I. INTRODUCTION AND QUALIFICATIONS

Q. PLEASE STATE YOUR NAME, EMPLOYER, AND BUSINESS LOCATION.

A. My name is Robert Jamond and I am employed by the Naval Facilities Engineering and Expeditionary Warfare Center (NAVFAC EXWC) located at Naval Base Ventura County, California.

Q. WHAT ARE THE RESPONSIBILITIES OF YOUR CURRENT POSITION?

A. I am a Materials Engineer. I evaluate, design, and consult on cathodic protection systems and corrosion control matters for Navy and Department of Defense (DoD) Facilities throughout the world. I do field work on cathodic protection systems and conduct condition assessments of tanks, pipelines, piers, and wharves. I also conduct metallurgical analysis and corrosion resistance testing in a laboratory setting where I test materials and assess them for their performance in corrosive environments.

I serve as the Navy and DoD's primary subject matter expert for developing corrosion control programs, and for inspecting Navy and DoD facilities to resolve corrosion issues and preserve the services' infrastructure.

I serve as the Chairman of the Office of the Secretary of Defense Corrosion Policy and Oversight Office Facilities Working Integrated Product Team. The team is responsible for developing DoD corrosion control strategies for DoD facilities and infrastructure.

I also draft criteria documents known as Unified Facility Criteria and Unified Facility Guide Specifications, which are used by the military services, including the Navy, to ensure proper corrosion control measures are utilized in construction and maintenance programs.

Q. HOW LONG HAVE YOU BEEN WORKING IN THE FIELD OF CORROSION CONTROL AND CATHODIC SYSTEMS?

A. I have specialized in corrosion prevention and control since I began my career with NAVFAC EXWC in 1992. I served as a Materials Engineer for most of that period, and in 2018 the Navy promoted me to my current position as the NAVFAC Corrosion and Inspection Subject Matter Expert.

Q. WHAT IS YOUR EDUCATIONAL BACKGROUND?

A. I earned a Bachelor of Science in Materials Engineering in 1991 from California Polytechnic State University San Luis Obispo.

Q. DO YOU HOLD ANY CERTIFICATIONS OR OTHER QUALIFICATIONS?

A. I have a National Association of Corrosion Engineers (NACE) International Registered Cathodic Protection Specialist Certification. I also hold Cathodic Protection Design Specialist Qualifications from the Naval Sea Systems Command (NAVSEA), Design Specialist Qualifications. I have a Defense Acquisition Workforce Improvement Act

(DAWIA) Facilities Engineering Certification Level III, and a NACE Coating Inspector Program (CIP) Level II certification.

Q. HAVE YOU WORKED ON ANY PROJECTS THAT ARE RELEVANT TO YOUR TESTIMONY IN THIS PROCEEDING?

A. Yes. I have conducted research on electrochemical chloride extraction to rehabilitate reinforced concrete waterfront structures at Naval Base Ventura County. I have also conducted research on sacrificial anode cathodic protection to extend the life of reinforced concrete piles for Navy piers at Joint Base Pearl Harbor-Hickam in Hawaii and at Naval Station Mayport in Florida. I have performed reinforced concrete pier condition assessments and made repair recommendations at both Naval Station San Diego in California and the Puget Sound Naval Shipyard in Washington. I have conducted forensic analysis and a condition assessment of cracked steel piles at Pier 15, Naval Submarine Base New London in Connecticut.

I was the project engineer for a corrosion control program research project titled "Use of Low Cost Stainless Steel Reinforcement in Concrete." This project evaluated using corrosion resistant steel in concrete pier rehabilitation project located at Pier B3 at Joint Base Pearl Harbor-Hickman. I also led a corrosion control project repair methods for fuel piping with corrosion damage. This project involved using carbon fiber wrap material to repair corrosion damaged fuel piping at Kwajalein Atoll in the Marshall

Islands and Naval Air Station Sigonella in Italy. Additionally, I worked with a Cold Spray Metallic Coatings research project for corrosion protection. This project involved using a novel cold spray metal deposition technology to repair corrosion damaged airfield components at Point Mugu in California.

II. <u>RED HILL</u>

Q. WHAT IS YOUR INVOLVEMENT WITH THE RED HILL BULK FUEL STORAGE FACILITY (RED HILL FACILITY)?

A. I am the lead engineer for the Navy's efforts on Section 5 of the Red Hill Administrative Order on Consent (AOC) Statement of Work (SOW). The AOC applies to the Red Hill Bulk Fuel Storage Facility located at Joint Base Pearl Harbor-Hickam (the Red Hill Facility). In this role I work directly with the Navy's Red Hill Program Management Office (PMO), the U.S. Environmental Protection Agency (EPA), and the Hawaii Department of Health (DOH) (collectively the EPA and DOH are referred to as the "Regulating Agencies") to complete the Navy's requirements to evaluate the possibility and extent of corrosion and metal fatigue at the Red Hill Facility, as required under the SOW.

