Notes to Reviewers
Hardware Workmanship Test Suite Version 1.0 for the VVSG-NI
April 1, 2009

This document represents a test suite for the hardware workmanship requirements (sometimes referred to as the *environmental requirements* and the corresponding testing materials as the *shake and bake tests*) of the next iteration of the Voluntary Voting System Guidelines (VVSG-NI). When the VVSG-NI is approved by the Election Assistance Commission (EAC), the test suites will be available for use by voting system testing laboratories as a common basis for testing voting systems to determine conformance to the VVSG-NI.

Test suite reviewers are advised to first read and understand the VVSG-NI, especially the sections relevant to the test suites under review, before reviewing the test suites. The hardware workmanship requirements are found in the following sections:

- Part 1 Section 6.4.3, General Build Quality
- Part 1 Section 6.4.4, Durability
- Part 1 Section 6.4.5, Maintainability
- Part 1 Section 6.4.6, Temperature and Humidity
- Part 1 Section 6.4.7, Equipment Transportation and Storage

These sections can be found at: http://www.eac.gov/vvsg/part1/chapter06.php/. A complete version of the VVSG-NI in HTML, MS-Word, or PDF formats can be found at http://www.eac.gov/vvsg.

Commenting:

Please send comments on the test suites, by July 1, 2009, to: crt-hardware-test@nist.gov.

You may provide comments directly in your email and/or send attachments in MS-Word or PDF. If you wish, you may embed your comments within the PDF documentation using the instructions provided below. In general, please tell us the features you like and provide us with comments, corrections, and suggestions on how to improve the test suites. Please provide the following items:

- Test suite version number (found in the test suite documentation, currently Version 1.0)
- Your name and affiliation (include contact information if desired)
- Identification of the particular tests and requirements in the VVSG-NI for which your comment applies
- If including suggestions for changes to the tests, a description of the suggested change including an adequate justification for the change, or a draft replacement for the test including the justification and any other necessary documentation or commentary

All comments will be considered. After all comments have been received and incorporated into the test suites, a new version of the test suites will be posted on the NIST web site.

Embedding comments in PDF files:

If you wish to embed comments within the PDF documentation, you may do so using the free Adobe Reader software available from Adobe. The following detailed instructions for commenting the PDF file are current as of 2009-03-25 and Adobe Reader version 9.1.0. Versions 8.1.X are also usable.

1. Ensure that Adobe Reader is installed on your computer. Adobe Reader may be obtained from http://get.adobe.com/reader/.
2. Open the documentation PDF file in Adobe Reader.
3. There should be a menu on the toolbar labeled Comment or Review & Comment. Select Show Comment & Markup Toolbar from that menu to get a new toolbar that includes the Sticky Note tool, the Text Edits tool, and others. (These tools can also be accessed via Tools → Comment & Markup.)
4. To insert a comment someplace in the document, go to that page and use the Sticky Note tool. Once the text of the comment has been entered, the yellow note icon can be dragged to place it near the text in question.
5. To indicate desired textual changes, use the Text Edits tool to insert, delete, or replace text.
6. Save your changes using File → Save.

Hardware Workmanship Test Suite for the VVSG-NI

Version 1.0
April 1, 2009

This document and associated files have been prepared by the National Institute of Standards and Technology (NIST) and represent draft test materials for the Election Assistance Commission's next iteration of the Voluntary Voting System Guidelines (VVSG-NI). It is a preliminary draft and does not represent a consensus view or recommendation from NIST, nor does it represent any policy positions of NIST.

Table of Contents

1. Background

By authorization of the 2002 Help America Vote Act (HAVA), the National Institute of Standards and Technology (NIST) is assisting the Election Assistance Commission (EAC) with the implementation of Voluntary Voting System Guidelines (VVSG) for states and local governments conducting Federal elections. The EAC's Technical Guidelines Development Committee (TGDC) in collaboration with NIST researchers has developed a draft of the next iteration of the VVSG. The draft document is a set of detailed technical requirements addressing core requirements, human factors, privacy, security, and transparency of the next generation of voting systems. The EAC plans to issue the next VVSG after receiving and reviewing public comments.

NIST is developing a set of uniform public test suites to be used as part of the EAC's Testing and Certification Program. Test Labs will be able to use these freely available test suites to help determine that VVSG requirements are met by voting systems. The test suites address human factors, security and core functionality requirements for voting systems as specified in the VVSG. Use of the public test suites will produce consistent results and promote transparency of the testing process. The test suites can also assist manufacturers in the development of conforming products by providing precise test specifications. Also, they will help reduce the cost of testing since each test lab would no longer need to develop its own test suites. Finally, a uniform set of public test suites can increase election officials' and voters' confidence that voting systems conform to VVSG requirements.

