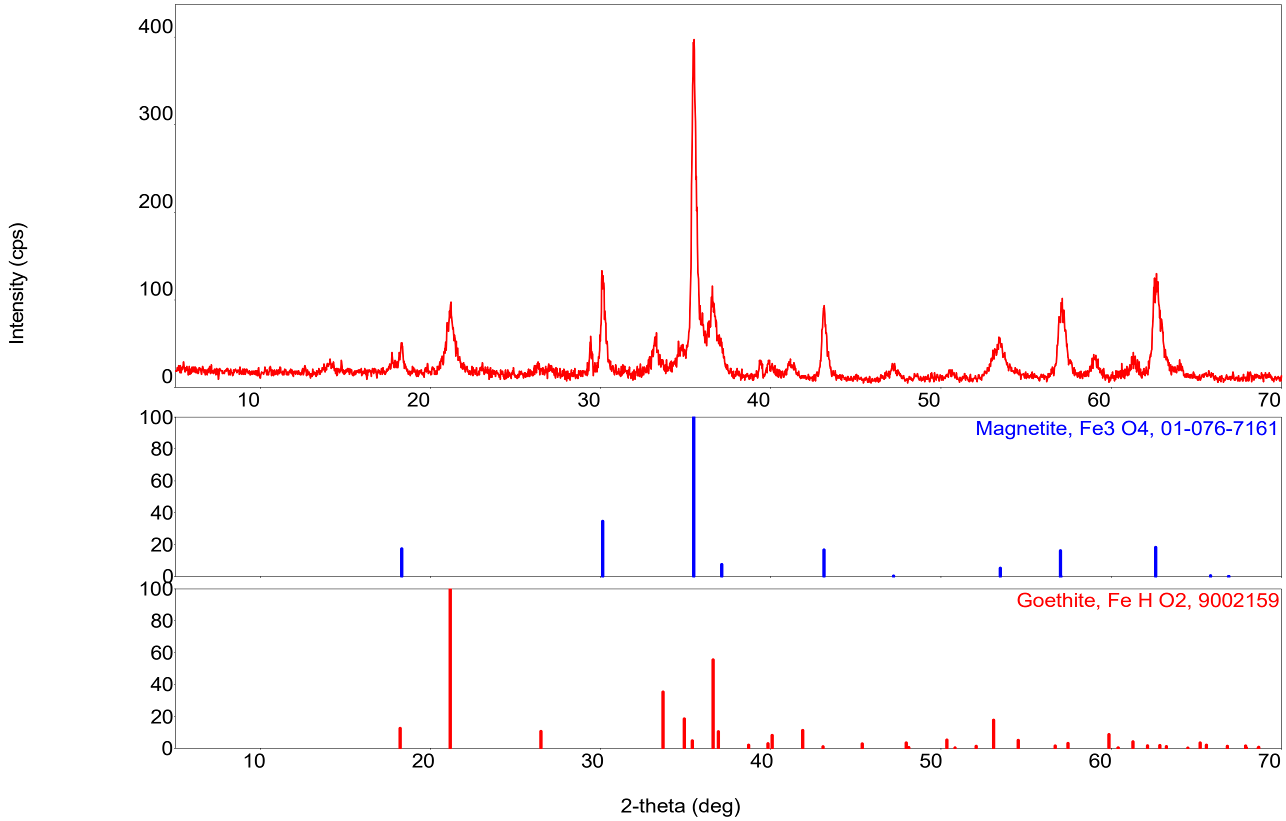


Figure 123. The XRD diffractogram generated from corrosion product removed Coupon 1.

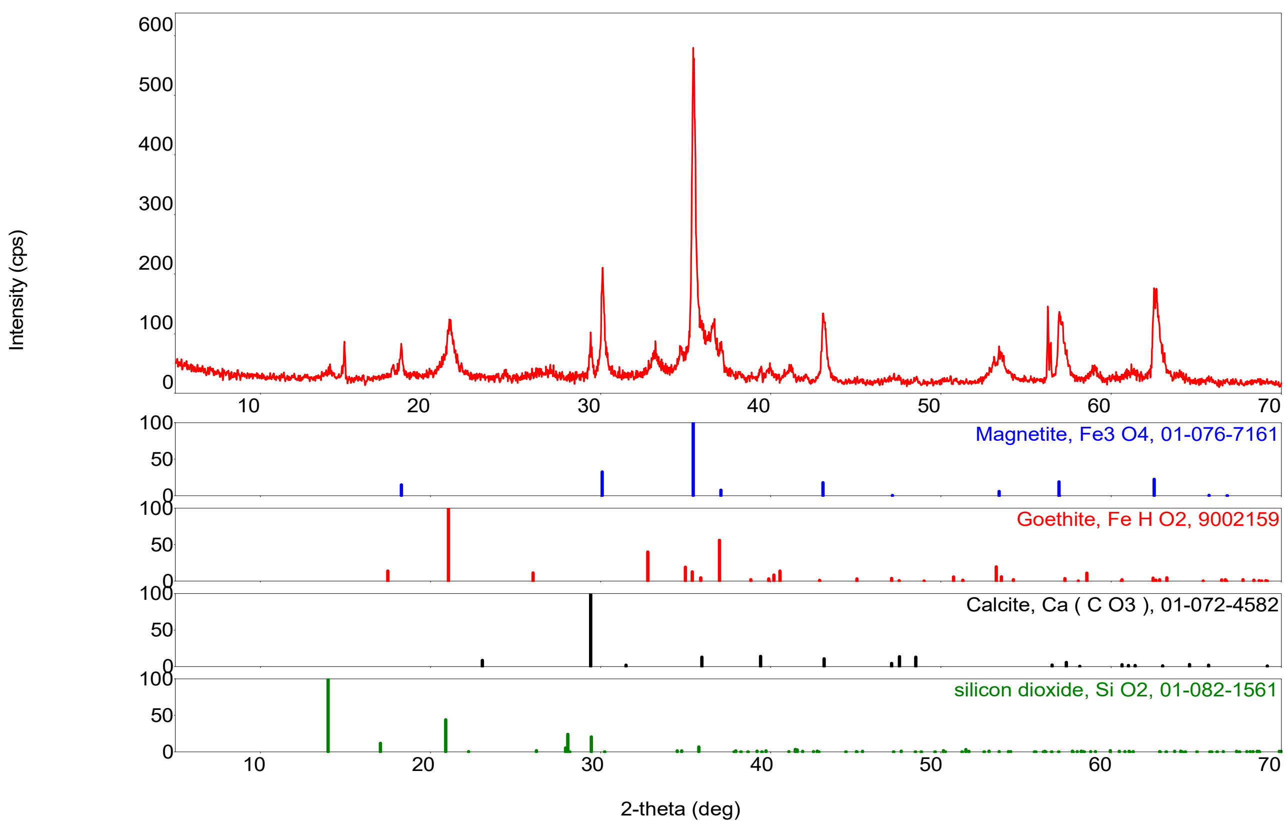


Figure 124. The XRD diffractogram generated from corrosion product removed Coupon 2.

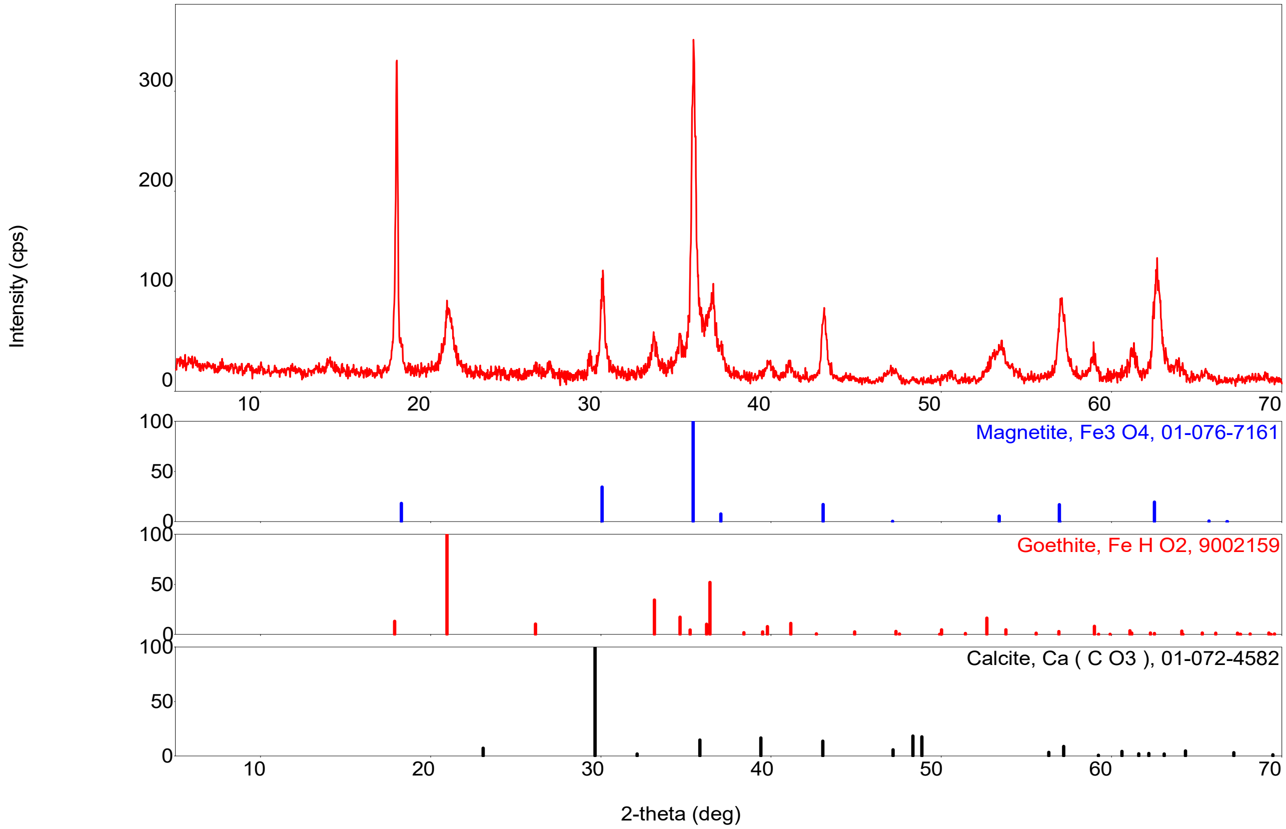


Figure 125. The XRD diffractogram generated from corrosion product removed Coupon 3.

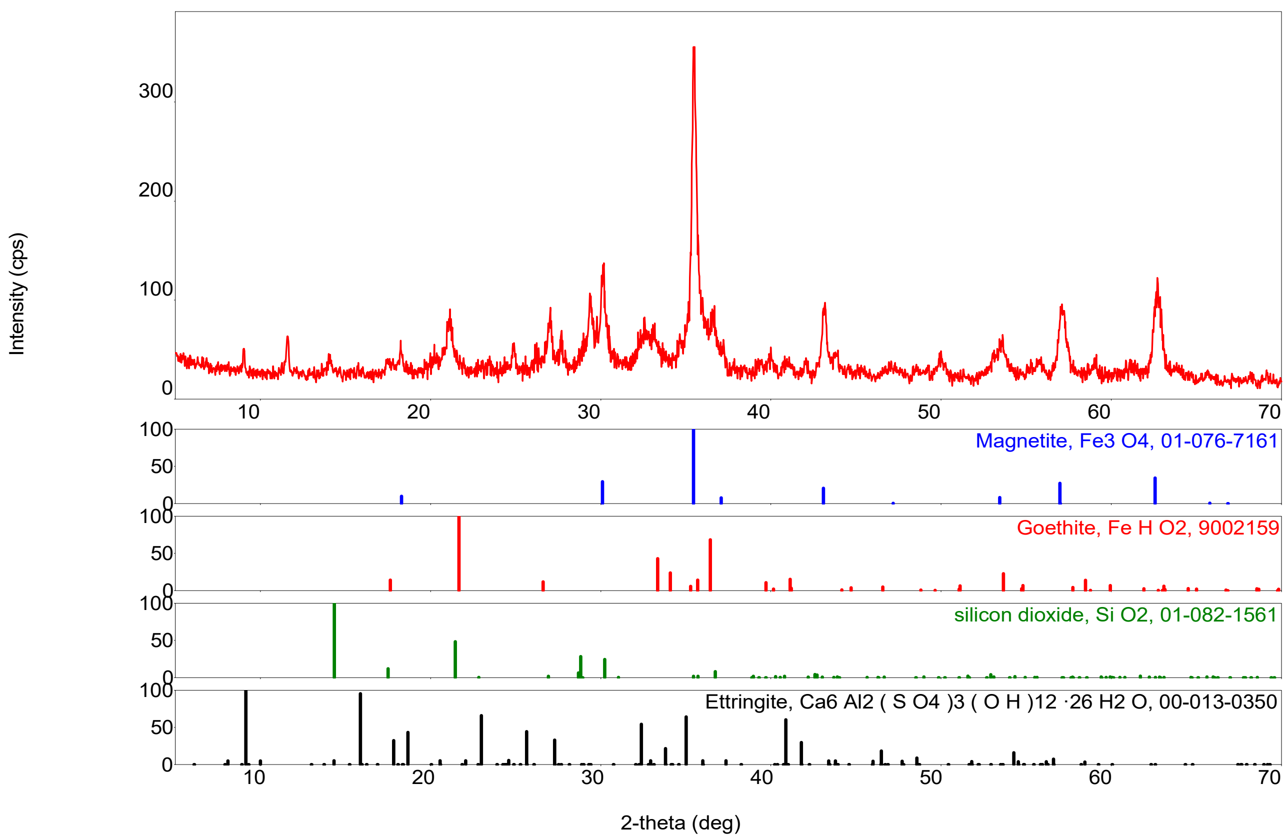


Figure 126. The XRD diffractogram generated from corrosion product removed Coupon 6.

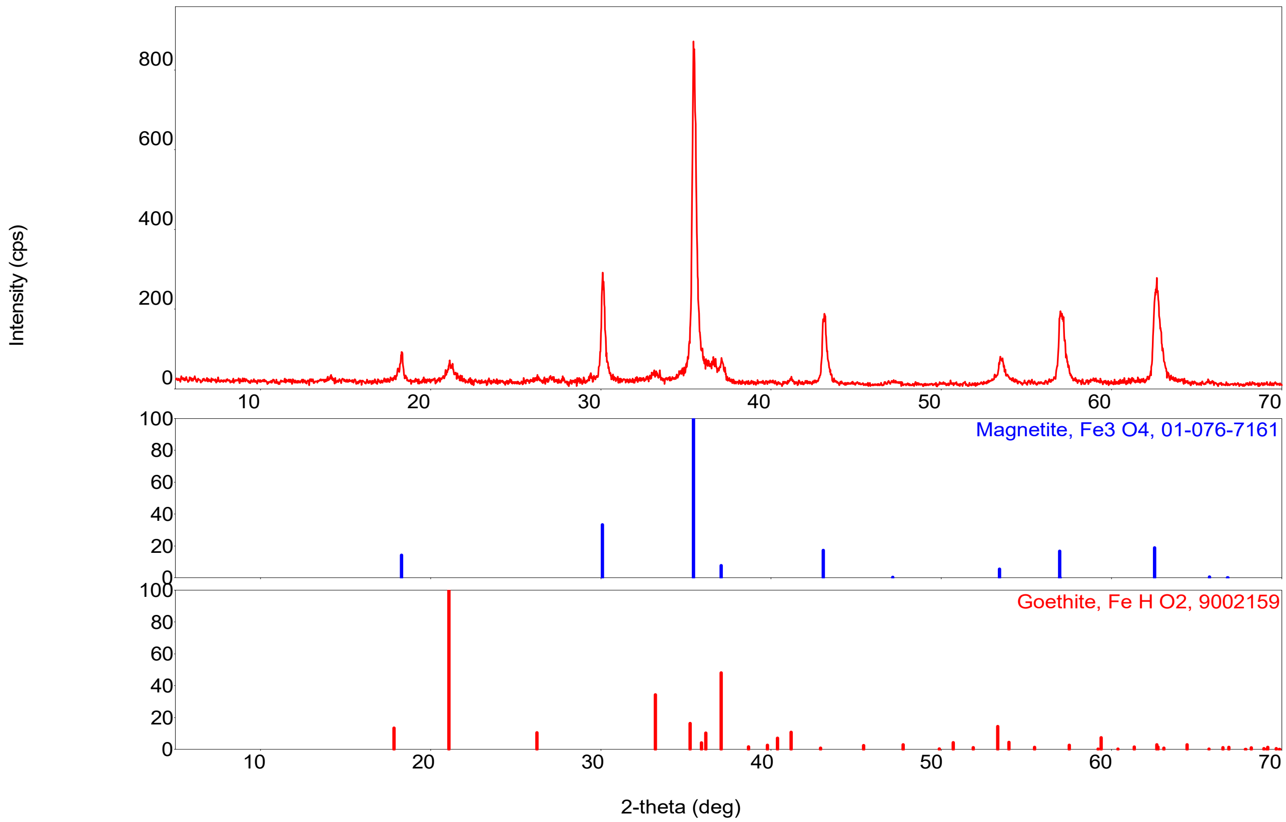


Figure 127. The XRD diffractogram generated from corrosion product removed Coupon 7.

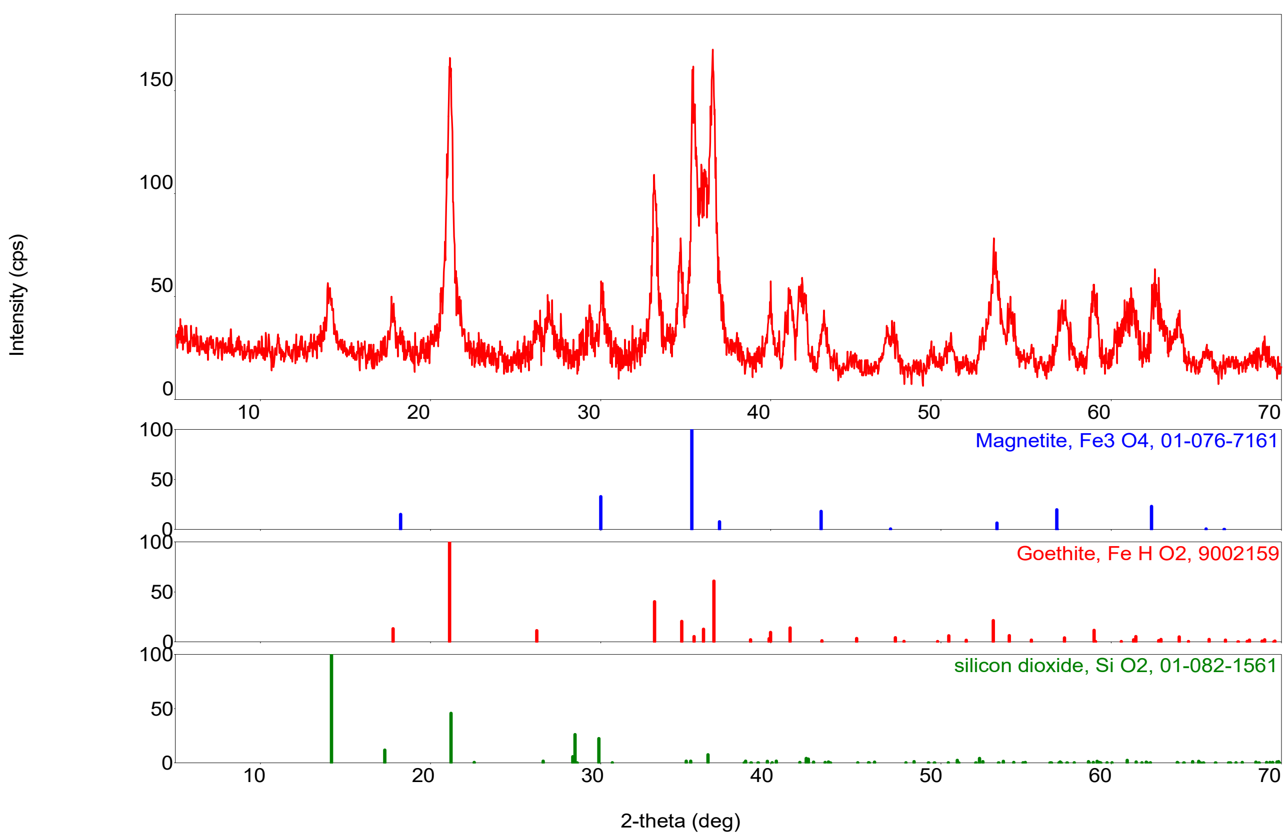


Figure 128. The XRD diffractogram generated from corrosion product removed Coupon 8.

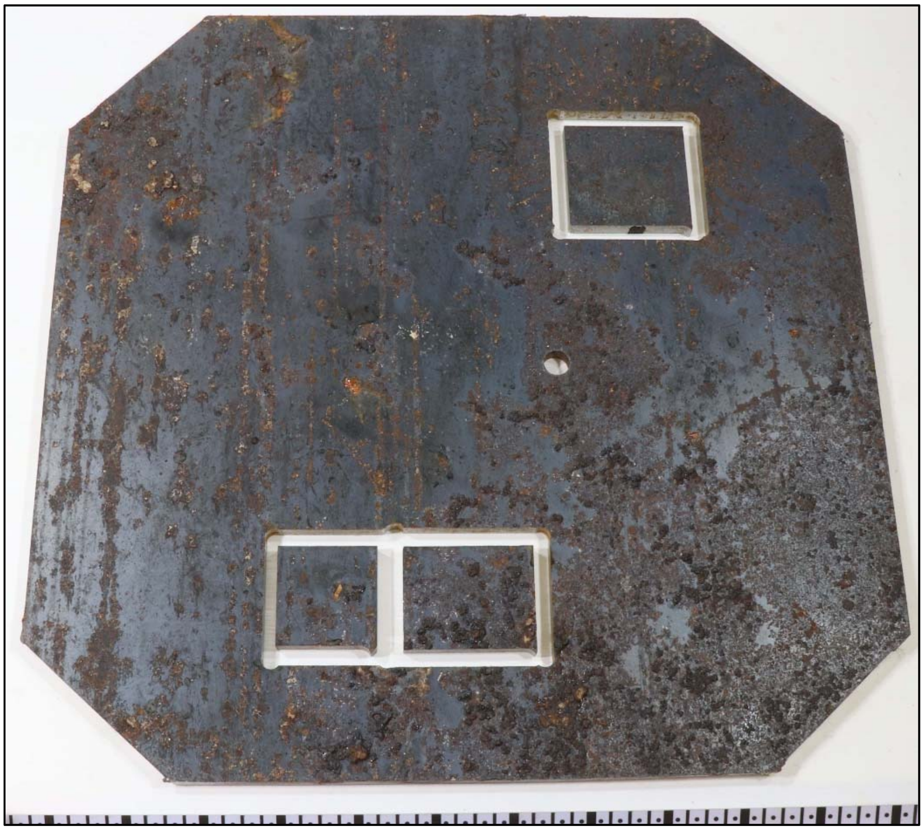


Figure 129. An image of the interior surface of Coupon 1 after CO_2 blast cleaning.