Q. HOW WAS THE RED HILL FACILITY CONSTRUCTED?

A. The Red Hill facility was constructed from approximately August 1940 to September 1943, and consists of twenty underground vertical cylindrical reinforced concrete fuel storage tanks (Tanks 1 - 20). The tanks have a domed top and bottom and internal steel liners, fuel piping, upper and lower tunnels, and associated infrastructure. It is a hardened facility, which means that tanks are built into the ground.

The lower dome was constructed of reinforced concrete and lined with 0.250 inch thick steel plates. The floor of the lower dome is flat and consists of 0.500 inch thick steel plates. After the barrel and lower dome were constructed, they were joined with the surrounding rock by injecting grout under pressure into the joint between the reinforced concrete and the gunite layer covering the surrounding basalt bedrock.

The reinforced concrete around the outside of the upper dome is eight feet thick at the base and gradually narrows to four feet thick at the top. The reinforced concrete surrounding the lower dome is a minimum of four feet thick except for the 20-feet diameter flat bottom plates at the center of the lower dome, which sits on top of a plug of concrete approximately 20 feet thick. The reinforced concrete surrounding the cylindrical "barrel" of the tank is an estimated minimum of 2.5 to 4 feet of concrete.

Tanks 1 through 4 are 100'-0" in diameter and 238'-6" in overall height and have a nominal storage capacity of 285,851 barrels (BBL) each. Tanks 5 through 20 are 100'-0" in diameter and 250'-6" in height and have a nominal storage capacity of 302,637 BBL each. The top of the tank upper domes are located 110 feet to 175 feet below ground. (Exhibit N-20).

Q. HOW DOES THIS TANK DESIGN PREVENT CORROSION?

A. In terms of corrosion control, the reinforced concrete provides a non-corrosive environment for the backside of the steel liner. Where the steel is in contact with the reinforced concrete, the steel forms a passive film that inhibits corrosion.

Cathodic protection[1] is not used to protect the steel liner because the steel is surrounded by concrete which is surrounded by rock. As a practical matter, the external rock and concrete prevent the application of cathodic protection to the external side of the steel plates. Passing current through the concrete could cause corrosion of the reinforcing steel and degrade the integrity of the concrete encasement around the steel tank.

[1] Cathodic protection (CP) is a technique used to control the corrosion of a metal surface by making it the cathode of an electrochemical cell. Sacrificial anode cathodic protection (SACP) systems use material that is electrochemically more active than steel such as magnesium, zinc, and aluminum. These materials form a galvanic cell when electrically connected to steel in conductive soil or water. The more active metal corrodes (discharging current), protecting the less active metal (receiving current). Impressed current cathodic protection (ICCP) uses a power source consisting of a transformer-rectifier, which provides direct current (DC) to the anode. Impressed current anodes can be graphite (carbon), high-silicon chromium cast iron, platinum-coated titanium and niobium, mixed metal oxide-coated titanium, or other materials depending upon specific applications.

Q. HOW DOES THE NAVY MANAGE CORROSION AT RED HILL?

A. The internal surfaces of the steel liner, which are in contact with the fuel, have a protective coating to control corrosion, protect the stored fuel, and prevent contamination. The interiors of the Red Hill storage tanks have been coated in their entirety, starting in 1960, with a fluoro-polyurethane coating specially developed by the Naval Research Laboratory (NRL). More recently, in 2017, the Navy developed an internal coating specification for a high performance Polysulfide Modified Novolac Epoxy. This coating is sprayed onto the interior of the tank.

For the external surfaces, the Red Hill tanks were constructed by excavating the lava rock formation to create a vault for each tank. The vault was then lined with concrete and a 0.25-inch thick steel liner (0.5 inches thick on the bottom plate). The steel in contact with the highly alkaline concrete developed a stable passive film.

In 2018, the formation of this passive film was verified qualitatively by examining the condition of several steel coupons from Tank 14. This passive film protects the steel from corrosion. If the concrete-steel bond is compromised and moisture is present, then corrosion is possible.

Q. HOW DOES THE NAVY IDENTIFY AND REPAIR CORROSION OF THE LINER?

A. The Navy has a robust inspection program called the Clean Inspect Repair (CIR) process, which it implemented in 1998. The inspection process utilizes three different state-of-the-art non-destructive testing technologies. These technologies examine the steel liner for its remaining wall thickness, and search for potential defects, but the tests do not damage or alter the condition of the structure. These testing technologies include:

- <u>Low Frequency Electromagnetic Technique (LFET):</u> LFET is a non-destructive corrosion assessment method utilizing low frequency electromagnetic energy to measure steel thickness. When the metal being scanned has a defect and the sensors are located above that defect, distortions in the magnetic field indicate the presence of the flaw. LFET instruments measure this distortion as changes in phase and amplitude. Depth of the flaw is proportional to these phase and amplitude changes. The diameter of the defect is shown by the number of sensors affected.

