Designation: D 6361 – 98 (Reapproved 2004)ε1

Standard Guide for Selecting Cleaning Agents and Processes[1]

This standard is issued under the fixed designation D 6361; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε1 NOTE—Editorial changes were made throughout in May 2004.

1. Scope

1.1 This guide is intended to assist design engineers, manufacturing/industrial engineers, and production managers in selecting the best fit cleaning agent and process. This guide takes into account environmental pollution prevention factors in a selection process.

1.2 This guide is not to be considered as a database of acceptable materials. It will guide the engineers and managers through the cleaning material selection process, calling for engineers to customize their selection based on the cleaning requirements for the cleaning tasks at hand. If a part can be cleaned, and kept clean, it can be cycled through several process steps that have cleaning requirements. This eliminates extra cleaning process steps during the total process. A total life cycle cost analysis or performance/cost of ownership study is recommended to compare the methods available.

1.3 This guide is for general industry manufacturing, equipment maintenance and remanufacturing operations, and to some extent precision cleaning of mechanical parts and assemblies. It is not intended to be used for optical, medical, or electronics applications, nor is it intended for dry-cleaning or super-critical fluid cleaning.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 56 Test Method for Flash Point by Tag Closed Tester
D 92 Test Method for Flash and Fire Point by Cleveland Open Cup
D 93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
D 2240 Test Method for Rubber Property—Durometer Hardness
D 3167 Test Method for Floating Roller Peel Resistance of Adhesives
D 3278 Test Methods for Flash Point of Liquids by Setaflash Closed-Cup Apperatus
D 3519 Test Method for Foam in Aqueous Media (Blender Test)
D 3601 Test Method for Foam Aqueous Media (Bottle Test)
D 3707 Test Method for Storage Stability of Water-in-Oil Emulsions by the Oven Test Method
D 3709 Test Method for Stability of Water-in-Oil Emulsions Under Low to Ambient Temperature Cycling Conditions
D 3762 Test Method for Adhesive-Bonded Surface Durability of Aluminum (Wedge Test)
E 70 Test Method for pH of Aqueous Solutions with the Glass Electrode
E 1720 Test Method for Determining Ready, Ultimate Biodegradability of Organic Chemicals in a Sealed Vessel, CO_2 Production Test
F 483 Test Method for Total Immersion Corrosion Test for Aircraft Maintenance Chemicals
F 484 Test Method for Stress Crazing of Acrylic Plastics in Contact With Liquid or Semi-Liquid Compounds
F 485 Test Method for Effects of Cleaners on Unpainted Aircraft Surfaces
F 502 Test Method for Effects of Cleaning and Chemical Maintenance Materials on Painted Aircraft Surfaces
F 519 Test Method for Mechanical Hydrogen Embrittlment Evaluation of Plating Processes and Service Environments
F 945 Test Method for Stress-Corrosion of Titanium Alloys by Aircraft Engine Cleaning Materials
F 1104 Test Method for Preparing Aircraft Cleaning Compounds, Liquid Type Water Base, for Storage Stability Testing
F 1110 Test Method for Sandwich Corrosion Test
F 1111 Test Method for Corrosion of Low Embrittling Cadmium Plate by Aircraft Maintenance Chemicals
G 44 Practice for Exposure of Metals by Alternate Immersion in Neutral 3.5 % Sodium Chloride Solution
G 121 Practice for Preparation of Contaminated Test Coupons for Evaluation of Cleaning Agents

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[1] This guide is under the jurisdiction of ASTM Committee D26 on Halogenated Organic Solvents and Fire Extinguishing Agents and is the direct responsibility of Subcommittee D26.03 on Cold Cleaning.

Current edition approved May 1, 2004. Published June 2004. Originally approved in 1998. Last previous edition approved in 1998 as D 6361-98.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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G 122 Test Method for Evaluating the Effectiveness of Cleaning Agents

2.2 *Other Documents:*

Aerospace Material Specification (AMS) 3204/AMS 3209 Test for Rubber Compatibility

ARP 1795 StockLoss Corrosion

FAA Technical Bulletin

2.3 *Military Standards:*

MIL-S-8802

MIL-S-81722

MIL-W-81381/11-20

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *cleaning efficiency*, *n*—the measure of how well a cleaning agent is able to clean a substrate.

