Electrochemical Investigation of Corrosion in the Space Shuttle Launch Environment

L.M. Calle[a,*], M.R. Kolody[b], R.D. Vinje[b]

[a]*National Aeronautics and Space Administration (NASA), YA-C2-T, Kennedy Space Center, Florida USA*
[b]*ASRC Aerospace Corp., ASRC-15, Kennedy Space Center, FL 32899*

Abstract

Corrosion studies began at NASA/Kennedy Space Center in 1966 during the Gemini/Apollo Programs with the evaluation of long-term protective coatings for the atmospheric protection of carbon steel. An outdoor exposure facility on the beach near the launch pad was established for this purpose at that time. The site has provided over 35 years of technical information on the evaluation of the long-term corrosion performance of many materials and coatings as well as on maintenance procedures. Results from these evaluations have helped NASA find new materials and processes that increase the safety and reliability of our flight hardware, launch structures, and ground support equipment. The launch environment at the Kennedy Space Center (KSC) is extremely corrosive due to the combination of ocean salt spray, heat, humidity, and sunlight. With the introduction of the Space Shuttle in 1981, the already highly corrosive conditions at the launch pad were rendered even more severe by the acidic exhaust from the solid rocker boosters.

Over the years, many materials have been evaluated for their corrosion performance under conditions similar to those found at the launch pads. These studies have typically included atmospheric exposure end evaluation with conventional electrochemical methods such as open circuit potential (OCP) measurements, polarization techniques, and electrochemical impedance spectroscopy (EIS).

The atmosphere at the Space Shuttle launch site is aggressive to most metals and causes severe pitting in many of the common stainless steel alloys such as type 304L stainless steel (304L SS). A study was undertaken to find a more corrosion resistant material to replace the existing 304L SS tubing. This paper presents the results from atmospheric exposure as well as electrochemical measurements on the corrosion resistance of AL-6XN (UNS N08367) and 254-SMO (UNS S32154). Type 304L SS (UNS S30403) was used as a control. Conditions at the Space Shuttle launch pad were simulated by using a hydrochloric acid (HCl) and alumina (Al_2O_3) slurry rinse for the atmospheric exposure and an electrolyte consisting of 3.55% sodium chloride (NaCl) with increased concentrations HCl for the electrochemical measurements. The results from both types of measurements revealed the superior corrosion performance of the higher-alloyed materials. Unlike 304L SS, 254-SMO and AL-6XN exhibited a significantly improved resistance to corrosion as the concentration of hydrochloric acid in the 3.55% NaCl electrolyte solution was increased.

Keywords: 304L, AL-6XN, 254-SMO, stainless steel corrosion, EIS.