DOI: 10.13009/EUCASS2023-093
Aerospace Europe Conference 2023 – 10TH EUCASS – 9TH CEAS

Roadmap Towards a Qualified Aluminium Green Propellant Diaphragm Tank

Timothy Jøraholmen†, Stian Korsvold*, Pål Sandvold*, Øystein Luktvasslimo*, Knut Erik Snilsberg**
** Nammo Raufoss AS*
Enggata 40, 2830 Raufoss, Norway
timothy.joraholmen@nammo.com
† Corresponding author

Abstract:
As part of the activities under an ESA funded contract Nammo is currently developing an H_2O_2 based RACS control system for integration in the Vega E system and possibly also earlier, in the Vega C system. The propellant storing and feeding function is served by an Aluminium PED tank with a polymeric diaphragm. This article explores some of the propellant tank development activities conducted thus far and shows the maturity level reached in the current project phase.

1. Introduction

The present article explores the activities performed, and the roadmap towards, a fully qualified green propellant diaphragm tank. The work is performed under the development scope of a hydrogen peroxide (H_2O_2) based roll and attitude control system (RACS) for the Vega launcher family [1].
In line with current trends in the space industry, the goal is to enable short lead time delivery of small-to-medium sized aluminium green propellant tanks for space application that are fully compatible with H_2O_2 and demisable during re-entry. By taking advantage of the decades-long hydrogen peroxide heritage present at Nammo and by basing the design foundation primarily on the extensive set of system requirements in the RACS [2], [3], the resulting product will be well suited to fit in such system and abide by the stringent requirements requested by such launchers.

Space products need to fulfil some of the most stringent requirements, in terms of weight, cleanliness and quality. Developing processes and designs that are able to pass the multiple development stages and be finally qualified for flight is inherently a tough engineering challenge. The team is hence focusing on robust design, manufacturing tolerances, robust manufacturing processes and semi-automatized acceptance tests, some details of which will be presented herein.

2. Product Overview

The Propellant Tank for the Nammo RACS is a sub-assembly of the RACS sub-system (S/S) which serves the RACS propellant storing, stable supply and pressurization function, upstream the systems pyro valve. It is connected to the rest of the RACS via the Tubing and Equipment sub-assembly on the gas and the fluid side. More details on the RACS system can be found in [4].
The propellant tank design has its origin in the tank developed for maturation program Ariane 5 ME HGRS and the flight proven separation and acceleration boosters developed by Nammo in the 1990s, flown successfully on the Ariane 5 system.

The propellant tank has a positive expulsion device (PED) utilizing a polymeric diaphragm membrane separating the propellant on top, from the pressurizing gas in the lower part of the tank (w.r.t. the launch vehicle's direction of travel). Figure 1 shows the current tank geometric CAD design presented for the PDR.

The current development model (DM) design has a semi elliptical shape with a cylindrical mid-section to fit exactly the allowable volume provided by the customer. With the required thickness of the walls, and the volume taken by the membrane, this represents a complete internal volume of 73 L, 45.5 L of which are nominally allocated to the propellant compartment. Due to the constant external tank volume and the internally expanding gas compartment, the tank will be operating in a blowdown-mode. Hence, a propellant budget and a blowdown factor are at the basis for the volumetric sizing of the tank and at the basis of the tank shell pressure dimensioning. This budget definition comes through RACS S/S simulations and calculations.

DOI: 10.13009/EUCASS2023-093

A selection of technical data is found in Table 1.

Table 1: Technical specifications of the Nammo green propellant tank.

Characteristics	Values – Development Model Tank
Envelope	
Length	640 mm
Shell cylindrical section diameter	Ø470 mm
Mass (incl. strut interface brackets)	16.05 kg
Materials	
Tank shell	Aluminium
Brackets	Stainless steel
Diaphragm	Fluoropolymer elastomer
Fluids/gases	
Propellant	85-88% (87.5% nominally) mass-percent hydrogen peroxide
Propellant Compatibility	Better than Class 1 iaw. SVPF norm 11. Oxygen evolution < 0.0010 [gO2/cm2, 24h]
Pressurising gas	N_2 grade B
Leak test gas	Helium >99%
Volumes	
Internal Volume	73 L
Propellant capacity	45.5 L nominal (61.37 kg max.)
Interfaces	
Fluidic (Internal to the RACS)	Straight tube stubs
Mechanical	Ears with M8 holes to interface tank bracket forks.
Pressure Ratings	
MEOP	32 barA
Acceptance Proof factor	1.5
Design burst factor	2.0
Functional parameters	
Expulsion Efficiency	>99%
Pressure drop (H_2O_2)	<0.15 bar at nominal flow rate
Natural Frequency (in filled condition)	>180 Hz
External leak rate	$<10^{-6}$ [mbar.l/sec] GHe @MEOP
Internal leak rate	$<10^{-3}$ [mbar.l/sec] GHe @0.5 barA

