Measurement of Insulation Compaction in the Cryogenic Fuel Tanks at Kennedy Space Center by Fast/Thermal Neutron Techniques

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Abstract

The liquid hydrogen and oxygen cryogenic storage tanks at John F. Kennedy Space Center (KSC) use expanded perlite as thermal insulation. There is evidence that some of the perlite has compacted over time, compromising the thermal performance and possibly also structural integrity of the tanks. Therefore an NDT method for measuring the perlite density or void fraction is urgently needed. Methods based on neutrons are good candidates because they can readily penetrate through the 1.75 cm outer steel shell and through the entire 120 cm thickness of the perlite zone. Neutrons interact with the nuclei of materials to produce characteristic gamma rays which are then detected. The gamma ray signal strength is proportional to the atomic number density. Consequently, if the perlite is compacted then the count rates in the individual peaks in the gamma ray spectrum will increase. Perlite is a feldspathic volcanic rock made up of the major elements Si, Al, Na, K and O along with some water. With commercially available portable neutron generators it is possible to produce simultaneously fluxes of neutrons in two energy ranges: fast (14 MeV) and thermal (25 meV). Fast neutrons produce gamma rays by inelastic scattering which is sensitive to Fe and O. Thermal neutrons produce gamma rays by radiative capture in prompt gamma neutron activation (PGNA) and this is sensitive to Si, Al, Na, K and H. Thus the two energy ranges produce complementary information. The R&D program has three phases: numerical simulations of neutron and gamma ray transport with MCNP software, evaluation of the system in the laboratory on test articles and finally mapping of the perlite density in the cryogenic tanks at KSC. The preliminary MCNP calculations have shown that the fast/thermal neutron NDT method is capable of distinguishing between expanded and compacted perlite with excellent statistics.