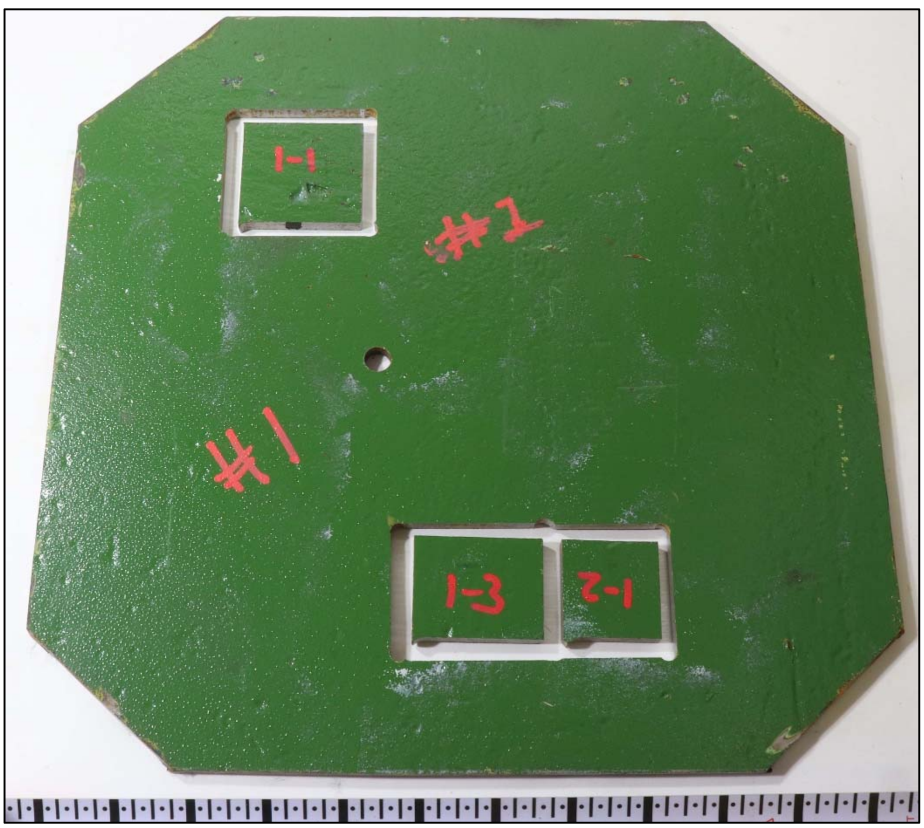


Figure 130. An image of the exterior surface of Coupon 1 after CO_2 blast cleaning.

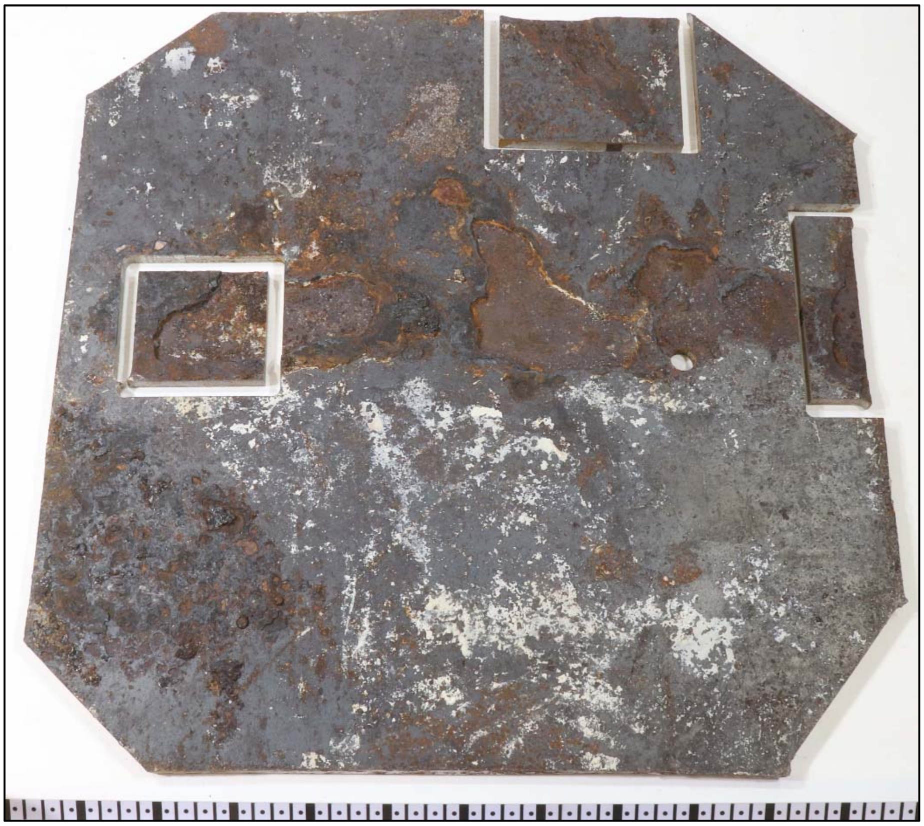


Figure 131. An image of the interior surface of Coupon 2 after CO_2 blast cleaning.

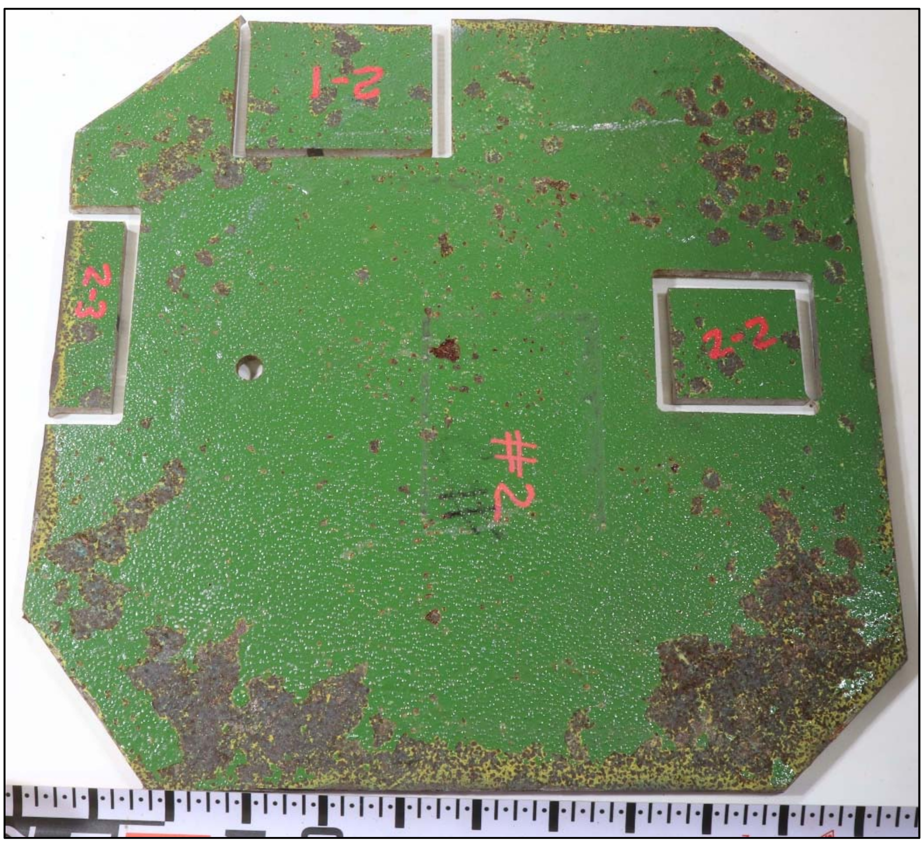


Figure 132. An image of the exterior surface of Coupon 2 after CO_2 blast cleaning.

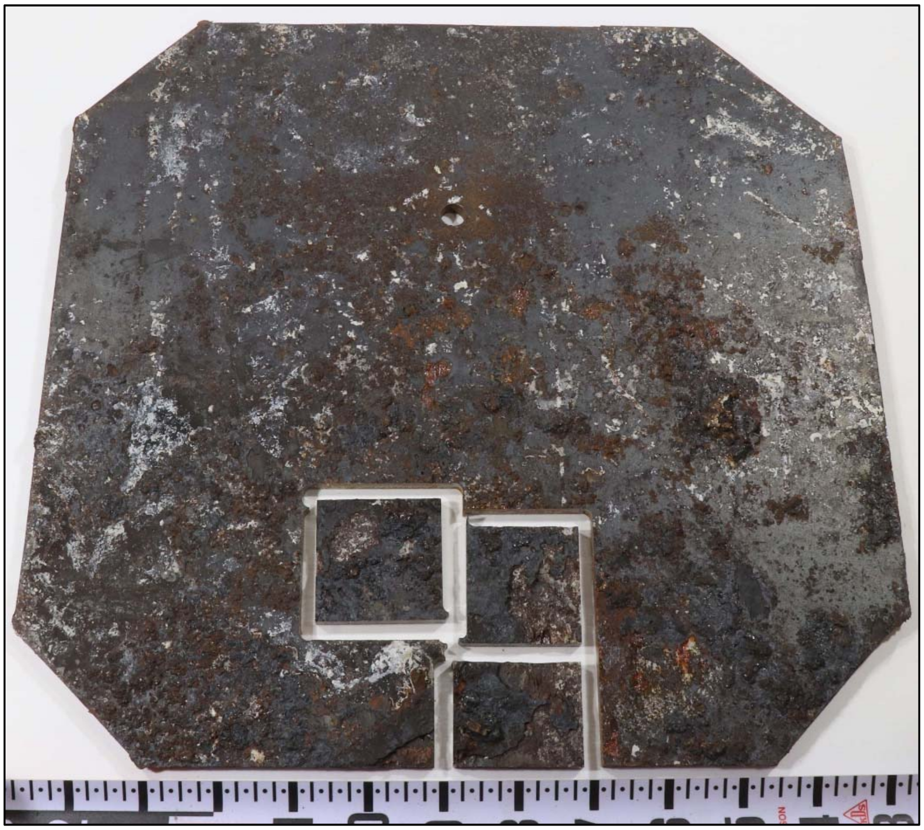


Figure 133. An image of the interior surface of Coupon 3 after CO_2 blast cleaning.

Figure 134. An image of the exterior surface of Coupon 3 after CO_2 blast cleaning.

Figure 135. An image of the interior surface of Coupon 5 after CO_2 blast cleaning.

Figure 136. An image of the exterior surface of Coupon 5 after CO_2 blast cleaning.

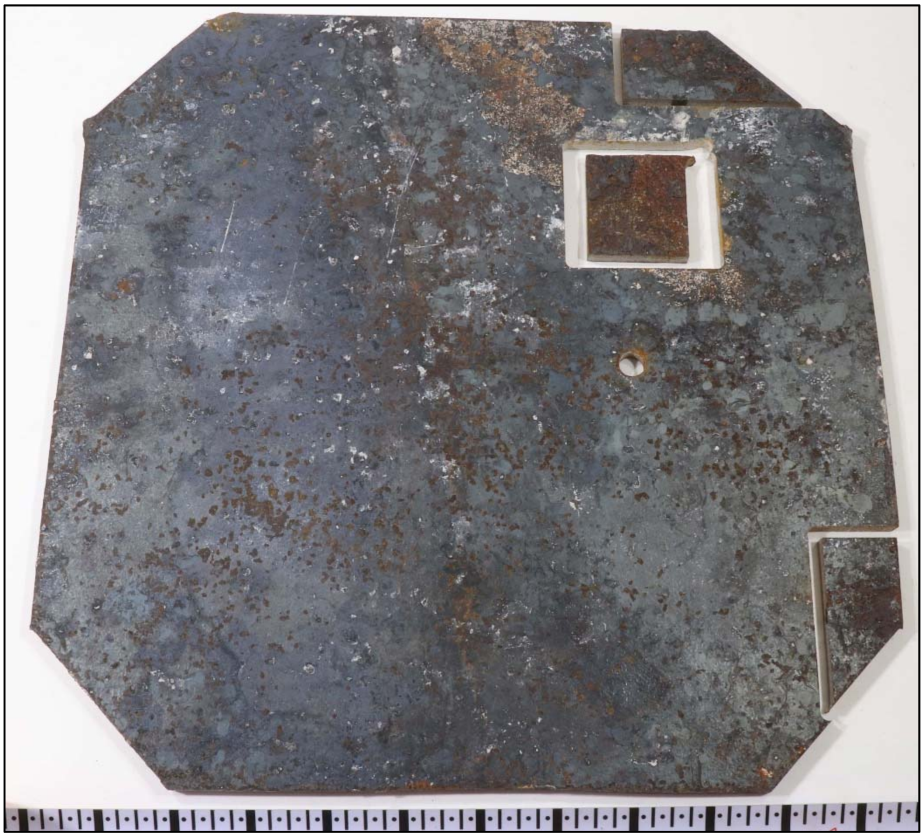


Figure 137. An image of the interior surface of Coupon 6 after CO_2 blast cleaning.

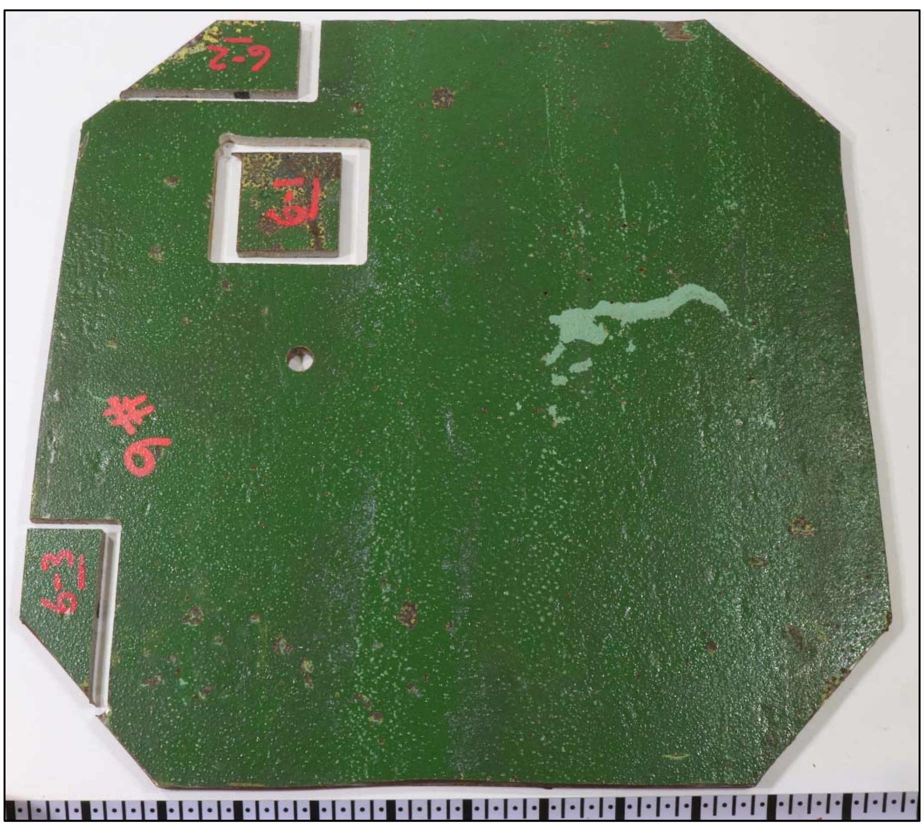


Figure 138. An image of the exterior surface of Coupon 6 after CO_2 blast cleaning.

Figure 139. An image of the interior surface of Coupon 7 after CO_2 blast cleaning.

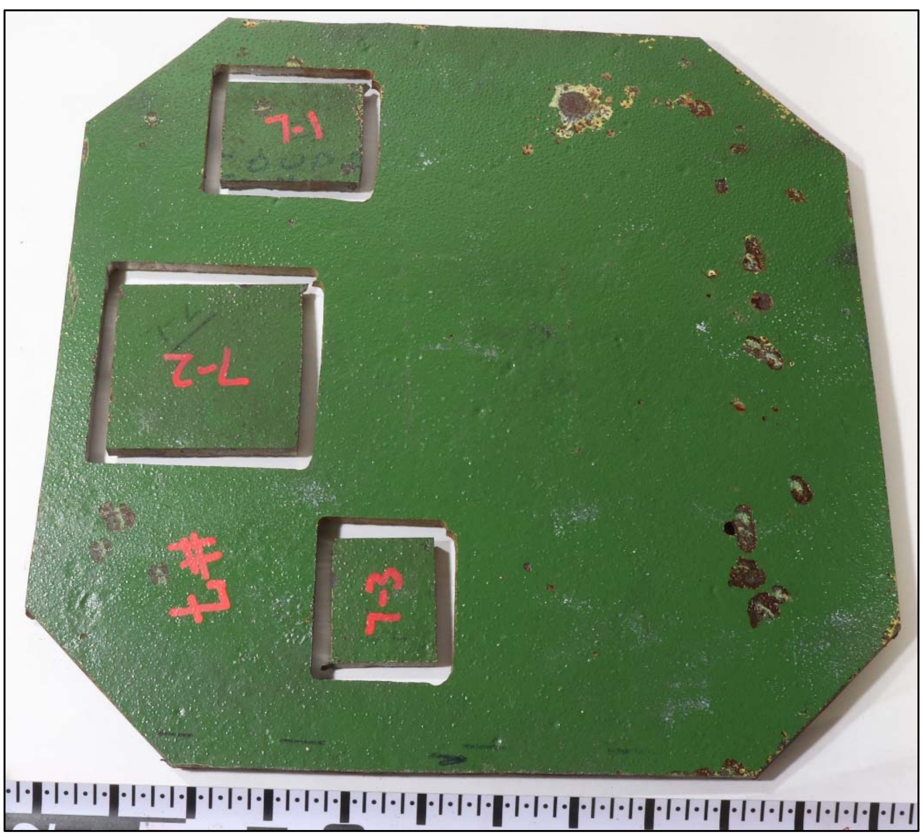


Figure 140. An image of the exterior surface of Coupon 7 after CO_2 blast cleaning.

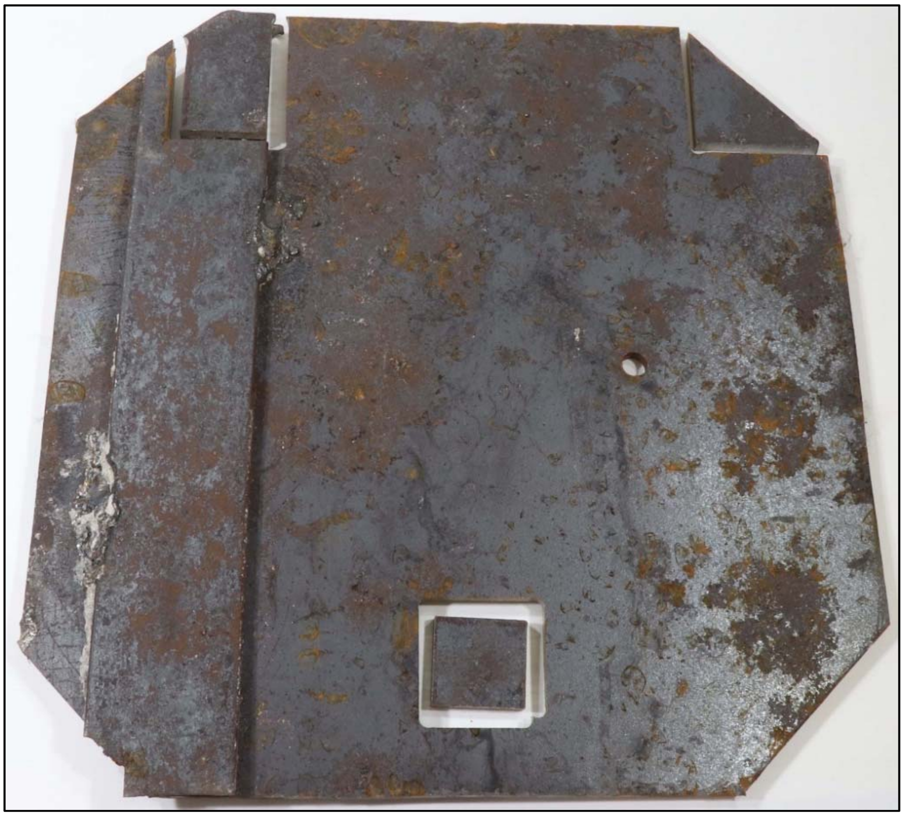


Figure 141. An image of the interior surface of Coupon 8 after CO_2 blast cleaning.

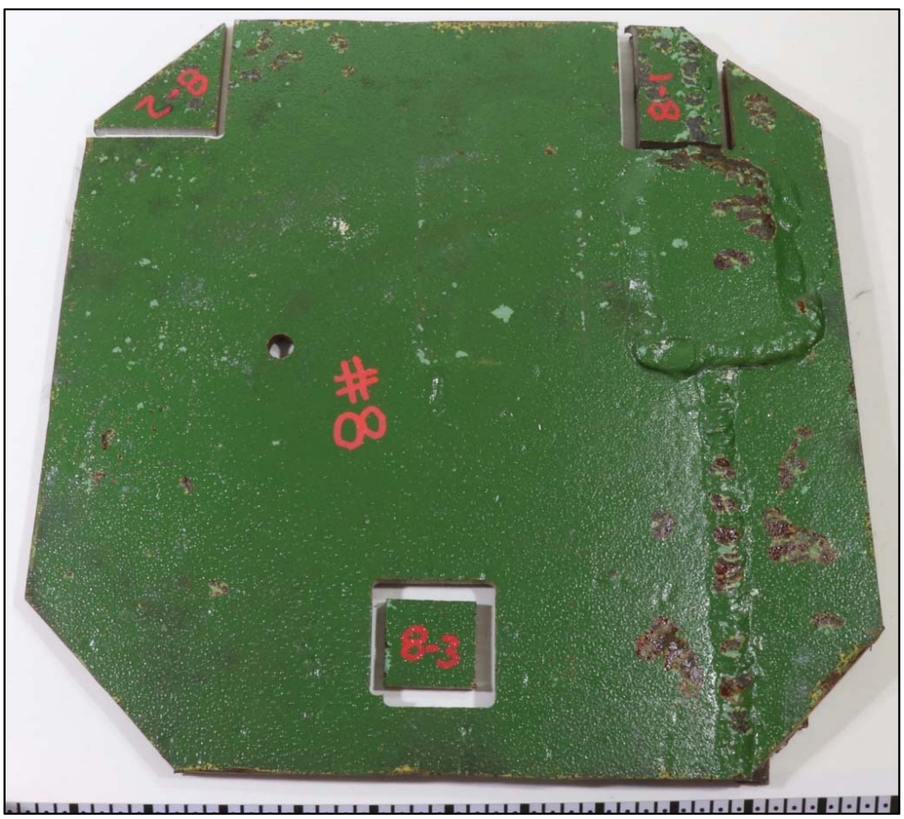


Figure 142. An image of the exterior surface of Coupon 8 after CO_2 blast cleaning.

Figure 143. An image of the interior surface of Coupon 10 after CO_2 blast cleaning.

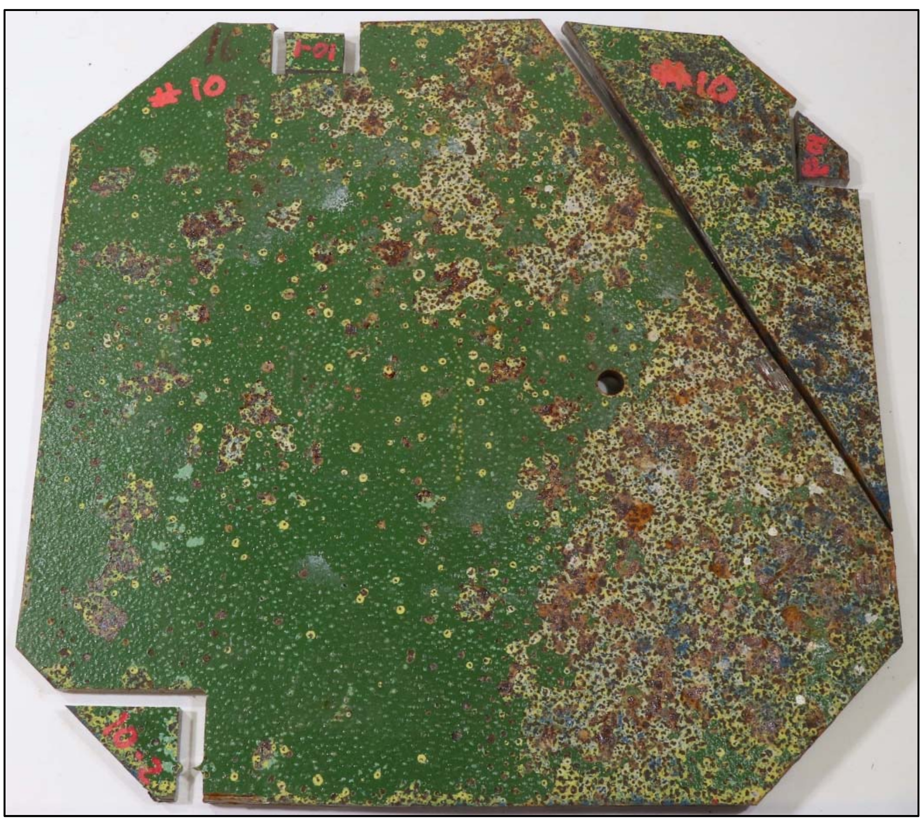


Figure 144. An image of the exterior surface of Coupon 10 after CO_2 blast cleaning.

