Statement of Work for
Study of Flow Loss Through Corrugated Lines
Dated, August 11, 2014

NASA Launch Services Program
Kennedy Space Center

Scope

The objective of this project is to experimentally quantify the pressure loss caused by flow through corrugated lines. The project requires the fabrication of an experimental setup complete with pressure gauges, flow meters and all necessary flow control and data acquisition hardware to accurately measure flow losses through corrugated lines. The test matrix shall experimentally test a variety of corrugated lines with varying internal diameter (Figure 1 D), corrugation height (Figure 1 E), corrugation pitch (Figure 1 S), and corrugation radius (Figure 1 R).

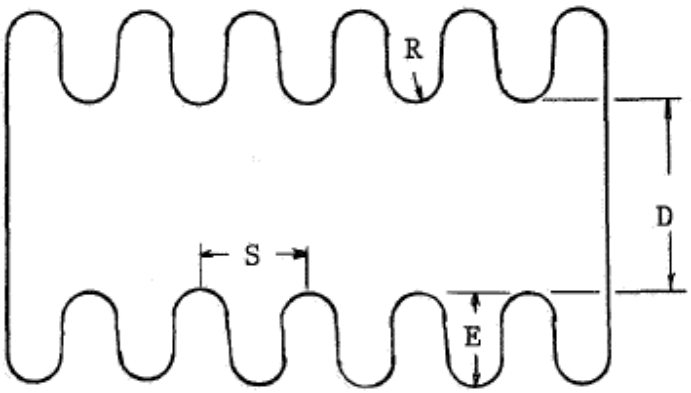

Figure 1

Background

Many launch vehicles use corrugated lines to route purge air gasses from a source outside the payload fairing to the purge fitting on the spacecraft. The payloads use the purge gas to control the humidity and cleanliness of their instruments. Since each payload is unique, the purge gas supply pressure must be adjusted to adequately meet the required flow rate. Since many payloads require a unique purge line routing, the line lengths vary from mission to mission. Due to this variation in line routings a flow analysis must be carried out ahead of time to determine a valve setting for the purge gas supply.

The current analysis method uses a friction factor to account for flow losses through the purge lines. This study will allow for the direct experimental verification of the pressure loss which will then be used to develop a more accurate value for the friction factor. This will greatly increase the accuracy of the analyses for use in future missions.

Technical Approach

The primary objective of the experiment is to quantify the pressure loss per unit length of corrugated purge line. The experiment shall be designed to measure the gas pressure at two separate points along a fixed length of corrugated line. Care must be taken to ensure the gas entering the first pressure gauge is fully developed and clear of entrance effects. The same must be true for the second pressure gauge; it

must be clear of any line exit effects. The pressure gauges used shall be sensitive enough and adequately calibrated to accurately measure the pressure difference between the two gauges. The test shall also include an appropriate amount of time to allow the gas flow to reach steady state before taking pressure readings.

The contractor shall propose a test matrix as part of their test plan that shall consist of a wide variety of commercially available corrugated lines (convoluted tubing) with varying internal diameter (Figure 1 D), corrugation height (Figure 1 E), corrugation pitch (Figure 1 S), and corrugation radius (Figure 1 R). At minimum, the contractor shall include the corrugated lines included in Table I. Additionally, the test matrix shall include a test using a non-corrugated pipe as a control. The gas used for all of the testing shall be nitrogen at room temperature with no cleanliness requirement. The flow rate shall also be varied to include a minimum of 10 different flow rates at regular intervals between 5 and 120 SCFH. Finally, the contractor shall quantify experimental uncertainty and ensure enough independent measurements are recorded to attain a student t value of 2.5 or less. The Government reserves the right to disapprove the test plan if the test matrix does not contain a sufficient variety of corrugated lines/varying internal diameter/height/pitch/radius/flow rates.

Table I

Part Number	Manufacturer	Hose size	SAE Standard
99SSC102909	Omegaflex	½”	N/A
NA56008402X001	US Hose Corp	½”	N/A
AS5458-04N Type 2 per AS1424	Smiths Tubular Systems	04	AS1424
AS5458-04N Type 2 per AS1424	Smiths Tubular Systems	05	AS1424
AS5458-04N Type 2 per AS1424	Smiths Tubular Systems	06	AS1424
AS5458-04N Type 2 per AS1424	Smiths Tubular Systems	08	AS1424
AS5458-04N Type 2 per AS1424	Smiths Tubular Systems	10	AS1424
AS5458-04N Type 2 per AS1424	Smiths Tubular Systems	12	AS1424
AS5458-04N Type 2 per AS1424	Smiths Tubular Systems	16	AS1424
AS5458-04N Type 2 per AS1424	Smiths Tubular Systems	20	AS1424

Prior to testing, the contractor shall develop a test plan. The test plan shall include a detailed explanation of the test setup, a full set of test procedures, a test matrix, experiment schedule, and adequately address safety preparations. The test setup explanation shall include, but is not limited to, details about all test equipment including manufacturer, part numbers, spec sheets and calibration information, as well as pictures or renderings. Additionally, the test plan shall include details about how the contractor shall quantify experimental uncertainty to ensure a student t value of 2.5 or less. The test procedures shall be complete and comprehensive enough for any person without knowledge of the project to be able to successfully carry out the experiment.

The test plan shall be presented to the government prior to any testing, at a test readiness review TRR (preferably via video conferencing). Upon successful completion of the TRR, and government approval of the test plan the experiment shall commence.

Mid way through the testing, the contractor shall participate (preferably via video conferencing) in a mid-term review. This review shall summarize all progress to date and present a sample of preliminary results as well as any suggestions for changes to the test.

After the experiment, all raw data shall be stored on an external hard drive or equivalent portable media device, which shall be delivered to the Government upon study completion. The results of the

experiment, including a chart with pressure loss measurements shall be compiled into a final report. Additionally, a one foot sample of every line tested will be included in the deliverables.

Task Descriptions

1. Develop a Government approved test plan
2. Participate in a Test Readiness Review (TRR)
3. Perform the Government approved test plan
4. Participate in a Mid-Term Review
5. Provide monthly activity/status reports
6. Participate in biweekly progress teleconferences
7. Provide a final report and all deliverables

Period of Performance

The period of performance for this SOW shall be from the Authority to Proceed (ATP) to ATP + 6 months

Travel

The contractor shall travel to the Kennedy Space Center at the end of the project for the final presentation.

Deliverables

1. Government approved Test Plan
2. Monthly activity/status reports
3. All raw and processed test data (including portable media device mentioned in the technical approach section)
4. One foot sample of each line tested
5. Final Report

The Final Report, test plan, test data, and monthly reports shall be provided in electronic format to the NASA Technical Point of Contact and the NASA Contracting Officer.

Milestones

Authority to Proceed (ATP)
ATP + 1 month: Test Readiness Review (TRR) and test plan approval
ATP + 2 months: Begin testing
ATP + 3.5 months: Mid-Term Review
ATP + 5 months: Testing complete
ATP + 6 months: Final Presentation and Report