3.1.2 *level of cleanliness*, *n*—the degree to which a part must be cleaned in order to perform successfully in subsequent manufacturing or maintenance procedures, or to perform adequately in its final application.

3.1.3 *pre-cleaning*, *n*—the initial cleaning step to remove gross contaminants prior to a precision cleaning process.

4. Summary of Guide

4.1 The following is a summary of the five step approach for selecting general cleaning agents and processes for use in manufacturing, overhaul, and maintenance in industrial operation. For each step, the user of the guide will provide specific information on a particular aspect of their process. Then, the user should consult the guide, which will provide appropriate guidance on evaluation criteria that should be followed in order to evaluate the potential cleaning agents. Table 1 provides a summary of the user-defined requirements information and the procedures to be provided by this guide. The order of the steps presented in Table 1 is suggested, but not crucial to the successful use of this guide. Section 6 will provide greater details on both the user input and the guidance provided.

5. Significance and Use

5.1 This guide is to be used by anyone developing cleaning requirements for specifications for manufacturing, maintenance, or overhaul. This guide has been designed to be application specific for each cleaning task and to assure the design engineer that the process selected by the industrial or manufacturing engineer will be compatible with both the part material and the subsequent process(es). This guide allows the industrial or manufacturing engineer to customize the selection of the cleaning product based on the materials of the part being cleaned; the cleanliness required for the subsequent process(es); and the environmental, cost, and health and safety concerns.

TABLE 1 Summary of Guide

Step	Defined User Requirements	Procedure
1	Define the ESH, physical and chemical requirements of the facility	*Physical and Chemical Properties Test*—Verify that the prospective agent is acceptable.
2	Define the material(s) to be cleaned	*Material Compatibility Test(s)*—Verify that the prospective agent will not harm the component(s) being cleaned.
3	Determine shape of part (part geometry)	Applicable processes and equipment
4	Define the reason for cleaning	*Performance Testing*—Verify that the prospective agent and process will perform to the desired level of cleanliness for the particular cleaning application.
5	Select cleaner	Validate environment, cost, and worker health and safety.

6. Procedure

6.1 *Step 1—Define the Requirements of the Facility*—The first step taken in selecting a replacement cleaner is to determine which cleaners or classes of cleaners are acceptable to the requirements of the facility. These requirements include environmental, safety, and health requirements and the physical and chemical properties of the cleaner itself.

6.1.1 *Environmental, Safety, and Health Requirements*—Table 2 presents some of the more common concerns regarding cleaning agents and their effects on the environment, and worker safety and health. To use Table 2, the engineer should find their concerns on the left-hand column and ensure that the cleaner meets the requirements listed in the right-hand column.

6.1.2 *Physical and Chemical Properties*—Table 3 presents some of the more common concerns regarding cleaning agents and their physical and chemical properties, and the corresponding tests required to evaluate those properties. To use Table 3, the engineer should find their concern(s) on the left-hand column and require the data from evaluations of the specifications listed in the remainder of the row. Please note that this guide does not provide values for the inspection results. These values are to be determined by the engineer based on the specific requirements of the operation.

6.2 *Step 2—Determine Materials of the Parts Being Cleaned to Ascertain Material Compatibility Test Requirements*—The second step in using this guide is to determine the material, or materials of the parts, being cleaned. The information will provide the engineer with the material compatibility test data required to ensure the cleaner will not damage the parts being cleaned. Table 4 presents a table to be used to determine the required material compatibility tests. To use Table 4, select the material type from the left-hand column. The remaining information in the corresponding row provides the short title and the specification number for each of the tests that must be performed in order to ensure material compatibility with the cleaning agent. It is important to note that alloys behave differently than pure metals and different alloys behave differently than other alloys; therefore, specific alloys must be utilized when conducting these compatibility tests. If data are

TABLE 2 Environmental, Safety, and Health Requirements

Concern	Requirement
Environment	Compliance with all federal, state, and local laws and regulations concerning the procurement, use, and disposal of the cleaning agent and associated materials.
Worker safety and health	Compliance with OSHA regulations, provide sufficient personal protective equipment to ensure the health and safety risks of using the cleaning agent are minimized.

