



NASA-STD-6016

Standard Materials and Processes

Requirements for Spacecraft

David B. Hirsch
NASA JSC White Sands Test Facility
Las Cruces, New Mexico
USA

International Organization for Standardization
Technical Committee 20, SC14 on Space Systems and Operations
Haifa, Israel
October 2009





- Provides minimum requirements for Materials and Processes (M&P) used in design, fabrication, and testing of flight components for NASA manned, unmanned, robotic, launch vehicle, lander, in-space and surface systems, and spacecraft program/project hardware elements
- Requirements may be tailored for specific programs/projects
- Tailoring could include using existing or previously developed contractor processes and standards



Requirements for Materials



- Selection by consideration of worst-case operational requirements and design engineering properties of candidate materials

Operational requirements

- Temperature limits
- Loads
- Contamination
- Life expectancy
- Moisture or other fluid media exposure
- Vehicle-related induced and natural space environments



Engineering Properties



- Flammability and toxic offgassing
- Corrosion
- Stress corrosion
- Thermal and mechanical fatigue
- Glass-transition temperature
- Coefficient of thermal expansion mismatch
- Vacuum outgassing
- Fluids compatibility
- Microbial resistance



Engineering Properties



- Moisture resistance
- Fretting
- Galling
- Susceptibility to electrostatic discharge (ESD)
- Susceptibility to contamination



General Requirements



- Materials and processes selection, control, and implementation plan
- Coordination, approval, and tracking of engineering drawings, engineering orders, and other documents that establish or modify materials and/or processes
- Specify approval process
- Materials and processes controls
- Updating, alternating, or using new materials or processes
- Commercial Off-The-Shelf Hardware (COTS)



General Requirements



- Materials and processes usage documentation
 - Materials Identification and Usage List (MIUL)
- Human-rated and non-human-rated spacecraft
- Materials Usage Agreements (MUAs) – submitted for M&P that are technically acceptable, but do not meet requirements of the approved M&P selection, control, and implementation plan
- Manufacturing planning
- Materials certification and traceability
- Materials design allowables



Detailed Requirements



- Flammability, offgassing, and compatibility requirements
 - Flammability control
 - Toxic offgassing
 - Fluid compatibility
 - Electrical wire insulation materials





- Aluminum
- Steel
- Titanium
- Magnesium
- Beryllium
- Cadmium
- Zinc
- Mercury
- Refractory metals
- Superalloys (Nickel-based and Cobalt-based)
- Tin



Nonmetallic Materials



- Elastomeric materials
- Polyvinylchloride
- Composite materials
- Lubricants
- Limited-life items
- Thermal vacuum stability
- External environment survivability
- Fungus resistance
- Glycols
- Etching fluorocarbons



Processes



- Forging
- Castings
- Adhesive bonding
- Welding
- Brazing
- Structural soldering
- Electrical discharge machining and laser machining



Material Nondestructive Inspection (NDI)



- Nondestructive evaluation (NDE) plan
- NDE etching
- Nickel plating



Special Materials Requirements



- Residual stresses
- Sandwich assemblies
- Corrosion prevention and control
 - Passivation
 - Sealing
- Hydrogen embrittlement
- Fastener installation
 - Liquid locking compounds
 - Silver-plated fasteners
- Contamination control
- Packaging