2. Introduction to this Document

This document describes one of the public test suites prepared by NIST. It represents the test materials for the hardware workmanship requirements specified in the August 31, 2007 draft of the next VVSG. These requirements are those in the following Part 1 sections:

- Section 6.4.3, General Build Quality,
- Section 6.4.4, Durability,
- Section 6.4.5, Maintainability,
- Section 6.4.6, Temperature and Humidity,
- Section 6.4.7, Equipment Transportation and Storage.

The requirements in these areas are sometimes referred to as "environmental," and the corresponding testing materials as "shake and bake" tests.

For each requirement, this test suite specifies how a test lab should go about determining whether or not the voting system under test meets that requirement. Of course, as with all conformance testing, one cannot be certain that a given system meets the requirements in all circumstances, only that the system is successful under the particular conditions actually tested. However, a failed test does constitute proof that the system in question does not meet the requirement.

Although the purpose of this document is to lay out defined and repeatable procedures for testing a voting system against the VVSG, the task of determining conformance is not one that can always be done "mechanically". The tester may need to apply reasoned judgment when performing the testing, taking into account the general meaning and purpose of the requirement under test.

3. Types of Test Materials

For most of the lowest level (testable) requirements in the hardware workmanship sections in the VVSG, this test suite provides either a test scenario or a test checklist. Some requirements, however, are considered verified if the voting system under test satisfies the tests associated with other requirements in the VVSG, as delineated in this document.

The test lab will use the test material in this document as a basis for its test plan. The development of this plan will include any tailoring of the test material needed to fit the respective tests to the particular type of equipment being tested (and full documentation of this tailoring).

3.1. Test Scenarios

3.1.1. What is a Test Scenario?

In the hardware workmanship test suite, many VVSG requirements are verified using a test scenario. As the term is used here, a test scenario is a set of steps, enhanced by supplemental material that is performed sequentially to verify that a voting system has successfully implemented a given requirement. The format of each test scenario is:

Test Scenario

- **VVSG References:** References to the draft VVSG requirements to which the test scenario is traceable.

- **Derivation:** Either a reference to a test scenario contained in Volume II of the 2005 VVSG from which the current scenario is derived, or else an indication that the current scenario is newly written.

- **Procedure:** A step-by-step procedure, which includes:
    - a description of any required starting conditions,
    - invocations of the Operational Status Check (see below),
    - pass/fail/not-applicable criteria for evaluating the performance of the voting system under test with respect to satisfying the given requirement. If the tester determines that the system fails a requirement, the tester shall document the precise conditions under which failure was detected.

- **Comments:** A set of comments providing additional background, justification, and other relevant information supplementing the step-by-step procedure. Many of the comments are hyperlinked from the test procedure.

3.1.2. The Operational Status Check

The Operational Status Check (OSC) is a self-contained set of steps invoked by test procedures. It is run to verify normal operation, at the time of invocation, of the voting equipment being tested. It is normally the first and last step of every hardware workmanship procedure, and is also invoked in the middle of some procedures.

The OSC is specified as follows:

Operational Status Check

Step 1: Inspect the equipment under test for evidence of damage.

Step 2: If the equipment is not yet in operational status, arrange it for normal operation.

Step 3: If the power is not already on, turn on the power. Unless the OSC occurs in the middle of an ongoing test, allow the equipment to reach recommended operating temperature, and make any adjustments necessary to achieve operational status.

Step 4: Operate the equipment in all modes, demonstrating all functions and features that would be used during election operations. In particular,

- check the operation of all buttons, switches, lights, and touchscreens,
- run a small number of test ballots (which will depend on the type of equipment), and verify the totals,
- check appropriate error conditions (which will depend on the type of equipment) for correct prompts or responses,
- check that all usability and accessibility features are operational,
- power off and on with no loss of function and no loss of previously entered data.

Step 5: If the next step in the test procedure does not require that the power be on, power down the equipment.

3.2. Test Checklists

3.2.1. What is a Test Checklist?

The VVSG specifies that some requirements are to be verified, through inspection, by a tester (see VVSG Part 3, section 3.1). For these requirements, the hardware workmanship test suite provides a set of questions, in the form of a test checklist, that guides and assists the tester in ensuring that the voting system under test displays its required characteristics.

The nature of these inspections requires reliance on the expert judgment of the tester. A given inspection may be of the voting system itself, the documentation submitted by the manufacturer, or both. The format of each test checklist is:

Test Checklist

- **VVSG References:** References to the draft VVSG requirements to which the test checklist is traceable.
- **Derivation:** An indication that the checklist is newly written.
- **Questions:** A set of "yes/no/not-applicable" questions to be considered by the tester. The tester should supplement the "yes", "no", or "not-applicable" answer with any appropriate notes or observations.
- **Comments:** A set of comments providing additional background, justification, and other relevant information supplementing the set of questions. Many of the comments are hyperlinked from the question set.

For requirements verified by a checklist, the voting system under test is considered to have failed verification of the given requirement if there are one or more "no" answers.