TABLE 3 Physical and Chemical Properties

Concern	ASTM Standard
Flash point	D 56 D 92 D 93 D 3278
pH value	E 70
Foaming properties	D 3519 D 3601
Biodegradability	E 1720
Storage stability	D 3707 F 1104
Temperature stability	D 3709

not available on a specific alloy with a specific cleaner, the data must be developed prior to the use of the cleaner.

TABLE 4 Material Compatibility Requirements

Material Type	Short Title	Standard
Steel	Total Immersion Corrosion or	ASTM F 483
	Stock Loss Corrosion	ARP 1795
	Effects on Unpainted Surfaces	ASTM F 485
	Hydrogen Embrittlement	ASTM F 519
	Sandwich Corrosion	ASTM F 1110
	Low-Embrittling Cadmium Plate Corrosion	ASTM F 1111
	Stress Corrosion	ASTM G 44 (Modified, see Appendix X2)
Cobalt alloys	Total Immersion Corrosion or	ASTM F 483
	Stock Loss Corrosion	ARP 1795
	Effects on Unpainted Surfaces	ASTM F 485
	Hydrogen Embrittlement	ASTM F 519
	Sandwich Corrosion	ASTM F 1110
	Low-Embrittling Cadmium Plate Corrosion	ASTM F 1111
	Stress Corrosion	ASTM G 44 (Modified, see Appendix X2)
Nickel alloys	Total Immersion Corrosion or	ASTM F 483
	Stock Loss Corrosion	ARP 1795
	Effects on Unpainted Surfaces	ASTM F 485
	Hydrogen Embrittlement	ASTM F 519
	Sandwich Corrosion	ASTM F 1110
	Low-Embrittling Cadmium Plate Corrosion	ASTM F 1111
	Stress Corrosion	ASTM G 44 (Modified, see Appendix X2)
Titanium alloys	Total Immersion Corrosion or	ASTM F 483
	Stock Loss Corrosion	ARP 1795
	Effects on Unpainted Surfaces	ASTM F 485
	Hydrogen Embrittlement	ASTM F 519
	Sandwich Corrosion	ASTM F 1110
	Stress Corrosion of Titanium[A]	ASTM F 945
	Low-Embrittling Cadmium Plate Corrosion	ASTM F 1111
	Stress Corrosion	ASTM G 44 (Modified, see Appendix X2)
Iron	Total Immersion Corrosion or	ASTM F 483
	Stock Loss Corrosion	ARP 1795
	Effects on Unpainted Surfaces	ASTM F 485
	Hydrogen Embrittlement	ASTM F 519
	Sandwich Corrosion	ASTM F 1110
	Low-Embrittling Cadmium Plate Corrosion	ASTM F 1111