DOI: 10.13009/EUCASS2023-093

Figure 1: Tank CAD. Section view (right) with the diaphragm in empty condition (blue).

2.1. Propellant compatibility

At the basis of H_2O_2 as an oxidiser, a natural outgassing phenomena is induced both in the bulk propellant and especially when in contact with other materials. The natural outgassing is dependent on temperature, compatibility of the material in contact with the propellant and the surface area in contact with the propellant, more precisely the surface to volume ratio. I.e. a low temperature, good material compatibility and a low surface to volume ratio will generate the best storing conditions. In the case of the tank, this effect needs to be limited to the minimum to allow for long term storage.

Once the system is pressurised awaiting launch (on-ground), the oxygen stemming from the natural decomposition will be confined within the tank shell, leading to a slight pressure increase in the tank and upstream system. With the priming of the system, the gas bubble will migrate to the thrusters and, when ingested by the latter during firing, may generate unwanted thrust instabilities. It is clear that the gas generation by decomposition of the propellant shall be minimized by correct design choices. The propellant evolution being inherent to the H_2O_2 physics, from the tank side, the only measures that can be controlled to some extent by part of the tank are:

1) Control the exposed surface, i.e. minimize the surface of the propellant compartment w.r.t. the propellant volume.
2) Control the storage temperature of the propellant while pressurised.
3) Control the compatibility of the surfaces in contact with the propellant.
4) An architecture that allows for the decomposition gas to be evacuated before mission start.

And any combination of the above.

In line with the first limiting parameter 1), the tank design has been parametrized to ensure an optimisation of the propellant compartment surface area, thus resulting in a (close to) spherical propellant compartment when filled.
From 2), the temperature control on ground is limited by the boundary conditions available to the launcher internal environment up-to launch. In the case of RACS, a temperature closer to 0°C would mean close to no decomposition. However, it is not practically an option to cool the pre-launch environment to this temperature even from a ground support equipment perspective. In addition, once the propellant is needed in the thruster, it has to be reactive enough to ensure full decomposition in the catalyst. In-line heaters are not provisioned by the power budget; hence, a storage temperature below a certain temperature is not beneficial to the thruster performance. In total, a temperature window has been set, to take into consideration the capacity of the on-ground air conditioning system thus ensuring an on-ground pressurised phase within the mission requirements.

DOI: 10.13009/EUCASS2023-093

From 3), a great technical effort has gone into assessing surface cleaning methods suitable to reduce the decomposition levels to a rate compatible with the mission duration and system requirements. Any non-compatible impurity or contamination present in the tank, in contact with the propellant during the on-ground phase, will tend to increase the reaction rate. During production, several automatized cleaning processes are under development to ensure a repeatable cleanliness level to within the defined specifications.
Finally from 4), the tank architecture was defined in close cooperation with the RACS system design. A reversed diaphragm type design has been selected. This configuration has several benefits when H_2O_2 is used. Mainly, this ensures that the decomposition gas generated is always located to the top of the propellant tank while on ground. In such a case, once primed, the system (already having a blanket pressure in the lines leading from the PV to the thrusters) receives also the additional decomposition gas. During the first system activations, this gas is then expelled through a predetermined thruster firing, ending up with a fully primed system. In the envisioned mission durations (<15000s after priming), the propellant is then not able to decompose enough to create disturbances to the thruster output.