4. General Rules for Testing

4.1. Order of Tests

The VVSG does not prescribe a required order of hardware testing. In addition, there is no requirement in the VVSG that the entire suite of tests be performed using the same physical piece of equipment (i.e., independent tests could be run on two or more identical systems in parallel). If, however, a single physical system is used, then the recommended order of tests is:

1. Vibration test
2. Bench Handling test
3. High Temperature Storage test
4. Low temperature Storage test
5. Storage Humidity test
6. Operating Temperature and Humidity test.

This order is consistent with the test sequence recommendations of MIL-STD-810D, which in turn is derived from a consideration of three testing approaches:

- Run the least stressful tests first "to conserve test item life".
- Choose a sequence "to maximize the likelihood of disclosing synergistic effects." This approach argues for performing vibration/shock tests before temperature/humidity.
- Try to match the expected life cycle of the equipment.

In any case, the sequence in which the tests were run must be documented by the test lab.

4.2. Serendipitous Detection of Failure

Although each test scenario is designed for a specific requirement, the running of any given scenario may also reveal violations of other requirements. These violations are to be noted by the tester and are counted as failures, just as if they had been the explicit purpose of the test.

4.3. Discontinuation of Testing

Notwithstanding the system under test failing a pass/fail/not-applicable criterion of a scenario or a checklist question, the test lab should continue to proceed through as much of the remaining test suite as is practical, so as to check the system thoroughly. But if, during the Operational Status Check or elsewhere, the tester determines that the equipment under test is sufficiently damaged that it clearly will not function properly, that further testing would present a safety hazard, or that an earlier failure renders the rest of the test suite meaningless, then testing may be discontinued, as long as the reasons are documented.

5. The Test Suite

The following sections describe the test materials for the hardware workmanship requirements in the VVSG. They are presented in the order in which the requirements appear in Part 1 of the VVSG.

5.1. General Build Quality

5.1.1. High Quality Products

Part 1, Requirement 6.4.3-A.1 will be considered to have been satisfied if the manufacturer satisfies the Quality Assurance requirements of the VVSG (Part 1: section 6.4.2, Part 2: chapter 2, Part 3: section 4.4).

5.1.2. High Quality Parts

Part 1, Requirement 6.4.3-A.2 will be considered to have been satisfied if the manufacturer satisfies the Quality Assurance requirements of the VVSG (Part 1: section 6.4.2, Part 2: chapter 2, Part 3: section 4.4).

5.1.3. Suitability of COTS Components

Part 1, Requirement 6.4.3-B will be considered to have been satisfied if the manufacturer satisfies the Quality Assurance requirements of the VVSG (Part 1: section 6.4.2, Part 2: chapter 2, Part 3: section 4.4).

5.2. Durability

5.2.1. Durability

Durability
Test Checklist

VVSG References:

Part 1, Requirement 6.4.4-A, Durability:

- "Voting systems ***SHALL*** be designed to withstand normal use without deterioration for a period of ten years."

Part 3, Section 4.3, Verification of Design Requirements, introductory paragraph:

- "…Other requirements that state that the system shall prevent something from occurring are not verifiable through operational testing, so inspection (with expert judgment) is the only effective testing strategy."

Derivation:

The test checklist is new. The 2005 VVSG provided no test materials for the analogous requirement (Volume I, 4.3.2, Durability).

Questions:

1. _____ Does the manufacturer supplied documentation include all the information pertaining to durability/lifetime required by the VVSG documentation requirements (see Comment 5)?
2. _____ Does the conformance of the equipment to the requirements of VVSG Part 1, 6.4.4-A "Durability" appear feasible in the context of the documentation on components and assemblies? (An example of a concern would be the use of a component with known durability issues.)
3. _____ Has the equipment passed conformance testing in accordance with VVSG Part 3, 5.1.4-A.3 "Storage Temperature" and 5.1.4-A.4 "Storage Humidity"?
4. _____ Has the equipment passed conformance testing in accordance with VVSG Part 3, 5.1.5-A.1 "Operating Temperature" and 5.1.5-A.2 "Operating Humidity"?
5. _____ Has the equipment passed conformance testing in accordance with VVSG Part 3, 5.1.4-A.1 "Bench Handling" and 5.1.4-A.2 "Vibration"?

Comments:

1. Durability is evaluated in relation to "normal wear and tear" – exposure to normally expected conditions (which may include "normal" extremes such as

normally expected temperature ranges).