- <u>Balanced Field Electromagnetic Technique (BFET):</u> BFET is used to detect surface and sub-surface cracks in metals/welds. The BFET method utilizes a single element to detect surface and subsurface cracking. This probe is very sensitive to small changes in electromagnetic field, and noise is significantly reduced by appropriate phase rotation of the horizontal and vertical component of the signal. Processing is used to reduce gradual changes in the waveform to make detection easier. Defects in the surface are indications of potential weld cracks or defects.

- Phased Array Ultrasonic Testing inspection (PAUT): PAUT is a more precise and localized technique used for proving up or verifying areas where defects were identified by LFET. This means that in areas where LFET examination indicates loss of material, ultrasonic measurements are used to verify the extent of underside corrosion. The PAUT probe consists of multiple ultrasonic transducers, each of which is pulsed independently. By varying the timing, the data from multiple beams are put together to make a visual image showing a slice through the object.

These three tests collectively determine the remaining wall thickness of the steel liner. The tests identify areas where the metal thickness is below a predetermined threshold and therefore whether those areas are deemed to be actionable metal loss. For the Red Hill Facility, the acceptable thickness threshold is 0.160 inch. Anything less than 0.160 inch is actionable and requires repair.

The Navy has conducted NDE on every tank at the Red Hill Facility since 1990. This test procedure combining LFET, BFET and ultrasonic testing is an industry standard. In addition to NDE inspection of the tanks, the Navy uses visual inspection, acoustic methods (like tapping the steel liner), and removing steel coupons as quality assurance methods to identify tank corrosion.

Q. HOW DOES THE NAVY DEAL WITH ACTIONABLE METAL LOSS THAT IS IDENTIFIED USING NDE?

A. If actionable metal loss is discovered, the area of the tank with the metal loss is repaired by welding a steel plate over the area. To accomplish this, ultrasonic testing is used to identify the size of the patch required. Since the weld must be executed on sound metal, ultrasonic testing is performed at an increasing distance from the actionable metal loss area until the thickness identified is greater than 0.160 inch. At the Red Hill Facility, NDE practices have been in use since 1990.

Q. DOES THE NAVY CONDUCT NON-DESTRUCTIVE EXAMINATION ON EVERY TANK AT THE RED HILL FACILIY?

A. Yes. The Navy conducts NDE on every tank as part of a routine inspection, repair and maintenance regimen. The intent of the current tank assessment program is to clean, inspect and repair all of the Red Hill tanks with the goal of returning each tank to service for another 20-year service interval. The current approach consists of an out of service inspection of the tank interior that includes non-destructive scanning of the steel liner plates and welds for corrosion and other defects, and repair of all defects found during the inspection.

Q. HOW HAS THE NAVY IMPROVED CORROSION CONTROL FOR THE INTERIOR SURFACE OF THE RED HILL TANKS?

A. In 2015, the general Navy coating system specification was revised by NAVFAC EXWC to specify the application of high performance polysulfide interior coating to the tanks at the Red Hill Facility. This coating is highly resistant to corrosion in aggressive environments. Case studies performed on other Navy fuel tanks in various locations indicate the coating to be a better life-cycle alternative than the FPU coating.

The condition of the tank's internal protective coating is assessed during routine tank integrity inspection assessments. Assessment results dictate the need and scope of any repairs for the protective coating system. During the Clean, Inspect, Repair process, a new coating is applied after repairs to the tank are completed.

Q. WHAT IS THE NAVY'S OBLIGATION UNDER SECTION 5 OF THE AOC?

A. Section 5 of the AOC requires the Navy and DLA and the Regulating Agencies to develop a scope of work (SOW) to evaluate the possibility and extent of corrosion and metal fatigue of the tanks at the Red Hill Facility. The SOW also requires the Navy to develop best practices to control corrosion and metal fatigue of the tanks.

Q. WHAT ARE THE SPECIFIC REQUIREMENTS OF SECTION 5 OF THE AOC?

A. Section 5 of the AOC describes four lines of effort. The first line of effort was to provide an Outline of Corrosion and Metal Fatigue Practices Report. The second was to provide a Corrosion and Metal Fatigue Practices Report. The third was to conduct Destructive

Testing on at least one tank at the Red Hill Facility, and the fourth requires the Navy and DLA to develop modified corrosion and metal fatigue practices.

The Navy has developed a draft SOW which outlines further analysis, condition assessments, research efforts that will be implemented in the next two years. These efforts will provide the data and tools to continuously improve corrosion and metal fatigue practices at the Red Hill Facility.

