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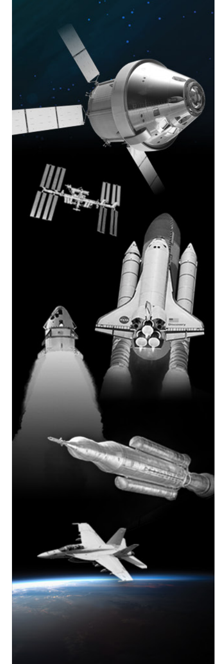

NESC tech bulletin

Revisiting Filtration Standards and Definitions for Spaceflight Propulsion and Pressurant Systems

The NESC performed an assessment of existing filtration standards and guidance documents for propellant and pressurant systems. The assessment included a vendor survey to better understand concerns about filtration systems, defined a common set of filtration and contamination-related terms, and developed guidelines for system filtration design and implementation.

Background

Contamination has been accepted as the root cause of many spaceflight system anomalies. Some of these could have been prevented if an appropriate filtration approach had been specified and implemented. No standards exist for sizing, building, and verifying the performance of spaceflight propulsion/pressurant filters. Component and system cleanliness standards exist, but the interpretation of cleanliness level applicability varies widely. There is no standard technique to determine how cleanliness levels are applied at a system level and how they correlate to filtration requirements. Basic filtration terms, such as "nominal" and "absolute" filter ratings, have different meanings from vendor to vendor.

The NESC assessment, which focused on particulate contamination, was undertaken to define a common approach to filtration terminology, suggested guidelines, design, and verification for spaceflight propulsion and pressurant systems. The guidance for the design of a filter element, such as filtration rating, contamination capacity, flow rate vs. pressure drop, and differential collapse pressure, was evaluated along with filter housing performance (i.e., proof and burst).

Space Launch System Core Stage RS-25 Engine Testing

Sources of Particulate Contamination

The assessment determined there are only four sources of particulate contamination:

1. Particulate loaded with the fluid or gaseous media.
2. Particulate built into parts and components at the vendor.
3. Particulate introduced by manufacturing processes, including welding and cutting at the sub-assembly and final assembly levels.
4. Self-generated particulate produced by moving parts and soft-good/material degradation within the system.

Filtration System Design Process

The filtration system design guidelines outline seven steps:

1. List the individual elements and their cleanliness level upstream of the filter.
   - Include all units and sub-assemblies ("elements"). The list should include the highest-level assembly that was verified clean to a specification.
2. Determine the multiplying factor for lifetime.
   - This is the total fluid that will flow through the element. Include pyrovalve actuation counts and weld repair counts.
3. Determine the particle decay rate.
   - Repeated flushing of an element will decrease the particle count within each size range. Omitting the decay rate will increase conservatism.
4. Total the particle counts.
   - Total across elements, which provides the total count within each particle size range.
5. Convert to test dust.
   - The Jet Propulsion Laboratory determined a correlation for the number of particles within each size range for a mass of air cleaner test dust [refs. 1-2].
6. Determine the necessary dirt holding capacity.
   - This is the largest mass value across the appropriate particle size ranges.
7. Specify the margin.
   - Factors of 2x to 4x are typical. The process recommends adding margin, but not the amount of margin.

The process was demonstrated on an example hydrazine propulsion system [ref. 3]. The guidelines developed in the NESC assessment are recommended for all launch vehicle and spacecraft propulsion systems and may be applicable to a range of other systems.

References

1. Jan, D., and Guernsey, C., "A Procedure for Sizing Propulsion System Filter Capacity," AIAA-92-3535, AIAA/SAE/ASME/ASEE 28th Joint Propulsion Conference and Exhibit, Nashville, TN, July 6-8, 1992.
2. "Road Vehicles - Test Dust for Filter Evaluation," ISO 12103-1, International Organization for Standardization, 1997.
3. *Filtration of Spaceflight Propulsion and Pressurant Systems*, NESC RP-19-01498, February 17, 2022.