2. Factors that affect the durability of voting equipment can include:
    a. Operational lifetime of electronic components – often rated for a certain number of hours of operation. Elevated temperatures inside a device can further shorten the lifetime of the electronics.
    b. Mechanical wear – buttons, switches, touch screens, hinges and latches will eventually wear out or become faulty to the point that they are no longer considered functional. Vibration and mechanical shock from transport can contribute to eventual failure of the components and the entire assembly. Equipment with motorized moving parts is subject to wear over time. The presence of dust and other contaminants can increase the rate of mechanical wear.
    c. Chemical deterioration – liquid crystal, electrolytic capacitors, and structural plastic components can eventually break down by normal aging or by exposure to electrical stresses, light, and chemical vapors. Electrical contacts can wear out or corrode. Electronics assembled with lead-free solder can be prone to the formation of "tin whiskers" that can cause electrical shorts. Batteries can emit chemicals that hasten corrosion processes.
    d. Environmental – repeated or prolonged temperature extremes, thermal cycling, and other environmental factors such as humidity can cause cumulative degradation of equipment.
    e. Current LCD displays often contain fluorescent backlights, which will dim over time and eventually fail.
    f. Flash memory devices, if present, support a finite number of write cycles, but this number may be so great (hundreds of thousands of cycles or more) that it is not a limiting factor in device lifetime. Magnetic storage has finite lifetime, which may be reduced at elevated temperatures.
3. A quantitative measure of durability can be obtained by one or more of several means, for example:
    a. Analysis of equipment operation, collected over time. This can be useful to a company in designing next generation equipment, but is not directly applicable to estimating the durability of a new equipment design.
    b. Accelerated aging. The equipment is subjected to conditions outside the range of normal conditions, in a manner that is generally agreed to increase the rate of degradation of the equipment by a certain factor. The intention is to estimate the functionality of the equipment over a long period (typically years), in a test that takes much less time (for example days to months) than the full period. This may work well for a relatively homogeneous object such as an optical disc, but may not be appropriate for a complex device with many components that respond at different rates to the accelerated aging process. Note that the environmental tests (storage and operational) specified for the VVSG focus on one-time events or a small number of environmental cycles, and do not represent accelerated aging. However, since the VVSG-specified environmental tests are representative of conditions of actual use, equipment that cannot

pass these environmental tests would not be compliant to the durability requirement specified in VVSG, Part 1, 6.4.4-A. A similar principle applies to the transportation (vibration and bench handling) tests specified for the VVSG.

c. Durability analysis. The known properties of the components are taken into account, the expected characteristics and combined operation of the device is evaluated, and an analysis is performed to estimate overall durability. The thoroughness of the analysis can vary considerably depending on the degree of assurance needed for the results, and can be extremely complex. Durability analysis can be extremely time consuming, and requires a detailed knowledge of all aspects of the design including component characteristics and the modeling and simulation that went into the design. For example, component lifetime is often strongly affected by operating temperature. A manufacturer of electronic equipment will usually perform extensive thermal analysis of the design to estimate the operating temperatures of all the components (which will vary considerably depending on the location of the component inside the device as well as the power consumed by the component and the cooling available at that location). Heat generation of processors and other logic components is often function dependent, meaning that whoever performs the thermal modeling must also understand the programming and the expected modes of operation.

4. Consideration of the role of a test lab in establishing equipment durability must take feasibility into consideration. Of the methods described above of determining durability:
    a. Analysis of past equipment performance does not apply to new equipment.
    b. Accelerated aging is unlikely to be a good fit for complex electronic devices such as voting equipment, and is very time consuming (e.g. weeks or months).
5. The following outline shows the relevance of required documentation (VVSG Part 2) to durability. Note that the organization of the documentation will not necessarily match the structure of the documentation requirements list in VVSG Part 2. In evaluating the documentation, it is the responsibility of the test lab to review all documentation provided and to determine which parts are relevant to a given documentation requirement. Cross-indices may be provided by the manufacturer to match the manufacturer-supplied documentation to the VVSG Part 2 documentation requirements, but it should not be assumed that a cross-index will correctly locate all the relevant information.
    a. Technical Data Package (TDP)
        i. Provided by manufacturer to the test lab
        ii. Provides device specifications and testing techniques to support the testing process
        iii. Cross-index reference: VVSG Part 2, 3.1.1.3-B “A cross-index SHALL be provided indicating the portions of the documents that are responsive to documentation requirements enumerated in

Requirement Part 2, 3.1.1.1-C." Note that documentation described in Chapter 4: "Voting Equipment User Documentation") is regarded as part of the TDP (Part 2, 3.1.1.1-C "TDP contents", item b), so the cross-index provided by the manufacturer as part of the TDP must include references to these documents as well.

iv. Specific references in TDP (other relevant data may be included but not listed here):
    1. 3.1.1.2-A "TDP, change notes", submitted when the manufacturer requests reassessment, may include "test documentation, and records of the system's performance history, failure analysis, and corrective actions".
    2. 3.3.1-A "TDP, system hardware characteristics", "The manufacturer SHALL provide a detailed discussion of the characteristics of the system, indicating how the hardware meets individual requirements defined in Part 1, including:
        a. Performance characteristics: Basic system performance attributes and operational scenarios that describe the manner in which system functions are invoked, describe environmental capabilities, describe life expectancy, and describe any other essential aspects of system performance…"
    3. 3.3.2 "Design and construction", detailed description of equipment, including individual components.

