

Contamination Control and Hardware Processing Solutions at the Marshall Space Flight Center

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The Contamination Control Team in Marshall Space Flight Center's Materials and Processes Laboratory supports many Programs/Projects that design, develop, manufacture, and test a wide range of hardware sensitive to contamination and foreign object debris / damage (FOD).

Examples where contamination/FOD concerns arise include sensitive structural bondline failure, critical orifice blockage, seal leakage, and reactive fluid compatibility (liquid oxygen, hydrazine) as well as performance degradation of sensitive instruments or spacecraft surfaces such as optical elements and thermal control systems. During the design phase, determination of the sensitivity of a hardware system to different types or levels of contamination/FOD is essential. A contamination control and FOD control plan must then be developed and implemented through all phases of ground processing, and, sometimes, on-orbit use, recovery, and refurbishment. Implementation of proper controls prevents cost and schedule impacts due to hardware damage or rework and helps assure mission success.

Current capabilities are being used to support recent and on-going activities for multiple Mission Directorates / Programs such as International Space Station (ISS), James Webb Space Telescope (JWST), Space Launch System (SLS) elements (tanks, engines, booster), etc. The team also advances Green Technology initiatives and addresses materials obsolescence issues for NASA and external customers, most notably in the area of solvent replacement (e.g. aqueous cleaners containing hexavalent chrome, ozone depleting chemicals (CFC's and HCFC's), suspect carcinogens). The team evaluates new surface cleanliness inspection and cleaning technologies (e.g. plasma cleaning), and maintains databases for processing support materials as well as outgassing and optical compatibility test results for spaceflight environments.

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National Aeronautics and Space Administration



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The Contamination Control Team of Marshall Space Flight Center's Materials and Processes Laboratory supports many Programs/Projects that design, manufacture, and test a wide range of hardware types that are sensitive to contamination and foreign object damage (FOD). Examples where contamination/FOD concerns arise include sensitive structural bondline failure, critical orifice blockage, seal leakage, and reactive fluid compatibility (liquid oxygen, hydrazine) as well as performance degradation of sensitive instruments or spacecraft surfaces such as optical elements and thermal control systems.

Contamination Control Solutions

MSFC contamination control engineers work with customers to derive hardware cleanliness requirements to achieve system performance and to attain and maintain cleanliness during production. They also evaluate systems for vulnerability to damage from foreign objects and develop and implement programs to prevent costly FOD damage. The team's mission is to reduce the risk of system failure or damage due to molecular contamination, particulate contamination, and FOD.



Clean processing of large hardware — the JWST mirrors.

► Products and Services

The Contamination Team provides the following products and services to design, manufacturing, test, and logistics organizations :

- Derivation of hardware cleanliness requirements
- Development, selection, and qualification of cleaning processes and cleanliness verification techniques
- Contamination Control and FOD Prevention Plans
- Review of contractor contamination and FOD documents and operations.
- Design review and characterization of materials for contamination potential such as outgassing and residue transfer.
- Cleanroom and clean work area design and operations support, including contaminant deposition monitoring and audits.
- Personnel training and tailored course materials for cleanroom operations and FOD prevention.

► Project Support

The capabilities and expertise of the Contamination Team support on-going NASA projects including the International Space Station, James Webb Space Telescope (JWST), Space Launch System, and small projects such as FastSat and Materials on International Space Station Experiments (MISSE). The team also performs process development and operational support tasks for external customers including the Department of Defense, academia, and private commercial space companies.



Applying a uniform contaminant film.

Clean Processing Technology

Team capabilities and expertise have been used to support manufacturing through launch operations supporting multiple systems for numerous mission directorates and programs. Phases of production considered include design, development, manufacturing, assembly/integration, test, transportation, launch site processing, and operations.

► Cleaning Process Development

Precision hardware requires engineered cleaning processes. The Contamination Team develops and validates critical cleaning processes to achieve hardware cleanliness requirements.

Materials Obsolescence and Green Technology

Many of the traditional materials used for decades to clean precision hardware have been found to be damaging to the atmosphere or toxic to humans, wildlife, or aquatic ecosystems. Some common cleaning solvents are ozone depleting substances (ODS) that are soon to be, or already have been, banned by international treaty and domestic legislation. Others are now known to be carcinogenic, requiring costly containment and personnel safety precautions. Environmental restrictions on chemical usage continue to expand as knowledge advances regarding effects on the ecosystem and long term human toxicity.



With a wide range of cleaning equipment, the Contamination Laboratory evaluates alternative cleaning chemistries and key process variables such as temperature, mechanical agitation force, and dwell time. Process capabilities include:

- Laboratory-scale and large-scale vapor degreasers with variable temperature, ultrasonic, dual sump, and solvent flush features.
- Laboratory-scale ultrasonic immersion
- Spray-in-air
- Automated grit-blast
- Plasma cleaning system
- Hand-wipe cleaning in Class 8 cleanroom and HEPA-filtered clean work benches

Leveraging the facilities and expertise of the MSFC Materials and Processes Laboratory, the Contamination Lab evaluates the compatibility of cleaning fluids and processes on materials and assemblies.

Capabilities include:

- Metallography, surface profilometry, and Scanning Electron Microscopy
- Mechanical tests including adhesive bond strength, peel strength, and durometer
- Corrosion testing including total immersion corrosion, sandwich corrosion, stress corrosion, and hydrogen embrittlement
- Nonmetals testing for swelling, cracking, and other factors
- Non-destructive evaluation (NDE) fluorescent penetrant inspection

► Foreign Object Debris/Damage (FOD) Database

The web-based MSFC FOD database, housed on the Materials and Processes Technical Information System (MPTIS) server, satisfies NAS 412 FOD Prevention Requirements for a measurement, trending, and feedback system. Available to MPTIS users, it provides the ability to track facility FOD walkdowns, FOD found, and FOD incidents such as lost tools and near misses, and to report results in FOD type Pareto charts and performance trend lines to support FOD prevention programs. The FOD database is customized to the project, contractor, and user locations and facilities.

Contaminant Measurement & Identification

Many methods may be employed to verify that a surface is clean and ready for processing. Visual and black-light inspections using the trained eye are good ways to determine if a surface meets cleanliness criteria. Portable instrumentation such as the hand-held FTIR can be taken to the production floor and used to spot check a surface for contamination. EM50 has experienced personnel that can perform surface and facility inspections to detect, identify, and quantify molecular and particulate contaminants.



Exoscan portable Fourier Transform Infrared (FTIR) surface inspection.

► Surface Contamination Measurement

Surface cleanliness inspection and measurement capabilities include:

- Bright white light and long-wave ultraviolet inspection lamps
- Portable hand-held Fourier Transform Infrared (FTIR) surface measurement system
- Image Analysis system for automated particle counting and sizing for facility fallout plates or sampled surfaces
- Variable Angle Spectroscopic Ellipsometer (VASE) for measurement of changes in the polarization of light reflected off smooth surfaces such as mirrors

The Contamination Team evaluates new contaminant detection and measurement technologies for accuracy, applicability, and practicality to meet specific hardware verification needs. High priority objectives include development of in situ contaminant measurement methods and qualification of green techniques to replace traditional solvent-based sampling methods.



Measuring the effect of contamination on a mirror with the VASE.

To learn more about the Contamination Laboratory, contact:

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