In summary, with a total volumetric capacity in the 70-liter class, the diaphragm tank is designed to maximize propellant compatibility and to ensure propellant expulsion in all mission phases. The main development drivers are the H_2O_2 specificities, requiring careful selection of the material in contact with the propellant. The very high mission loads, with the tank being attached directly to the launcher structure, generates many boundary conditions that must be respected by the design. Finally, a link between design and manufacturing processes shall be established in order to enable both low-cost production and scalability of the final product. Successes in all those areas will enable Nammo to develop and qualify a robust design which could be readily reused and adapted for multiple space applications. The tank designed for VEGA RACS is for example planned to be used as well for the CALLISTO reusable demonstrator [5]. Furthermore, basing the design on commercially available materials and parts, in addition to integrating modularity and scalability in the design, will aim at ensuring a secure value chain for many years of production.

3. Product development and design phase

The development of a new space product unfolds into several steps like requirement flow down, ideation and design phase, verification, and many other.

Requirements tailoring
Requirement flow down is the phase where all upstream requirements are flown down and tailored for the product at hand. Much of the work in this phase is to do a thorough translation of an upper level requirement to fit the tank. E.g. if the upper level requirement is for the system to provide a certain total impulse, for the tank, the requirement could be translated to a propellant capacity. Once the complete requirement set is tailored into verifiable requirements for the tank, these are frozen in the tank sub-assembly requirement specification.

Technology down-selection
Moving into the ideation phase, the requirements and heritage solutions are collected to form a product architecture. Technology down-selection is a crucial part of this phase, to ensure all expertise is collected and informed decisions are made on the technology used in the product.

Iterative design
The design phase directly follows, and consists of starting to generate the CAD models and drawings of the product. Often, iterative analysis and calculations are needed to correctly size each part, ensuring that the designs is within reach of tolerating the environmental and functional loads.
Partly in parallel, the analytical modelling phase is also started by the definition of the design load cases and the material database containing all the allowable material property values to be used in each official analysis. Clearly defined load cases, including boundary conditions, analysis type, meshing plan and material data coming from a configuration controlled database for each analysis case aid in keeping the iterations systematic and easily comparable. Efficient iterations between design and analysis are paramount to ensure a momentum in this phase. Coordination meetings between the design, analysis and system group helps everyone keep the overall progress picture.

Design freeze and gate review
Once the design is finished and the sizing analysis is complete, the design freeze can be done, releasing all the technical documentation to present in the project documents for the upcoming gate review (e.g. the PDR). After a successful review, final touches to the manufacturing documentation is made, before a manufacturing readiness review (MRR) is held.

DOI: 10.13009/EUCASS2023-093

Manufacturing
During the manufacturing phase, all new tools and fixtures to aid the operators to manufacture the product are taken from the drawing board and into hardware, with all their associated specifications and work instructions. In parallel, work can begin on the upcoming test campaign.

Test planning
The test plan presented for the gate review is updated and test specifications, procedures and prediction models are generated. All this work culminates in the assembly, integration and testing phase (AIT), where the test campaign is finally initiated with a test readiness review (TRR). Pending a successful test campaign, marked with the final test review board (TRB), results can be collected and decisions on lessons learned can be systematized. A new development cycle then begins, preparing the requirements and documentation for the next review.

In the scope of the tank manufacturing, multiple processes are developed, starting with a solid heritage basis from other products. The main stages in the production of a tank are described in the next section.

3.1. Manufacturing process development

To manufacture the tank, the following stages apply:

Cold forming
The first manufacturing stage is commonly referred to as the cold forming stage. Starting from the specific aluminium alloy purchased in thick plates, circular billets are cut to the needed size and subsequently forged through a heritage cold impact extrusion process.

Heat treatment
Heat treatment is then performed to achieve the needed material properties and is later verified by specific tests on witness samples. The forging and heat treatment process is already in use for other products at Nammo, but due to the material type and geometry, a process development which aims at proving stability of the process also for this tank is in place.

Machining
The forged parts are then sent to machining, where the initial tank shell net-shape is given to the parts, including a few other components needed for diaphragm integration and bracket assembly. Bespoke fixtures are needed to ensure the tolerances on the half-shells are met. Some specific geometries are left on the shell surface to aid the subsequent manufacturing. This geometry will later be machined away in the final stages of the tank production.