b. Voting Equipment User Documentation
    i. Provided by manufacturer to the users (election officials)
    ii. Also referenced by the test lab (see VVSG Part 2, Chapter 4, introductory paragraph)
        1. Test lab is expected to check these specifications and instructions for completeness, clarity, and consistency with information in the TDP.
    iii. Cross-index reference: Mandatory as part of the cross-index for the TDP (3.1.1.3-B), also recommended for the Voting Equipment User Documentation as a stand-alone document set (VVSG Part 2, Chapter 2, introductory paragraphs).
    iv. Specific references in User Documentation (other relevant data may be included but not listed here):
        1. 4.5, "System Maintenance Manual", may provide information on expected failure modes of equipment.

5.2.2. Durability of Paper

Durability of Paper
Test Checklist

VVSG References:

Part 1, Requirement 6.4.4-B, Durability of paper:

- "Paper specified for use with the voting system **SHALL** conform to the applicable specifications contained within the Government Paper Specification Standards, February 1999 No. 11, or the government standards that have superseded them."
- Discussion in VVSG: "This is to ensure that paper records will be of adequate quality to survive the handling necessary for recounts, audits, etc. without problematic degradation. The Government Paper Specification Standards include different specifications for different kinds of paper. As of 2007-04-05, the Government Paper Specification Standards, February 1999 No. 11, are available at http://www.gpo.gov/acquisition/paperspecs.htm [GPO99]."

Part 3, Section 4.1, Initial Review of Documentation, introductory paragraph:

- "The accredited test lab reviews the documentation submitted by the manufacturer for its completeness and satisfaction of requirements."

Derivation:

The test checklist is new. There was no analogous requirement in the 2005 VVSG.

Questions:

Note: If paper is used with the voting system, the type of paper for each use should be evaluated separately. If paper is not used, the equipment is not subject to the requirements of VVSG Part 1, 6.4.4-B, and the checklist should be omitted.

1. _____ Is the paper specified for use with the voting system in accordance with the requirements of VVSG Part 2, 4.5.4.2 (see Comment 6)?
2. _____ Does the manufacturer documentation identify the current Government paper specification standards (see Comment 3), whether the February 1999 No. 11 version, or any newer specification that has superseded them, as the Government standard to which conformance is claimed?
3. _____ Does the paper specified for use with the voting system conform to applicable specifications, including those relating to durability, contained within the current Government paper specification standards (see Comment 4)?

Comments:

1. Paper used in the voting process may include paper ballots and paper used to print out voting records.
2. Paper records that are part of the documentation of the voting process are required to last at least 22 months after the election.
3. The Government Paper Specification Standards are a set of specifications, test methods, and acceptance criteria for a large number of different types of paper that are suitable for government use in different applications. Not all of the types of paper specified in the standards would be suitable for voting applications. Conformance of the voting equipment to the requirements of Part 1, 6.4.4-B is determined by matching the paper specifications supplied by the voting equipment manufacturer to the specifications in the Government Paper Specification Standards, and using expert judgment to determine whether the paper specified conforms to the "applicable specifications" (in this case the ones relating to durability, as explained in the Discussion section of Part 1, 6.4.4-B).
4. Particular paper specifications that relate to durability include:
    a. "Weight" or "grammage". Based on the weight of 500 sheets of a particular size, it depends on the thickness and density of the paper, and significantly affects both handling properties and durability of the paper.
    b. Acidity. Paper with acid content from the manufacturing process tends to age more rapidly than paper with higher pH value. Paper for archival storage is typically treated to increase the pH value.
    c. Other specifications relate to mechanical properties of paper, and could relate to durability depending on intended usage.
5. Durability is evaluated in relation to "normal wear and tear" – exposure to normally expected conditions (which may include "normal" extremes such as normally expected temperature ranges). Paper used in the voting process may be manipulated a certain number of times near the time of the election, then stored for up to the maximum required time, then taken out of storage and manipulated again. The anticipated possible usage pattern and storage conditions should be taken into account in evaluating durability.
6. The following outline shows other sections of the draft VVSG that relate to paper durability requirements:
    a. Part 1, 6.5 Archival Requirements: Requires that records (including paper records) be preserved for at least 22 months.
    b. Part 1, 7.2.1 Procedures required for correct system functioning: Responsibilities of elections officials in verifying the properties of any paper ballots.
    c. Part 2, 4.5.4.2 Paper-based systems: Requirements on voting equipment manufacturers to specify in the user documentation any paper to be used with the equipment, in particular ballot stock and printer paper.

