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## Thermographic Methods of detecting insulation voids in large cryogenic tanks

Four very large (900Kgal) cryogenic liquid hydrogen and oxygen storage tanks at Kennedy Space Center's LC-39 launch pads were constructed in 1965 to support the Apollo/Saturn V Program and continue to support the Space Shuttle Program. These double-walled spherical tanks with powdered insulation in the annular region, have received minimal refurbishment or even inspection over the years. Intrusively inspecting these tanks would mean a significant down time to the program as the cryogenic liquid and the perlite insulation would have to be removed which would be a significant task and long-term schedule disruption.

A study of the tanks was performed to determine the extent to which performance and structural information could be revealed without intrusive inspection. Thermal images of the tanks were taken over a variety of environmental conditions to determine the best conditions under which to compare and use thermography as a health monitoring technique as the tanks continue to age. The settling and subsequent compaction of insulation is a serious concern for cryogenic tanks. Comparison of images from the tanks reveals significant variations in the insulation in the annular regions and point to the use of thermography as a way to monitor for insulation migration and possible compaction. These measurements, when combined with mathematical models of historical boil-off data provide key insight to the condition of the vessels. Acceptance testing methods for new tanks, before they are filled with cryogenic commodity (and thereby thermally cycled), are needed and we explore how thermography can be used to accomplish this.

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