Figure 145. An image of the interior surface of Coupon A1 after CO_2 blast cleaning.

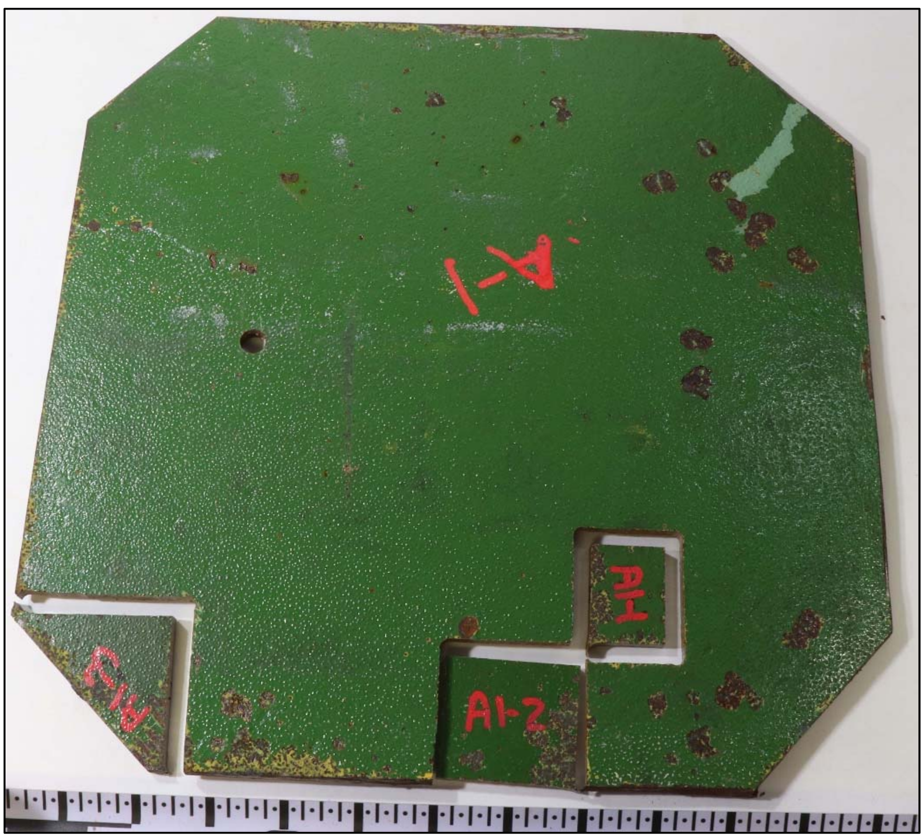


Figure 146. An image of the exterior surface of Coupon A1 after CO_2 blast cleaning.

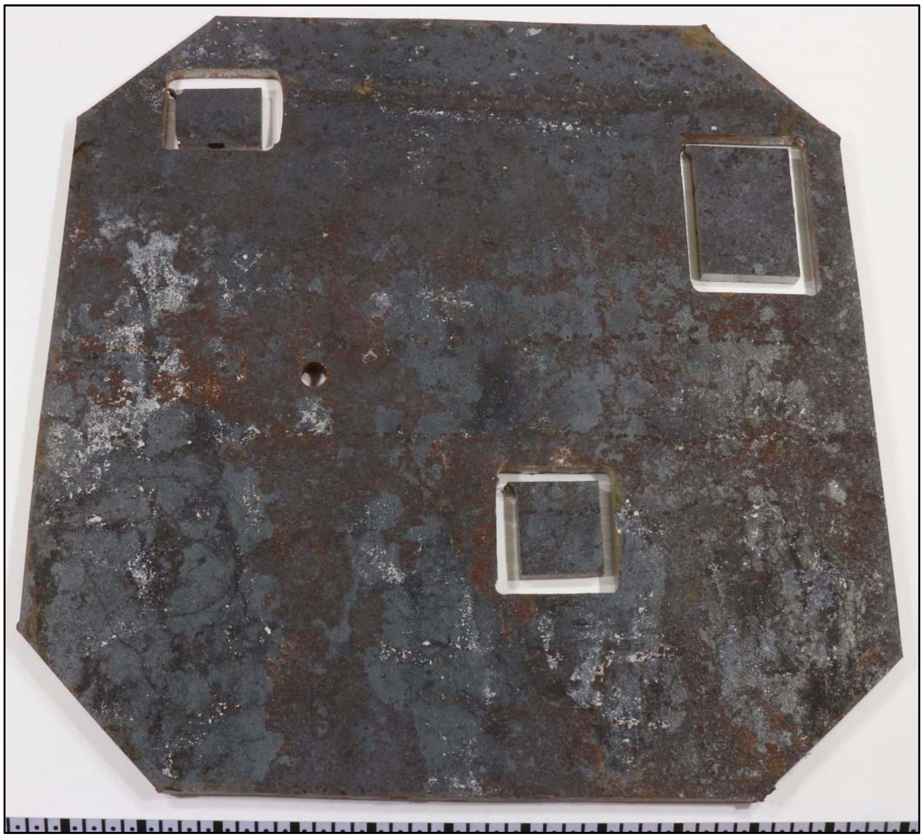


Figure 147. An image of the interior surface of Coupon A2 after CO_2 blast cleaning.

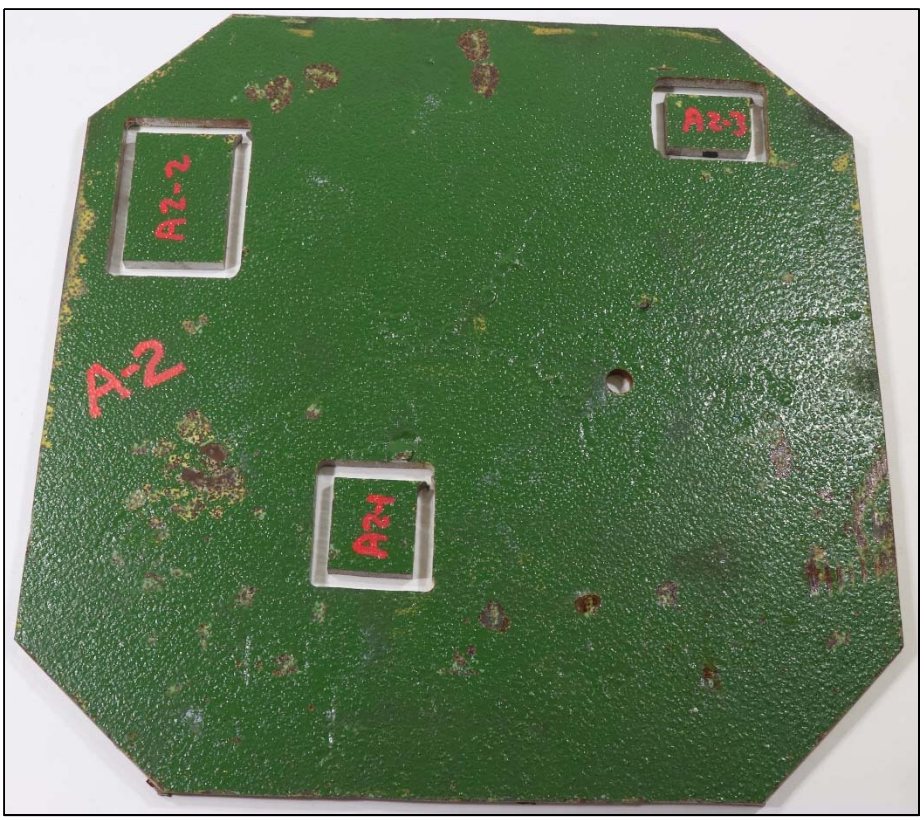


Figure 148. An image of the exterior surface of Coupon A2 after CO_2 blast cleaning.

Figure 149. A screenshot of the 3D digital image of a specimen excised from Coupon 1 labeled as 1-1, after CO_2 blast cleaning

Figure 150. A screenshot of the 3D digital image of a specimen excised from Coupon 1 labeled as 1-2, after CO_2 blast cleaning

Figure 151. A screenshot of the 3D digital image of a specimen excised from Coupon 1 labeled as 1-3, after CO_2 blast cleaning

Figure 152. A screenshot of the 3D digital image of a specimen excised from Coupon 2 labeled as 2-1, after CO_2 blast cleaning

Figure 153. A screenshot of the 3D digital image of a specimen excised from Coupon 2 labeled as 2-2, after CO_2 blast cleaning

Figure 154. A screenshot of the 3D digital image of a specimen excised from Coupon 2 labeled as 2-3, after CO_2 blast cleaning

Figure 155. A screenshot of the 3D digital image of a specimen excised from Coupon 3 labeled as 3-1, after CO_2 blast cleaning

Figure 156. A screenshot of the 3D digital image of a specimen excised from Coupon 3 labeled as 3-2, after CO_2 blast cleaning

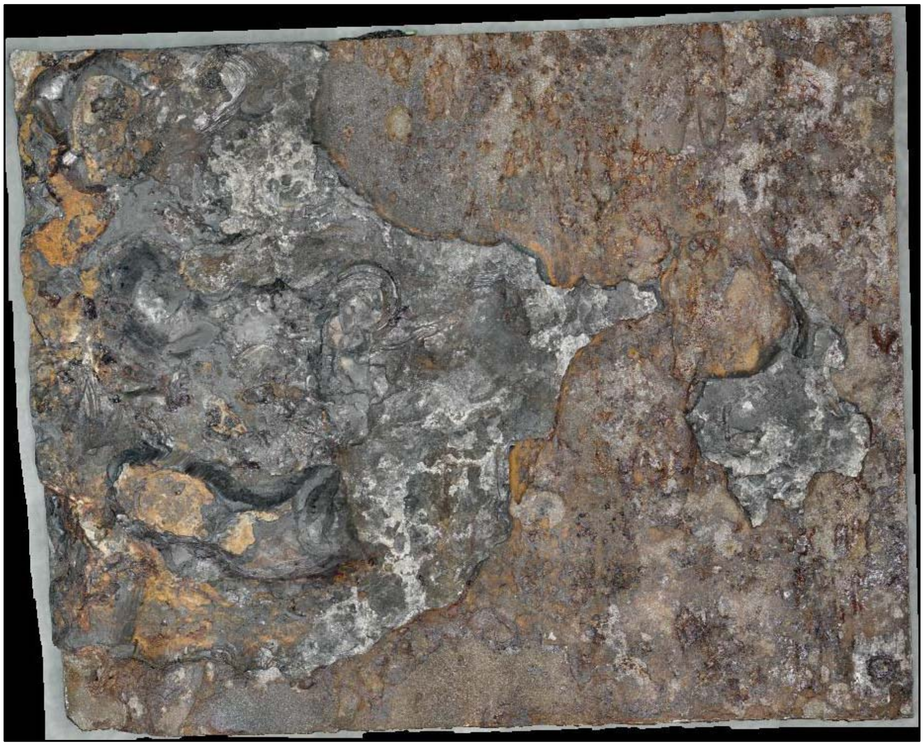


Figure 157. A screenshot of the 3D digital image of a specimen excised from Coupon 3 labeled as 3-3, after CO_2 blast cleaning

Figure 158. A screenshot of the 3D digital image of a specimen excised from Coupon 5 labeled as 5-1, after CO_2 blast cleaning

Figure 159. A screenshot of the 3D digital image of a specimen excised from Coupon 5 labeled as 5-2, after CO_2 blast cleaning

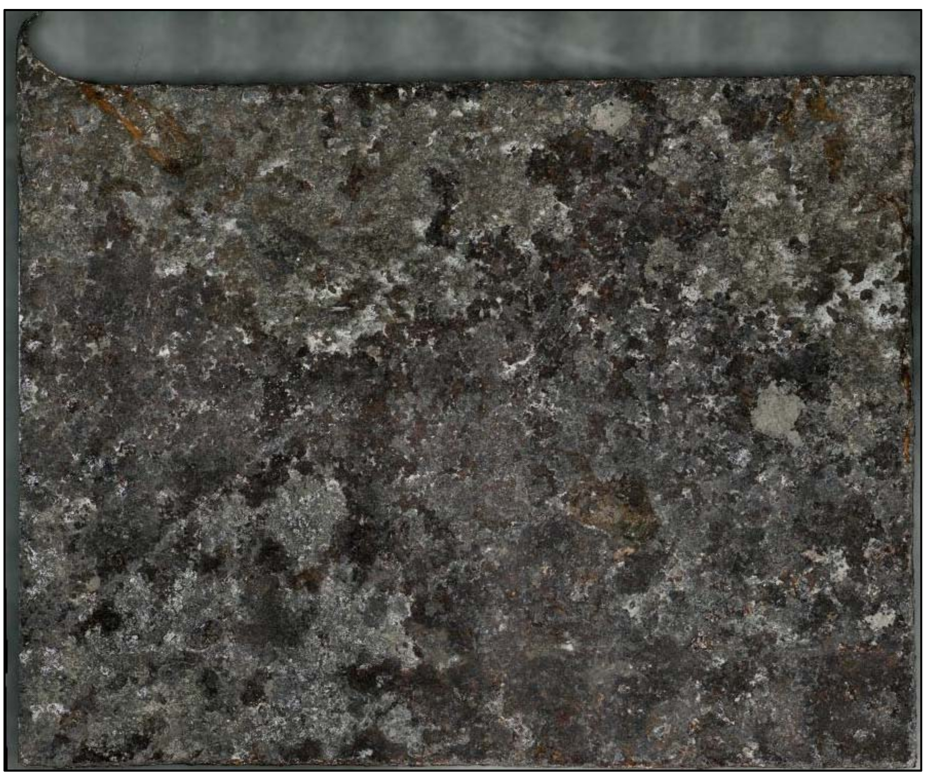


Figure 160. A screenshot of the 3D digital image of a specimen excised from Coupon 5 labeled as 5-3, after CO_2 blast cleaning

Figure 161. A screenshot of the 3D digital image of a specimen excised from Coupon 6 labeled as 6-1, after CO_2 blast cleaning

Figure 162. A screenshot of the 3D digital image of a specimen excised from Coupon 6 labeled as 6-2, after CO_2 blast cleaning

Figure 163. A screenshot of the 3D digital image of a specimen excised from Coupon 6 labeled as 6-3, after CO_2 blast cleaning

Figure 164. A screenshot of the 3D digital image of a specimen excised from Coupon 7 labeled as 7-1, after CO_2 blast cleaning

Figure 165. A screenshot of the 3D digital image of a specimen excised from Coupon 7 labeled as 7-2, after CO_2 blast cleaning.

Figure 166. A screenshot of the 3D digital image of a specimen excised from Coupon 7 labeled as 7-3, after CO_2 blast cleaning

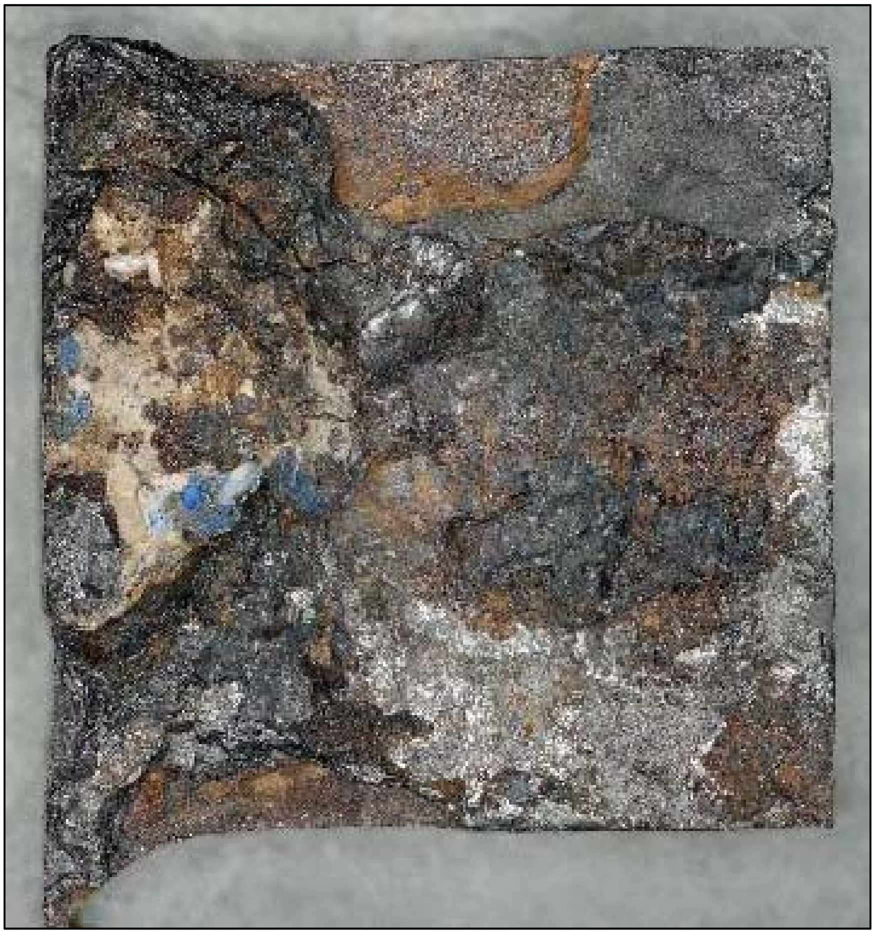


Figure 167. A screenshot of the 3D digital image of a specimen excised from Coupon 7 labeled as 7-4, after CO_2 blast cleaning

Figure 168. A screenshot of the 3D digital image of a specimen excised from Coupon 8 labeled as 8-1, after CO_2 blast cleaning

Figure 169. A screenshot of the 3D digital image of a specimen excised from Coupon 8 labeled as 8-2, after CO_2 blast cleaning

Figure 170. A screenshot of the 3D digital image of a specimen excised from Coupon 8 labeled as 8-3, after CO_2 blast cleaning

Figure 171. A screenshot of the 3D digital image of a specimen excised from Coupon 10 labeled as 10-1, after CO_2 blast cleaning

Figure 172. A screenshot of the 3D digital image of a specimen excised from Coupon 10 labeled as 10-2, after CO_2 blast cleaning

Figure 173. A screenshot of the 3D digital image of a specimen excised from Coupon 10 labeled as 10-3, after CO_2 blast cleaning

Figure 174. A screenshot of the 3D digital image of a specimen excised from Coupon A-1 labeled as A1-1, after CO_2 blast cleaning

Figure 175. A screenshot of the 3D digital image of a specimen excised from Coupon A-1 labeled as A1-2, after CO_2 blast cleaning

Figure 176. A screenshot of the 3D digital image of a specimen excised from Coupon A-1 labeled as A1-3, after CO_2 blast cleaning

Figure 177. A screenshot of the 3D digital image of a specimen excised from Coupon A-2 labeled as A2-1, after CO_2 blast cleaning

Figure 178. A screenshot of the 3D digital image of a specimen excised from Coupon A-2 labeled as A2-2, after CO_2 blast cleaning

Figure 179. A screenshot of the 3D digital image of a specimen excised from Coupon A-2 labeled as A2-3, after CO_2 blast cleaning

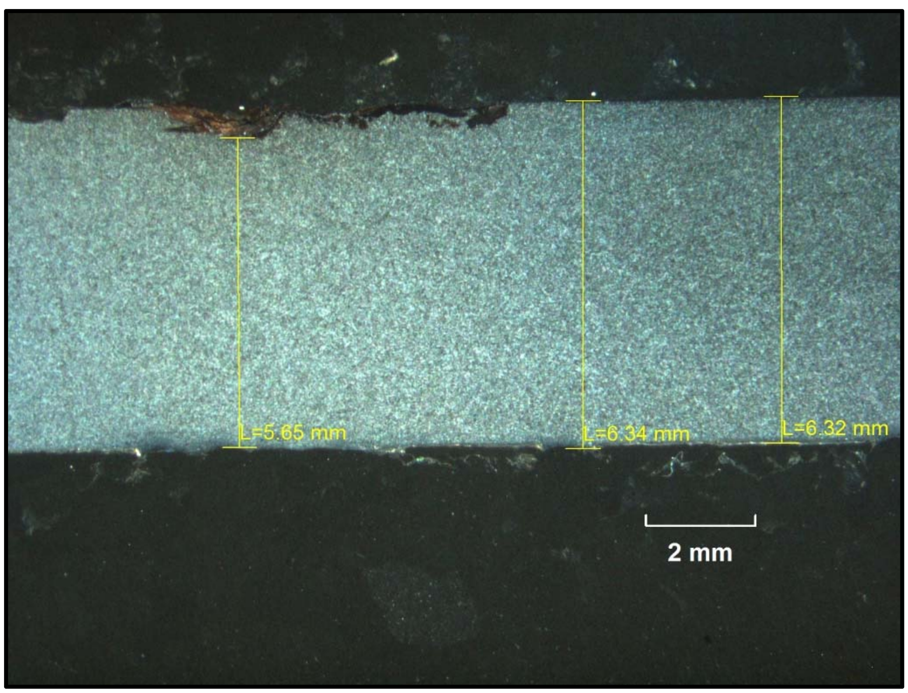


Figure 180. The prepared metallographic cross-section from Sample 1-2 is shown during examination with a stereomicroscope. The thickest location(s) are shown, as well as the thickness remaining underneath the deepest observed pit. (7X)

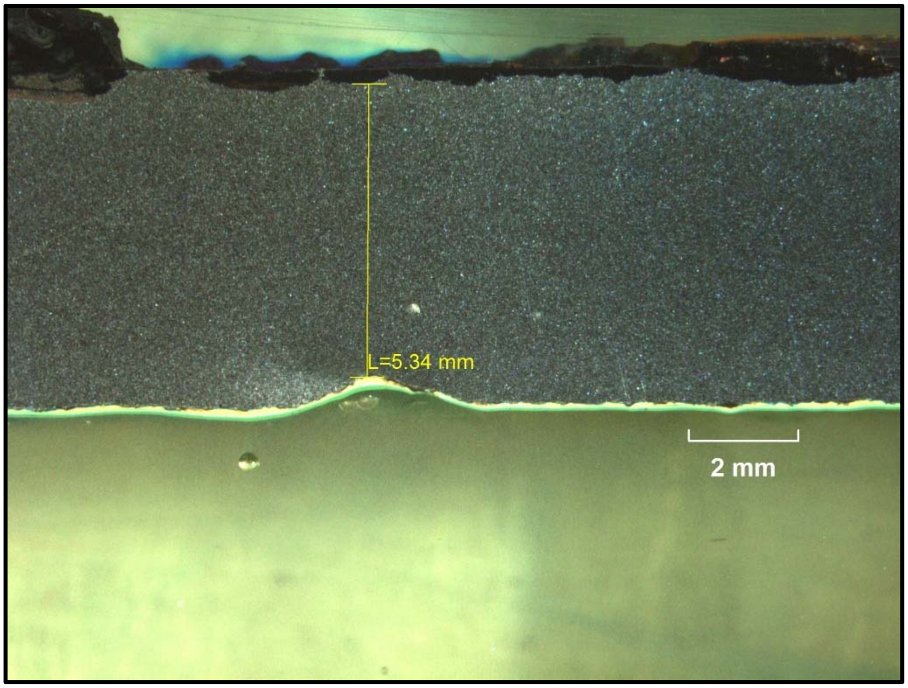


Figure 181. The prepared metallographic cross-section from Sample 1-3 is shown during examination with a stereomicroscope. The thickest remaining wall is shown. Note that the reduction in wall thickness was due to a depression on the painted face of the specimen. (7X)

