Executive Summary

This report presents the conceptual design of an inspection system for MPCs. The inspection system is capable of determining surface cracks or deformities on the MPC through the use of non-destructive testing, with a detection focus on areas prone to stress corrosion cracking. In addition, the system meets secondary objectives which include the following: accessing all regions of the MPC, shielding personnel and equipment from radiation, passively cooling the MPC, and cleaning the MPC before and after inspection.

The MPC is a cylindrical structure composed of Alloy X (Type 316, 316LN, 304, 304LN S.S.). The MPC structure is enclosed by circumferential welds at its center, top, and bottom, along with vertical welds spanning the height of the MPC. Due to a heightened presence of chloride near marine environments, chloride-induced stress corrosion cracking can become problematic. As the canister cools over time, the probability of deliquescence on the outer surface of the MPC increases. Of particular concern for stress corrosion cracking is the lower portion of the MPC, as it is subjected to bear significant weight and contains several welds. The cracks originate on the outside diameter of the MPC since the MPC being backfilled with helium gas. Left unattended, stress corrosion cracks can propagate over time and negatively affect the structural integrity of the MPC. An effective method to detect the presence of cracks and deformations is necessary to prevent crack propagation and ensure that the fuel inside of the MPC is confined.

Several non-destructive inspection techniques were considered for the outer surface inspection of the MPC. The effectiveness and safety of the inspection technique in crack and deformity detection was of the utmost importance. Other parameters like ease of use, durability, ease of storage, and cost effectiveness were also taken into consideration. The inspection techniques of particular interest were eddy current testing, magnetic particle detection, ultrasonic testing, liquid penetrant testing, and guided wave testing. Each of the methods was examined carefully, listing of positive and negative aspects along with a parameter weighting matrix select the best method.

Analysis yielded a combination of liquid penetrant testing, ultrasonic testing, and guided wave testing as the best non-destructive inspection options. Each of the three inspection techniques selected offers attributes that complement the geometry of the MPC. Liquid penetrant testing provides a preliminary visual inspection and location method for deformities on the outer surface of the MPC. Ultrasonic testing provides more specific information about an identified crack or deformity, including size, depth, and orientation. Guided wave testing offers limited wave energy loss, allowing the technique so penetrate several inches of dense material. For this reason, guided wave testing has been selected to inspect the bottom surface of the MPC. These three methods can effectively and safely determine the presence of surface cracks and deformities when used in conjunction with one another. The three methods also successfully inspect the areas on the MPC most susceptible to stress corrosion cracking, a primary objective of the inspection system design. The inspection system, called the InSpec360, is designed to include one foot of shielding and cooling vents to promote vertical flow through the use of natural convection. The shielding and passive cooling of the InSpec360 ensure worker safety and effective heat management of the MPC. The inspection system meets the design objectives of the project. For the successful implementation of an operational InSpec360, some areas of the system would require future work and development. Some of these areas include the following: a transfer cask mating mechanism, power supply, fluid controls, drive system, and crack mapping for the support structure containing the non-destructive technologies.