Guidelines for Qualifying Cleaning and Verification Materials

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TECHNICAL MEMORANDUM

GUIDELINES FOR QUALIFYING CLEANING AND VERIFICATION MATERIALS

INTRODUCTION

Because of increased environmental awareness, chemicals used in cleaning and cleanliness verification processes must be reevaluated and replaced as necessary. Many of the chemicals historically used in these processes are now being phased out due to their adverse environmental impact, i.e., ozone depletion, ground water and air pollution potentials.

Selection and qualification of a material (chemical) as a cleaning and/or cleanliness verification media necessitates a systematic approach to assure that all technical issues are addressed in a comprehensive manner. This document is intended to serve as a guide in this selection/qualification process. Narrative portions of this document clarify the use of the enclosed matrix and define the terms used.

APPROACH

The first step in the down-select/qualification process is to establish the cleaning related process being addressed. The list of candidates are enumerated in the left column of figure 1. Cleaning processes addressed are categorized as follows:

General Cleaning—Removal of manufacturing contaminants; for example, mill oils/debris, handling stains, and marking inks for general fabrication/processing. This category includes precleaning for the categories to be described.

Cleaning for Adhesive Bonding—Removal of surface oxides and contaminants to facilitate formation of chemical bonds upon application of heat and pressure (primary bonding) or upon application of adhesives (secondary bonding).

Precision Cleaning—Cleaning of an object to be used in a critical application and for which cleanliness must be quantitatively verified.

Fuel/Pneumatics—Cleaning of objects to be used in fuel or pneumatic applications—quantitative particulate determination is required.

Electronic Applications—Cleaning of objects to a level adequate to permit soldering and to facilitate adhesion of conformal coating, potting, or staking materials.

Wire, Cables, and Harnesses—Cleaning of wire bundles with or without insulation and/or connectors.

Hydraulics—Cleaning of objects to be used in hydraulic applications—qualitative cleanliness generally required with additional requirements for quantitative particle count for critical flight applications.

Optics—Cleaning of mirrors, windows, lens, or optical coatings which require removal of all contaminants without chemical/static residue or surface etching.

The matrix, shown in figure 1, identifies, in the top row, relevant issues and considerations normally encountered in selection of a candidate cleaning chemical. The dot notation correlates process with issue and provides the user with a checklist requiring consideration during the qualification process. It is the responsibility of the user to prioritize the identified issues and to determine the method(s) and criteria required to satisfy these requirements.

PRELIMINARY CONSIDERATIONS

Prior to consideration of steps or "gates" required to "qualify" a candidate material, issues such as environmental constraints, personnel safety constraints, availability/cost, etc., should be resolved. The first major category in figure 1 is denoted as "prequalification." These "prequalification" concerns do not necessarily require testing, thus the direct expenditure of funds; analysis of existing information from sources such as product literature, Occupational Safety and Health Administration/Environmental Protection Agency (OSHA/EPA) regulations, existing data bases, etc., may be sufficient. If a candidate cleaner does pass the prequalification screening process, it may then be considered for qualification.

A candidate material/chemical successfully negotiating the prequalification screening process is ready for closer scrutiny and consideration for qualification. Qualification entails generation of sufficient relevant data to assure that the selected cleaning candidate will successfully and consistently achieve the desired results without unexpected long-term deleterious effects on personnel, hardware, environment, or budget. The qualification gates presented herein should be all inclusive in most instances. Some may not apply to specific circumstances or applications; however, all require careful consideration.

QUALIFICATION PROCESS CHECKPOINTS

Cleaning Performance—Includes definition of contaminants being removed, solubility factors, and loading capacities of the cleaning/verification media. Maintenance of the cleaning media within specification limits should be given careful consideration for cost and scheduling impacts.

End Item Cleanliness Levels—Defines how clean the resultant hardware must be to assure usability. Quantitative and/or qualitative criteria must be determined.

Validation/Test Methodologies—Identifies how hardware cleanliness is to be verified.

Quantitative data may include analysis of cleaner residues, solution pH, chemical analysis of the residual cleaner, nonvolatile residue (NVR), particle count/dimensions, mechanical tests (i.e., bondline tests such as lap shear, etc.), and oxygen compatibility testing (e.g., liquid oxygen/gaseous oxygen (lox/gox) impact tests, etc.).

Qualitative information may include visual inspections, water break testing, chemical species detection, etc.

Substrate Issues—Intends to preclude deleterious/latent effects on the hardware.

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Metallics—Corrosion, embrittlement, etc.

Nonmetals—Leaching, crazing, etc.

Optics—Etching, ionic residues, fogging, etc.

Chemical Reactivity—Scouring, etching, or other phenomena which may affect the long-term suitability of either the cleaning/verification material or the hardware to perform its intended task requires special attention.