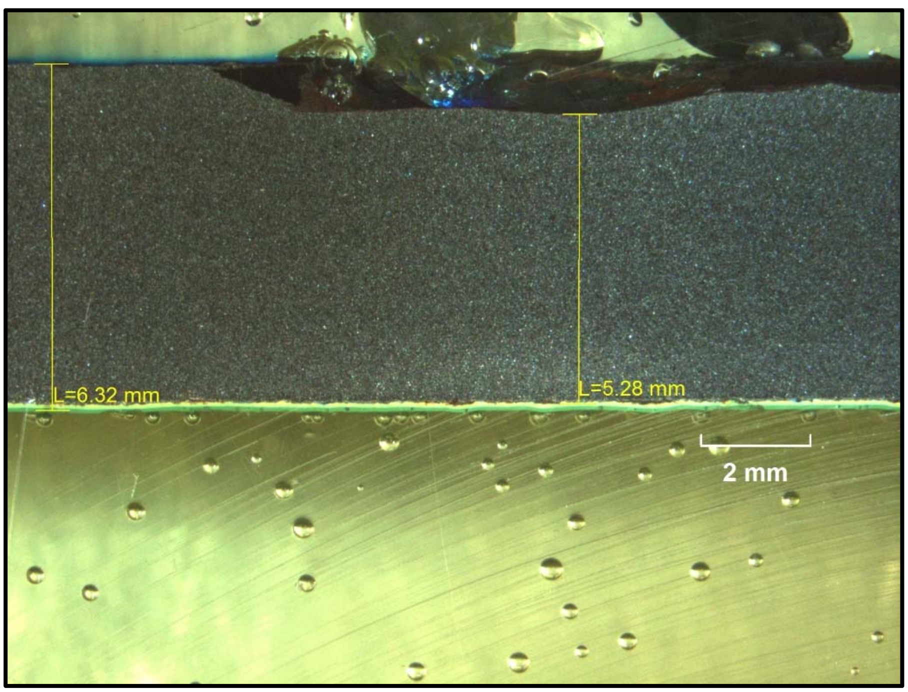


Figure 182. The prepared metallographic cross-section from Sample 1-4 is shown during examination with a stereomicroscope. The thickest location(s) are shown, as well as the thickness remaining underneath the deepest observed pit. (7X)

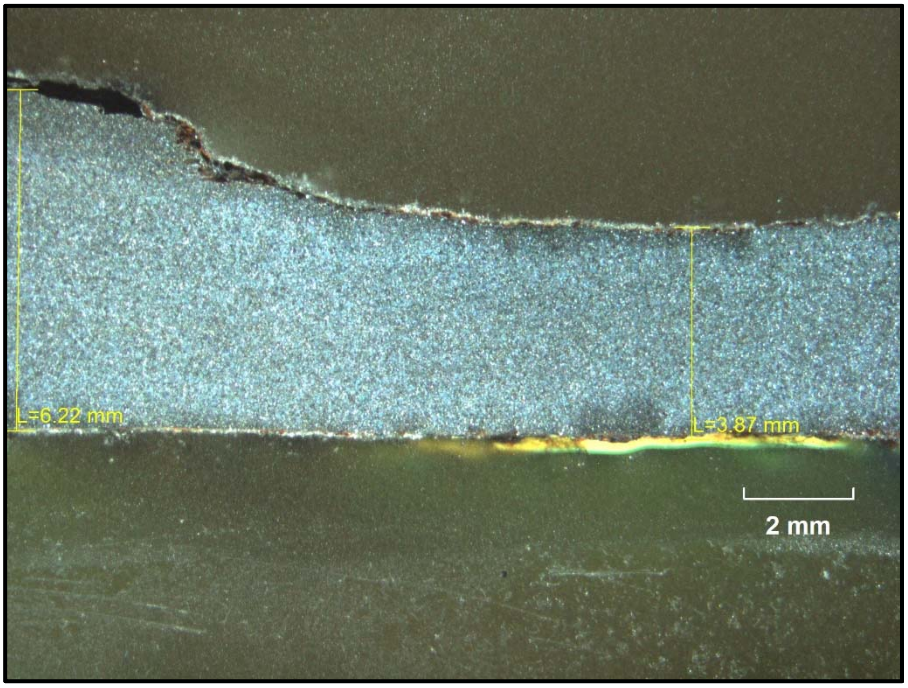


Figure 183. The prepared metallographic cross-section from Sample 2-1 is shown during examination with a stereomicroscope. The thickest location(s) are shown, as well as the thickness remaining underneath the deepest observed pit. (7X)

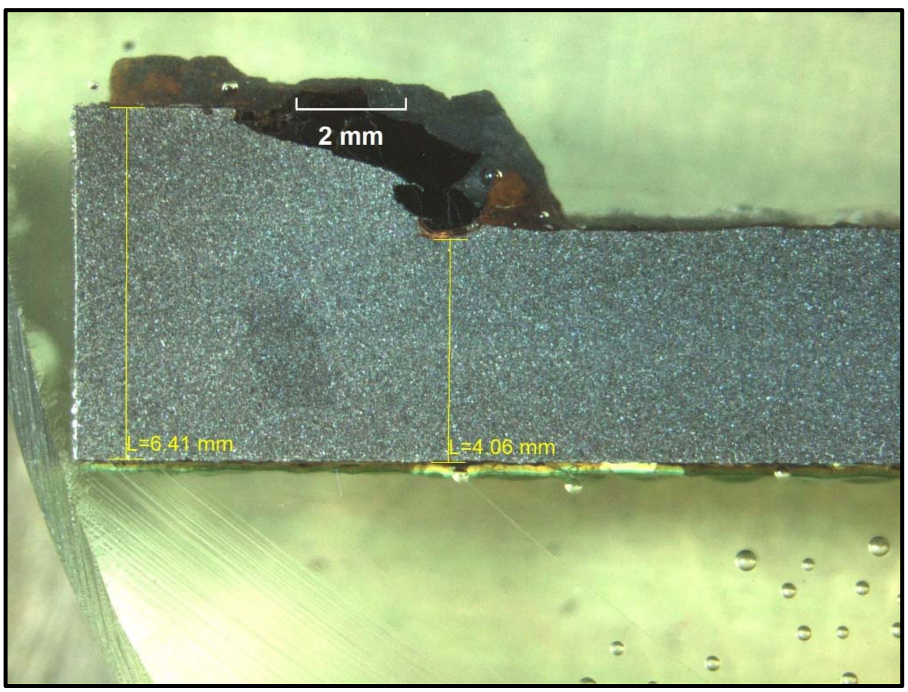


Figure 184. The prepared metallographic cross-section from Sample 2-2 is shown during examination with a stereomicroscope. The thickest location(s) are shown, as well as the thickness remaining underneath the deepest observed pit. (7X)

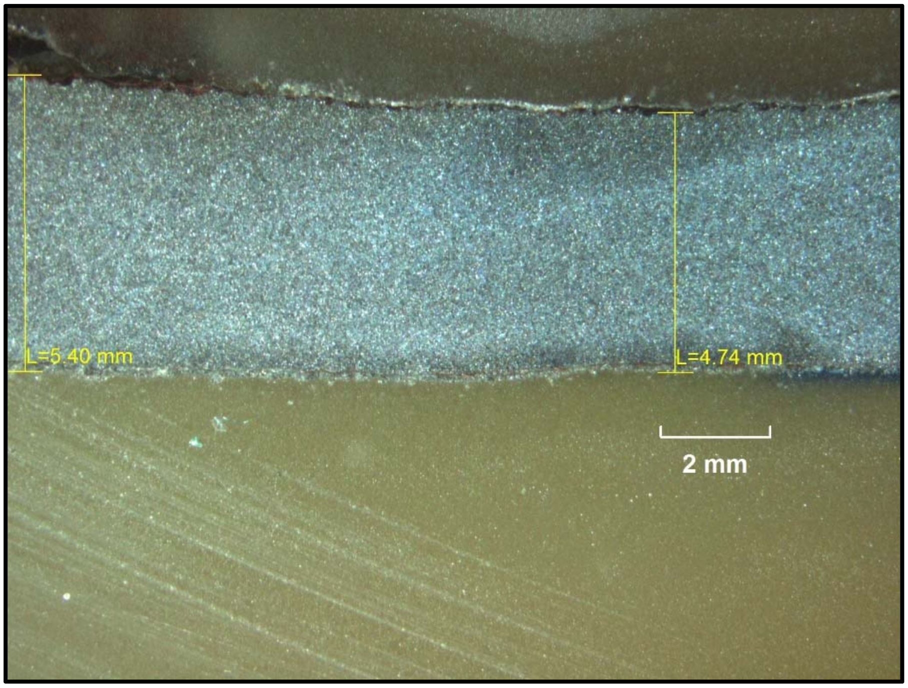


Figure 185. The prepared metallographic cross-section from Sample 2-3 is shown during examination with a stereomicroscope. The thickest location(s) are shown, as well as the thickness remaining underneath the deepest observed pit. (7X)

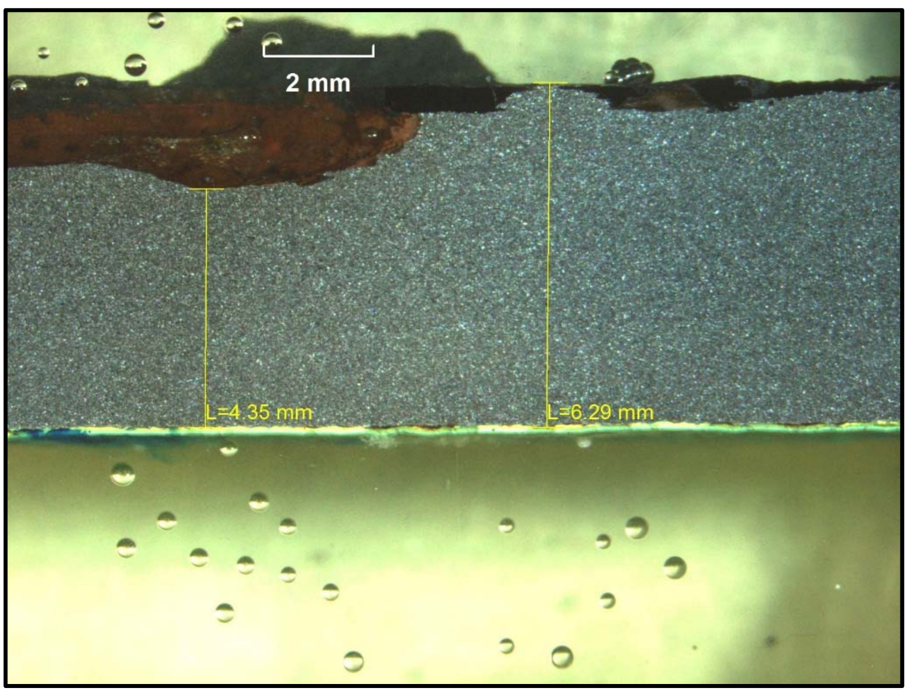


Figure 186. The prepared metallographic cross-section from Sample 3-1 is shown during examination with a stereomicroscope. The thickest location(s) are shown, as well as the thickness remaining underneath the deepest observed pit. (7X)

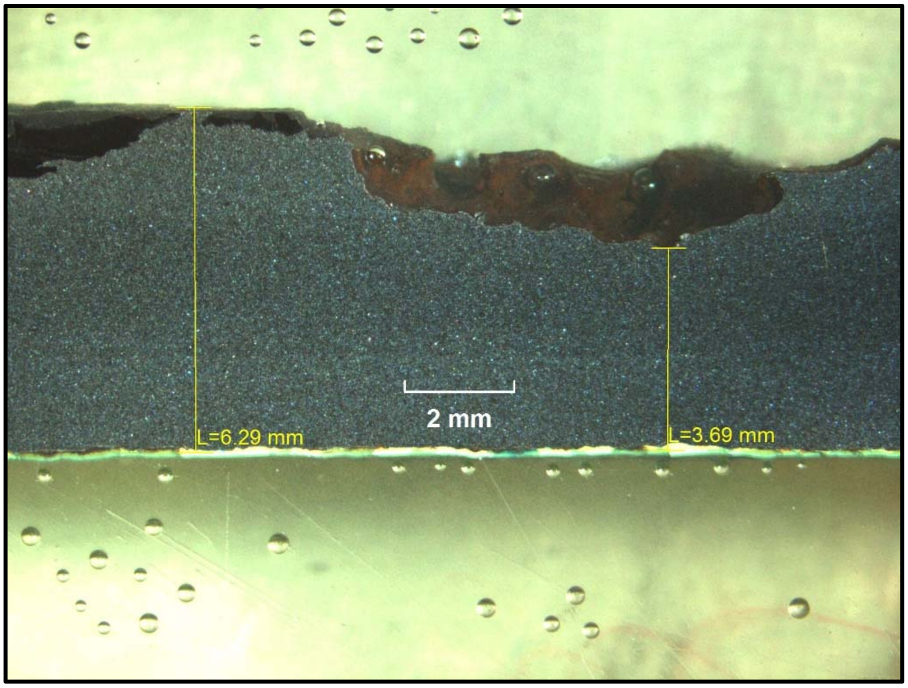


Figure 187. The prepared metallographic cross-section from Sample 3-2 is shown during examination with a stereomicroscope. The thickest location(s) are shown, as well as the thickness remaining underneath the deepest observed pit. (7X)

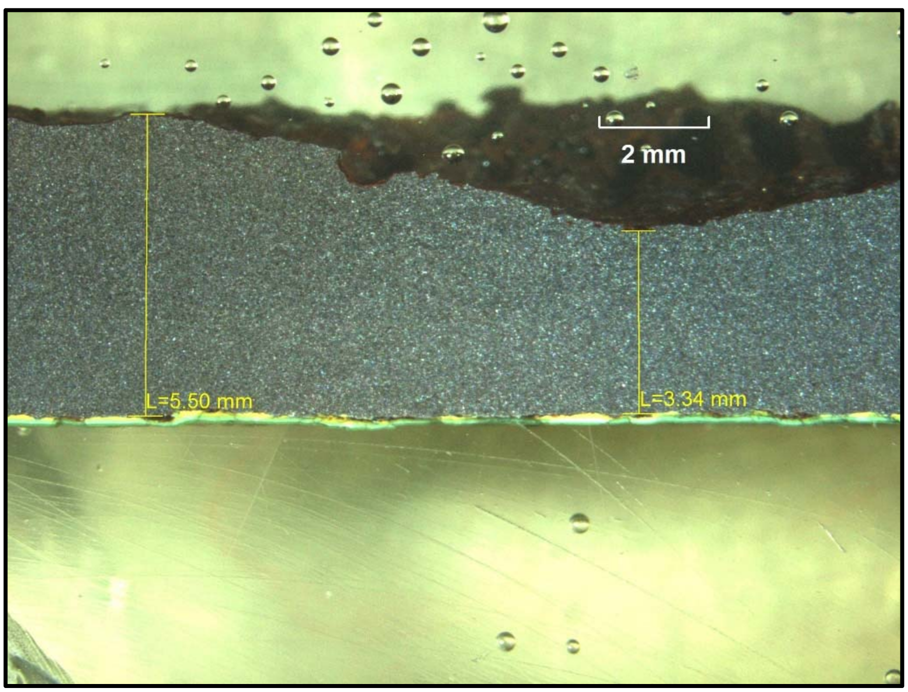


Figure 188. The prepared metallographic cross-section from Sample 3-3 is shown during examination with a stereomicroscope. The thickest location(s) are shown, as well as the thickness remaining underneath the deepest observed pit. (7X)

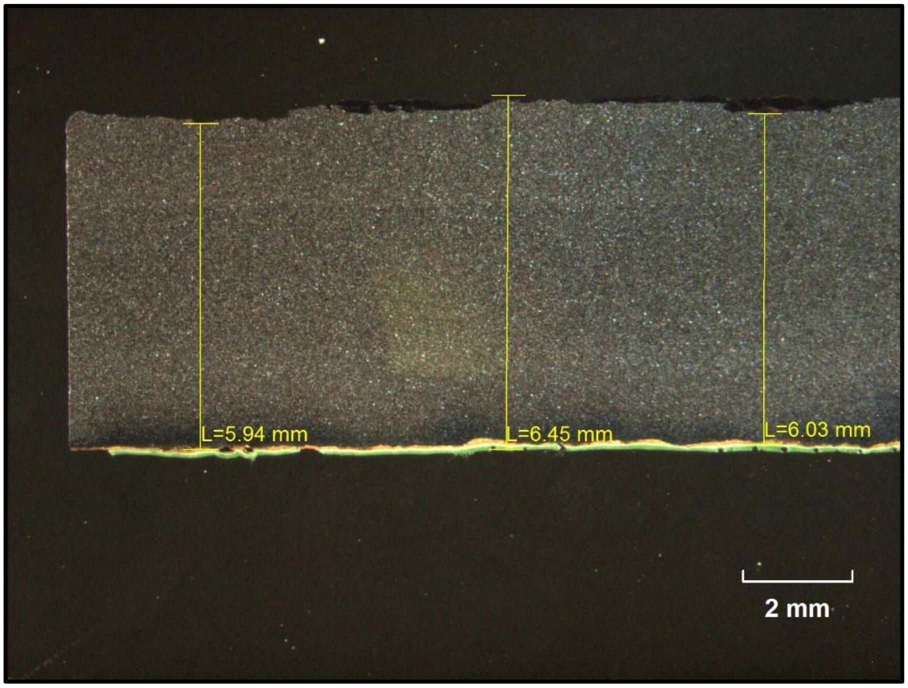


Figure 189. The prepared metallographic cross-section from Sample 3-4 is shown during examination with a stereomicroscope. The thickest location(s) are shown, as well as the thickness remaining underneath the deepest observed pit. (7X)

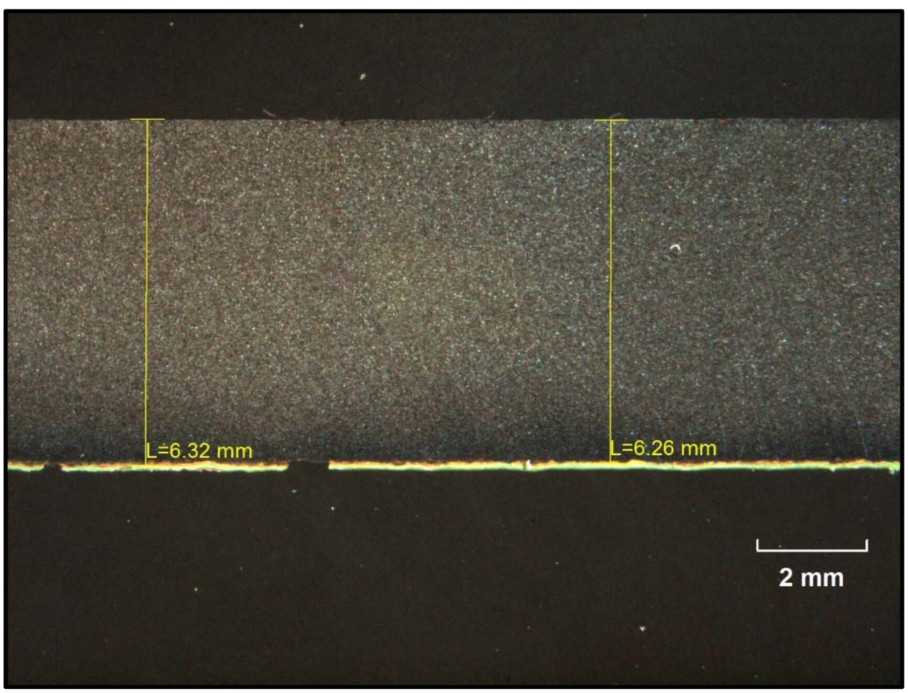


Figure 190. The prepared metallographic cross-section from Sample 5-1 is shown during examination with a stereomicroscope. No significant corrosion was observed. (7X)

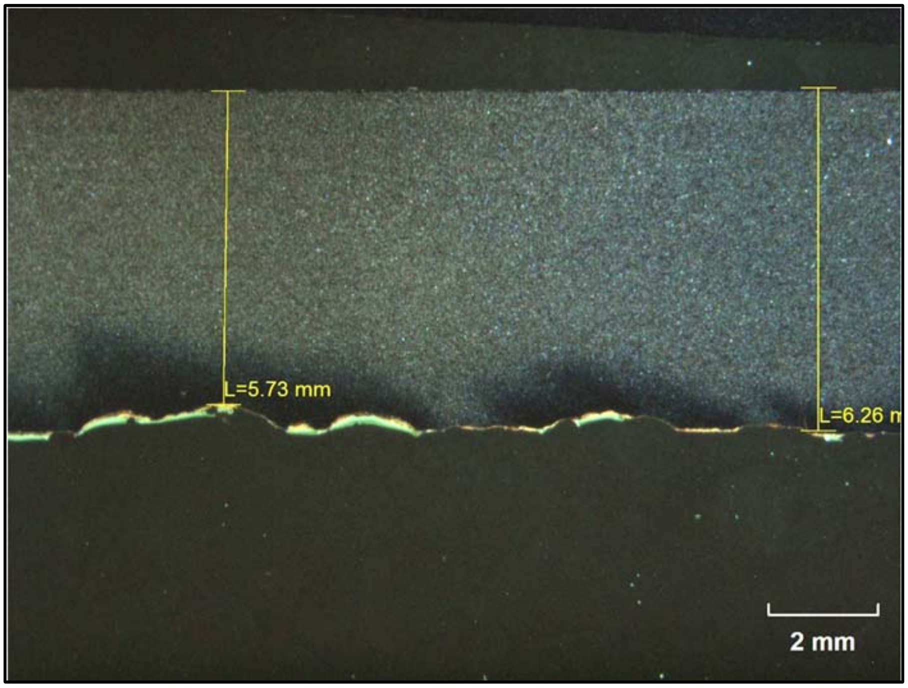


Figure 191. The prepared metallographic cross-section from Sample 5-4 is shown during examination with a stereomicroscope. The thickest remaining wall is shown. Note that the reduction in wall thickness was due to a depression on the painted face of the specimen. (7X)

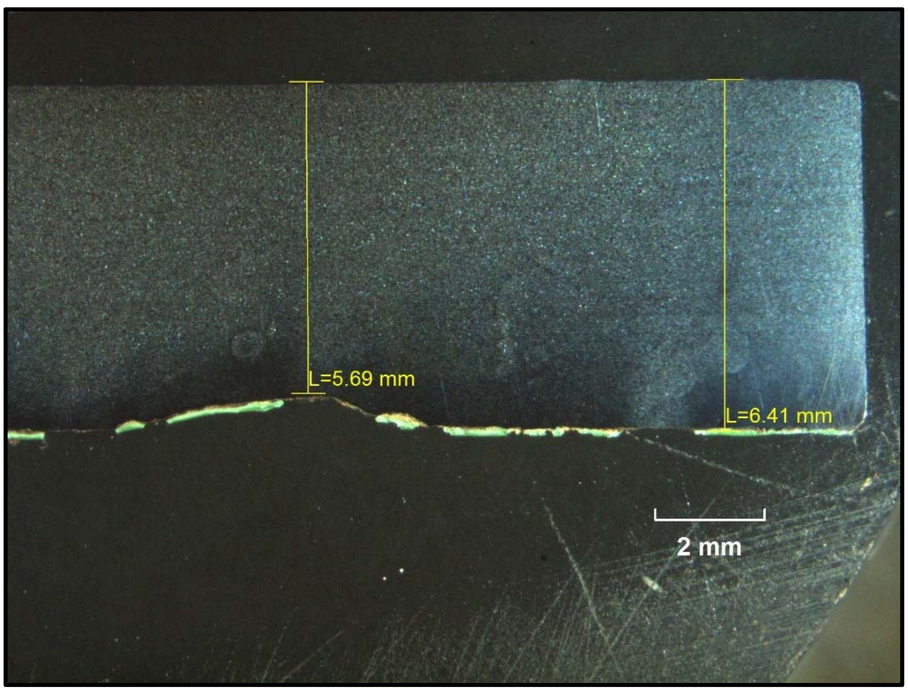


Figure 192. The prepared metallographic cross-section from Sample 5-5 is shown during examination with a stereomicroscope. The thickest remaining wall is shown. Note that the reduction in wall thickness was due to a depression on the painted face of the specimen. (7X)

