# Deformation and Leakage Test of a Type III Composite Pressure Vessel

## Contact Information


- Martin Liebisch, Institute of Lightweight Systems, German Aerospace Center, martin.liebisch@dlr.de
- Bernd Hildebrandt, Institute of Lightweight Systems, German Aerospace Center, bernd.hildebrandt@dlr.de
- Jan Rehra, Institute of Lightweight Systems, German Aerospace Center, jan.rehra@dlr.de
- Andrija Dabanovic, Institute of Aerodynamics and Flow Technology, German Aerospace Center, andrija.dabanovic@dlr.de
- Joel Martin, Institute of Aerodynamics and Flow Technology, German Aerospace Center, joel.martin@dlr.de
- Georg Poppe, Responsive Space Cluster Competence Center, German Aerospace Center, georg.poppe@dlr.de


## Abstract


The present dataset describes the deformation behaviour of a Type III composite pressure vessel during its qualification for the ATHEAt sounding rocket flight experiment [1] from the German Aerospace Center (DLR). The tank is used as a pressure supply for the pressure fed oxidizer supply system of the ALDUINA hybrid rocket.


## Description of the Composite Vessel

The tested vessel is one two nominal identical composite vessels labelled SN01 and SN02. The present dataset refers to SN01. The Liner is made of Aluminum Faser. The laminate is made of the carbon fiber type T700SC-12000-60E-P1 and the matrix type LY556/HY917-1/DY070. It is cured for 4 h at 80 degree celsius followed by 5 h at 150 degree Celsius.

**Table 1: Liner dimensions of vessel SN01.**

| Symbol | Parameter | Unit | Value |
|---|---|---|---|
| $D_{a,l}$ | Outer liner diameter | mm | 355.6 |
| $l_{zyl}$ | Length of cylindrical segment | mm | 280.0 |
| $l_{tot}$ | Total liner length | mm | 645.0 |
| $t_l$ | Liner thickness | mm | 4.0 |
| $D_{a,t,avg}$ | Average tank diameter | mm | 400.0 |
| $V$ | Tank Volume | l | 39.3 |

### Laminate Design Considerations:

The laminate design was created based on the following modified design load specifications based on the space standard ANSI/AIAA S-081 [2].

### Table 2: Pressure levels and safety margins considered in design.

| Symbol | Name | Unit | Value |
|---|---|---|---|
| MEOP | Maximum expected operating pressure | bar | 600 |
| SF | Safety Factor | - | 2.0 |
| DBP | Design burst pressure | bar | 1200 |
| PP | Proof Pressure | bar | 900 |

### Test Setup

The tank was mounted in vertical position via a spring ring at the top fitting towards a mounting plate. The top fitting was connected to the fluid system which provides pressurization. Two valves were used to control the pressurization and depressurization of the tank. A pressure sensor was used to measure the acting tank pressure.

### Test Matrix

The following table highlights the test matrix conducted throughout the program. From test no. 2 to 11, the tank is filled with water which is removed during test no. 12. Test no. 8. represents the proof pressure (PP) test. In test no. 10 and test no. 11, 14 cycles of pressurization and depressurization between 0 bar and 600 bar (MEOP) are conducted to investigate the degradation and fatigue behavior. The leakage test in no. 13. uses gaseous helium for pressurization to represent the real flight conditions as close as possible. The leakage is measured indirectly by the measured pressure loss. Several pressurization steps are used to investigate the leakage at different pressure levels. It has to be emphasized, that the resulting leakage is an integral measure of tank and pipe leakage, which is a conservative estimate for the real leakage between fueling of the tank and rocket lift-off in the finale flight experiment.

### Table 3: Test Matrix

| No. | Designation | Date | Time | Pressurization |
|---|---|---|---|---|
| 1 | Visual Inspection | 08.04.2025 | - | 0 bar |
| 2 | Volume quantification | 08.04.2025 | - | 0 bar |

| No. | Designation | Date | Time | Pressurization |
|---|---|---|---|---|
| 3 | Trial recording | 09.04.2025 | - | 0 bar |
| 4 | Initial pressurization | 09.04.2025 | 10:48:44 | up to 50 bar |
| 5 | Pressurization | 09.04.2025 | 10:23:38 | up to 245 bar |
| 6 | Pressurization | 09.04.2025 | 10:48:37 | up to 425 bar |
| 7 | Pressurization | 09.04.2025 | 11:15:25 | up to 550 bar |
| 8 | Pressurization | 09.04.2025 | 11:36:18 | up to 840 bar |
| 9 | Max. Pressurization | 09.04.2025 | 14:30:46 | up to 900 bar |
| 10 | Cycle Test part 1 | 09.04.2025 | 15:08:50 | 7 x 0 bar up to 600 bar |
| 11 | Cycle Test part 2 | 10.04.2025 | 08:07:35 | 7 x 0 bar up to 600 bar |
| 12 | Water removal | 10.04.2025 | - | 0 bar |
| 13 | Leakage Test | 10.04.2025 | 12:01:49 | up to 600 bar |

## Data Acquisition

The measurement of strain and pressure is conducted with two separate data acquisition (DAQ) systems. The first DAQ system recorded pressure over time and was used to control the system valves. The second DAQ system recorded strains. In the present dataset, the measurements of both systems is aligned and reduced from a data rate of 300 Hz measurement frequency to 10 Hz to reduce the file size. The data has been reviewed for verifying that no significant detail has been removed/lost by this procedure. It has to be highlighted, that some of the strain gauges failed over the measurement campaign. The measured tank pressure signal contains an offset. An zeroized version of the pressure signal is appended to the data with 0 bar refering to the atmosphere pressure level acting at test start. The strain levels of each sensors are zeroized at the beginning of the campaign and were not further manipulated throughout the test campaign.

## File Structure and Data Description

This repository contains following files:

- readme.txt
- SN01_metadata_straingauges.csv
- SN01_metadata_pressuresensor.csv
- testdata.7z
  - SN01_test04_synced.csv
  - SN01_test05_synced.csv
  - SN01_test06_synced.csv
  - SN01_test07_synced.csv
  - SN01_test08_synced.csv
  - SN01_test09_synced.csv

  - SN01_test10_synced.csv
  - SN01_test11_synced.csv
  - SN01_test13_synced.csv
- images.7z
  - SN01_Liner.jpg
  - SN01_WindedTank.jpg
  - SN01_Testsetup.jpg

Notes: - the file “test_data.7z” contains the test data named in accordance with Table 3. - the file “SN01_metadata_straingauges.csv” contains all metadata available for each strain gauge sensor. The coordinate system given refers to the central tank axis.

## References


1. Dabanović, A., Martin, J., May, S. et al. Design of a sounding rocket upper stage based on the hybrid rocket engine VISERION. CEAS Space J 15, 467–476 (2023). https://doi.org/10.1007/s12567-022-00451-2
2. Standard: Space Systems—Composite Overwrapped Pressure Vessels (ANSI/AIAA S-081B-2018 (Reaffirmed 2024)) https://doi.org/10.2514/4.105425.001