TABLE 4 *Continued*

Material Type	Short Title	Standard
	Stress Corrosion	ASTM G 44 (Modified, see Appendix X2)
Aluminum	Total Immersion Corrosion or	ASTM F 483
	Stock Loss Corrosion	ARP 1795
	Effects on Unpainted Surfaces	ASTM F 485
	Sandwich Corrosion	ASTM F 1110
	Stress Corrosion	ASTM G 44 (Modified, see Appendix X2)
Magnesium	Total Immersion Corrosion or	ASTM F 483
	Stock Loss Corrosion	ARP 1795
	Effects on Unpainted Surfaces	ASTM F 485
	Sandwich Corrosion	ASTM F 1110
	Stress Corrosion	ASTM G 44 (Modified, see Appendix X2)
Brass and bronze	Total Immersion Corrosion or	ASTM F 483
	Stock Loss Corrosion	ARP 1795
	Effects on Unpainted Surfaces	ASTM F 485
	Sandwich Corrosion	ASTM F 1110
	Stress Corrosion	ASTM G 44 (Modified, see Appendix X2)
Copper and alloys	Total Immersion Corrosion or	ASTM F 483
	Stock Loss Corrosion	ARP 1795
	Effects on Unpainted Surfaces	ASTM F 485
	Sandwich Corrosion	ASTM F 1110
	Stress Corrosion	ASTM G 44 (Modified, see Appendix X2)
Epoxy matrix with metals	Total Immersion Corrosion or	ASTM F 483
	Stock Loss Corrosion	ARP 1795
	Effects on Unpainted Surfaces	ASTM F 485
	Hydrogen Embrittlement	ASTM F 519
	Sandwich Corrosion	ASTM F 1110
	Low-Embrittling Cadmium Plate Corrosion	ASTM F 1111
	Stress Corrosion	ASTM G 44 (Modified, see Appendix X2)
Rubber compounds	Effects on Unpainted Surfaces	ASTM F 485
	Rubber Compatibility	AMS 3204/3209
	Rubber Property—Durometer	ASTM D 2240
Thermoset plastics	Stress Crazing of Acrylic Plastics	ASTM F 484
	Rubber Property—Durometer	ASTM D 2240
Thermo plastics	Stress Crazing of Acrylic Plastics	ASTM F 484
	Rubber Propery—Durometer	ASTM D 2240
Acrylics	Stress Crazing of Acrylic Plastics	ASTM F 484
Polycarbonates	Stress Crazing of Acrylic Plastics	ASTM F 484
Optics	Stress Crazing of Acrylic Plastics	ASTM F 484
	Rubber Property—Durometer	ASTM D 2240
Wiring (insulation)	Effects on Unpainted Surfaces	ASTM F 485
	Effect on Polymide Insulated Wire	Appendix X1
	Rubber Compatibility	AMS 3204/3209
	Rubber Propery—Durometer	ASTM D 2240
Leather and fabrics	Effects on Unpainted Surfaces	ASTM F 485

TABLE 4 *Continued*

Material Type	Short Title	Standard
Painted surfaces	Effects on Painted Surfaces	ASTM F 502 (with primers and paints that are being cleaned)
Polysulfide sealants	Effects on Polysulfide Sealants	Appendix X3

[A]Only applicable when dealing with engine parts exceeding 500°F.

6.3 *Step 3—Analyze Part Geometry to Determine Acceptable Cleaning Processes and Equipment*—Once the engineer has determined that a cleaning agent will meet the material compatibility and facility requirements, the next step is to determine the process in which it is to be used. The shape of the part will be a critical parameter in determining the type of cleaning operation for which the part can be subjected with satisfactory results. Some shapes are not conducive to certain types of cleaning processes. Table 5 can be used to determine the acceptable cleaning processes for a given part shape. To use Table 5, the engineer should select the appropriate part shape from the top row. The potential process types are listed down the left-hand column, and if there is a "YES" in the block under the shape and across from the process, then that process is acceptable. If there is a "NO" in the block, that process is not acceptable for that part shape. Please note that process equipment material compatibility with the cleaning agent also must be performed in the same manner as for parts to be cleaned (see 6.2).

6.4 *Step 4–Define the Reason for Cleaning to Determine Performance Requirements*—The next step in selecting a cleaning agent is to define the reason for cleaning. Different cleaning applications require varying levels of cleanliness. The reason for cleaning will direct the user to a set of inspection types and performance criteria for their particular cleaning applications. Table 6 presents a table to be used in determining these parameters. To use Table 6, find the most representative reason for cleaning from the left-hand column. The remaining information in the corresponding row will provide the type of inspection that must be performed and a description of the test method or performance requirement, or both. Please note that this guide does not provide values for the inspection results.