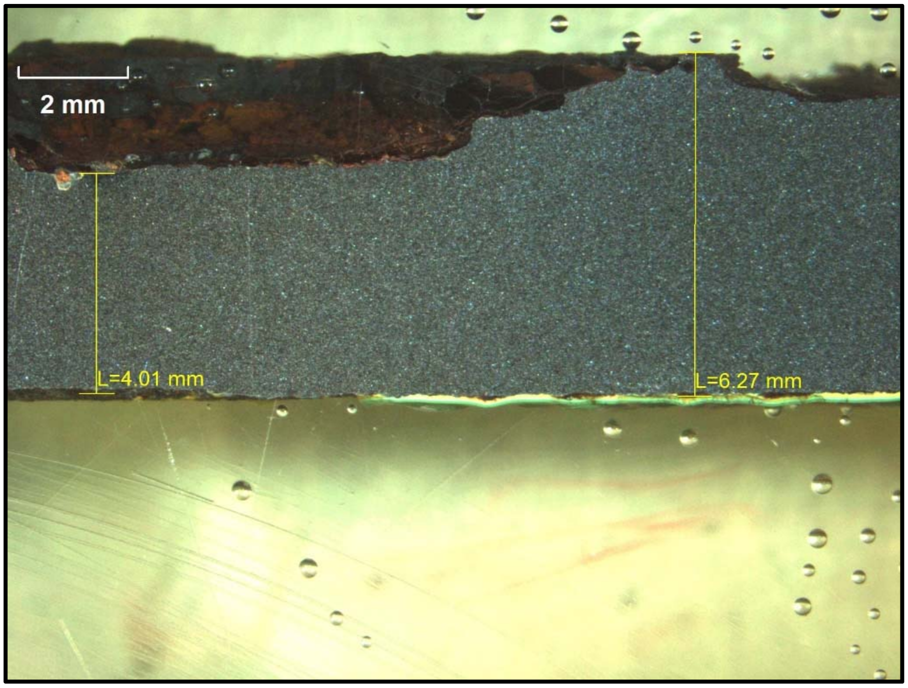


Figure 193. The prepared metallographic cross-section from Sample 6-1 is shown during examination with a stereomicroscope. The thickest location(s) are shown, as well as the thickness remaining underneath the deepest observed pit. (7X)

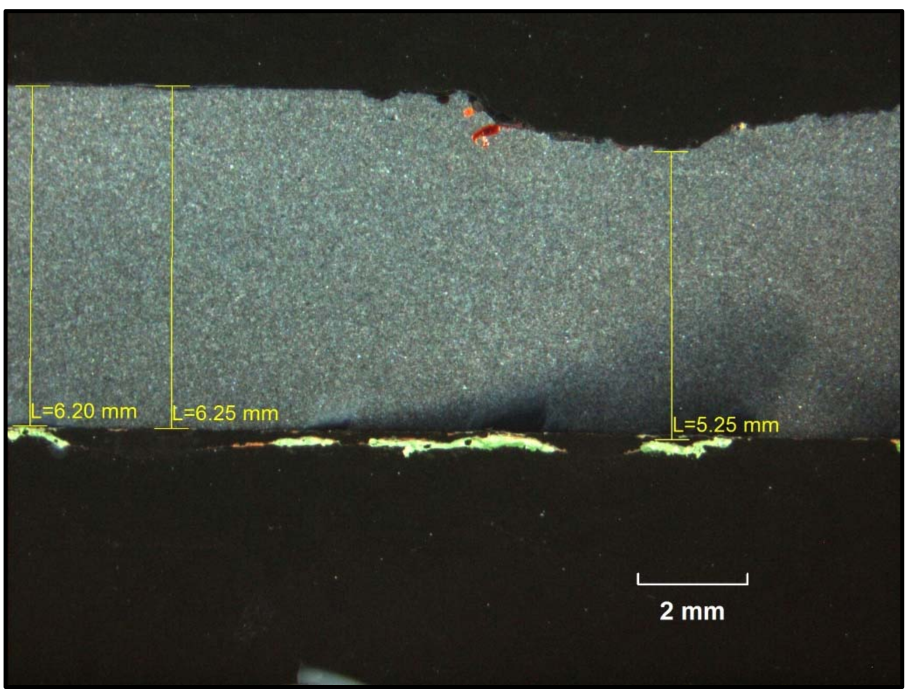


Figure 194. The prepared metallographic cross-section from Sample 6-2 is shown during examination with a stereomicroscope. The thickest location(s) are shown, as well as the thickness remaining underneath the deepest observed pit. (7X)

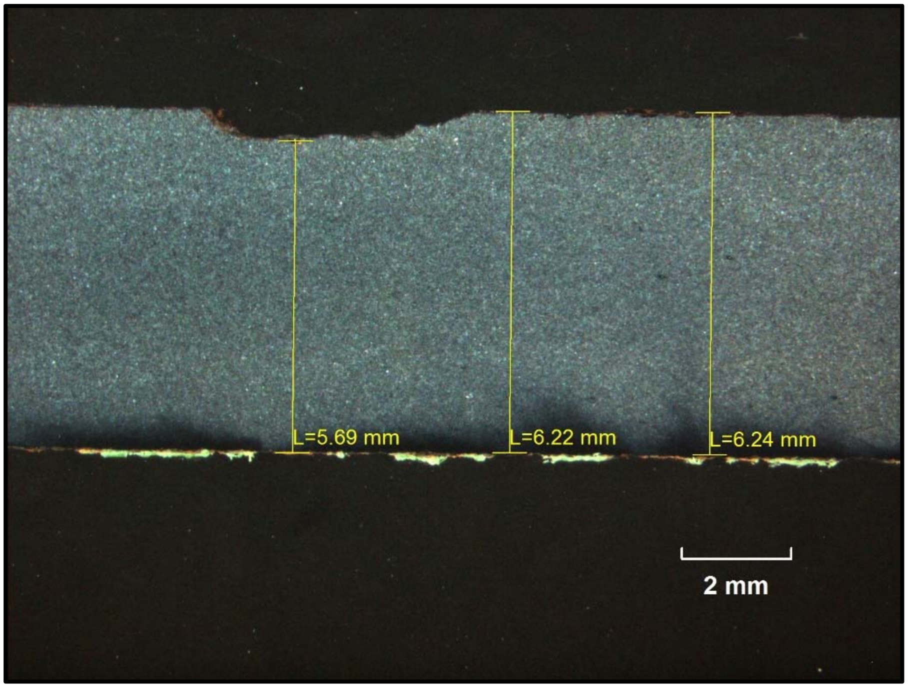


Figure 195. The prepared metallographic cross-section from Sample 6-3 is shown during examination with a stereomicroscope. The thickest location(s) are shown, as well as the thickness remaining underneath the deepest observed pit. (7X)

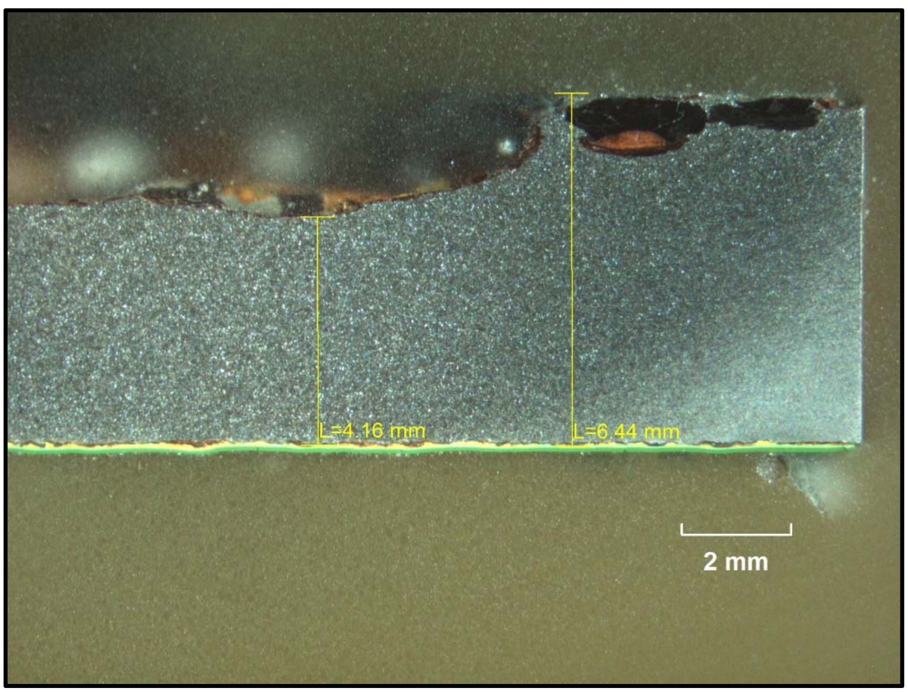


Figure 196. The prepared metallographic cross-section from Sample 7-1 is shown during examination with a stereomicroscope. The thickest location(s) are shown, as well as the thickness remaining underneath the deepest observed pit. (7X)

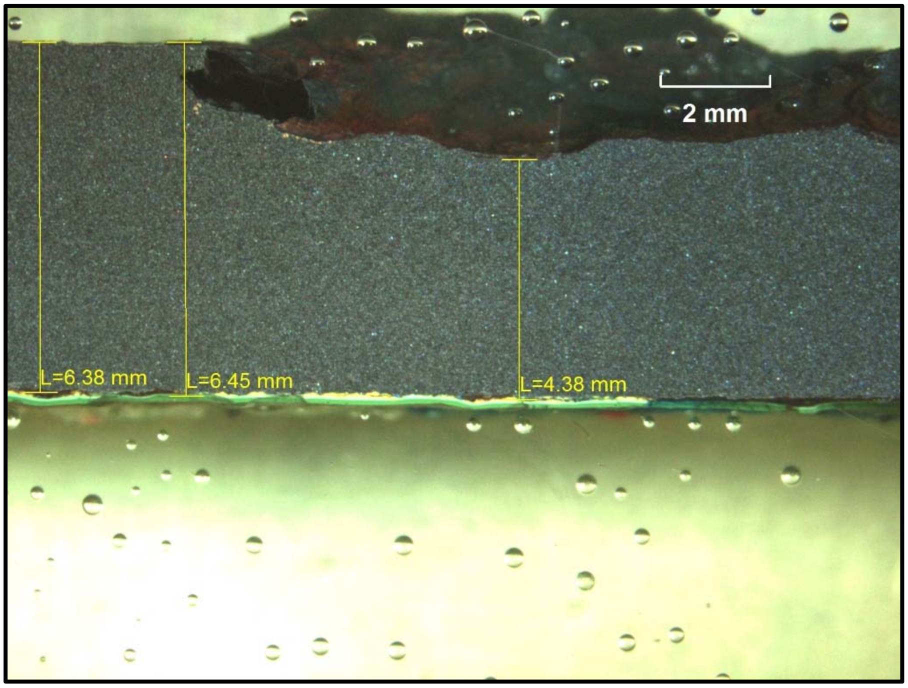


Figure 197. The prepared metallographic cross-section from Sample 7-3 is shown during examination with a stereomicroscope. The thickest location(s) are shown, as well as the thickness remaining underneath the deepest observed pit. (7X)

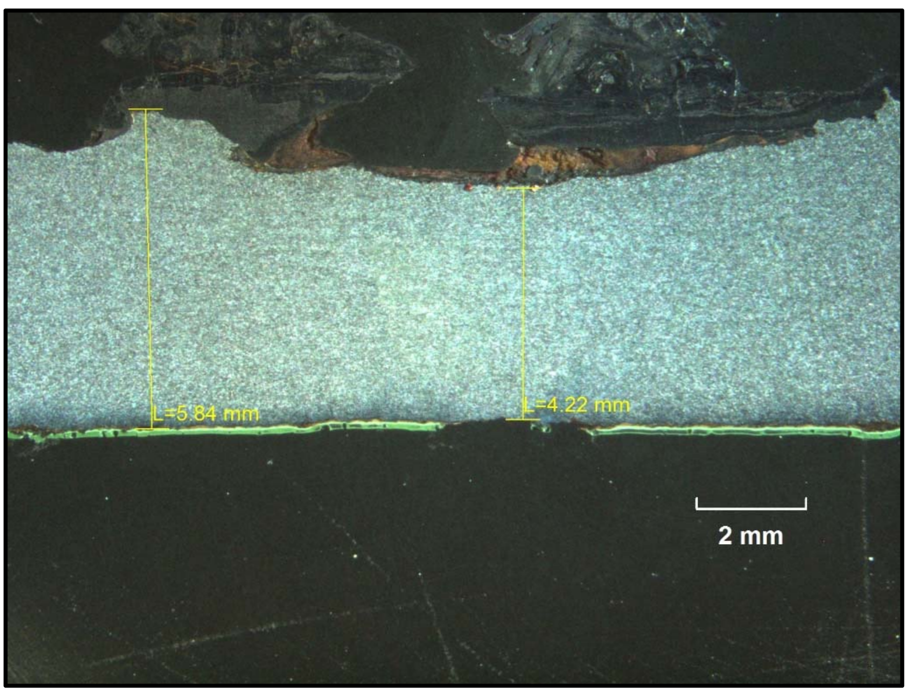


Figure 198. The prepared metallographic cross-section from Sample 7-4 is shown during examination with a stereomicroscope. The thickest location(s) are shown, as well as the thickness remaining underneath the deepest observed pit. (7X)

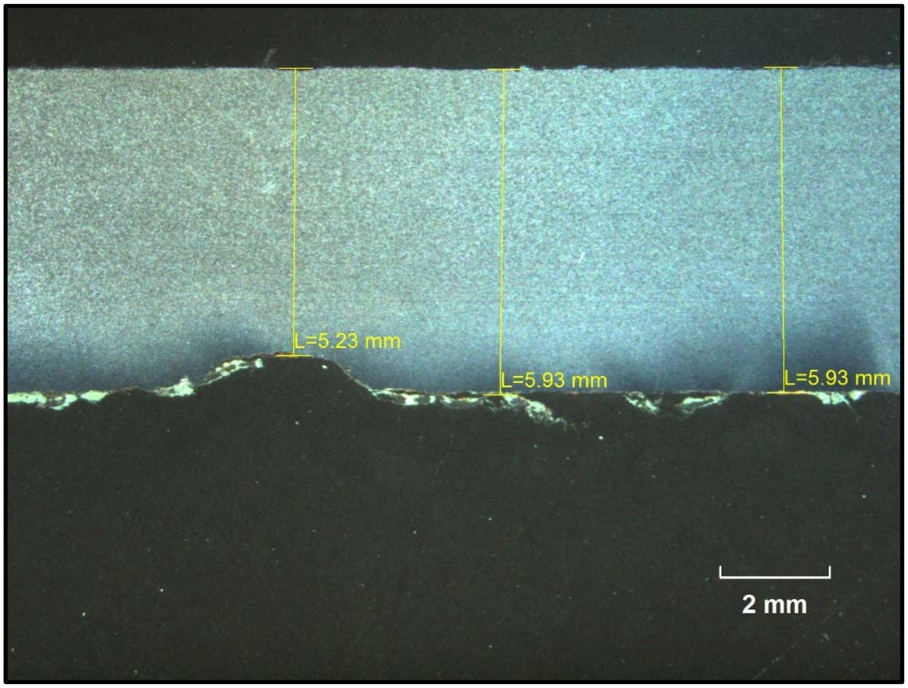


Figure 199. The prepared metallographic cross-section from Sample 8-3 is shown during examination with a stereomicroscope. The thickest remaining wall is shown. Note that the reduction in wall thickness was due to a depression on the painted face of the specimen. (7X)

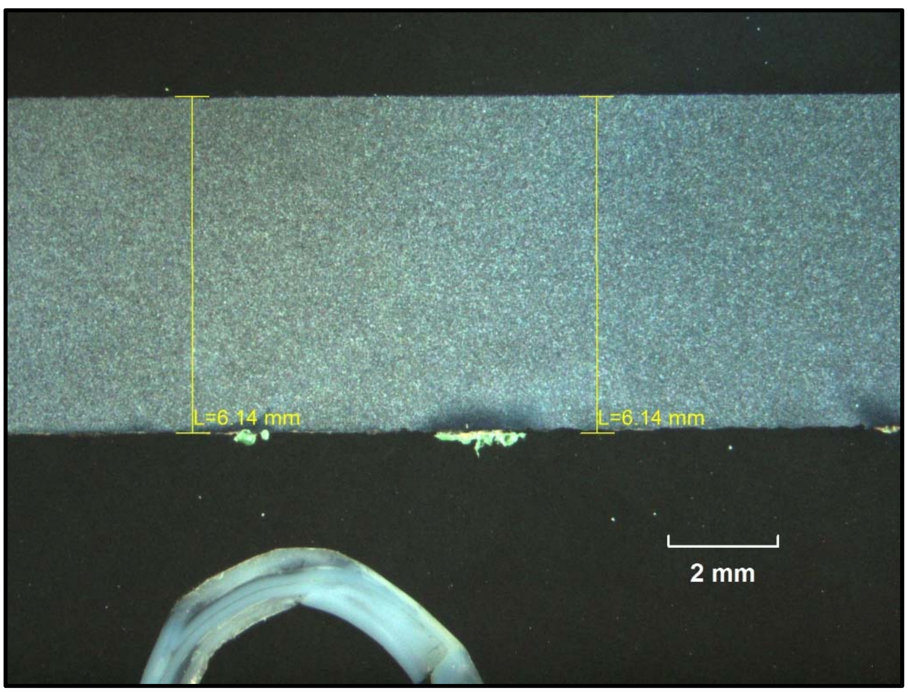


Figure 200. The prepared metallographic cross-section from Sample 10-1 is shown during examination with a stereomicroscope. The thickest location(s) are shown. No pitting was observed. (7X)

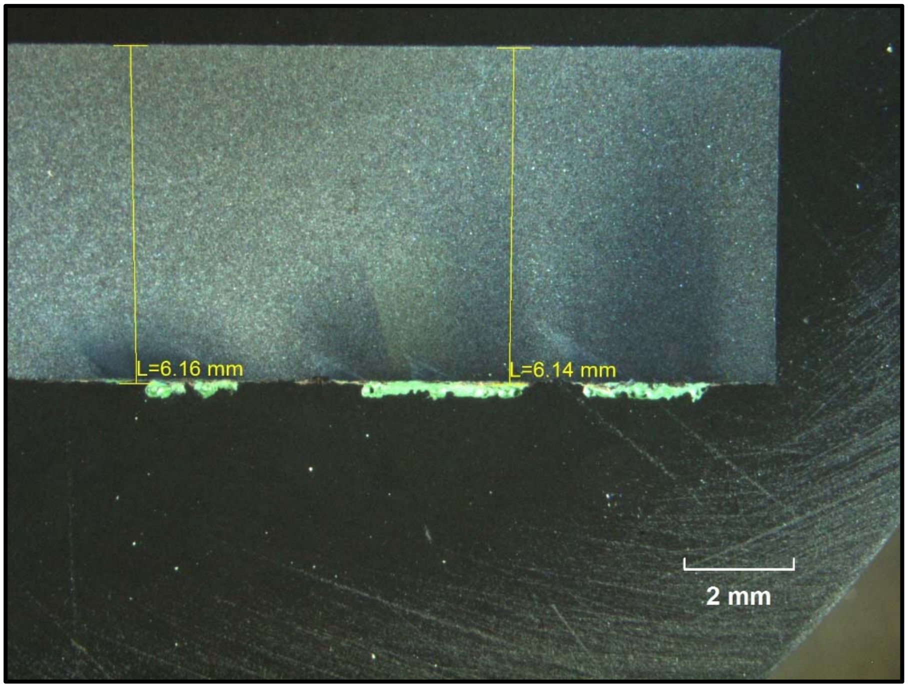


Figure 201. The prepared metallographic cross-section from Sample 10-2 is shown during examination with a stereomicroscope. The thickest location(s) are shown. No pitting was observed. (7X)

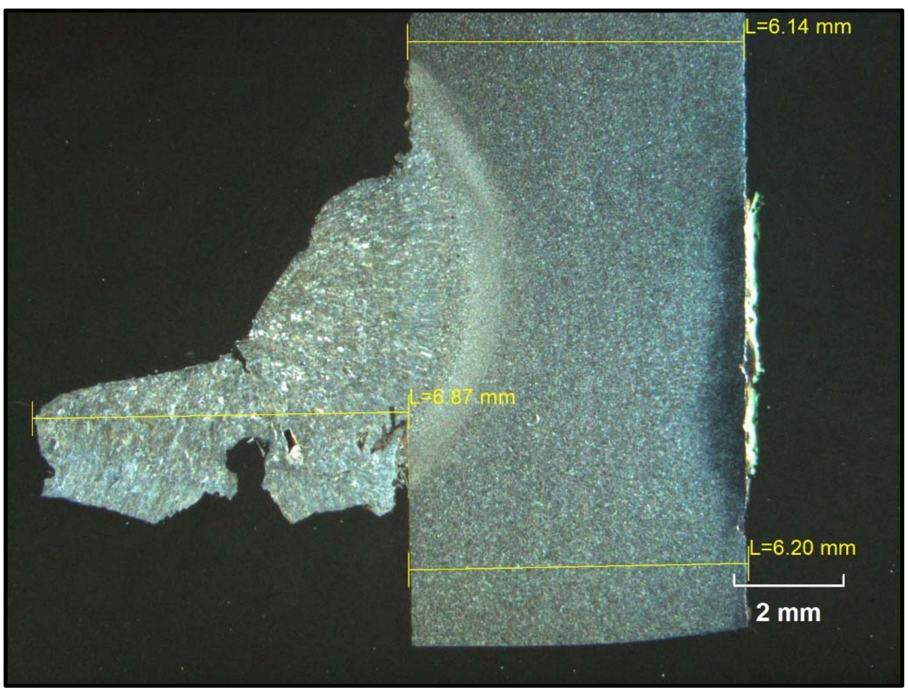


Figure 202. The prepared metallographic cross-section from Sample 10-4 is shown during examination with a stereomicroscope. Image is rotated 90° from other images. The anomaly detected during NDE was likely the weld nugget on the interior surface of the coupon (left). No pitting or significant wall loss was observed. (7X)

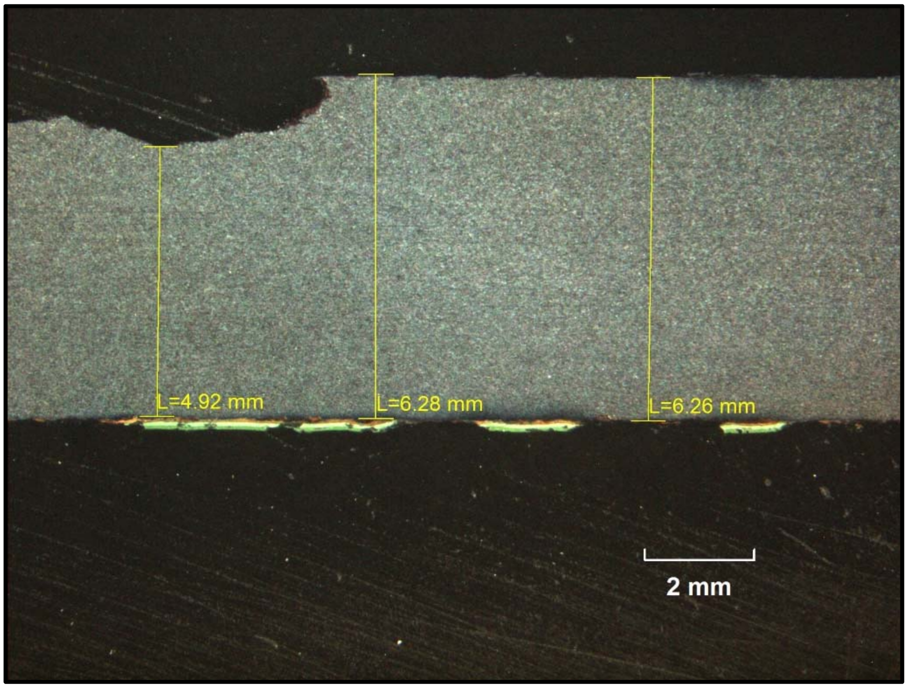


Figure 203. The prepared metallographic cross-section from Sample A1-1 is shown during examination with a stereomicroscope. The thickest location(s) are shown, as well as the thickness remaining underneath the deepest observed pit. (7X)