5.3. Maintainability

5.3.1. General Maintainability Comments

General Maintainability Comments

1. The test lab should check all relevant references (which may include design documentation and test results) for indications of what may be problems with the equipment, items needing periodic maintenance, or any other maintenance needs. (This item is a search for notes on possible problem areas that may or may not be fully addressed in the service and maintenance documentation.)
2. Security / access control is a major concern for maintenance of voting equipment. Authorized personnel must have access to all parts of the equipment needed for maintenance, but unauthorized persons must not be able to gain inappropriate access. Security / access control requires different conformance evaluation procedures, and is discussed elsewhere in the VVSG (see General Maintainability Comment 4).
3. The VVSG has stringent requirements on the usability of equipment and the overall system with respect to voters and with respect to routine operation by poll workers. For diagnosis, maintenance, and repair, it is required that certain physical attributes be present sufficient to support maintenance, and that the maintenance tasks be "easy". Determination of the latter is a judgment call by the test lab. Widely used guides to human factors and design for maintainability may be useful as references for identifying key system features for which the lab is to judge ease of performing maintenance tasks:
    a. MIL-STD-1472F (DEPARTMENT OF DEFENSE DESIGN CRITERIA STANDARD: HUMAN ENGINEERING, http://safetycenter.navy.mil/instructions/osh/MILSTD1472F.pdf)
    b. DOE-HDBK-1140-200 (HUMAN FACTORS/ERGONOMICS HANDBOOK FOR THE DESIGN FOR EASE OF MAINTENANCE, http://www.hss.energy.gov/NuclearSafety/techstds/standard/hdbk1140/HDBK11402001_Part1.pdf, also …Part2.pdf, …Part3.pdf)
4. The following outline shows other sections of the draft VVSG that relate to maintainability. Note that there may be maintenance/repair instructions that are included in the TDP for reference by the test lab, but not in the Voting Equipment User Documentation (see VVSG Part 2, 4.5-A, Discussion). For VVSG Part 2, note that the organization of the manufacturer-supplied documentation is not required to match the organization of VVSG Part 2. While the manufacturer is required to supply a cross-reference to match the relevant portions of these two documents, it is not guaranteed that this cross-reference will be complete or accurate. It is the responsibility of the test lab to inspect all supplied documentation to identify relevant portions.
    a. Part 1, 3.2.8 Usability for poll workers: related to maintainability, makes reference to Part 1, 6.4.5.
    b. Part 1, 6.4.5 Maintainability: The parent section of 6.4.5-A contains informative language explaining the VVSG's interpretation of

maintainability. It explains that a quantitative measure such as mean time to repair (MTTR) would be desirable, but is not included as a requirement in the VVSG.

c. 6.4.1.8-I Diagnostics (Workmanship): The requirement for electronic devices to include diagnostic capability.
d. Part 2, 2.1 Quality and Configuration Management Manual: Documentation the manufacturer is required to provide, identifying (among other things) problem areas in the design process, and problem areas and critical items (items for which failure would render the voting system unable to function properly) in individual parts, components and assemblies.
e. Part 2, Chapter 3: Technical Data Package (TDP): the body of technical information that the manufacturer is required to provide to the test lab. Of particular interest:
    i. 3.3.1-A TDP, system hardware characteristics, (d) Maintainability.
    ii. 3.3.2-C TDP, design and construction miscellany: includes operator (and voter) safety considerations and human factors considerations.
    iii. 3.5.2 Access Control.
    iv. 3.5.5 Physical Security, including listing of all ports and access points.
    v. 3.5.7 Setup Inspection.
    vi. 3.8 Configuration for Testing.
f. Chapter 4: Voting Equipment User Documentation. Of particular interest:
    i. 4.3.1 Access control.
    ii. 4.3.2 System event logging.
    iii. 4.3.5 Setup inspection.
    iv. 4.4 System Operations Manual.
        1. 4.4.3 System installation and test specification.
        2. 4.4.5 Operating procedures.
        3. 4.4.7-A Operations manual, operations support.
    v. 4.5 System Maintenance Manual: the main body of documentation on diagnosis, maintenance, and repair.

5.3.2. Electronic Device Maintainability

Electronic Device Maintainability
Test Checklist

VVSG References:

Part 1, Requirement 6.4.5-A, Electronic Device Maintainability:

- "Electronic devices **SHALL** exhibit the following physical attributes:
  a. Labels and the identification of test points;
  b. Built-in test and diagnostic circuitry or physical indicators of condition;
  c. Labels and alarms related to failures; and
  d. Features that allow non-technicians to perform routine maintenance tasks."

Part 3, Section 4.3, Verification of Design Requirements, introductory paragraph:

- "…Other requirements that state that the system shall prevent something from occurring are not verifiable through operational testing, so inspection (with expert judgment) is the only effective testing strategy."

Derivation:

The test checklist is new. The 2005 VVSG provided only generic test materials (Volume II, 4.7.2, Maintainability Test) for the analogous requirement (Volume I, 4.3.4.1, Physical Attributes).