Rinsability—Addresses the level of effort required to remove residual chemical cleaner from complex hardware geometries, small diameter tubing, faying surfaces, etc. Drying of hardware is to be included in this context.

Effects of Multiple Cleaning Cycles—A cleaning candidate may not produce detectable deleterious effects should numerous cleaning cycles be required over the life of the hardware. Additionally, the cleaning media may perform adequately with limited use but degrade in performance significantly upon multiple exposures to contaminated hardware. Both phenomena must be addressed during the qualifica- tion process.

Finally, the most significant gate to negotiate:

Statistical Analysis—Statistical verification that the cleaning/verification media performs ade- quately without significant degradation of hardware life or performance.

SUMMARY/DISCUSSION

To achieve an acceptable level of confidence in the cleaning process, careful selection of tests and attention to details during the qualification phase of the program is required. Clearly defined test plans and close scrutiny of details is necessary. Each cleaning or verification process requires a tailored approach to qualification. Tests to be conducted, number of tests, data analysis techniques, etc., must be identified and a consensus reached prior to initiating potentially costly qualification efforts. It is gener- ally advisable to review relevant government and industry, i.e., American Society for Testing Materials (ASTM), American Society of Mechanical Engineers (ASME), etc., test procedures and specifications for guidance in designing a test program. Because of the diverse range of materials and item end uses, it is probable that features of several established test procedures and specifications would be employed.

Once the qualification process has begun, it is important to recognize "escape points" in the plan, i.e., "points beyond which further testing is unwarranted—the candidate material has failed and further expenditure of funds is not justified. The escape points cannot be predetermined so they are not addressed in this document. Information presented in this report, however, should be of value in identifying check- points and "escape" points in the qualification process.
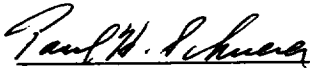
The user organization must rationalize which qualification aspects must be supported by statis- tically significant data and which may be addressed by similarity or other analysis methodology.

Down-Select Matrix

Figure 1. Guidelines for qualifying cleaning and verification materials.

Column headings (application/material categories):
- General Cleaning
  - Cleaning for Adhesive Bonding
  - General
  - Hand Wipe
- Precision Cleaning
  - General
  - Hand Wipe
  - Optics
  - Gyros, etc.
  - Lox/Gox
- General*
  - Hand Wipe
  - Field Cleaning
- Verification
- Fuel/Pneumatics
- Electronics
- Cable, Harness, etc.
- Hydraulics *incl. all compressed gases

*"When interface with Oxygen Systems

Phase groupings (right side): **Pre-Qualification**, **Qualification**

Row items:

Pre-Qualification
- Personnel Safety-MSDS Handling Issues; EPA Reporting Issues
- Pollution Abatement Issues
- Chemical Properties-Stability/Impurities/Vapor Pressure etc.
- Physical Properties-State vs. Temperature
- Availability/Cost
- Facility Implementation-Special Air Handling; Field vs. Shop Issues

Qualification
- Cleaning Performance-Contaminant; Solubility Factors; Solvent Loading Capacities
- End Item Cleanliness Level
  - Validation/Test Methodologies
    - Qualitative
      - Water Break Test
      - Coating Adhesion
      - Vis/Black Light
      - Chemical Analysis
    - Quantitative
      - pH
      - Chemical Analysis
      - Signal Attenuation
      - Optical Clarity
      - NVR
      - Particle Count
      - Mechanical Test
      - Electronic Methods
      - Oxygen Compatability
      - TOC
      - Functional Testing
- Substrate Issues
  - Metallics
    - Corrosion
    - SSC
    - Embrittlement
    - Mask crack Indic.
    - Surface Finish
  - Non-Metallics
    - Leaching
    - Crazing
    - Reversion
    - Hardness Change
    - Coating Softening
    - Compression Set
    - Stress Cracking
  - Optics
    - Etching
    - Ionic Contamination
    - Electrical Charge
    - NVR/Particle
    - Elipsometry
    - Non-Contact Laser
- Chemical Reactivity
- Rinsibility
  - Faying Surfaces
  - Complex Geometries
  - Blind Holes
- Effects of Multiple Cleaning Cycles
- Statistical Analysis
  - Analysis of Variance

APPROVAL

GUIDELINES FOR QUALIFYING CLEANING AND VERIFICATION MATERIALS

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The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

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This document is intended to provide guidance in identifying technical issues which must be addressed in a comprehensive qualification plan for materials used in cleaning and cleanliness verification processes. Information presented herein is intended to facilitate development of a definitive checklist that should address all pertinent materials issues when down selecting a cleaning/verification media.

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