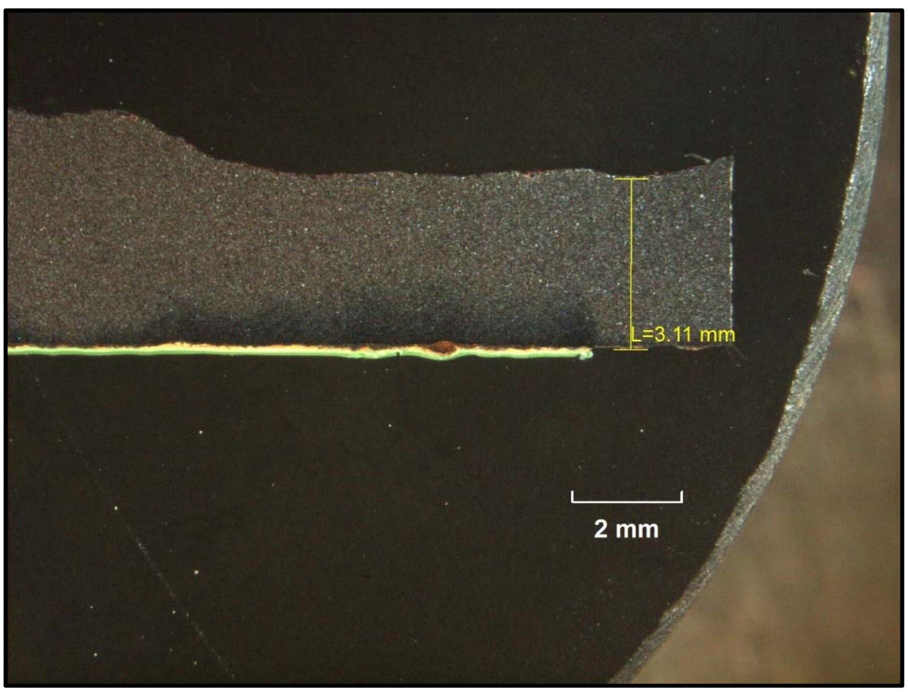


Figure 204. The prepared metallographic cross-section from Sample A1-4 is shown during examination with a stereomicroscope. The thickness remaining underneath the deepest observed pit is shown. (7X)

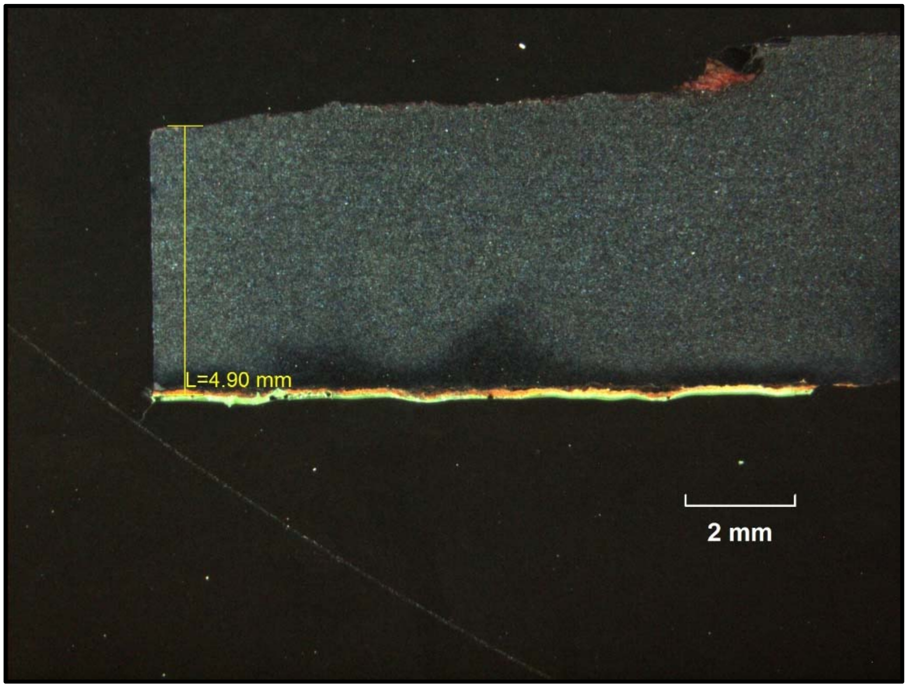


Figure 205. The prepared metallographic cross-section from Sample A1-5 is shown during examination with a stereomicroscope. The thickness remaining underneath the deepest observed pit is shown. (7X)

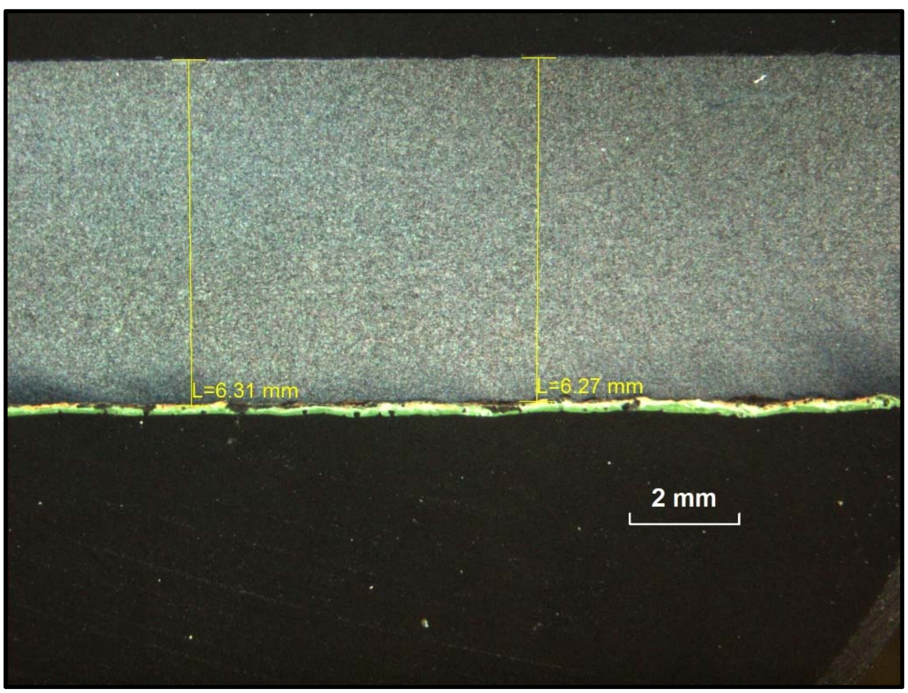


Figure 206. The prepared metallographic cross-section from Sample A2-3 is shown during examination with a stereomicroscope. No pitting was observed. (7X)

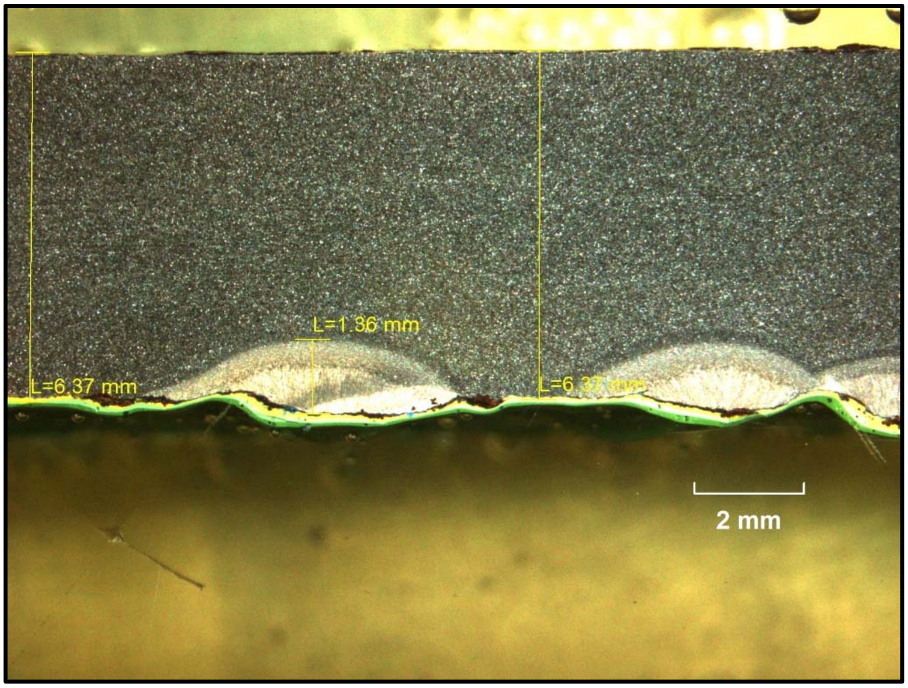


Figure 207. The prepared metallographic cross-section from Sample A2-4 is shown during examination with a stereomicroscope. The NDE indication was most likely locations of melting/re-solidification underneath the painted surface. No pitting was observed. (7X)

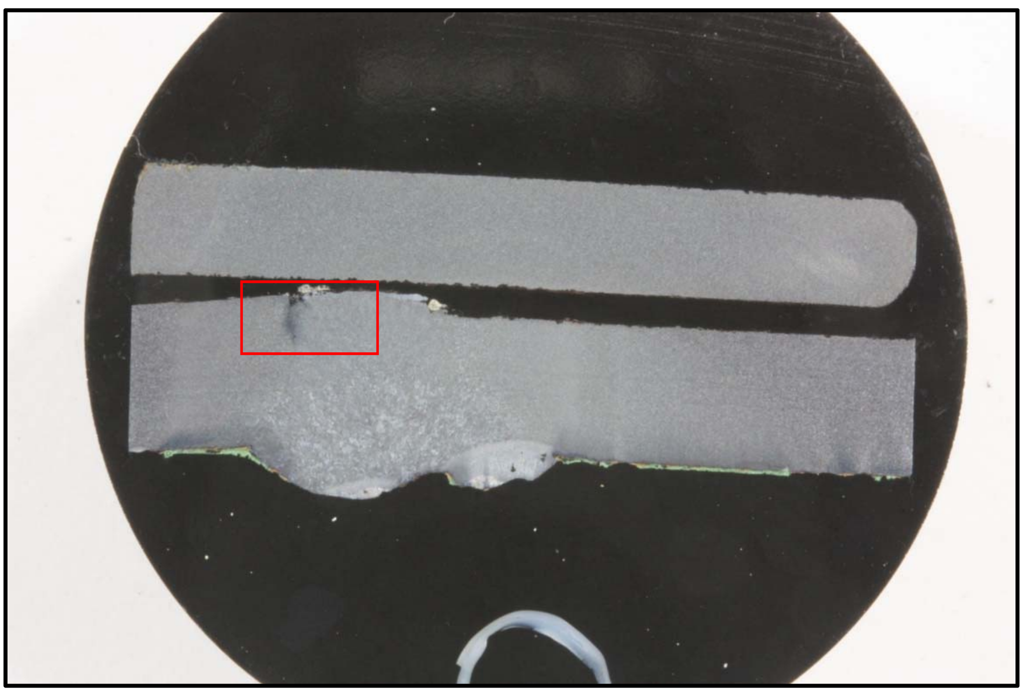


Figure 208. The prepared metallographic cross-section through welded sample 8-1 is shown in an overall view. The painted exterior surface is along the bottom section. The area identified by the red box is shown in the next figure at higher magnification.

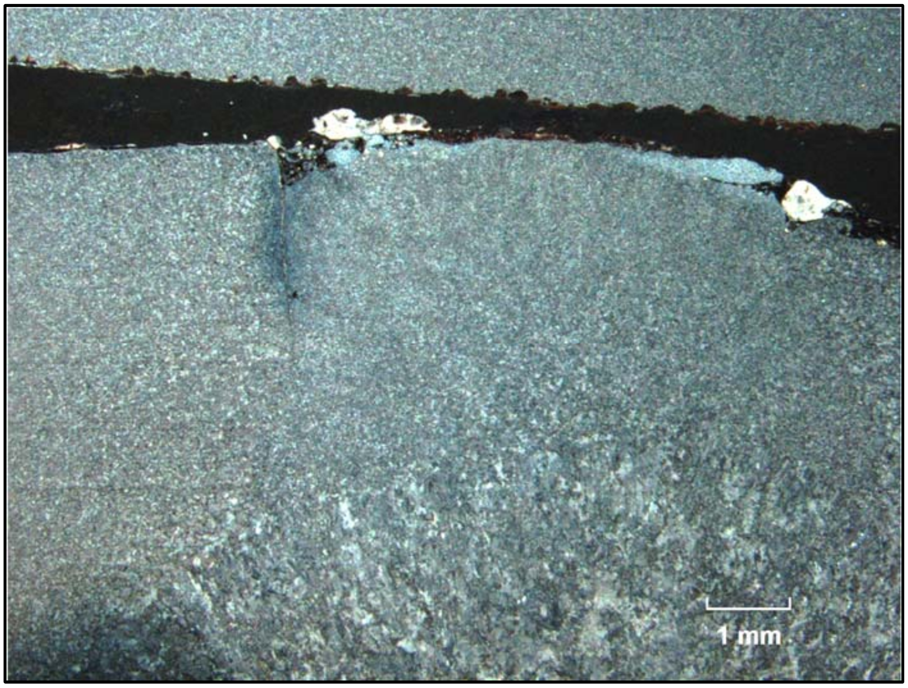


Figure 209. The location identified in the previous figure is shown at higher magnification. The weld indication (arrow) appeared to be an area of incomplete fusion.

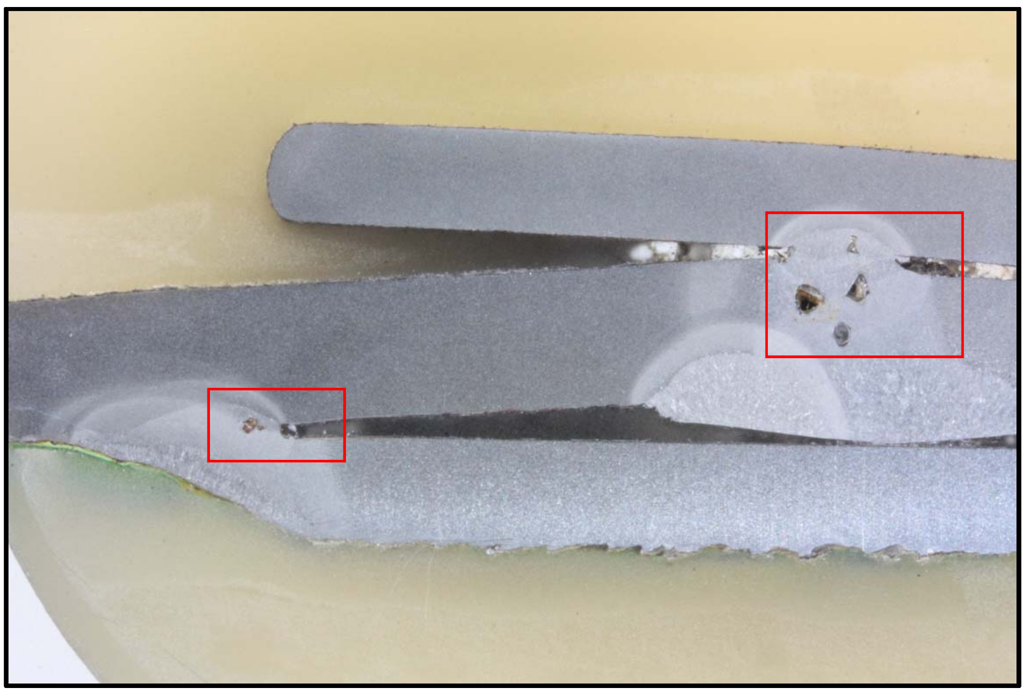


Figure 210. The prepared metallographic cross-section through welded sample 8-4 is shown in an overall view. The painted exterior surface is along the bottom section. The areas identified by the red boxes are shown in the next two figures at higher magnification.

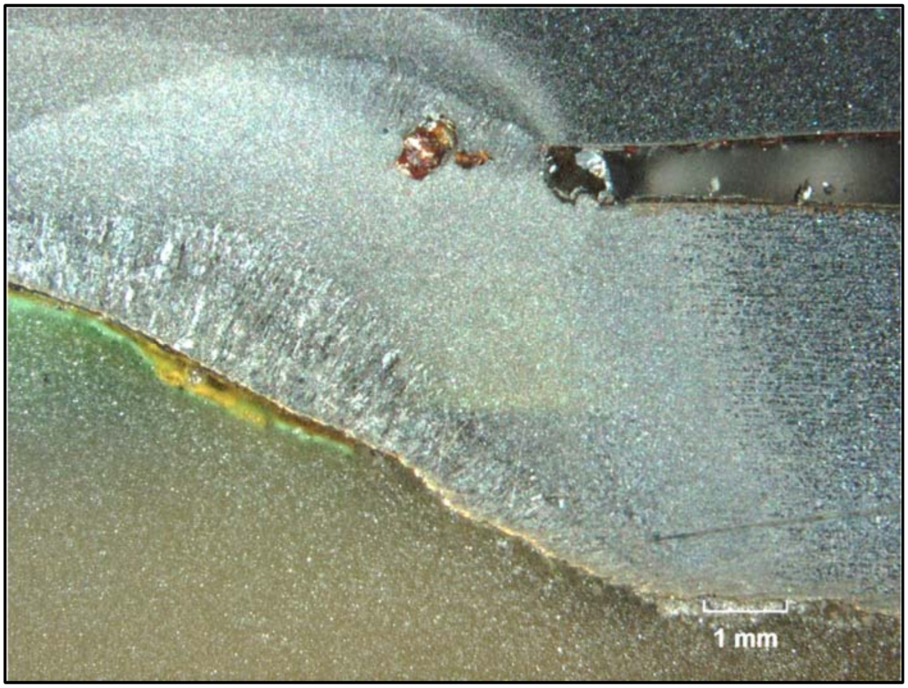


Figure 211. The left-hand feature in Figure 210 is shown at higher magnification. The weld indication (arrow) appeared to be an area of porosity.

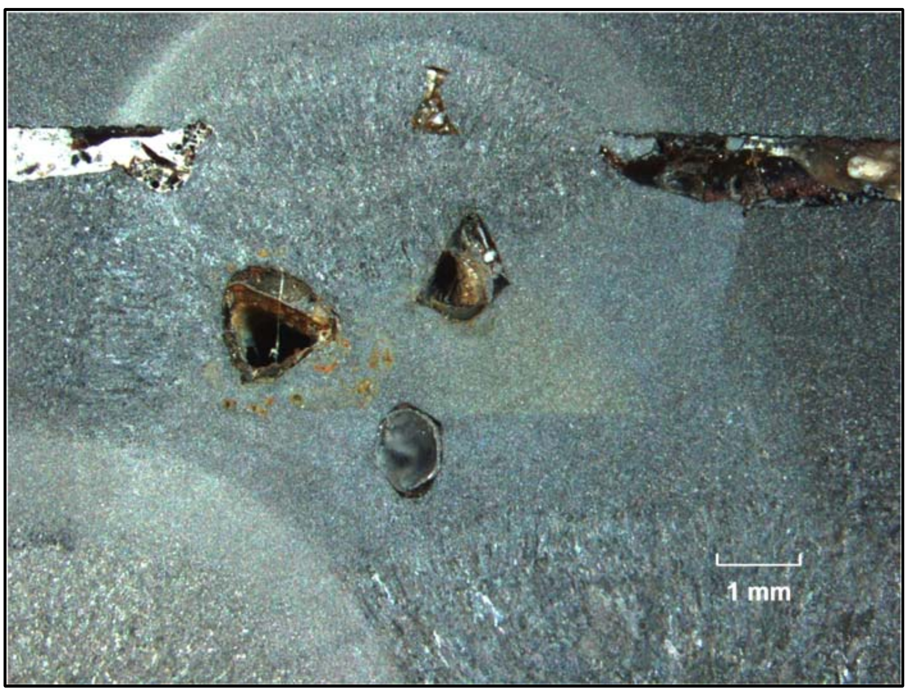


Figure 212. The right-hand feature in Figure 210 is shown at higher magnification. The weld indications appeared to be porosity.

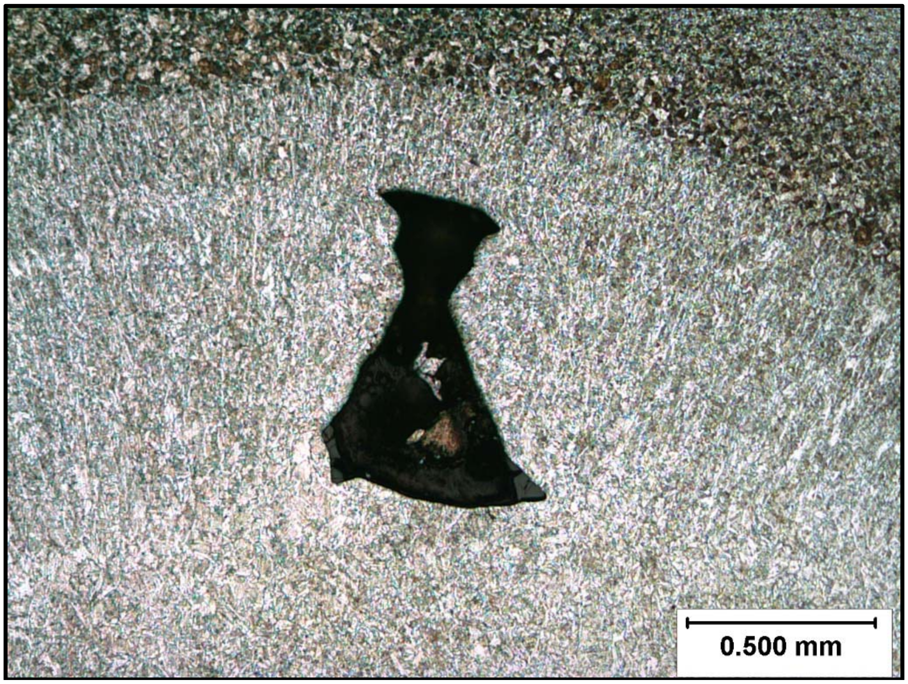


Figure 213. The one of the voids is shown at higher magnification. (2% Nital Etch, 50X)

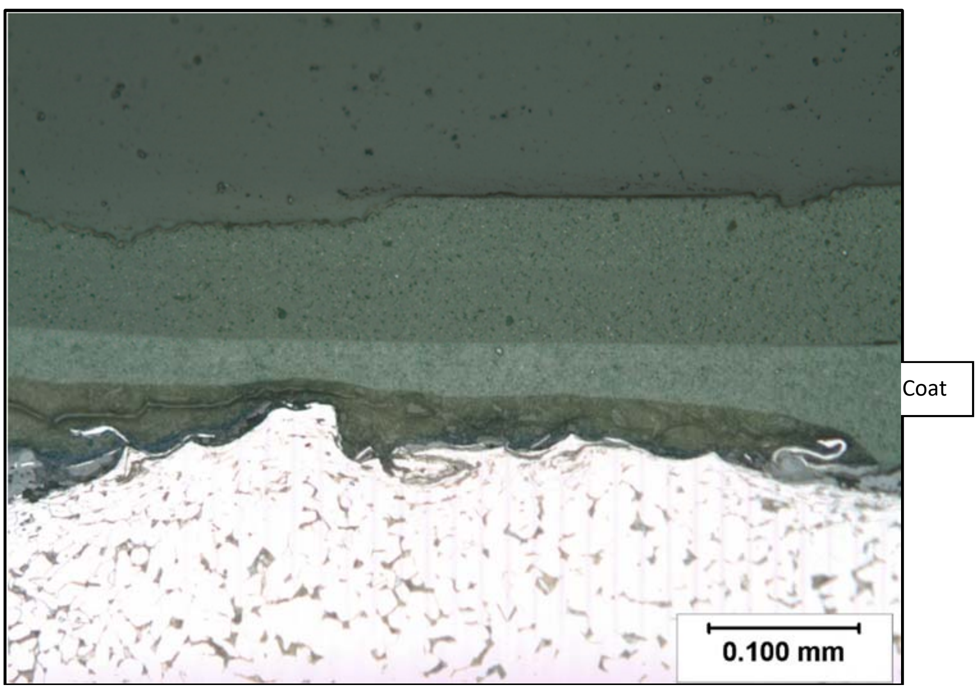


Figure 214. A typical paint layer is shown in cross-section, with key characteristics identified. (2% Nital Etch, 200X)

APPENDIX A:
Additional Inspection of Coupon #7 Edge
March 20, 2019

SUMMARY

Following the initial issue of this report on December 17, 2018, there was concern regarding photographs of the sectioned edge of Coupon #7 from Tank #14 that was taken prior to shipment of the coupons to IMR Test Labs, but was not provided at that time (see Figures A-1 and A-5). These photographs were provided to IMR on March 13, 2019 and March 20, 2019 and show what appears to be a corrosion pit that spanned nearly the entire wall thickness of the coupon, and the fact that this area was not noted and addressed in the initial report was called into question.

