FLUOROCARBON

CASE STUDY

ENGINEERING LOW-OUTGASSING COATINGS FOR VACUUM TRIBOLOGY IN SPACE APPLICATIONS

OVERVIEW

A European space technology company requested a PTFE coating for aluminium components operating in vacuum conditions, where very low outgassing, stable friction behaviour, and predictable coating performance were essential to system reliability.
The combination of vacuum constraints, material pairing, and performance expectations meant a standard coating system could not be recommended without first resolving fundamental material and process trade-offs. The requirement set effectively eliminated conventional approaches and demanded a structured engineering evaluation.

THE ENGINEERING CHALLENGE

The application involved aluminium components in sliding contact with metallic counterparts, including titanium, under vacuum conditions where even minor outgassing could compromise performance. Traditional lubricants were not viable, and graphite, often used in dry lubrication, was explicitly excluded due to its incompatibility with the environment.

This created a three-way constraint: the coating needed to provide low friction, maintain adhesion to aluminium, and remain chemically stable in vacuum without releasing volatile components. At the same time, the coating had to meet practical requirements such as controlled thickness, the ability to coat internal geometries and durability over load cycles. Complicating matters further, key parameters such as the required coating thickness had not yet been defined.

This uncertainty directly affected the feasibility of different coating systems, meaning that premature material selection would introduce unnecessary risk.

OUR APPROACH

Rather than beginning with material selection, the process started by defining what was physically and chemically permissible within the application.

The vacuum environment immediately ruled out several conventional solutions. Liquid lubrication and graphite-based systems were excluded, narrowing the field to fluoropolymer coatings. However, even within this category, not all options were equal. While PTFE is widely recognised for its low friction, its suitability in space environments depends heavily on formulation and binder chemistry.

At this stage, the initial request for PTFE was deliberately challenged. In vacuum applications, thermal and chemical stability take precedence over familiarity. This led to a shift in focus towards PFA-based systems, which offer improved structural integrity and reduced outgassing risk under such conditions

Only after this reframing did material selection begin in earnest. Input from coating manufacturers was incorporated to validate feasible systems, comparing PTFE-based coatings with multi-layer PFA architectures. The evaluation was not limited to frictional properties but extended to adhesion mechanisms, wear resistance, and long-term behaviour in vacuum.

What emerged was not a single coating choice, but a system design. The selected approach combined a primer layer for adhesion to aluminium, a high-build intermediate layer to provide thickness and durability, and a PFA topcoat to deliver the required low-friction surface. This layered structure allowed each functional requirement, adhesion, wear resistance, and tribological performance, to be addressed independently rather than compromised within a single coating. Throughout this process, unknowns such as coating thickness were explicitly identified and held as decision gates, rather than assumed. This ensured that the proposed solution remained robust as further application details became available.

THE SOLUTION

Fluorocarbon recommended using F-LON® 7200, a multi-layer PFA-based coating system engineered for vacuum operation, combining adhesion, durability, and low-friction performance within a single architecture.

The system was designed to achieve three outcomes simultaneously:

- Minimise outgassing risk
- Maintain stable tribological behaviour against metallic counterparts
- Ensure reliable bonding to aluminium substrates.

By separating these functions across layers, the coating avoided the compromises typically associated with single-layer systems.

WHY FLUOROCARBON

This project demonstrates Fluorocarbon’s engineering-led approach to solving complex application challenges, particularly where performance requirements extend beyond standard material selection. Rather than defaulting to familiar solutions, our team systematically evaluated the physical, chemical, and operational constraints of the application to define what was truly viable.

This combination of materials expertise, application insight, and collaborative validation enables Fluorocarbon to deliver reliable, high-performance coating solutions in the most demanding environments.