

Low-Profile Diffuser

Project Manager(s)/Lead(s)

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Sponsoring Program(s)

Human Exploration and Operations Mission Directorate
Space Launch System Advanced Development

Project Description

The propellant tanks used in liquid rockets require pressurization gases in order to maintain tank pressure while the tanks are being drained during engine operation. The pressurization gas, which is typically much warmer than the relatively cold propellants in the tank, must be introduced into the empty ullage space at the top of the tank. The purpose of the diffuser is to control the flow of the gas into the tank in order to prevent direct impingement of the gas on the liquid surface and/or the tank walls. If the diffuser did not perform those tasks, the warm gas can create excess heat transfer causing an increase in the amount of pressurization mass required.

Typical diffusers are long vertical cylinders that create a large exit area in order to minimize gas velocities. However, long vertical cylinders limit the amount of liquid that can be loaded into the tank in order not to have the liquid surface near the diffuser. A design goal for a pressurization diffuser is to create uniform flow in order to prevent jets that can impact the liquid surface and/or tank walls.

The purpose of the task was to create a diffuser design that had a lower vertical profile (in order to be able to raise the liquid surface) while still maintaining uniform flow.



Low-profile diffuser being tested without wire-cloth attached in order to validate CFD model.

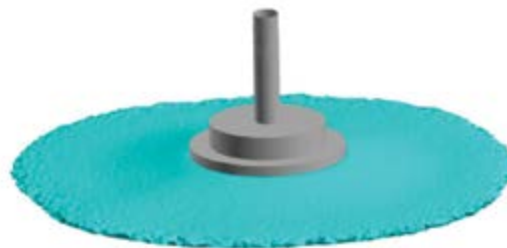


Low-profile diffuser being tested with wire-cloth attached using hot-wire anemometer to measure external velocity profiles.

50 ft/s Iso-Surface



GN₂ Test Conditions—No Screen



GN₂ Test Conditions—With Screen

CFD model prediction of flow velocities showing the benefit of using wire-cloth.

Anticipated Benefits

Rocket designers are constantly trying to improve the performance of their rocket. Using a more compact diffuser such as the low-profile diffuser will allow designers to use more of the available tank volume for propellant. Increasing the amount of loaded propellant can show improvement in the amount of payload delivered to orbit.

Potential Applications

The low-profile diffuser (or variations on the concept) can be used in any liquid propellant tank in order to maximize the amount of loaded propellant. The low-profile diffuser that was designed and tested was sized for the Space Launch System core stage.

Notable Accomplishments

Computational fluids dynamics (CFD) models were used heavily during this task in order to ensure the exit flow could be made uniform in a smaller package (relative to typical diffusers). The CFD analyzed ~20 design iterations during a period of a couple of months in order to arrive at the final design. In addition, the CFD model was validated with the test data that were obtained. This gives confidence that the CFD tool can be successfully employed to analyze other diffuser designs.

Also, part of this task involved generating flow characteristics for two different weaves of wire-cloth. These data were used in the CFD model, but can also be used

for analyzing pressure drop of these particular weaves of wire-cloth for other applications.

Finally, a full-size prototype was built and tested. The testing generated data used for CFD model validation.

References

Martin, M.A.: “Low Profile Diffuser Final Report for Task ADO-06,” NASA Marshall Space Flight Center, Huntsville, AL, December 31, 2014