TABLE 5 Acceptable Cleaning Processes and Equipment

Process Type	Part Shape		
	Solid Parts, or Parts with Large or Shallow Holes	Hollow Parts, or Parts With Small or Deep Holes	Delicate or Honeycomb Composite Parts
Agitated bath—cold	Yes	Yes	No
Agitated bath—hot	Yes	Yes	No
High pressure spray—glove box	Yes	No	No
High pressure spray—rotating spray	Yes	No	No
High pressure spray—turntable	Yes	No	No
Hand wipe	Yes	Yes	Yes
Immersion bath—cold	Yes	Yes	No
Immersion bath—hot	Yes	Yes	No
Manual—steam clean	Yes	Yes	No
Manual—mechanical	Yes	Yes	No
Spray booth	Yes	No	No
Spray bottle	Yes	Yes	Yes
Ultrasonic immersion	Yes	Yes	Yes[A]
Vapor degreaser	Yes	Yes	Yes

[A]Some delicate parts may be damaged by high power ultrasonics

TABLE 6 Inspection Type and Performance Requirements

Reason for Cleaning	Inspection Type	Performance Requirement
Pre-cleaning	Visual inspection (white light)	Under strong white light, the item is inspected for the presence of contaminants and for the absence of accumulation of lint fibers. This method will detect particulate matter larger than 50 µm and moisture, oils, greases, etc., in visual amounts.
Planting, welding, or metal spray	Water break free test	See Appendix X4
Fluorescent penetrant inspection NOTE—Surfaces clean enough for this NDI method will be clean enough for all methods of NDI.	Brightness	See FAA Technical Bulletin
	Number of indications	See FAA Technical Bulletin
Adhesive bonding	Floating roller peel resistance	Test Method D 3167
	Adhesive bonded surface durability (wedge test)	Test Method D 3762 NOTE—All materials concerned should be evaluated separately according to the specifications.
Painting	Water break free test	See Appendix X4
Cosmetic	Wipe test (white glove test)	Should be used to detect oils and other surface contaminants that may be inaccessible or undetectable by visual inspection. Rub the surface lightly with a clean white paper, then examine the paper under white light. The paper should be free of oils and other contaminants. NOTE—The area should not be rubbed hard enough to remove an oxide film, as this could be confused with surface contamination.
Hydraulic parts	Water break free test	See Appendix X4

These values are to be determined by the engineer based on the specific requirements of the operation. Also note, for a quantitative comparison of a proposed cleaning agent with the current cleaning method, Practice G 121 and Test Method G 122 may be used.

6.5 *Step 5—Make Final Selection*—After completing the first four steps of this guide, the user may be faced with choosing between several cleaning agents that meet the requirements. At this point the user should consider economic and other business-related choices in making the final decision. The user also may want to take a look at the facility requirements of Step 1 to determine whether any of the candidate cleaners better complies with the requirements for the facility, for example, lower flash point, less personal protective equipment needed, etc. If after completing the first four steps there are no cleaning agents and processes that meet the material compatibility and performance requirements for the particular cleaning application, then the user must go back to Step 1 and reevaluate the facility requirements to allow for a larger universe of potential cleaners. Once chosen, the new set of cleaners also must be evaluated in Steps 2 through 4. This cycle must be repeated until an acceptable cleaner is found. There can be no compromises made on the material compatibility or performance requirements.

7. Other Emerging Technology Considerations

7.1 Technologies, such as plasma, pressurized gas, laser, abrasive and liquid blasting, and supercritical fluid cleaning also are choices. Both performance and life cycle costs of these technologies must be evaluated by the facility and are beyond the scope of this guide.

8. Keywords

8.1 aqueous cleaners; cleaner selection; cleaning agents; solvent substitution; solvents

APPENDIXES

(Nonmandatory Information)

X1. TEST FOR EFFECT ON POLYIMIDE INSULATED WIRE

X1.1 The cleaning compound shall not cause dissolution, crazing, or dielectric breakdown of polyimide insulated wire in excess of that produced by distilled water.

X1.1.1 Coil two segments of MIL-W-81381/11-20 wire approximately 61 cm (24 in.) tightly around a 0.3 cm (0.125-in.) diameter bar, and place into separate 118-mL (4-oz) wide mouth jars. To one jar add sufficient concentrate cleaning compound to completely cover the wire coil. To the other jar (control sample) add sufficient distilled water to completely cover the wire coil. Cap both jars and store at room temperature for 14 days.