The area-of-concern was positively identified on the remains of Coupon #7 after the second photograph was provided by Mr. Jamond on March 20, 2019. Following the effects of the CO_2 cleaning, sectioning of test samples and subsequent storage, the edge did not exhibit a similar appearance to the provided photographs. After documenting the edge condition as of March 20, 2019, shown in Figure A-2, the edge was sand-blasted. No pitting was observed, as shown in Figures A-3 and A-4. It can be concluded that the rust-colored feature shown in the photographs provided to IMR on March 13, 2019 was a stain on the surface or some other artifact and not a deep pit.

Figure A-1. Image provided by Robert Jamond on 3/20/19. This image was taken of the edge of Coupon #7 after extraction from Tank #14 and prior to shipping to IMR. The red circle identifies and area-of-concern identified prior to shipment of the coupon to IMR.

Figure A-2. The same edge of Coupon #7 is shown on 3/20/19 after laboratory testing by IMR and subsequent storage. The red circle corresponds to the same area shown in Figure A-1. Note that the left ~1/4 of the coupon was consumed for mechanical testing, etc., but the area-of-concern remained intact.

Figure A-3. The same area is shown after sandblasting on 3/20/19. A slight shadowing was observed in the area-of-concern, but no corrosion product was noted.

Figure A-4. Detail of the sandblasted edge on 3/20/19 in the same location as shown in the picture below. The sandblasting revealed that the feature was not a corrosion pit, as shiny metal was revealed when the red-colored staining was removed. There was an unusual appearance to the edge in this location, as though the sectioned edge had been superficially altered by heat associated with sectioning or some other post-sectioning reaction (atmospheric corrosion or corrosive media attack). That alteration gave the appearance of a deep corrosion pit.

Figure A-5. The same area is shown in an image provided prior to shipping Coupon #7 to IMR (provided to IMR on March 13, 2019). What appeared to be a deep corrosion pit was actually rust-colored staining of the edge surface

APPENDIX B:
Photographs of Coupons 1, 3, 5, 7, 8, 10 and A1
Showing the location of Additional Metallographic Specimens Referenced in Table 23

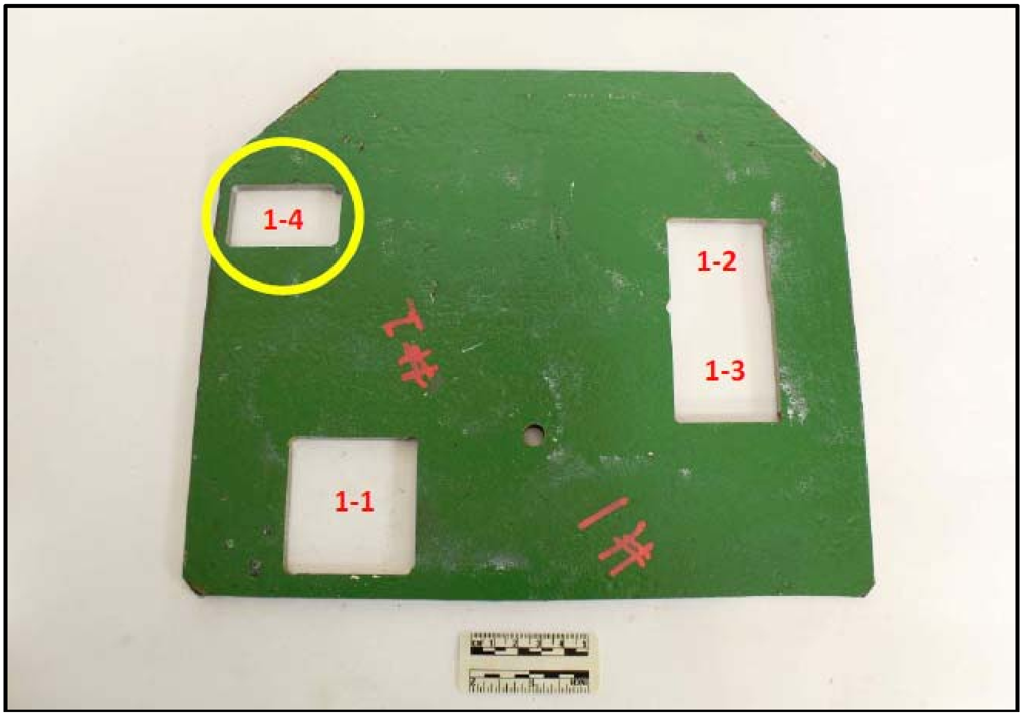


Figure B-1. Coupon #1 photograph showing the location of metallographic specimen 1-4 in relation to 1-1, 1-2 and 1-3.

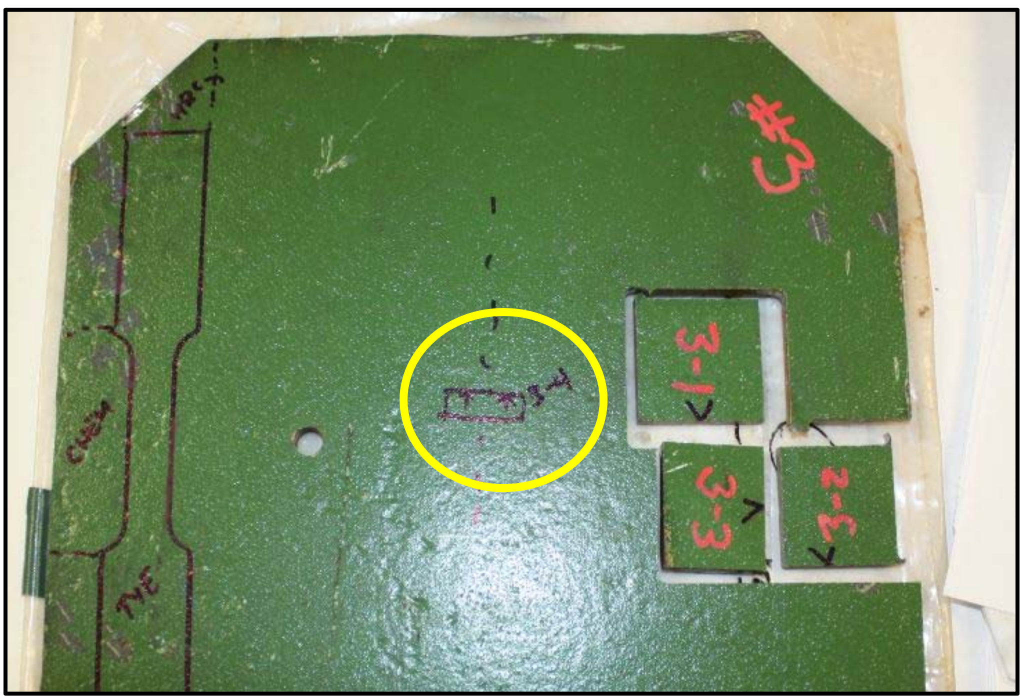


Figure B-2. Coupon #3 photograph showing the location of metallographic specimen 3-4 in relation to 3-1, 3-2 and 3-3.

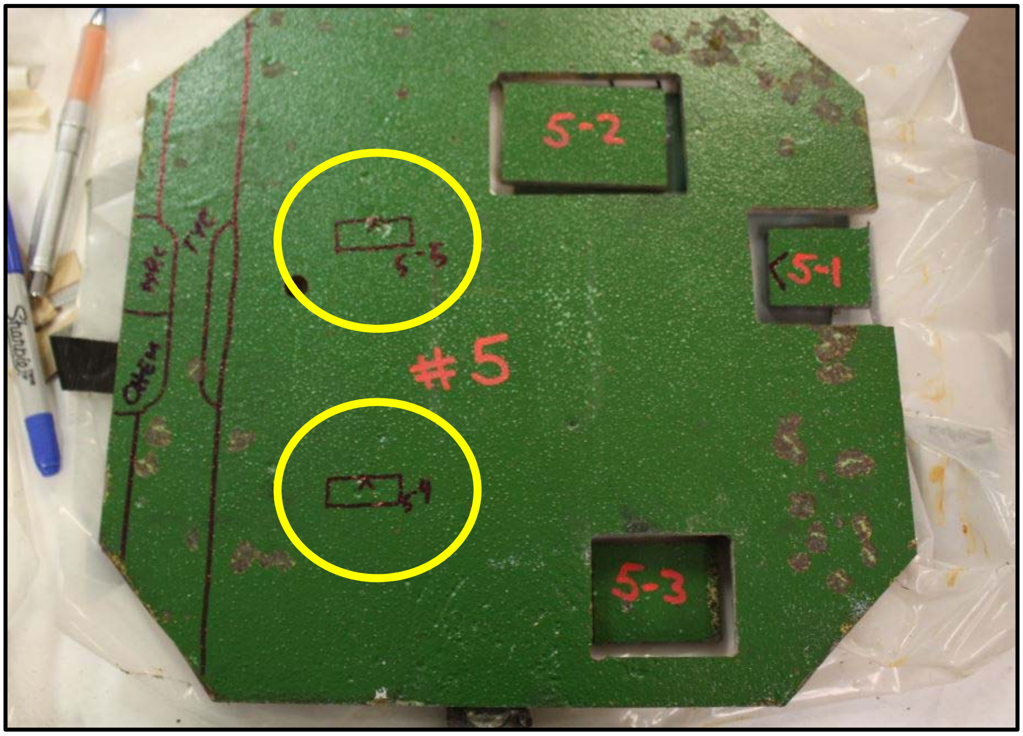


Figure B-3. Coupon #5 photograph showing the location of metallographic specimens 5-4 and 5-5 in relation to 5-1, 5-2 and 5-3.

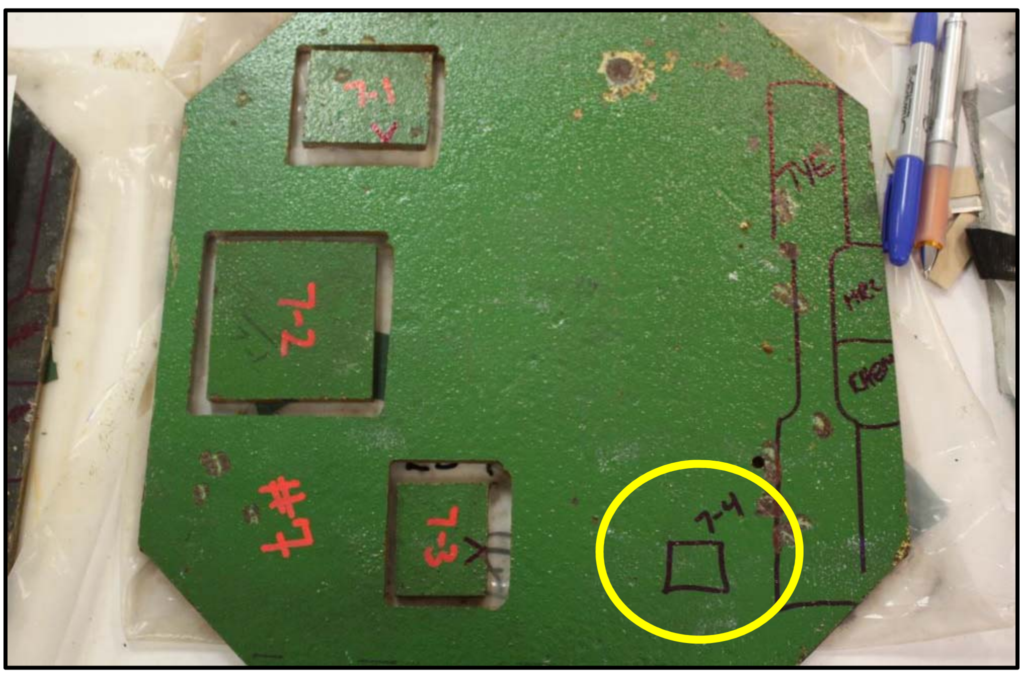


Figure B-4. Coupon #7 photograph showing the location of metallographic specimen 7-4 in relation to 7-1, 7-2 and 7-3.

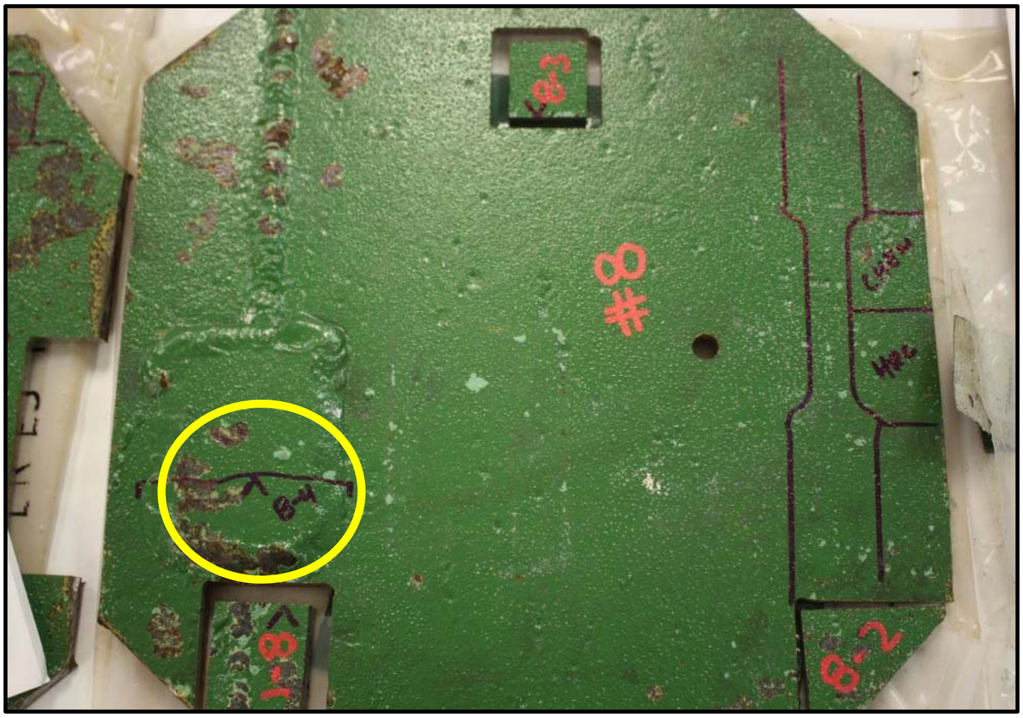


Figure B-5. Coupon #8 photograph showing the location of metallographic specimen 8-4 in relation to 8-1, 8-2 and 8-3.

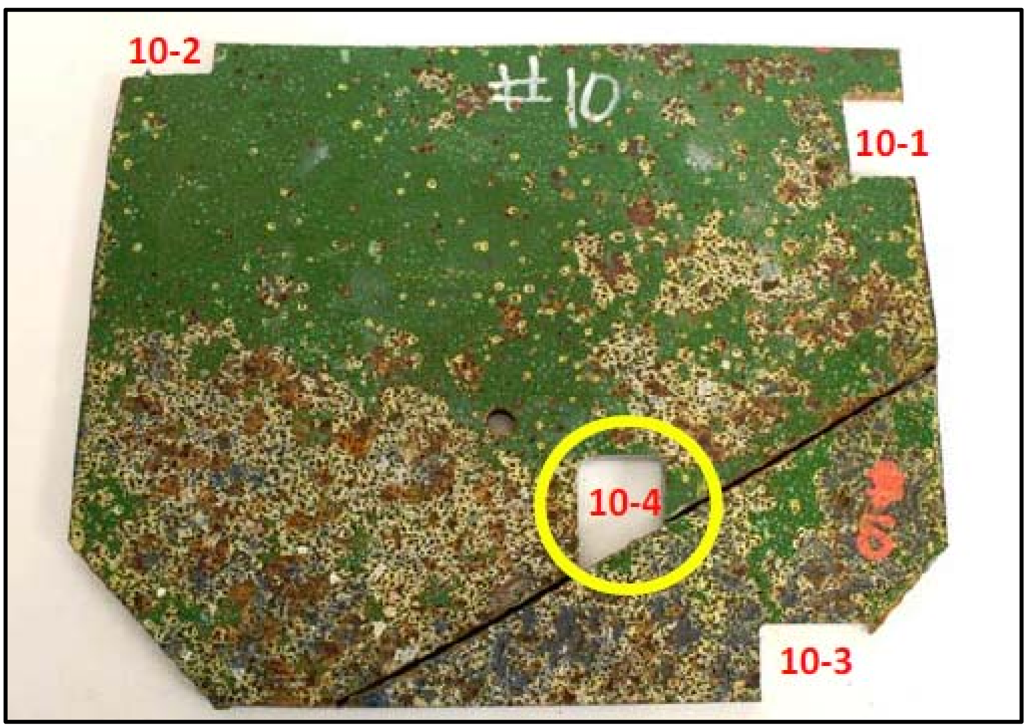


Figure B-6. Coupon #10 photograph showing the location of metallographic specimen 10-4 in relation to 10-1, 10-2 and 10-3.

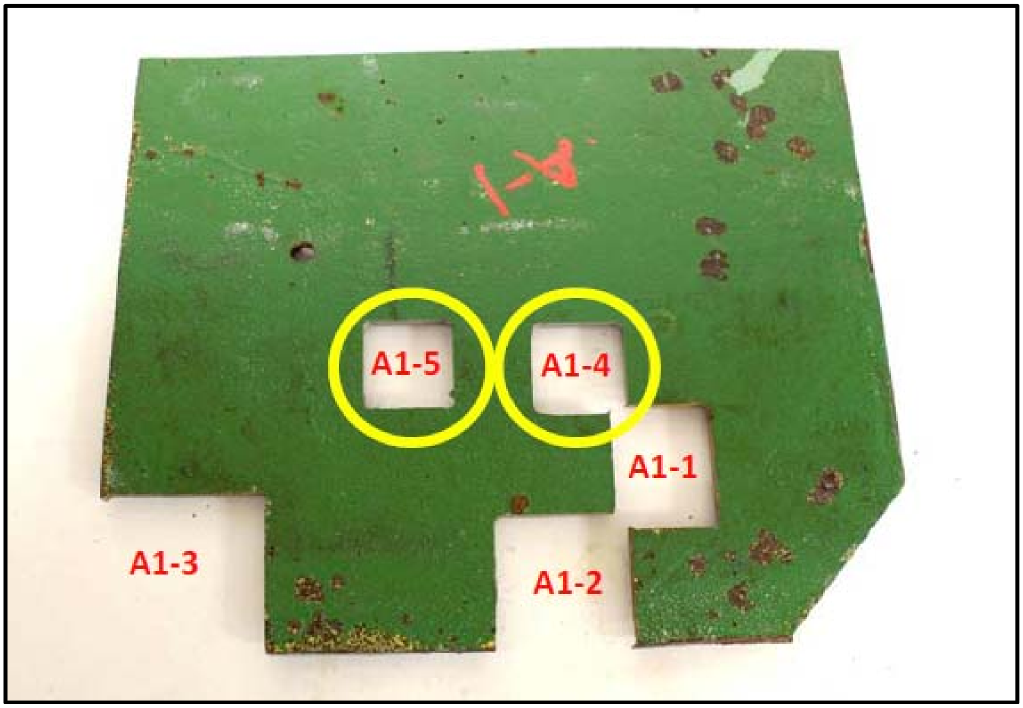


Figure B-6. Coupon #A1 photograph showing the location of metallographic specimens A1-4 and A1-5 in relation to A1-1, A1-2 and A1-3.

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APPENDIX B

On-Site Concrete and Coupon Notes

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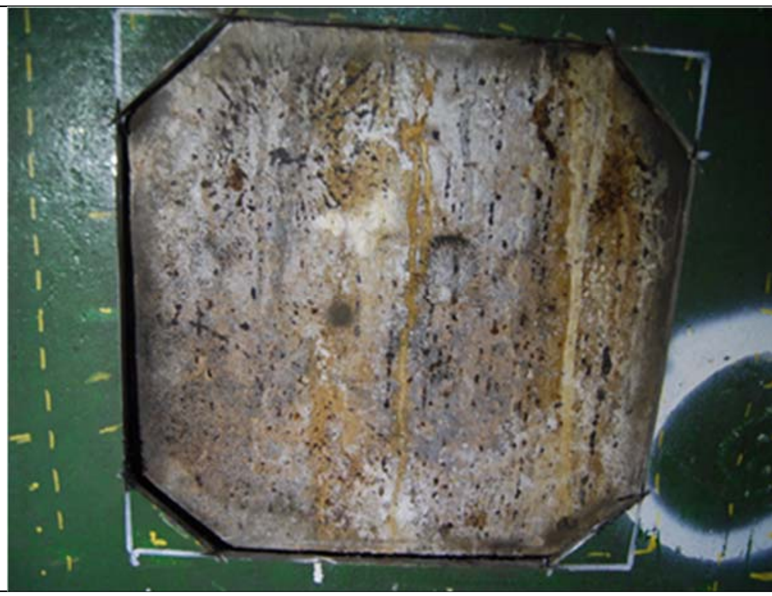
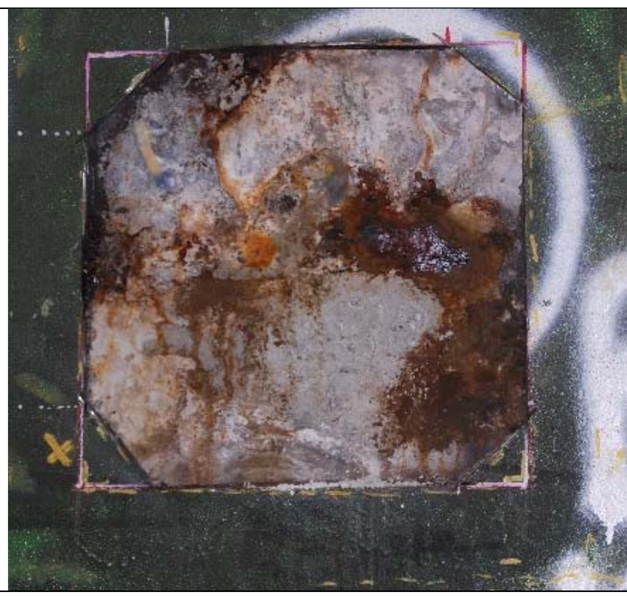
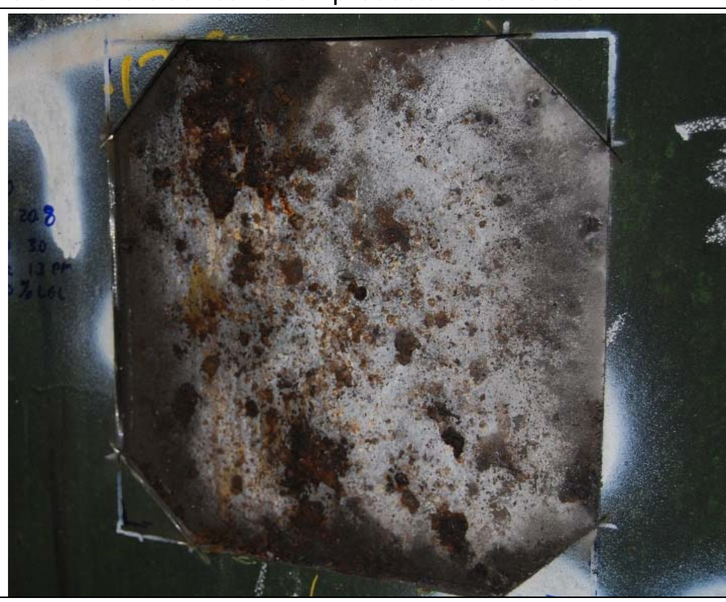
		6/20/2018: 1400
CONCRETE SAMPLE SPECIFICS		
Sample ID	1	**1**
Sample Location	14-UD-A-42-45-107	
Sample Dimensions	12X12 INCHES	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	1/8" Void on left side, no voids in all other areas	
Biological Materials	None	
Wet or Dry	Dry	
Smell	None	
Temperature	76.9	F
Surface pH	9 to 9.5	
Structure to Electrolyte	-0.252	Volts/CSE
Concrete Resistivity	26.4 Horizontal 31.1 Vertical	k-ohm-cm k-ohm-cm
General Condition	Excellent, sound concrete with some discoloration and no cracks and no delamination	
		

		6/19/2018: 0930
CONCRETE SAMPLE SPECIFICS		
Sample ID	2	**2**
Sample Location	14-ER-E3-12-33-40	
Sample Dimensions	12X12 INCHES	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	1/8" void at upper left side. Otherwise no voids.	
Biological Materials	None	
Wet or Dry	Slightly damp	
Smell	Musty, no fuel	
Temperature	80.0	F
Surface pH	10-11 corroded area 11-12 non-corroded area	
Structure to Electrolyte	-0.380	Volts/CSE
Concrete Resistivity	19.0 Horizontal 17.5 Vertical	k-ohm-cm k-ohm-cm
General Condition	Good sound condition with some minor spalling and corrosion product. Coupon took some hammering to remove	
		

		6/19/2018: 14:00
CONCRETE SAMPLE SPECIFICS		
Sample ID	3	**3**
Sample Location	14-ER-E3-13-7-18	
Sample Dimensions	12X12 INCHES	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	On left side, uneven corrosion product and a 1/16-inch void. Otherwise, no voids.	
Biological Materials	None	
Wet or Dry	Mostly dry, with some damp spots	
Smell	None	
Temperature	79.3	F
Surface pH	11-12 dry areas, 7-8 in areas with corrosion product	
Structure to Electrolyte	-0.488	Volts/CSE
Concrete Resistivity	27.8 Horizontal 31.2 Vertical	K-Ohm-cm
General Condition	Good, with some corrosion products. Corrosion product was black on the left side, and brown in some other areas. Concrete was hard and difficult to drill for powder samples. Coupons required some hammering and prying to remove after cutting.	
		

