

Nuclear Thermal Propulsion (NTP) Engine Ground Testing Status

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Numerous concepts have been developed to ground test NTP engines with the continual challenge of developing a system that is affordable while still ensuring compliance with nuclear regulations. Concepts such as the Rocket Exhaust Capture System (RECS) and Real-Time Processing (RT) are robust options that would likely meet regulatory requirements but come at a high cost. More affordable options such as the Post Run Capture System (PRCS) and High-pressure Exhaust Capture System (HECS) offer more affordable options but significantly limit the run duration, preventing a full ground test campaign. The High Pressure Real-Time (HPRT) exhaust processing system has recently been developed as an attempt at an affordable system that can meet regulatory requirements and does not limit run duration. A paper was written on this concept and presented at NETS 2024 [1]. It suggests that operating at high-pressure results in a 70% height reduction and an 89% diameter reduction for some ducts, enabling the use of commercial off the shelf (COTS) components. Size reductions and COTS utilization lower HPRT cost to an estimated 25% or less of the RECS and RT concepts' cost without impacting its ability to meet regulatory and safety requirements. Since NETS 2024, the HPRT concept has evolved. When the original RT concept was being developed, an exhaust system was required to operate at 20 psia backpressure for 50 minute test durations. Under those conditions, a filter capable of capturing radioactive gases over a long test duration was deemed infeasible due to the size filter that would be required. Today, backpressure can be up to 300 psia. This reduces filter size so that filtering all exhaust is feasible. This allowed HPRT to be redesigned without a separator and with a larger filter. The redesigned system is referred to as the High-pressure Filter System (HFS).

HFS, shown in Figure 1, utilizes water sprays to cool and break down the exhaust plume. The water is then extracted through a demister and desiccant bed and the exhaust is further cooled with a heat exchanger prior to passing through an adsorbent filter. The filter extracts a large majority of the fission products and then the clean exhaust is released through a flare stack. The adsorbent material to be used for this filtration system is still under investigation.

There is some historical precedent for this type of approach. The Effluent Cleanup System (ECS) was tested in 1972 during the Nuclear Engine for Rocket Vehicle Applications (NERVA) Program. ECS filtered all exhaust during Nuclear Furnace-1 (NF-1) testing [2]. The Effluent Treatment System (ETS) was presented in a Space Nuclear Thermal Propulsion (SNTTP) Preliminary Design Review (PDR) in 1990. ETS was designed to filter all exhaust from the Particle Bed Reactor Integral Performance Tester (PIPET). ECS and ETS both produce backpressures at their test article interfaces, but the ECS filter operates at low pressure and the ETS filter operates at high pressure [3]. Additionally, NASA funded a Small Business Innovative Research (SBIR) grant in 2021 where TDA research was able to test and evaluate a number of novel sorbents they have developed. The SBIR produced promising results with some sorbent options retaining greater than 99.5% of injected isotopes in a hydrogen flow and performing better than charcoal filters in the same test conditions. [4]

Current work is assessing filter options in conjunction with projected fission product release estimates to determine which filter options may provide a viable solution that is expected to achieve regulatory approval. This assessment is likely to require a subscale demonstration to optimize filter operating conditions and verify filter performance. Configuration and design options are in development. Additionally, a subscale demonstration to verify CFD analysis for the sizing of the vertical ducting is being assessed. Data from filter assessments and subscale demonstrations will be utilized to develop a preliminary design and move NTP engine ground testing forward.

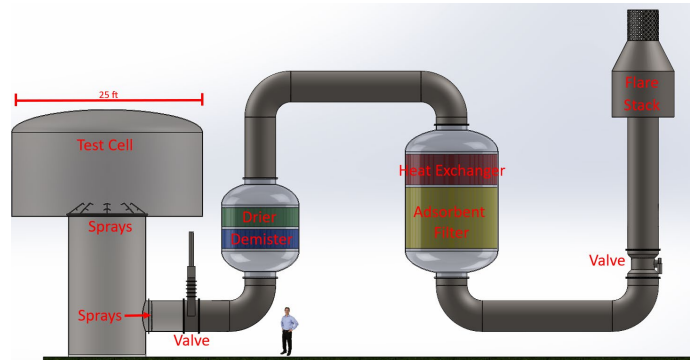


Figure 1. High-pressure Filtration System

Keywords: Nuclear Thermal Propulsion, Engine Ground Testing, Exhaust Processing, Nuclear Facilities

A. Jayaraman, "Phase II Final Report--Novel Sorbent to Remove Radioactive Halogens and Noble Gases from NTP Engine Exhaust.," TDA Research, Wheat Ridge, CO, 2021.

References

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