X1.1.2 At the end of the storage period remove both coils, rinse thoroughly with distilled water, and suspend to allow complete draining and drying.

X1.1.3 Uncoil the wires, examine each closely for dissolution, and record the results.

X1.1.4 Both wires shall then be subjected to a double reverse wrap on a 0.3-cm (0.125-in.) diameter bar and examined for cracking under a 10 power lens. If cracking occurs the results shall be recorded.

X1.1.5 Wire passing X1.1.1-X1.1.4 shall then withstand a 1 minute dielectric test of 2500 V (rms), using a Hypot Model Number 4045, or equivalent, and examined for breakdown or leakage, or both.

X1.2 Wire immersed in the cleaner shall perform equally well as the control wire immersed in distilled water.

X2. MODIFICATION OF PRACTICE G 44

X2.1 *Modification*—Replace salt solution with cleaning agent. Use the material of concern, 100 min out of solution, 20 min in solution.

X2.2 *Rationale for Modification*—While Practice G 44 predicts the SCC resistance of alloys in a natural environment, the modification predicts the SCC resistance to repeated exposure to maintenance chemicals. The metal materials can undergo stress corrosion within certain cleaning solutions. These mechanisms are different than typical corrosion and actually can happen with very little corrosion occurring in the case of certain solvents (this is usually referred to stress hydride cracking). Repeated cyclic exposure to cleaning agents occurs at maintenance facilities. This cyclic exposure can cause SCC damage not uncovered by other tests. The test cited may be extreme in terms of length (and maybe this length can be reduced), but it is relevant and should be evaluated.

X3. COMPATIBILITY WITH POLYSULFIDE SEALANT

X3.1 The concentrated cleaning solution and a 25 % solution of the cleaning solution in distilled water shall not change the durometer hardness more than five units when tested in accordance with X3.2.

X3.2 *Effects of Polysulfide Sealant*:

X3.2.1 *Preparation of Test Specimens*—MIL-S-81722, Type I, and MIL-S-8802, Type I, sealants shall be mixed as specified by their respective manufacturers and each pressed into a ⅛ in. thick sheet mold until cured (this shall be the sheet stock for each sealant). The sealants shall be cured for 7 days at 49°C. The specimens shall be cut from the sheet stock.

X3.2.2 *Test Procedures*—Immerse two specimens of each sealant in the concentrated cleaning agent and a 25 % solution of the cleaning agent at room temperature for 30 min. Remove from the solution, rinse with cool tap water, and test within 30 min for Shore A hardness in accordance with Test Method D 2240.

X4. WATER BREAK FREE PERFORMANCE REQUIREMENTS

X4.1 *Condition of Surface*—All properly cleaned and pretreated surfaces shall be examined just prior to processing to ensure that the surface is dry and free from soil or contamination of any kind. Immediately prior to processing, the surface must be subjected to a water break test. A mist of distilled water shall be atomized on the surface, employing any convenient small atomizing device. If the water droplets tend to coalesce intro large lenses lasting for 25 s (without a sudden flashout), the surface shall be considered as having satisfactorily passed the water break test. If the water gathers into droplets within 25 s (if the surface shows a water break within that time), the surface shall be considered as having failed the test. If the water forms a continuous film by flashing out suddenly over a large area, this shall be considered evidence of the presence of an impurity on the surface such as free alkali, residual detergent, etc., and the surface shall be considered as having failed the test. Failure to support an unbroken water film shall be sufficient cause to do additional cleaning. If more than 4 h have passed since performing the water break test, reexamine the surface for corrosion, foreign matter, or oily residues and repeat the water break test prior to pretreatment. After testing, all moistures must be removed (by clean forced air for example, blown over the entire item) to ensure a clean, dry surface for processing. Cleaning materials that may be effective against one type of contaminant may be ineffective against others. Multiple cleaning procedures may be required to provide the required water break free surface.

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