Q. DID THE NAVY COMPLETE THE OUTLINE OF CORROSION AND METAL FATIGUE PRACTICES AND SUBMIT THE CORROSION AND METAL FATIGUE PRACTICES REPORT TO THE REGULATING AGENCIES?

A. Yes. On 13 January 2016, the Navy completed the Outline of Corrosion and Metal Fatigue Practices Report. (Exhibit N-19). On 4 April 2016, the Navy completed the Corrosion and Metal Fatigue Practices Report and submitted it to the Regulating Agencies. (Exhibit N-20). On June 30, 2016, the Regulating Agencies approved the Navy's Corrosion and Metal Fatigue Practices Report. (Exhibit N-21). The purpose of this Corrosion and Metal Fatigue Practices Report was to describe current practices to control corrosion of the tanks and evaluate the possibility and extent of metal fatigue at the Red Hill Facility in accordance with the AOC and its SOW. This report includes an explanation of the current practices for assessing the condition of the tanks and associated fuel containment infrastructure, including Current Corrosion Assessment Practices, Tank

Construction Features – Effects on Corrosion Control and Assessment Practices, Cathodic Protection, Internal Protective Coating, Tank Integrity Assessment, Metal Fatigue Design Considerations, and Historical Records. The report also describes recordkeeping relating to corrosion and metal fatigue practices at the Red Hill Facility.

Q. DID THE NAVY CONDUCT DESTRUCTIVE TESTING ON AT LEAST ONE TANK?

A. Yes. In 2018, the Navy conducted destructive testing on Tank 14 in 2018. The purpose of the destructive testing was to validate the findings of the Navy's NDE results with destructive lab testing to measure the corrosion pits on each steel coupon. The analysis of the destructive tests used a calibrated metallurgical microscope and compared the results with the NDE testing results, which the Navy obtained at the exact location.

In total, the Navy removed 10 pieces of steel from Tank 14. Each coupon was 12 inches by 12 inches in size. (Exhibit N-24).

Q. WHY DID THE NAVY CHOOSE TANK 14 FOR DESTRUCTIVE TESTING?

A. Tank 14 was selected because it was undergoing the Navy's Clean, Inspect, Repair process and was out of service at the time. Therefore, the inspection and the non-destructive testing had recently been completed on the tank. (Exhibit N-23).

Q. HOW DID THE NAVY CHOOSE THE 10 COUPON LOCATIONS?

A. Selection of coupon locations was based on scanning data from the three non-destructive test methods utilized – Low Frequency Electromagnetic Technique (LFET), Balanced Field Electromagnetic Technique (BFET), and Phased Array Ultrasonic Testing (PAUT). Target areas were chosen to provide representative sampling of a range of reported reductions in wall thickness, pitting, and weld defects.

After the non-destructive LFET scan inspections were conducted, a Navy contractor, under Navy direction, conducted a prove-up and inspection, per normal tank inspection procedures. A prove-up inspection is performed in areas where LFET examination indicated loss of material. Using PAUT, the ultrasonic measurement back up was then performed to verify the extent of underside corrosion. The Navy then reviewed the inspection results and determined proposed coupon locations in accordance with the screening criteria.

Q. WHAT DID NON-DESTRUCTIVE TESTING (NDE) PREDICT ABOUT THE CONDITION OF EACH COUPON?

A. Per Exhibit N-25, the expected conditions of the coupons as predicted by NDE are detailed below:

Coupon 1 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 PAUT indicated a minimum wall thickness of 0.112 inch.

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 PAUT indicated a minimum wall thickness of 0.150 inch.

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

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.

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.

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 using PAUT indicated a minimum wall thickness of 0.135 inch.

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)

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)

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.

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.

Q. WHY DID THE NAVY AND THE REGULATING AGENCIES SAMPLE ONLY 10 COUPON LOCATIONS?

A. The coupons were not selected with the intent to characterize the overall condition of the tank, but instead to field-test the NDE findings. To meet this goal, areas displaying a range of characteristics identified by the NDE were selected. With input from the Regulating Agencies and their engineers, the Navy selected coupons that NDE indicated could have isolated pitting, general corrosion, pitting with general corrosion, and no corrosion.

Q. WAS THERE AGREEMENT BETWEEN THE NAVY AND THE REGULATING AGENCIES ON ALL 10 COUPON LOCATIONS?

A. Yes, the Navy presented a complete scan data spreadsheet for Tank 14 and proposed coupon locations to the Regulating Agencies for review and comment. Final coupon selection was performed at face-to-face meetings between the Navy and the Regulatory Agencies in March 2018, and documented in the Red Hill Destructive Testing Plan Supplement dated 1 June 2018. (Exhibit N-26). Coupons A1 and A2 were alternate coupon locations that were agreed upon by the Navy and the Regulating Agencies in the event that a coupon could not be removed due to accessibility or proximity to a weld or any other reason. They were tested because Coupons 4 and 9 could not be removed.