Diaphragm manufacturing
In parallel, the diaphragms are compression moulded to net shape and subsequently cured before being run through a factory acceptance test (FAT), non-destructive investigation (NDI) and a thorough cleaning operation. This is done to ensure each diaphragm used in a tank are capable to endure the tank lifetime.

Cleaning and first assembly
Once the NDI is performed on the half-shells, they are thoroughly cleaned in a multi-staged cleaning operation, to ensure particle cleanliness and dryness within the ECSS standards and a suitable propellant compatibility. Subsequently, after introduction to the clean-room facility, the cleaned diaphragm is integrated and preliminary verified by a sniffer leak test.

Friction stir welding
The tank top shell assembly is transferred, together with the bottom half, to be welded by a specially developed friction-stir welding process. This technology is in common use for larger tanks in space. The novelty here lies in the size of the current tank that is being welded. A great deal of development has gone into finding solutions that enables the reliable welding of a small diameter tank. The selected process ensures that the material properties in the aluminium material experience only a minor knockdown, when compared to other fusion-based welding processes. Notably, the tank shells cannot be heat treated after welding, due to the diaphragm already being installed. Weld NDI is performed to verify a successful process outcome, before the tank is released to the downstream value chain.

Final machining, assembly and workmanship checks
The last stages of the tank manufacturing include the final machining of the weld interfaces, leaving behind the net tank shape. NDI is performed on newly altered surfaces before a complete cleaning and drying is performed. A final

DOI: 10.13009/EUCASS2023-093

assembly stage in the clean-room then occurs, where flanges and brackets are permanently installed on the product. When all workmanship checks are completed, including the documentation review, the tank is ready for the acceptance testing.

4. Test Setups and Procedures

Once the tank is manufactured, the analysis used to validate the design needs in turn to be validated. This happens by testing, where also all the requirements related to functional aspects of the product are verified. In this chapter, a summary of the test typology and set-ups planned for the development model (DM) tank is given, with some insights collected during the proof of concept (PoC) tank campaign, manufactured in the phase leading up to the PDR.
The planned test matrix is presented in Table *2*.

Table 2: Test matrix planned for the DM test campaign.

Test type	DM tank 1	DM tank 2	Separate tests	Comment
Acceptance tests	X	X		Inspection, Proof, Internal and External Leakage, Expulsion Efficiency, Acceptance Vibration
High level vibration	X			
Shock test	X			
Sloshing test			X	Separate tank mock-up with transparent shell.
Compatibility test		X		
Durability Cycling Test	X			
Diaphragm structural test	X	X		
Burst test	X	X		

4.1. Physical Inspection

As part of the last manufacturing steps, before each tank is released to the acceptance tests, a physical inspection is conducted. The goal is to verify the product integrity, physical interfaces, and gather evidence for any deviation from the as planned configuration. The inspection is then repeated at the end of the test-campaign and partly in-between every new test.
In the development phase, this data is used to monitor the product degradation and to determine which operation is causing the discrepancy. In later serial production, this inspection is critical to ensure deliverability of the product.

4.2. Proof Pressure Test

One of the first tests conducted on every single tank is the proof test. Its main function is to ensure that a positive margin of safety is shown towards the Maximum Operational Pressure (MEOP) of the design. In the case of the development phase, an additional cycle factor of four is added on this test, meaning that the tank is cycled multiple times to 1.5xMEOP to show margins towards pressure cycling expected during its lifetime in serial production. At the basis of the test, is the overstressing of potential localized stress-concentrations in the product, such that local plasticisation occurs thus ensuring that any potential failure propagation is stopped. Theoretically, if any critical manufacturing defects are present in the structure, these will be set off by the proof pressure test.
The present strategy to perform this test is by completely filling and priming the tank with water. This ensures that the energy contained in the tank, in case of an anomaly, is relatively small. Other up-sides to the use of water, especially during development, is the possibility to measure the exact tank capacity and the tank expansion over pressure. This data gives important validation to the FEA prediction models and to the system budget calculations.

DOI: 10.13009/EUCASS2023-093

Proof pressure test	
Requirement:	2 min @ proof test level. No permanent global deformation.
Method:	Fully primed water test set-up.
Measurements:	Water mass, tank mass, pressure sensors and strain gauges.
Pressure:	1.5*MEOP [barG] (with structural margins added to the pressure under development).
Results:	All PoC tanks passed – nominal results.