Questions:

1. _____ Does the manufacturer supplied documentation include all the information pertaining to maintainability required by the VVSG documentation requirements (see General Maintainability Comment 4)? Look in particular for alarm, diagnosis, and routine maintenance features, and for physical attributes of electronic devices to support these features.
2. _____ Inspect the equipment for all labels and identified test points that the documentation indicates as present to support maintainability. Does the equipment have the indicated labels and identification of test points (see Comment 1)?
3. _____ Inspect the equipment for all built-in test and diagnostic circuitry and physical indicators of condition that the documentation indicates as present. Does the equipment have the indicated circuitry and indicators of condition?

4. _____ Inspect the equipment for all labels and alarms related to failures that the documentation indicates as present. Does the equipment have the indicated labels and alarms?
5. _____ Inspect the equipment for all features that allow non-technicians to perform routine maintenance tasks that the documentation indicates as present. Does the equipment have the indicated features?
6. _____ Check all relevant references (which may include design documentation and test results) for indications of what may be likely problems with the equipment, items needing periodic maintenance, or any other likely maintenance needs (see General Maintainability Comment 4).
7. _____ Do the physical attributes of the equipment (as described in Part 1, 6.4.5-A) provide sufficient support for maintainability for compliance with Part 1, 6.4.5-A (see General Maintainability Comment 3)?

Comments:

1. VVSG Part 1, 6.4.5-A refers to physical attributes. "Labels and the identification of test points" refers to physical markings on the equipment (use of which is supported by the manufacturer-supplied documentation). Items b, c, and d in the requirement refer to features that can be accessed by non-technical personnel without disassembly of the equipment. For "labels and the identification of test points" that require partial disassembly of the equipment to access, they and the means of access should be fully documented by the manufacturer. It is not the responsibility of the test lab to disassemble the equipment to search for undocumented labels or identification of test points to support maintainability – any inspection other than the exterior of the equipment need only be as specified by the documentation. Any physical attributes to support maintainability must be properly explained in the manufacturer-supplied TDP (and in the Voting Equipment User Documentation if tasks are to be performed by users) to be regarded as useful for maintainability.

5.3.3. System Maintainability

System Maintainability
Test Checklist

VVSG References:

Part 1, Requirement 6.4.5-B, System Maintainability:

- "Voting systems **SHALL** allow for:
  a. A non-technician to easily detect that the equipment has failed;
  b. A trained technician to easily diagnose problems;
  c. Easy access to components for replacement;
  d. Easy adjustment, alignment, and tuning of components; and
  e. Low false alarm rates (i.e., indications of problems that do not exist)."

Part 3, Section 4.3, Verification of Design Requirements, introductory paragraph:

- "…Other requirements that state that the system shall prevent something from occurring are not verifiable through operational testing, so inspection (with expert judgment) is the only effective testing strategy."

Derivation:

The test checklist is new. The 2005 VVSG provided only generic test materials (Volume II, 4.7.2, Maintainability Test) for the analogous requirement (Volume I, 4.3.4.2, Additional Attributes).

Questions:

1. _____ Does the manufacturer supplied Technical Data Package, Voting Equipment User Documentation, and Quality and Configuration Management Manual include all the information pertaining to system maintainability required by the VVSG documentation requirements (see VVSG references to required documentation in General Maintainability Comment 4)? Look in particular for documentation on detection of system failure that can be performed by non-technicians, diagnoses that can be performed by trained technicians, access to components for replacement, adjustment, alignment, and tuning of components, and provisions for minimization of false alarms.
2. _____ If appropriate, exercise the documented techniques for diagnosis (non-technician level and technician level), access to components for replacement, and adjustment, alignment, and tuning of components, all following the instructions provided by the manufacturer. Can these actions, in the expert judgment of the tester, be performed "easily" (see Comment 1)?
3. _____ Does the documentation (and the tester's experience exercising the equipment, if appropriate) indicate an easy method for a non-technician

to detect that the equipment has failed (see General Maintainability Comment 3)?

4. _____ Does the documentation (and the tester's experience exercising the equipment, if appropriate) indicate an easy method for a trained technician to diagnose problems (see General Maintainability Comment 3)?
5. _____ Does the documentation (and the tester's experience exercising the equipment, if appropriate) indicate easy access to components for replacement (see General Maintainability Comment 2, General Maintainability Comment 3)?
6. _____ Does the documentation (and the tester's experience exercising the equipment, if appropriate) indicate ease of adjustment, alignment, and tuning of components (see General Maintainability Comment 3)? (This question is applicable only if the equipment has a potential need for adjustment, alignment, or tuning of components).
7. _____ Does the documentation (and the tester's experience exercising the equipment, if appropriate) indicate equipment design and/or refer to test results to substantiate low false alarm rates for indication of maintenance needs?