Q. WHO PERFORMED THE DESTRUCTIVE TESTING?

A. For the onsite evaluation, NAVFAC EXWC personnel were present and conducted the testing. The laboratory testing was completed by IMR Test Labs – Louisville, which is accredited to ISO 17025 by the American Associate for Laboratory Accreditation (A2LA), Certificate #1140-03 and 1140-04.

Q. WHAT ON-SITE OBSERVATIONS WERE COLLECTED DURING THE DESTRUCTIVE TESTING?

A. See Exhibit N-27. Coupons 2, 3, 7 and A1 had some moisture present and corrosion products were identified. No fuel or fuel odors were detected. These findings were included in the Destructive Testing Report, Exhibit N-40.

Q. WHAT DOES THIS INFORMATION INDICATE ABOUT THE TANK LINER?

A. The presence of moisture indicated there is potential for corrosion to occur or continue. The presence of corrosion product indicated that some corrosion had occurred. The absence of fuel odor indicated that no fuel was present on the exterior surface of the steel liner and no fuel was present on the concrete.

Q. DID THE NAVY EVALUATE THE CONCRETE BEHIND THE COUPONS?

A. Yes. Concrete powder samples were taken from the surface of the concrete. These samples were taken to measure the chloride content of concrete at the liner-concrete interface and to measure the pH of the powder samples.

The Navy observed and measured any void spaces between the concrete and the liner in the area surrounding each coupon site. It checked these areas to determine if the material behind the coupons taken was grout or concrete. The Navy also measured the pH at the concrete surface, which can affect the corrosion rate of steel in contact with the concrete. The Navy also tapped into the concrete with a hammer to see if any delamination or unsound concrete was found and found none in the areas tested.

Q. WHAT WAS THE CONDITION OF THE CONCRETE BEHIND THE STEEL LINER?

A. On-site and laboratory testing of concrete powder samples behind the steel tank liner did not reveal any indications of concrete cracking, concrete spalling or otherwise unsound concrete.

The chloride content of the powder samples ranged 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 were well below this threshold. This means that neither chloride-induced corrosion on the liner nor on the concrete reinforcing is to be expected.

Q. WHAT DID THE CONCRETE TESTING INDICATE?

A. 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, cracks or delamination were detected in the concrete behind the coupons. The concrete was found to be in good condition. On-site testing of surface pH showed values ranging up to 12.5, while laboratory measured values of pH from concrete powder extracted from the concrete behind each coupon ranged from 9.9 to 11.8. The difference may be attributable to contamination of powder specimens with corrosion products. However, all specimens tested in the alkaline range and are able to help protect the steel liner from corrosion.

The Navy identified some separation between the liner and the concrete behind Coupons 1, 3, 5, 8, A1 and A2.

Coupons 2, 3, 7 and A1 had some moisture present. This means that the external sides of these coupons were damp when extracted from the tank.

Q. WHAT LABORATORY TESTS WERE CONDUCTED ON THE STEEL COUPONS?

A. See Exhibit N-32. The Navy submitted the 10 coupons to IMR Test Labs – Louisville which is accredited to ISO 17025 by the American Association for Laboratory Accreditation (A2LA), Certificate #1140-03 and 1140-04. The coupons were first photographed with a standard high resolution camera. Then the lab noted visual observations and dimensional measurements.

The lab performed a metallurgical and chemical analysis of the coupons using an electron microscopy (SEM) with energy dispersive X-ray analysis (EDXA) to obtain chemical analysis of general-corrosion products on each coupon's back surface.

Each coupon also underwent a chemical analysis for any coatings to determine coating type.

Each coupon had a complete elemental analysis of the steel to determine American Iron and Steel Institute (AISI) steel type. The results indicated that the steel tank liner was made from steel that generally conformed to ASTM A36 specification. This type of steel is compatible with fuel storage.

The coupons then underwent a microscopic examination of surfaces, before and after they were cleaned, to characterize the surface condition with any corrosion products present and the amount of corrosion damage present after the corrosion products were removed.

The hardness of the coupons was measured by using a Rockwell Hardness Tester in accordance with ASTM E18-17e1. The hardness of the coupon is an indication of the tensile strength of the steel liner.

The lab also tested each coupon to establish yield strength, ultimate tensile strength, and ductility. Tensile testing provides the mechanical properties of the steel liner. The yield strength is the stress value at which the steel liner will deform and not return to its original shape (plastic deformation). The tensile strength is the stress at which fracture of the steel will occur. Ductility is a measurement of how much the steel liner deforms before fracturing. ASTM A36 steel has strength, formability, and excellent welding properties that make it suitable for a large variety of applications, including welding, fabricating, and bending. ASTM A36 steel is easy to weld using any type of welding methods, and the welds and joints that are formed are of excellent quality. The excellent ductility and damage tolerance means that it will not fail catastrophically because the steel will deform to significant degree and not crack suddenly.