Figure 2: PoC tank ready for proof test.

4.3. Leak Tests

Leak tests are one of the functional tests that are repeated in every functional key point (KP) during a test campaign. The goal is to be within the set leak requirements and that for every repeated leak test, the result value does not migrate. As for every case where a compressed gas is contained by polymeric materials, permeation can potentially contaminate results. This effect is at the basis of the polymeric material, and cannot be removed. However, by empirical testing and modelling, it can be predicted and then validated by testing. This can in turn help and inform the selection of correct permeation allowances and also help selecting test methodology. Polymeric materials such as the diaphragm and O-rings will in our case be susceptible to this permeation effect.

For the present tank, the following test parameters were selected:

DOI: 10.13009/EUCASS2023-093

External leakage test	
Requirement:	10^-6 mbar.l/s
Method:	Vacuum chamber with positive applied inner pressure.
Measurements:	Pressure, vacuum, leak rate
Pressure:	MEOP barA
Results:	All PoC tanks passed, until permeation onset.

Internal leakage test	
Requirement:	10^-3 mbar.l/s
Method:	Internal vacuum with applied He pressure on the pressurant compartment
Measurements:	Pressure, vacuum, leak rate
Pressure:	0.5 barA forcing pressure
Results:	All PoC tanks passed until permeation onset.

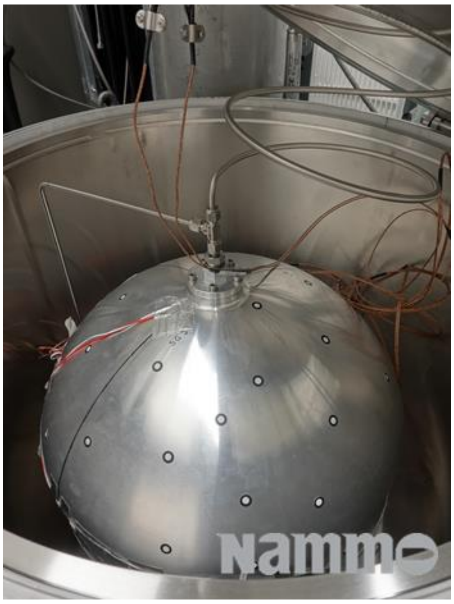

Figure 3: PoC tank ready for the external leak test in the vacuum chamber.

DOI: 10.13009/EUCASS2023-093

4.4. Functional, Expulsion Efficiency and Durability Cycling Test

One of the more complex test set-up is the fully automated system capable of filling, pressurizing draining and venting the tank repeatedly. Characterisations include:
- Filled mass (propellant/gas)
- Draining mass flow (2 scales and orifice)
- Pressure-drop characterisation
- Draining efficiency
- Temperature liquid and gas

This set up is both used to ascertain the tanks functional capability after major structural tests, but also as the durability cycling set-up where several cycles with representative pressurisation and filling gradients can be run. Notably, the tank will need to undergo a factor 4 testing on all the cycles, during qualification. This amounts to approximately 150 cycles to different pressures. Having an automated test set-up greatly reduces the human factor and need of personnel, thus compressing the schedule and increasing result accuracy.

	Functional, Expulsion Efficiency and Durability Cycling Test
Requirement:	Different flow levels (interchangeable orifice), pressure drop below 0.15 bar. Cycle life x4.
Method:	Fully automated valve system with reservoirs, orifice and scales. Fill, pressurize, drain with pre-set holding time logic and PLS commanded valves.
Measurements:	Pressure, vacuum, tank mass, reservoir mass, mass flow, gas pressure, pressure at outlet, pressure after orifice, valve positions, temperature on gas side shell, temperature on propellant side shell and gas temperature (probe).
Pressure:	MEOP and BOL (depending on cycle-type).
Results:	All PoC tanks passed functional tests. One tank tested and passed full durability cycling.

4.5. Diaphragm Structural Test

Due to the tank propellant capacity and the low blowdown factor, the pressurising gas compartment needs to be quite large at beginning of life (BOL). Hence the diaphragm will not be supported by the lower shell when reversed. During the production/acceptance testing and assembly, integration and test (AIT) phase there is a risk that the diaphragm is by accident reversed and pressurised, leading it to be stretched and pushed towards the bottom shell.
The tank hence needs to be able to survive and function nominally after such an extreme operation.
The diaphragm structural test repeats this operation with a cycle factor of 4 and is preceded and followed by an internal leakage test to verify that no damage has occurred to the diaphragm.

