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THE SUBSCALE ORBITAL FLUID TRANSFER EXPERIMENT*

Frank G. Collins**
Basil N. Antar+

Center for Advanced Space Propulsion
The University of Tennessee Space Institute
Tullahoma, TN 37388

Reinhard W. Menzel++
Center for Science and Engineering
UT-Calspan Center for Aerospace Research
Tullahoma, TN 37388

Jere S. Meserole
Ogden Jones
Boeing Aerospace and Electronics
Seattle, WA 98124

Abstract

The Subscale Orbital Fluid Transfer Experiment (SOFTE) is a planned Shuttle Orbiter fluid transfer experiment. CASP performed certain aspects of the conceptual design of this experiment. The CASP work consisted of the conceptual design of the optical system, the search for alternative experimental fluids, the determination of the flow meter specifications and the examination of materials to use for a bladder that will empty one of the tanks in the experiment.

Introduction

The Subscale Orbital Fluid Transfer Experiment (SOFTE) is a planned Shuttle Orbiter experiment designed to obtain fluid-dynamic data pertinent to on-orbit liquid acquisition and tank filling operations. The experiment will mount in two Get Away Special canisters. It will involve transferring Freon 113 between two transparent plexiglas tanks. A screened-channel liquid acquisition device with plexiglas channels will be included in one tank. The experiments will examine axial and tangential no-vent fills between the two tanks plus the vapor breakdown and channel refill process of the liquid acquisition device. Video cameras will record the processes. The work at The Center for Advanced Space Propulsion consisted of certain aspects of the conceptual design of the SOFTE experiment. Only those aspects of the conceptual design performed by CASP will be described here.

Optical System Design

The primary data from the SOFTE experiment will consist of video recordings of the flow processes. The Get Away Special placed severe requirements on the lighting and recording of the fluid motion. In addition, distortion due to the curvature of the tanks posed problems. Various alternative optical systems were considered and tested on a model of the SOFTE experiment. These included miniature video cameras, either mounted external to the tank or on the tank wall, a borescope (endoscope) and a fiber optic bundle. The fiber optic bundle was rejected because of lack of resolution, large size and cost. It was shown that a video camera mounted next to the tank was almost as useful as a

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**Professor of Aerospace Engineering, Principal Investigator
+ Professor of Engineering Science and Mechanics, Co-Investigator
++ System Technology Area Manager, Center for Aerospace Research

borescope. For that reason, miniature video cameras were recommended.

Alternative Fluids

A fluid that was saturated at 300K with a vapor pressure on the order of 0.5 atmosphere was desired. It was also desired to have a fluid which could simulate the fluid dynamic characteristics of cryogenic fluids during a no-vent fill in microgravity. Finally, the fluid must be safe for Shuttle Orbiter use. The baseline fluid was Freon 113. Thirty-four other fluids which satisfied the vapor pressure criteria were identified, including a DuPont alternative to Freon 113. All of these other liquids were rejected either because they were not safe for Shuttle Orbiter use or they were incompatible with the SOFTE construction materials. It was recommended that the experiment fluid remain Freon 113.

Flowmeter

The flowmeter will be the primary means of gauging the mass of fluid in each of the two tanks. Since one of the objectives of the SOFTE experiment will be to determine the maximum amount of fluid that can be transferred from one tank to the other under no-vent fill conditions, the accuracy of the flow meter was of primary concern. The flowmeter had to meet the other requirements of size, pressure drop, ruggedness and read-out requirements. All types of flowmeters were considered but only the turbine meter met most of the requirements. This meter will not operate accurately under two-phase flow conditions so means for preventing vapor from occurring within the meter were examined. To operate accurately, it was recommended that the meter be calibrated with Freon 113.

Bladder Materials

A bladder will be used to empty the receiver container. A bladder material that was compatible with the optical requirements, was not degraded by Freon 113 and was very flexible had to be identified. Various materials were tested in Freon 113 for an extended period of time. It was found that a particular polyurethane/binder material satisfied the experiment requirements.