Lastly, the testing included chemical analysis of the substrate inside pit areas using Energy Dispersive X-ray Spectroscopy (EDXA) to identify the chemical content of the corrosion products inside the pit.

Q. WAS ANY METAL FATIGUE IDENTIFIED?

A. To date, there has been no data to suggest there are any metal fatigue issues in the tanks. If the steel plates ever experienced cyclic loads or stresses, fatigue would be expected to accumulate in cracks in the tank steel plate welds.

NDE weld examination results for the entirety of Tank 14 showed that no linear indications of fatigue were found. No linear weld indications have been found during any Red Hill tank inspection conducted in recent years. Therefore, metal fatigue has not been identified as an issue in the steel tank liners at the Red Hill Facility.

Q. HOW WELL DID THE DESTRUCTIVE TESTING MATCH THE NDE FINDINGS?

A. Coupon 1 was found to have less metal loss than what was identified by the non-destructive examination. The LFET non-destructive examination identified 0.147 inch minimum remaining thickness. PAUT prove-up identified 0.112 inch remaining thickness. The lab measured a minimum remaining thickness of 0.208 inch.

Coupon 7 also had less metal loss than the non-destructive examination identified. The LFET minimum screening thickness was 0.157 inch. The prove-up thickness taken with the PAUT indicated the coupon had 0.135 inch, which would have required repair. The destructive lab testing identified a minimum wall thickness of 0.164 inch. The remaining wall thickness was within the 20-mil range but thicker than expected for the prove-up testing.

Coupon 3 had less metal loss than LFET indicated, but more than PAUT indicated. LFET identified a minimum wall thickness of .033 inch, but follow-up testing with PAUT failed to confirm this metal loss. The destructive testing results identified a minimum wall thickness of 0.1315 inch.

LFET testing for Coupon 6 indicated remaining metal that was above 0.200 inches, so no PAUT testing was done. The destructive testing for Coupon 6 identified 0.1579 of an inch remaining thickness at the thinnest point of the coupon, just 0.0021 of an inch less than the action threshold of 0.160 inch. LFET does not always detect extremely small volume pits like this one.

Coupons 2, 5, 8, 10, A1 and A2 had measured thicknesses consistent with what was found using NDE.

Coupon 2: The LFET minimum screening thickness found was 0.157 inch. Therefore, a repair was specified in this area. Backside pitting corrosion was expected. Later prove-up with PAUT indicated an expected minimum remaining wall thickness of 0.150 inch. Destructive testing showed pitting and minimum wall thickness of 0.1524 inch.

Coupon 5: NDE indicated a minimum wall thickness of 0.1600 of an inch and destructive testing showed that it was 0.2240 inch.

The NDE of Coupon 8 indicated a minimum wall thickness of 0.2000 of an inch and destructive testing showed that it was 0.2067 inch.

The NDE of Coupon 10 indicated a minimum wall thickness of greater than 0.200 of an inch, and destructive testing showed that it was 0.2417 inch.

The NDE of Coupon A1 indicated a minimum wall thickness of greater than 0.134 of an inch, and destructive testing showed that it was 0.1224 inch.

The NDE of Coupon A2 LFET indicated a minimum thickness of 0.161 inch. The prove-up testing showed that the thickness was greater than the repair threshold of 0.160 inch. Destructive testing showed that it was 0.2468 inch.

Q. DO THE COUPON 6 AND COUPON 3 RESULTS INDICATE SIGNIFICANT RISK OF CORROSION?

A. No. The likelihood that this single small pit, which was smaller than the non-destructive examination equipment could detect and had more than 64% metal thickness remaining after 75 years in service, would corrode all the way through the liner before the next inspection is extremely low. The original thickness of the steel plate was 250 mils, and the current metal thickness is 158 mils, indicating a total loss of 92 mils. Assuming a constant rate of corrosion between the original construction of the tank in 1943 and coupon removal in 2018 (75 years), the highest corrosion rate occurring at any point on Coupon 6 is 1.23 mils per year (mpy). Therefore, in 2038, when the tank is scheduled to be re-inspected, at least 0.133 inches are expected to remain at that point on Coupon 6, which is more than the minimum allowable thickness of 0.100 inch prescribed by API 653. There was no evidence of accelerated corrosion at Coupon 6.

Coupon 3 was the only coupon for which destructive testing showed actionable metal loss and the non-destructive examination did not. For Coupon 3, the LFET identified a minimum wall thickness of .033 inch, which was actionable. Follow-up testing with PAUT failed to confirm this metal loss. However, NDE found actionable metal loss in an adjacent area, which would have resulted in the detection and repair of the damage at Coupon 3 when ultrasonic testing was used to identify sound metal for welding during the repair process.