	Diaphragm Structural Test
Requirement:	Number of cycles: 4. Each cycle: Full reversal towards the gas side of the shell. EOL pressure with margin towards the nominal direction.
Method:	Manual valve system with He gas supply. Measure leak-rate by sniffer-test.
Measurements:	Pressure on gas and propellant sides. Leak rate He.
Pressure:	MEOP and BOL (depending on cycle-type).
Results:	One PoC tank tested and passed

DOI: 10.13009/EUCASS2023-093

4.6. Propellant Compatibility and Pressure Build-up Test

During development it is important to verify the propellant compatibility behaviour of the vessel, to ensure the tank can fulfil the mission requirements, especially related to the on-ground storage of propellant up to launch.
To assess the exact propellant compatibility, a test set-up is devised to handle the H_2O_2 and measure the rate of decomposition over time, when loaded into an actual tank. In addition, a variant of this test also include pressurisation to beginning of life (BOL) pressure and monitoring of the pressure build-up over time in temperature controlled conditions. This ensures that the performance models are validated, which in turn is fed into the RACS system models.

Propellant Compatibility and Pressure Build-up Test	
Requirement:	Within class 1 iaw. SVPF norm 11. 0.001 [g_{O2}/cm^2, 24h]
Method:	Filled tank with H_2O_2. Pressurised to BOL during pressure build-up test. Temperature controlled chamber.
Measurements:	Milligas counter and propellant concentration pre and post testing.
Pressure:	Vented or BOL
Results:	All PoC tanks passed the compatibility test tests (class 0.1). One tank passed the pressure build-up test.

4.7. Vibration and Shock Test

As the tank will be situated on the fourth stage of the Vega launcher, a severe vibration and shock environment is expected. As such, the propellant tank is tested during development for both extensive vibration testing and shock testing. During acceptance a low level vibration test is planned. Specificities of the tank design and the fluid contained within the shell during such tests, makes the set-up and predictions a specifically non-trivial exercise. As such, focus during development is put on validating the analysis models with reduced input tests at the Nammo test centre, capable of reaching certain levels below requirements. Then, for the qualification loads, external test facilities will be used to perform the tests.

Vibration Test and Shock Test	
Requirement:	All axis shaking and shock or 3 times along worst axis. Iaw. levels set by the RACS project.
Method:	Filled tank with H_2O_2 simulant. Pressurised to MEOP.
Measurements:	Accelerometers placed on the interfaces and on the test objects.
Pressure:	MEOP
Results:	One PoC tank was vibration tested at the Nammo test centre facility to reduced vibration levels. Analysis models are correlated with experimental data.

DOI: 10.13009/EUCASS2023-093

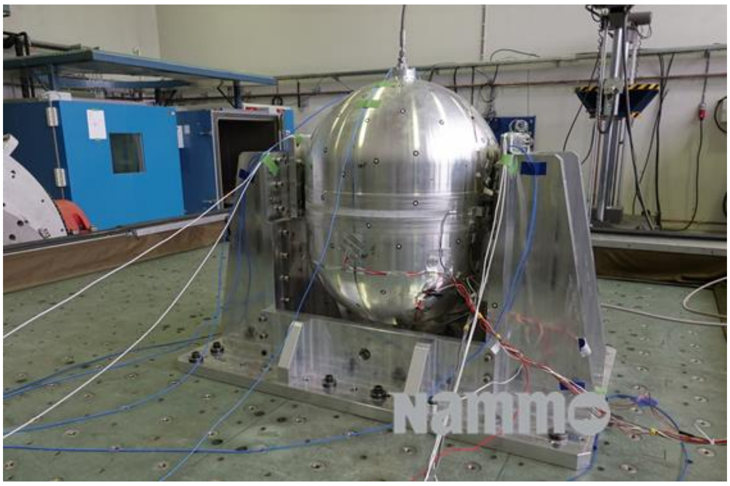

Figure 4: PoC tank integrated in the vibration test fixture at the Nammo test centre.