		6/20/2018: 0800
CONCRETE SAMPLE SPECIFICS		
Sample ID	5	**5**
Sample Location	14-DA-26-15-15-8	
Sample Dimensions	12X12 INCHES	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	1/16” Void on top right side, no voids in all other areas	
Biological Materials	None	
Wet or Dry	Dry	
Smell	None	
Temperature	78.5	F
Surface pH	11-12	
Structure to Electrolyte	-0.220	Volts/CSE
Concrete Resistivity	19.1 Horizontal 22.0 Vertical	k-ohm-cm k-ohm-cm
General Condition	Excellent, sound concrete	
		

		6/21/2018: 1100
CONCRETE SAMPLE SPECIFICS		
Sample ID	6	**6**
Sample Location	14-BA-24-8-36-30	
Sample Dimensions	12X12 INCHES	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	None, however some loose adhering grout present	
Biological Materials	None	
Wet or Dry	Dry	
Smell	None	
Temperature	77.4F	F
Surface pH	12.5	
Structure to Electrolyte	-0.387	Volts/CSE
Concrete Resistivity	Horizontal = 387 Vertical = 359	k-ohm-cm k-ohm-cm
General Condition	Concrete is sound, no delamination. There is loose adhering grout on left side and middle	
		

		6/21/2018: 1030
CONCRETE SAMPLE SPECIFICS		
Sample ID	7	**7**
Sample Location	14-BA-23-7-38-49	
Sample Dimensions	12X12 INCHES	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	3/8” void on left side. 1/16” void on top right otherwise no voids	
Biological Materials	None	
Wet or Dry		
Smell	none	
Temperature	77.5F	F
Surface pH	9- 10	
Structure to Electrolyte		Volts/CSE
Concrete Resistivity	Horizontal = 39.3 Vertical = 42.4	k-ohm-cm k-ohm-cm
General Condition	Concrete is sound with no delamination or cracks. Some brown and black corrosion products on concrete	
		

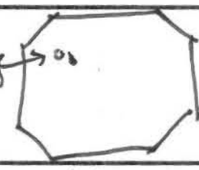
		6/20/2018: 1400
CONCRETE SAMPLE SPECIFICS		
Sample ID	8	**8**
Sample Location	14-BA-20-13-23-4	
Sample Dimensions	12X12 INCHES	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	1/16” Void on left side, no voids in all other areas	
Biological Materials	None	
Wet or Dry	Dry	
Smell	None	
Temperature	80.0	F
Surface pH	11-12	
Structure to Electrolyte	-0.248	Volts/CSE
Concrete Resistivity	30.9 Horizontal 27.5 Vertical	k-ohm-cm k-ohm-cm
General Condition	Excellent, sound concrete with no cracks or delamination. Coupon had steel backing plate	
		

		6/21/2018: 0930
CONCRETE SAMPLE SPECIFICS		
Sample ID	10	**10**
Sample Location	14-LD-3-9-24-215	
Sample Dimensions	12X12 INCHES	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	None	
Biological Materials	None	
Wet or Dry	Dry	
Smell	Smells like coal tar	
Temperature	77.6	F
Surface pH	12-12.5	
Structure to Electrolyte	-0.181	Volts/CSE
Concrete Resistivity	27.3 Horizontal 38.1 Vertical	k-ohm-cm k-ohm-cm
General Condition	Excellent, sound concrete with no cracks or delamination. Coupon had to be cut into two pieces to remove. What appears to be coal tar coating present on backside of coupon and concrete.	
		

		6/20/2018: 1100
CONCRETE SAMPLE SPECIFICS		
Sample ID	A1	**A1**
Sample Location	14-BA-23-9-95-50	
Sample Dimensions	12X12 INCHES	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	1/8" Void on left side, no voids in all other areas	
Biological Materials	None	
Wet or Dry	Mostly dry with damp areas around corrosion product	
Smell	None	
Temperature	77.5	F
Surface pH	11-12 in dry areas, 7-8 in corroded area	
Structure to Electrolyte	-0.448 (dry area) -0.432 (damp area w. corrosion products)	Volts/CSE
Concrete Resistivity	32.9 Horizontal 37.0 Vertical	k-ohm-cm
General Condition	Good condition with sound concrete, no cracks or delamination. Corrosion products are present on concrete.	
		

		6/20/2018: 1530
CONCRETE SAMPLE SPECIFICS		
Sample ID	A2	**A2**
Sample Location	14-BA-11-4-226-50	
Sample Dimensions	12X12 INCHES	
ON SITE VISUAL EXAMINATION		
Checks	Observations	
	Exterior	Units
Void space between concrete and liner (if any)	1/2” Void on left and bottom side. ¼”void on the right side	
Biological Materials	None	
Wet or Dry	Dry	
Smell	None	
Temperature	78.4	F
Surface pH	11-12	
Structure to Electrolyte	-0.226 (middle) -0.230 (right side)	Volts/CSE
Concrete Resistivity	35.8 Horizontal 36.1 Vertical	k-ohm-cm
General Condition	Good condition with sound concrete, no cracks or delamination. There is a layer of concrete which appears to have come off. Below that layer is sound concrete.	
Provide photo documentation with a minimum resolution of 2560 x 1920 of the coupon, front and back.		

Table 2. On-Site Characterization of Steel Coupon

COUPON SPECIFICS		
Coupon ID #	1	
Coupon Location	14-UD-A-42-45-107	
Coupon Dimensions	12 x 12	
Coupon Thickness	1/4"	
Locations of Welds (If Any)	None	
ON-SITE VISUAL EXAMINATION		
Checks	**Observations**	
	In ~~Ex~~terior	Ex ~~In~~terior Back
Deposits, Coatings, Debris	Coating + paint	? Deposits
Scale	None	None
Observed biological Materials	None	None
Wet or Dry	Dry	Wet
Smell	Burnt	Damp, burnt
Presence of petroleum product between steel and concrete surface, and on or above the leg of the angle backer bar embedded in the concrete.	No	No
Provide a sketch of the coupon showing all indications. Provide ID#s for all indications on coupon and compare with NDE expected results sketch	dimples 	
Presence of corrosion	No	Yes
Isolated pitting	No	No
Isolated pitting within areas of general corrosion	No	No
Linked pitting within areas of general corrosion	No	No
Identify color of corrosion products	No	Brown
Identify if selective attack at welds	No	No
Provide photo documentation with a minimum resolution of 2560 x 1920 of the coupon, front and back	Camera	Camera

$3\frac{1}{2}$" from left + $2\frac{1}{2}$" from top : 2 dimples

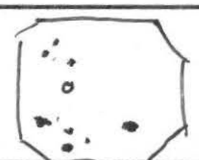
4.1.4 Exterior Concrete Containment

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.

Tue, 19 Jun, First Cut 09:07. Coupon #32
End 10:46

Table 2. On-Site Characterization of Steel Coupon

COUPON SPECIFICS		
Coupon ID #	32	
Coupon Location	E3 P 12	
Coupon Dimensions		
Coupon Thickness		
Locations of Welds (If Any)	None	
ON-SITE VISUAL EXAMINATION		
Checks	**Observations**	
	(Front) In Exterior	(Back) ~~Ext~~Interior
Deposits, Coatings, Debris	Regular coating	Lots (Deposits, Coatings)
Scale	None	None
Observed biological Materials	None	None
Wet or Dry	Dry	Wet
Smell	Burnt but less intense	Thick, Burnt, Musty, Muddy
Presence of petroleum product between steel and concrete surface, and on or above the leg of the angle backer bar embedded in the concrete.	No	No
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	~~No~~ Yes	Yes
Isolated pitting	~~No~~ Yes	Yes
Isolated pitting within areas of general corrosion	No - Pit is not in area of gen. corr.)	Yes
Linked pitting within areas of general corrosion	No	No
Identify color of corrosion products	~~None~~ Brown	Brown, Black, Grey
Identify if selective attack at welds	No	No
Provide photo documentation with a minimum resolution of 2560 x 1920 of the coupon, front and back	Yes (by me)	Yes (by ET)

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.

Sample 3 Notes - Tue, 19 Jun 2018

Loc: 14-ER-E3-13-9-18

Dimensions: 12" × 12"

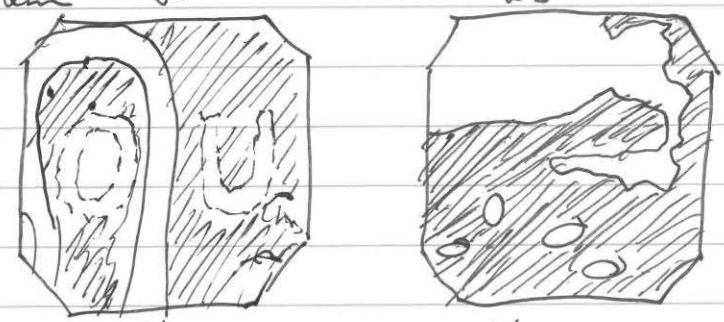
Thickness: 1/4"

Locations of Welds: None

	~~Ext~~ Front (int)	~~Int~~ Back (ext)
Deps, Coats, Debris	Green (White Spray Paint)	Thick, brown, grey
Scale	None	None
Obs. Bio. Mats	None	None
Wet/Dry	Dry	Wet
Smell	—	Burnt: wax or coconut oil
Presence of petroleum	No	Yes

what does this mean?

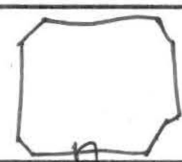
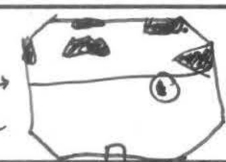
Sketch



Presence of corr	Yes	Yes
Isol pit	Yes	Yes
Isol pit w/in corr areas	No	Yes
Linked pit	No	No
Color of corr prods	Brown	White, Brown
Selective attack at welds	No	No
Photo Doc	On camera	On camera

Corrosion product (powder) is black; likely FeO [iron (II) oxide]

Table 2. On-Site Characterization of Steel Coupon

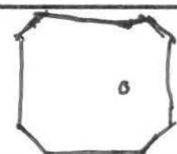
COUPON SPECIFICS		
Coupon ID #	5	
Coupon Location	14-BA-26-15-15-18	
Coupon Dimensions		
~~Coupon Thickness~~		
Locations of Welds (If Any)	None	
ON-SITE VISUAL EXAMINATION		
Checks	**Observations**	
	(Front) ~~Exterior~~ Interior	(Back) ~~Interior~~ Exterior
Deposits, Coatings, Debris	Standard coating	Concrete layer, thin
Scale		
Observed biological Materials	None	No
Wet or Dry	Dry	Dry
Smell		Burnt; not so thick
Presence of petroleum product between steel and concrete surface, and on or above the leg of the angle backer bar embedded in the concrete.	No	No
Provide a sketch of the coupon showing all indications. Provide ID#s for all indications on coupon and compare with NDE expected results sketch		heavy → bilge 
Presence of corrosion	N.	Yes
Isolated pitting	No	No
Isolated pitting within areas of general corrosion	N.	No
Linked pitting within areas of general corrosion	No	No
Identify color of corrosion products	None	Brown
Identify if selective attack at welds	None	No
Provide photo documentation with a minimum resolution of 2560 x 1920 of the coupon, front and back	Camera	Camera

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.

Table 2. On-Site Characterization of Steel Coupon

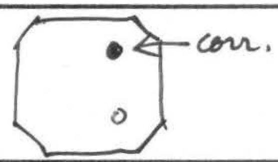
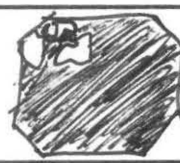
COUPON SPECIFICS		
Coupon ID #	6	
Coupon Location	14-BA-24-8-36-30	
Coupon Dimensions	12 × 12"	
Coupon Thickness	1/4"	
Locations of Welds (If Any)	None	
ON-SITE VISUAL EXAMINATION		
Checks	**Observations**	
	~~Exterior~~ Front	~~Interior~~ Bak
Deposits, Coatings, Debris	Standard coating	Scrapes
Scale	None	Concrete
Observed biological Materials	None	None
Wet or Dry	Dry	Dry
Smell	Burnt	~~None~~ Burnt
Presence of petroleum product between steel and concrete surface, and on or above the leg of the angle backer bar embedded in the concrete.	None	None
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	Yes (tiny)	Yes (small)
Isolated pitting	No	No
Isolated pitting within areas of general corrosion	No	No
Linked pitting within areas of general corrosion	No	No
Identify color of corrosion products	~~No~~ Brown	Brown
Identify if selective attack at welds	No	No
Provide photo documentation with a minimum resolution of 2560 x 1920 of the coupon, front and back	Camera	Camera

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.

Table 2. On-Site Characterization of Steel Coupon

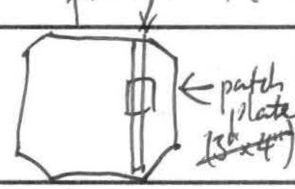
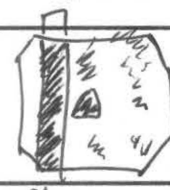
COUPON SPECIFICS		
Coupon ID #	7	
Coupon Location	14-BA-23-7-38-49	
Coupon Dimensions	12" x 12"	
Coupon Thickness	1/4"	
Locations of Welds (If Any)	None	
ON-SITE VISUAL EXAMINATION		
Checks	**Observations**	
	~~Exterior~~ Front	~~Interior~~ Back
Deposits, Coatings, Debris	Standard coating	Lots of general corr.
Scale	None	~~None~~ Yes, thick, varied
Observed biological Materials	None	None
Wet or Dry	Dry	Wet
Smell	Burnt	~~None~~ Burnt, damp
Presence of petroleum product between steel and concrete surface, and on or above the leg of the angle backer bar embedded in the concrete.	No	None
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	Yes	Yes
Isolated pitting	No	~~No~~ Yes
Isolated pitting within areas of general corrosion	No	~~No~~ Yes
Linked pitting within areas of general corrosion	No	No
Identify color of corrosion products	Brown	Brown, black
Identify if selective attack at welds	No	No
Provide photo documentation with a minimum resolution of 2560 x 1920 of the coupon, front and back	Camera	Camera

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.

Table 2. On-Site Characterization of Steel Coupon

COUPON SPECIFICS		
Coupon ID #	8	
Coupon Location	14-BA-20-13-236-43	
Coupon Dimensions	~~[illegible]~~ 12" x 12"	
Coupon Thickness	1/4"	
Locations of Welds (If Any)	~~1 3/4 in from fro~~ on front, 1 3/4 in from right, vertical	
ON-SITE VISUAL EXAMINATION		
Checks	**Observations**	
	(front) ~~Exterior~~ Interior	(back) ~~Interior~~ Exterior
Deposits, Coatings, Debris	green, pink, white paint	white coating
Scale	None	None
Observed biological Materials	None	None
Wet or Dry	Dry	Dry
Smell	fuel	faint metal
Presence of petroleum product between steel and concrete surface, and on or above the leg of the angle backer bar embedded in the concrete.	none fillet weld (1/2")	none ~2" backing strip
Provide a sketch of the coupon showing all indications. Provide ID#s for all indications on coupon and compare with NDE expected results sketch	 ← patch plate (2"x3") ~~1 3/4"x4"~~	
Presence of corrosion	no	yes
Isolated pitting	no	~~no~~ yes
Isolated pitting within areas of general corrosion	no	~~no~~ yes
Linked pitting within areas of general corrosion	no	no
Identify color of corrosion products	n/a	brown
Identify if selective attack at welds	no	yes (more corr on weld than off)
Provide photo documentation with a minimum resolution of 2560 x 1920 of the coupon, front and back	camera	camera

backing strip on seam weld

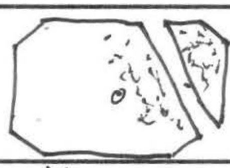
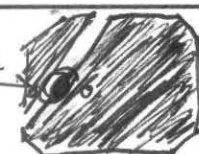
pit ~~[illegible]~~, 5" from left, ~~[illegible]~~ 2" from top
~~[illegible]~~ 7" from left, 5" from top (pit w/o corr. prod.)

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.

Table 2. On-Site Characterization of Steel Coupon

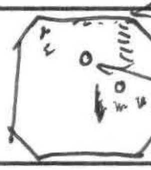
COUPON SPECIFICS		
Coupon ID #	10	
Coupon Location	14-LD-3-9-24-215	
Coupon Dimensions	12" x 12"	
Coupon Thickness	1/4	
Locations of Welds (If Any)	None	
ON-SITE VISUAL EXAMINATION		
Checks	**Observations**	
	~~Exterior~~ Front	~~Interior~~ Back
Deposits, Coatings, Debris	Lots of surface ~~coating~~ deposits	Coal tar
Scale	None	None
Observed biological Materials	None	None
Wet or Dry	Dry	~~Dry~~ Wet
Smell	None	Coal tar
Presence of petroleum product between steel and concrete surface, and on or above the leg of the angle backer bar embedded in the concrete.	No	No 4.5"
Provide a sketch of the coupon showing all indications. Provide ID#s for all indications on coupon and compare with NDE expected results sketch		 backer bar 8"
Presence of corrosion	Yes	~~No~~ Yes (small)
Isolated pitting	Yes	No
Isolated pitting within areas of general corrosion	No	No
Linked pitting within areas of general corrosion	No	No
Identify color of corrosion products	Brown	~~No~~ Brown
Identify if selective attack at welds	No	No
Provide photo documentation with a minimum resolution of 2560 x 1920 of the coupon, front and back	Camera	Camera

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.

Table 2. On-Site Characterization of Steel Coupon

COUPON SPECIFICS		
Coupon ID #	A1	
Coupon Location	14-BA-23-9-95-50	
Coupon Dimensions	12" × 12"	
Coupon Thickness	1/4"	
Locations of Welds (If Any)	none	
ON-SITE VISUAL EXAMINATION		
Checks	**Observations**	
	(Front) Exterior Interior	(Back) ~~Interior~~ Exterior
Deposits, Coatings, Debris	~~coati~~ standard intact	lots of corr prod
Scale	none	none
Observed biological Materials	none	none
Wet or Dry	dry	dry
Smell	burnt	burnt, musty
Presence of petroleum product between steel and concrete surface, and on or above the leg of the angle backer bar embedded in the concrete.	none	none
Provide a sketch of the coupon showing all indications. Provide ID#s for all indications on coupon and compare with NDE expected results sketch	 scratches, grinding marks, rust	 corrosion, calcarious passivating deposit
Presence of corrosion	~~none~~ yes	yes (pitting)
Isolated pitting	none	yes
Isolated pitting within areas of general corrosion	none	yes
Linked pitting within areas of general corrosion	none	yes
Identify color of corrosion products	brown	dark brown
Identify if selective attack at welds	none	
Provide photo documentation with a minimum resolution of 2560 x 1920 of the coupon, front and back	camera	camera

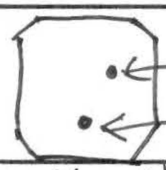
g. deep pit: 7.5" from left
2.5" from top
pits are visible but not easily measurable w/ presence of corr. prod.

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.

Table 2. On-Site Characterization of Steel Coupon

COUPON SPECIFICS		
Coupon ID #	A2	
Coupon Location	14-BA-11-4-220-50	
Coupon Dimensions	12" x 12"	
Coupon Thickness	1/4"	
Locations of Welds (If Any)	None	
ON-SITE VISUAL EXAMINATION		
Checks	**Observations**	
	~~Exterior~~ Front	~~Interior~~ Back
Deposits, Coatings, Debris	Standard coating	Concrete adhesion (thin film on 50% of surface)
Scale	None	None
Observed biological Materials	None	None
Wet or Dry	Dry	Dry
Smell	None	No 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.	No	No
Provide a sketch of the coupon showing all indications. Provide ID#s for all indications on coupon and compare with NDE expected results sketch	 dimple 5" from top 3 1/2" from right; dimple 5" from bottom 5" from ~~left~~ right	 ← no void; grey ← void
Presence of corrosion	~~[illegible]~~ No	~~No~~ Yes (general)
Isolated pitting		No
Isolated pitting within areas of general corrosion	No	No
Linked pitting within areas of general corrosion	No	No
Identify color of corrosion products	No	Brown
Identify if selective attack at welds	No	No
Provide photo documentation with a minimum resolution of 2560 x 1920 of the coupon, front and back	Camera	Camera

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.

APPENDIX C

List of Acronyms

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List of Acronyms

AISI	American Iron and Steel Institute
AOC	Administrative Order on Consent
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
BA	Barrel
BC	Backside Corrosion
CIR	Clean, Inspect, Repair
CSE	Copper/Copper-Sulfate Electrode
CT	Computed Tomography
DLA	Defense Logistics Agency
DLA-E	Defense Logistics Agency-Energy
DOH	(State of Hawaii) Department of Health
EDXA	Energy Dispersive X-ray Analysis
EPA	Environmental Protection Agency
ER	Extension Ring
ID	Identification
LD	Lower Dome
LFET	Low-Frequency Electromagnetic Technique
mpy	mils per year
NADCAP	National Aerospace and Defense Contractors Accreditation Program
NAVFAC EXWC	Naval Facilities Engineering and Expeditionary Warfare Center
NDE	Non-Destructive Examination
PAUT	Phased Array Ultrasonic Technique
pH	power of Hydrogen (a number indicating acidity or alkalinity)
ppm	parts per million
S/E	Structure-to-Electrolyte
SEM	Scanning Electron Microscopy
SME	Subject Matter Expert
SOW	Statement of Work
Std	Standard
TIRM	Tank Inspection, Repair, and Maintenance
UD	Upper Dome
UST	Underground Storage Tank
UT	Ultrasonic Testing
XRD	X-Ray Diffraction