Q. HOW DID THE REGULATING AGENCIES RESPOND TO THE DESTRUCTIVE TESTING RESULTS?

A. On March 16, 2020, the Regulating Agencies responded to the Navy's Destructive Testing Results Report (DTRR), Exhibit N-44. The Navy and the Regulating Agencies subsequently met to discuss future efforts to improve the NDE protocol and evaluate the need for any further destructive testing to address deficiencies to evaluate proposed improvements to the NDE. (Exhibit N-86). The Regulatory Agencies conditionally approved the DTRR on July 7, 2020 under an agreement that the Navy and DLA will work to identify and implement practicable improvements to the NDE process, with the specific goal of defining performance objectives that are protective of human health and the environment. (Exhibit N-79).

Q. WHAT ARE THE NEXT STEPS UNDER THE AOC SOW 5.3.2?

A. Based on the results from the Destructive Testing under Section 5.3, the Navy and the Regulatory Agencies agree there is a need for further evaluation of practices to control corrosion or metal fatigue, which is the next step, Section 5.4, contemplated in the AOC. The purpose of AOC Section 5.4 is to improve the current inspection process in the AOC SOW Section 2.4 Tank, Inspection, Repair and Maintenance (TIRM) Decision Document, dated 24 April 2017. The goal agreed upon by the Regulatory Agencies and Navy is an improved TIRM process that ensures no releases will occur during the service interval between Clean, Inspect, and Repair events.

Under the Section 5.4 Execution Plan, the Navy will conduct the following efforts:

Navy/DLA Interpretation of the Coupon Results. This study will address the significance of field NDE results versus laboratory results, the significance of false positives and false negatives, the scale of damage mechanism, and the accuracy and precision of NDE, and the reliability of the NDE process.

Preliminary Liner Corrosion Assessment. This study will address the potential for increased rates of corrosion, the potential for weld stress due to crevice corrosion in the gap between the steel liner and a new patch plate, rainfall effects on Red Hill metal liners factor of safety, and corrosion rates.

Preliminary Concrete Assessment. This study will address additional analyses on the condition of the concrete structure and embedded reinforcing steel.

Concrete Tank Degradation Inspection and Retrofit. The objectives of this portion (secondary containment-corrosion in concrete) are to 1) identify the locations and extent of cracking/degradation of the concrete and steel structure surrounding the oil tanks, 2) understand the causes and mechanism of the concrete and steel degradation based on chemical and mineralogical analysis, and 3) propose appropriate retrofitting technologies and strategies.

Element, Phase, and Oxidation State Mapping of Red Hill. This study will attempt to distinguish between recent and historic corrosion, and will be performed by the Advanced Electron Microscopy Center at University of Hawaii (UH).

UST Corrosion by Advanced Microscopy Methods. This UH study will address: 1) The limits of nondestructive evaluation on severely corroded steel panels with adherent corrosion products, 2) develop protocols to measure in situ corrosion rates of steel panels that can be used for the Red Hill USTs, and 3) evaluate repair and patch protocols to prevent premature failures.

Inspection Data, LFET, and Step 2 Analysis. This study will address: probability of detection, changes and refinements to LFET, changes to Step 2 prove-ups (PAUT or another technology), and develop a list of known NDE techniques and their applicability to the Red Hill Facility.

Executed this 25th day of November, 2020 at Ventura County, CA.

__/s/_ Robert Jamond_____________

Robert Jamond

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Robert Michael Jamond

Robert Michael Jamond
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Highest Clearance: Secret

Education and Registration

Bachelor of Science Materials Engineering
California Polytechnic State University, San Luis Obispo 1991
NACE International Registered Cathodic Protection Specialist Certification # 8224
NAVSEA Cathodic Protection Design Specialist Qualification
DAWIA Certification Level III
NACE International Coating Inspector CIP Level II

Work Experience:

Corrosion Control and Inspection Subject Matter Expert (2018 to present)
Naval Facilities Engineering and Expeditionary Warfare Center (NAVFAC EXWC)

- SME Consultation on Corrosion, Coatings and Materials
- Cathodic Protection Testing, System Evaluation, Troubleshooting, Consultation and Design
- Material Characterization - Mechanical Testing of Metals and Composites, Metallurgical Analysis, and Corrosion Resistance Testing
- Condition Assessments of Navy Piers and Wharves
- Criteria Documents UFC, UFGS - Modifications, Updates, Reviews
- Coating System Specifications, Inspections, and Failure Analysis
- Lead for Red Hill AOC Section 5 – Interface with Red Hill Program Office and Regulators
- OSD Corrosion Policy and Oversite Office Facilities WIPT Team Member
- Principal Investigator for OSD CPO Funded Corrosion Research Projects

1991 to 2018: Materials Engineer
Naval Facilities Engineering and Expeditionary Warfare Center (NAVFAC EXWC)

- Corrosion Control of Waterfront Facilities Division, Design of Cathodic Protection Corrosion Control Systems.
- Materials Research, Testing and Evaluation.
- Corrosion and Cathodic Protection Surveys at Navy Activities Worldwide
- Prepare Materials Specifications for Waterfront Facilities Applications.
- Design Concrete Structure and infrastructure repair and rehabilitation strategies.
- Field assistance consultations for materials selection and corrosion mitigation efforts.