4.8. Sloshing Test

To ensure the diaphragm responsible for handling the propellant expulsion behaves according to the system requirements, a sloshing test will be performed in a separate test set-up. Transparent shells will be manufactured and paired with a DM diaphragm. The propellant compartment will then be filled with simulant and agitated on a low level sine curve. The goal is to show a sloshing frequency of more than 10Hz, congruent with the predictions made. Input from this test will be used to validate the models and answer the requirements.

Sloshing Test	
Requirement:	>10Hz sloshing frequency in 1g environment.
Method:	Filled transparent tank with H_2O_2 simulant.
Measurements:	Accelerometers and video of the diaphragm movement for post-processing.
Pressure:	1 barA
Results:	No results collected at this stage.

4.9. Burst Test

The final test during development is the burst test. As the name suggests, the tank is loaded with water in the proof test set-up and pressurised until burst. Correlation with structural models is paramount in this test.

Burst Test	
Requirement:	30 sec @ design burst level. Actual burst above design burst.
Method:	Fully primed water test set-up.
Measurements:	Water mass, pressure and strain gauges.
Pressure:	2.0*MEOP [barG] (with structural margins added to pressure level).
Results:	One tank tested to burst with nominal results and actual burst as predicted. Predictions for this test set a confidence interval of between 80 and 89 barG. PoC tank burst at 86 barG.

DOI: 10.13009/EUCASS2023-093

5. Development Status, PDR and Upcoming Milestones

Referring to all the activities presented above, the tank development project was able to collect a substantial amount of documentation for its PDR. A document package was submitted to the project team, containing:

1. Full set of technical requirements flown down from the RACS project,
2. DM tank model design,
3. All test results from the PoC models test campaign,
4. Manufacturing lessons learned and process development plans,
5. Validated analysis and models presented to support the validity of the new design,
6. Current requirement verification matrices and justification files,
7. Supporting documents including the DM test campaign plan and manufacturing documentation iaw. the expected ECSS guidelines.

As such the project was able to pass this milestone and continue its development towards the next iteration of design and testing.

Figure 5: PoC tanks in different test configurations pre-PDR.

All in all, the pre-PDR phase has delivered a functioning proof of concept design that has already endured some of the major qualification tests expected from this product. Manufacturing such a product in this early phase gave some invaluable insights on the maturity level needed to succeed in the future development and put a focus on the milestones moving forward.

Currently the project is working hard to prepare the manufacturing phase of the DM models and plan for the upcoming DM test campaign.

6. Conclusion

This article has summarised the status and development work in progress in the scope of developing a novel aluminium diaphragm tank for use with H_2O_2. Presenting a high level overview of the focus applied to a wide variety of fields, it creates an understanding of the challenges faced by the development team and the road that lies ahead to qualify this product for flight with the new hydrogen peroxide based RACS system under development at Nammo.

7. Acknowledgments

Nammo would like to acknowledge ESA and NOSA for their support to this development and to AVIO for their continuous collaboration and technical guidance to ensure the success of the RACS project.

DOI: 10.13009/EUCASS2023-093

References

[1] Haemmerli B. and al. (2021); Overview of the Development of a H_2O_2 Based Chemical Attitude Control System for VEGA-C, Proceeding of 3AF Space Propulsion Conference 2020+1; SP2020-00363,
[2] Faenza, M. G. and al. (2017). Getting Ready for Space: Nammo's Development of a 30 kN Hybrid Rocket Based Technology Demonstrator, Proceeding of the 7th EUCASS Conference, Milan, Paper 410.
[3] Solli, L. and al. (2016). Development of a Propellant Tank for Hydrogen Peroxide for Launcher Applications. Space Propulsion 2016, SP2016_3124782
[4] Guerra, G. and al. 2023. Achievements and Development Status of the H_2O_2 based Roll and Attitude Control System for VEGA launchers – 10TH EUCASS – 9TH CEAS
[5] Furnes, S. and al. 2023. CALLISTO – on repurposing an expendable reaction control system (RCS) for a reusable demonstrator. Aerospace Europe Conference 2023 – 10TH EUCASS – 9TH CEAS

Disclaimer: The view expressed herein can in no way be taken to reflect the official opinion of the European Space Agency.