NASA TECH BRIEF

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Study of Cryogenic Container Thermodynamics During Propellant Transfer

During initial phases of transfer of cryogenic liquids from dewar to receiver tank, certain transient and complex thermodynamic phenomena are evident. These include pressure surging and flow oscillations in the transfer line and pressure fluctuations in the receiver tank. Catastrophic failures involving transfer line rupture and receiver tank implosion have been experienced.

In order to pinpoint the causes of these problems, an exhaustive study has been made using laboratory model analyses derived from empirical data fed to a digital computer. Based on the computer printout, model systems have been operated for both transfer line and receiver tank reactions to programmed parameters of flow, pressure, fluid phase, and hardware configuration. Of particular interest in receiver tank performance is the reaction of tank pressure in early transfer phase to the average size of liquid droplets in the liquid/vapor jet entering the tank.

The basic cause of tank implosion is found to be the evaporation rate of droplets entering the tank in the early transfer phase. If the droplets are small, evaporation is rapid and energy is removed from the vapor in the tank thus causing a rapid drop in tank pressure. In order to reduce the rate of pressure drop, a baffle is placed within the tank, facing the inlet. This forces the incoming liquid along the tank wall, and reduces ullage-liquid heat transfer.

Notes:

1. The study concludes with a summary of analyses of the results concerning transfer line thermodynamics, tank fill thermodynamics, complete fill system thermodynamics, and implosion prevention techniques.
2. Inquiries concerning this study may be directed to:
   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B68-10108

Patent status:

No patent action is contemplated by NASA.

Source: R. M. Vernon and J. J. Brogan
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Category 02