2016 to 2018 Work Experience

DLA-E Cathodic Protection Program.

Provided support for this centrally funded cathodic protection program. I conducted surveys, analyzed systems, developed repair strategies and prepared cost estimates of POL facilities worldwide.

Red Hill Tank Farm Administrative Order on Consent Section 5 Destructive Testing Lead

Served as lead for the destructive testing section on the Red Hill Tanks Farm assessment. Stated objectives: 1) Validate the continued use of the NDE process at Red Hill as well as other tanks in the Department of Defense and industry, 2) Characterize steel material, 3) Analyze corrosion rate calculation procedures and recommend improvements as warranted, 4) Evaluate results against current corrosion mitigation practices, 5) Work with the EPA and other regulatory agencies to devise strategies to properly evaluate destructive testing results.

CNIC Cathodic Protection Program.

Provided support for this centrally funded cathodic protection program. I conducted surveys, analyzed systems, developed repair strategies and prepared cost estimates of CNIC facilities worldwide.

North VLF Array Towers NCTAMS LANT DET Cutler Coating Evaluation and Analysis.

Performed coating and corrosion evaluation of towers exhibiting accelerated coating failures. Provide recommendations on improved coating repair application procedures in this technically challenging configuration.

USMA West Point Natural Gas System CP System Survey and Design

Performed cathodic protection survey and designed cathodic protection system to mitigate corrosion for natural gas pipeline. I provided specifications and cost estimate.

OSD Corrosion Office Support

Represented NAVFAC at the OSD level by participating in OSD Corrosion Program forums. This includes participation on the working integrated product teams for Facilities and Outreach & Communications. We worked to implement innovative corrosion control technologies into Unified Field Criteria Guide Specifications.

DLA-E CP CMP Program Support and COR for CP Construction Contract

Designated the Contracting Officers Representative and managed two GPOL construction task orders for cathodic protection repairs. I performed cost estimating and source evaluation and selection. Once contract was awarded, I performed project management, evaluated safety plans, processed invoices and wrote evaluations in CPARS.

San Clemente Island Maritime Offshore Test Bed Ground Bed Design

Teamed with CIO FP1 division in designing and developing installation procedures for the at-shore DC ground system for their system test array. I am transitioning into a large role to provide consultation and on-site technical support for future ground bed installations.

Tall Tower Diagonal Connection Nut Corrosion Coating and Metallurgical Analysis

Performed corrosion and failure analysis of tower connection bolts that were identified to be heavily corroded during a contractor performed tall tower inspection.

Corrosion and Metallurgical Assessment USAMRIID Steam Sterilization Plant Fort Detrick, MD.

Performed metallurgical analysis to determine cause and severity of corrosion. Recommend short-term and long-term solutions. I recommended materials selection and corrosion monitoring techniques.

Manage and execute OSD Corrosion Control Water Storage Tank Galvanic Anode Cathodic Protection (GCP) Controller

Lead investigation on novel cathodic protection system. This project utilizes automatic controller for sacrificial anode corrosion control system control water storage tank interiors. We installed, tested and performed system modifications. Guide specifications were updated to include this new technology for broader Navy implementation. I transitioned this technology to other Navy installations.

Materials, Corrosion Engineering, and Laboratory Testing

Provided ongoing engineering field assistance and failure analysis and materials testing throughout the year to customers in NAVFAC, POL, Utilities, and NAVSEA.

Work experience prior to 2016

Conducted OSD funded research on electrochemical chloride extraction to rehabilitate reinforced concrete waterfront structures.

Conducted OSD funded research on sacrificial anode cathodic protection to extend life of reinforced concrete piles for Navy piers.

Performed reinforced concrete pier condition assessments and made repair recommendations

Conducted forensic analysis and condition assessment of cracked steel piles at Pier 15, Naval Submarine Base New London.

Project Engineer for Office of Secretary of Defense funded Corrosion Control Program Research Projects: 1) Use of Low Cost Stainless Steel Reinforcement in Concrete. 2) Corrosion Control Project Repair methods for POL piping with corrosion damage. 3) Cold Spray Metallic Coatings for corrosion protection.

Provided field assistance in corrosion, materials selection and failure analysis for Navy activities worldwide