# KSC Corporate S&MA Project Status Report
# FY 2009 Project Review

## Task
Developing NDE Techniques for Large Cryogenic Tanks

## Center Point of Contact
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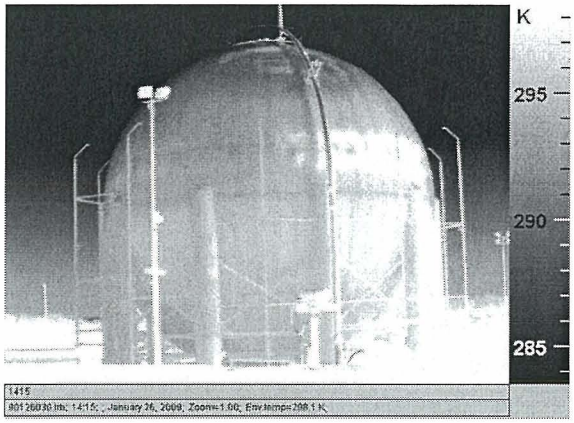
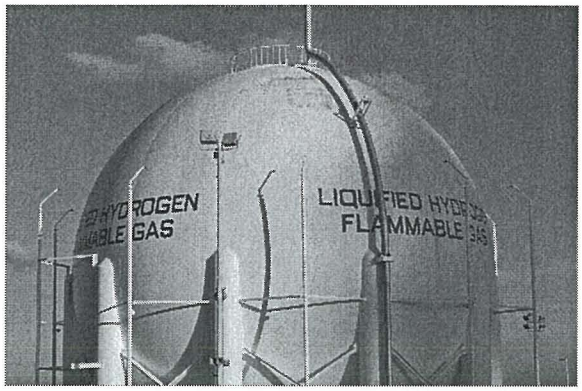
## Objective
- Develop NDE techniques to detect problems early in existing large cryogenic storage tanks so that corrective actions can be scheduled
- Explore the use of NDE techniques as acceptance testing methods to apply when new tanks are constructed, as planned, for the Constellation program.

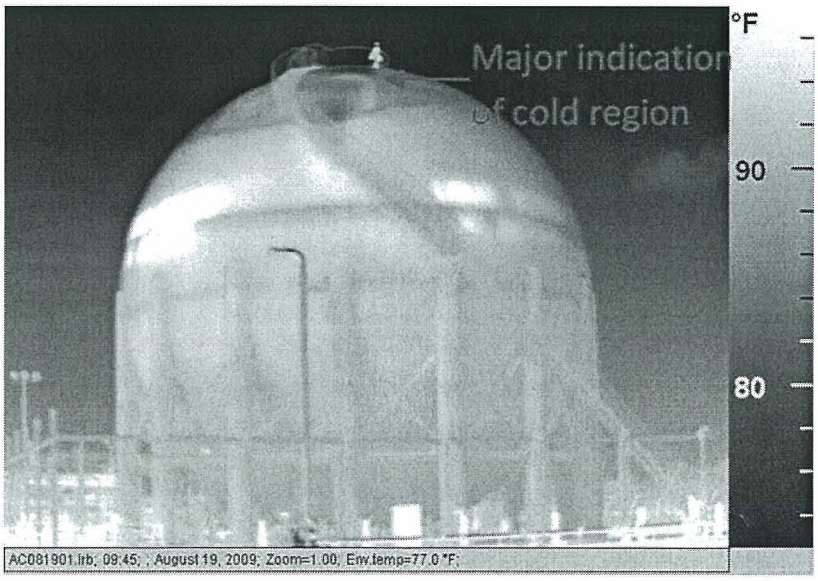
## Background
The Shuttle and Constellation Programs require very large cryogenic ground storage tanks in which to store liquid oxygen and hydrogen. The existing LC-39 pad tanks, which will be passed onto Constellation, are 40 years old and have received minimal refurbishment or even inspection, because they can only be temperature cycled a few times before being overhauled (a costly operation in both time and dollars). Numerous questions exist on the performance and reliability of these old tanks which could cause a major Program schedule disruption. Consequently, with the passing of the first two tanks to Constellation to occur this year, there is growing awareness that NDE is needed to detect problems early in these tanks so that corrective actions can be scheduled when least disruptive.

## Approach
- Time series thermal images of two sides of the Pad B LH2 tank have been taken over multiple days to demonstrate the effects of environmental conditions to the solar heating of the tank and therefore the effectiveness of thermal imaging. The two pictures below show the Pad B LH2 tank in the infrared and in the visible. Both show the cold spot at the top of the tank, a location where a suspected void in insulation exists. In the visible image this spot is dark due to growth of mold over an area that stays wet from condensation. In the IR image it is cold around the edges, but warmer at center due to the presence of the mold. Also, in the IR image the internal support structures are visible, due to solar heating. As the sun rises the tank warms, the plate steel heating first except where underlying steel beams increase the heat capacity, causing a delay in the heating process.




- Thermal imaging of a simulation tank has been performed to demonstrate the benefits of external insulation applied over internal insulation void areas. Embrittlement issues with the Pad B LH2 outer sphere tank material prevent this method from effectively reducing boil-off of LH2 in this tank due to limiting temperature specification of the carbon steel. Thermal imaging of a simulation tank to has been performed to demonstrate the benefits of external insulation applied over internal insulation void areas.
- A math model has been developed to explain the effect of the possible insulation void which seems to verify the existence of the void based on detailed analysis of liquid level records over many years.
- Imaging of the Pad A LOX and LH2 tanks and the Pad B LOX tank has shown that there are no obvious structural issues but there is a likely Perlite void in the upper space of the Pad A LOX tank which is consistent with analysis of liquid level (boil-off data). The picture below shows the cold spot at the top of this tank, consistent with a possible perlite void caused by settling/compaction of this powder-like insulation material.



**Benefits/Payoff/Products**

- The primary benefit of this work has been in helping the Constellation Program decide whether the Pad B LH2 tank needs to be refurbished and to what degree. The technical expertise developed under this project, along with the math models, allowed us to address numerous questions that arose during the evaluation of the tank. At present the Constellation Program has decided to move forward with refurbishment, though this is contingent on funding, and they may have to settle for selective repairs. Our knowledge and the NDE techniques developed under this NWG project will be used as we at KSC bring down this tank and engage in the refurbishment process.
- An annual report was prepared and distributed to KSC and Stennis Cryogenic communities and will be posted on the PBMA NNWG website.

**Status/Recent Accomplishments**

- Develop a Class 1 Div 2 displacement sensor to be used during LH2 loading to determine if stress is transferred to the outer sphere due to Perlite compaction.
- Determine the effectiveness of NDE techniques for the evaluation and acceptance of new cryogenic storage tanks before cryogens are introduced.
- Support Engineering Review Boards and Program Review Boards at KSC to make decisions regarding the refurbishment of the Pad B LH2 tank.
- Coordinate with Stennis Space Center to identify issues they may be having with Cryogenic vessels amenable to NDE innovations.