



**PREFERRED
RELIABILITY
PRACTICES**

**SELECTION OF SPACECRAFT MATERIALS
& SUPPORTING VACUUM OUTGASSING DATA**

Practice:

Each flight project provides requirements for defining and implementing a contamination control program applicable to the hardware for the program. The program consists first in defining the specific cleanliness requirements and setting forth the approaches to meeting them in a Contamination Control Plan. One significant part of the Contamination Control Plan is a comprehensive Materials and Process Program beginning at the design stage of the hardware. This program helps ensure the safety and success of the mission by the appropriate selection, processing, inspection, and testing of the materials employed to meet the operational requirements for the application. The following potential problem areas are considered when selecting materials: radiation effects, thermal cycling, stress corrosion cracking, galvanic corrosion, hydrogen embrittlement, lubrication, contamination of cooled surfaces, composite materials, atomic oxygen, useful life, vacuum outgassing, toxic offgassing, flammability, and fracture toughness. The practice described here for the collection and compilation of vacuum outgassing data is used in conjunction with a number of other processes in the selection of materials.

Vacuum outgassing tests are conducted on materials intended for space flight use, and a compilation of outgassing data, Reference 1, is maintained and constantly updated as new materials are tested. This includes materials used in the manufacture of parts intended for space applications.

Benefit:

These test data provide outgassing information on a wide variety of materials and should be used as a guide by engineers in selecting materials with low outgassing properties.

Programs That Certified Usage:

All GSFC Flight Programs

Center to Contact for More Information:

GSFC, Office Of Flight Assurance, Materials Branch

Implementation Method:

Contamination Control Plans (CCPs), Reference 2, that are prepared and approved for space flight projects, require that materials intended for space

GODDARD
SPACE FLIGHT
CENTER

SELECTION OF SPACECRAFT MATERIALS & SUPPORTING VACUUM OUTGASSING DATA

applications must be tested and must comply with the outgassing test criteria defined below. These plans generally describe methods for controlling contaminants and verifying that they have been prevented or abated such that the hardware will meet performance requirements. Contamination requirements for space flight hardware specify that materials intended for use in space flight applications shall be tested for their vacuum outgassing properties in accordance with ASTM E-595-77/84. In general, a material is qualified on a product-by-product basis. However, lot testing may be required of any material for which lot variation is suspected. Only materials that meet the criteria of ASTM E-595-77/84 [i.e., have a total mass loss (TML) < 1.0% and a collected volatile condensable mass (CVCM) < 0.10%] are approved for use in a space environment unless application considerations dictate otherwise. The outgassing test is conducted in a vacuum of 10^6 Torr at a temperature of 125° Centigrade with a test exposure time of 24 hours. The equipment and test procedures required to conduct the outgassing test are defined by ASTM E-595-77/84.

Materials based on these selection criteria are normally used for space applications; however, some applications may require more or less stringent criteria depending upon such factors as the amount of material involved, expected temperature of exposure, location of the materials on the payload, the criticality of the contamination requirements, etc. A CVCM collector temperature colder than the standard may be required to reflect the intended use.

The proposed use of a noncompliant material that does not meet the TML<1.0% and/or the CVCM<0.1% requirements is documented for GSFC review and approval by a Materials Usage Agreement.

Data on tested materials included in reference 1 are presented in three different ways in order to facilitate materials selection. In Section A, the materials are divided by category into 18 probable uses, such as adhesives, greases, paints, potting compounds, and so forth. In Section B, all the material contained in Section A is listed in alphabetical order by manufacturer's identification. In Section C, the only materials listed are those having TML and CVCM equal to or lower than a maximum 1.0% TML and a maximum 0.10% CVCM grouped by use. It should be noted that data has been collected over a period of 20+ years and variations in materials may require retesting in some cases.

Technical Rationale:

The selection of polymeric materials with low vacuum outgassing characteristics is an essential part in the selection of materials for use in space flight hardware. Materials must be selected which do not exceed specified levels of outgassing in the vacuum of space. Excessive outgassing can degrade the structural integrity of materials, thereby changing their characteristics and causing

SELECTION OF SPACECRAFT MATERIALS & SUPPORTING VACUUM OUTGASSING DATA

excessive contamination of critical surfaces. Outgassing molecules can deposit on cold optical and other critical surfaces, become baked-on when exposed to sunlight, and in some cases change color. These baked-on deposits can not be removed easily. These deposits can significantly degrade ultraviolet scientific instruments and measurements and infrared measurements by obscuring specific wavelengths of interest. Additionally, thermal control surface properties such as solar absorption, infrared emissions, etc., can also be significantly affected.

Impact of Nonpractice:

Noncompliance with outgassing requirements could result in degraded science data due to excessive contamination of an instrument, or in the complete failure of a space flight mission.

Noncompliance with outgassing requirements could result in non-approval of materials for space flight use. If the non-approved materials are already assembled in a flight vehicle or scientific instrument, they may have to be removed and replaced by approved materials.

References:

1. NASA, Reference Publication 1124, Revision 2, Outgassing Data For Selecting Spacecraft Materials, November 1990
2. GSFC, SPAR-3, Standard Payload Assurance Requirements (SPAR) for GSFC Orbital Projects, Paragraph 6.2.5.2 and Section 9, March 1990