Title: Summary of Activities for Nondestructive Evaluation of Insulation in Cryogenic Tanks

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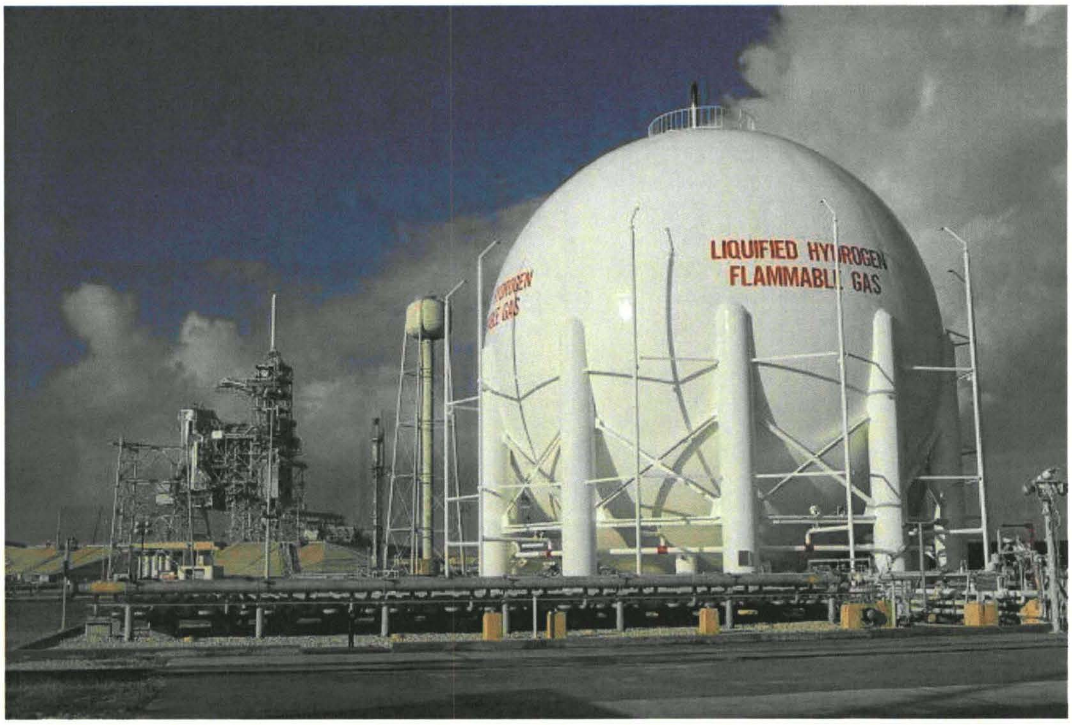
Description: This project was undertaken to investigate methods to non-intrusively determine the existence and density of perlite insulation in the annular region of the cryogenic storage vessels, specifically considering the Launch Complex 39 hydrogen tanks at Kennedy Space Center. Lack of insulation in the tanks (as existed in the pad B hydrogen tank at Kennedy Space Center) results in an excessive loss of commodity and can pose operational and safety risks if precautions are not taken to relieve the excessive gas build-up. Insulation with a density that is higher than normal (due to settling or compaction) may also pose an operational and safety risk if the insulation prevents the system from moving and responding to expansions and contractions as fluid is removed and added to the tank.

In the first two years of the project thermal imaging, using the sun as the thermal heat source with and without cryogenic fluid in the tank, was demonstrated as a useful tool for determining the underlying mechanical structure of the tank and for identifying locations of large insulation voids. It was shown that large insulation voids were detectable even in a tank with no cryogenic fluid in it due to the slight temperature differences cause by day to night cycling.

In the last half of the project a method for determining insulation density without having to cut into the tank and take a physical sample was explored. The proposed technique, prompt gamma neutron activation analysis, uses a neutron source to irradiate an area of the tank. The neutrons produced would penetrate through the steel walls of the tank and the total count and energy of the gamma rays produced by the interaction of the neutrons with the steel walls and the perlite insulation would be measured. The gamma ray information could then provide data on the composition and density of the materials within the tank. This technique is often employed in the petroleum and cement industries to evaluate sediments and measure water (hydrogen) content, and so there was firm footing for investigating the applicability of the technique to KSC concerns.

The initial Monte Carlo calculations indicated that the total inelastic gamma ray count rate showed significant response to variations in the perlite density. The size of the variation of inelastic gamma ray count rate from the Monte Carlos simulations of the tank configuration was about 28% between full void and full compacted perlite. This variation is very large compared to the differences usually considered acceptable for measurements of density (typically 1-2% is considered reasonable). Experiments were performed at Goddard Space Flight Center with a test fixture to mimic the geometry of the cryogenic tanks at Kennedy Space Center. In all experimental tests a positive count increase was seen when perlite was contained in the test fixture compared to the void condition. However, it would be prudent to perform more Monte Carlo simulations and experimental testing to increase the confidence level of being able to discriminate density variations prior to any tank inspection.

The goal of the overall project was achieved by providing various methods for inspecting the health of cryogenic tanks. The results directly supported decisions concerning the extent of refurbishment required for the Launch Complex 39 Pad B hydrogen tanks made under the Constellation program. These techniques can also be used to support future programs as additional cryogenic tanks will be needed to support heavy launch vehicle fuel needs.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