Comments:

1. The test lab should attempt a simple exercise of the techniques listed in Part 1, 6.4.5-B, to aid in determining whether their use is "easy", as required by the VVSG. Examples of simply exercising the techniques include running a diagnostic routine, or checking to see whether a warning light is lit or whether an error message is present or absent. The test lab should document the nature of the exercise that they perform.

5.3.4. Nameplate and Labels

Nameplate and Labels
Test Checklist

VVSG References:

Part 1, Requirement 6.4.5-C, Nameplate and Labels:

- "All voting devices **SHALL**:
  a. Display a permanently affixed nameplate or label containing the name of the manufacturer, the name of the device, its part or model number, its revision identifier, its serial number, and if applicable, its power requirements; (see

Comment 1)

b. Display a separate data plate containing a schedule for and list of operations required to service or to perform preventive maintenance, or a reference to where this can be found in the Voting Equipment User Documentation; and
c. Display advisory caution and warning instructions to ensure safe operation of the equipment and to avoid exposure to hazardous electrical voltages and moving parts at all locations where operation or exposure may occur."

Part 3, Section 4.3, Verification of Design Requirements, introductory paragraph:

- "…Other requirements that state that the system shall prevent something from occurring are not verifiable through operational testing, so inspection (with expert judgment) is the only effective testing strategy."

Derivation:

The test checklist is new. The 2005 VVSG provided only generic test materials (Volume II, 4.7.2, Maintainability Test) for the analogous requirement (Volume I, 4.3.6, Product Marking).

Questions:

1. _____ Does the manufacturer supplied Technical Data Package, Voting Equipment User Documentation, and Quality and Configuration Management Manual include all the information pertaining to service and maintenance required by the VVSG documentation requirements (see VVSG references to required documentation in General Maintainability Comment 4)? Look in particular for scheduling and listing of operations required to service or to perform preventive maintenance.
2. _____ Does the equipment display a separate data plate containing (1) a schedule for and list of operations required to service or to perform preventive maintenance, or (2) a reference to where this can be found in the Voting Equipment User Documentation? Does the combination of any information on the data plate and any supplied references on the data plate completely and accurately present the scheduling for and listed operations required to service or to perform preventive maintenance on the equipment, as documented in the manufacturer-supplied references (see Comment 2)?
3. _____ Check all references relevant to cautions and safety warnings on hazardous electrical voltages and moving parts in the manufacturer-supplied Technical Data Package, Voting Equipment User Documentation, and Quality and Configuration Management Manual (see Comment 3, General Maintainability Comment 4). Does the equipment display advisory caution and warning instructions to ensure safe operation of the equipment and to avoid exposure to hazardous

electrical voltages and moving parts, and are the displayed caution and warning instructions found at all locations where operation or exposure may occur, consistent with all manufacturer-supplied references?

4. _____ Are all displayed plates and labels (of the types that are required under VVSG Part 1, 6.4.5-C) permanent?
5. _____ Do the displayed plates and labels adequately address the maintenance and safety needs for the equipment?
6. _____ Are all displayed plates and labels (of the types required under VVSG Part 1, 6.4.5-C) sufficiently usable to perform their intended purposes (see General Maintainability Comment 3)?

Comments:

1. 6.4.5-C a. will be considered satisfied if the manufacturer satisfies the Configuration Management requirements of the VVSG.
2. Given the many instructions needed for service and preventive maintenance, it appears unlikely that they can be fully addressed on an attached plate; therefore a reference to the user documentation is a more likely scenario. If an instruction plate provides some instruction, plus a reference to the user manual (e.g. "Perform preventive maintenance procedure xx every 12 months or 200 hours of use, whichever comes first, following the procedure in the User Manual, section yy"), then the combination of direct information and references provided by the plate is regarded for this checklist procedure as the basis for judging accuracy and completeness of the provided information.
3. Note that a moving part does not have to be powered to be a hazard. Cuts, pinches, and bruises can be caused even if the user provides the power to move the movable part (car doors and paper cutters are classic examples).
4. Beyond general maintenance issue, the following outline shows other sections of the draft VVSG that relate to nameplates and labels.
    a. Part 1, 3.2.8.2 Safety.
    b. Part 1, 6.3.4 Electromagnetic Compatibility (EMC) immunity: includes discussion of scenarios for electrical hazards, including those relating to power lines and power connectors.
    c. Part 1, 6.3.6.1 Dielectric withstand: includes discussion of electrical hazards.
    d. Part 1, 6.4.5 Maintainability: The parent section of 6.4.5-C, contains informative language explaining the VVSG's interpretation of maintainability. Emphasis is placed on physical attributes (including nameplates and labels) of the equipment to facilitate maintenance.

5.4. Temperature and Humidity

5.4.1. Operating Temperature and Humidity

Operating Temperature and Humidity
Test Scenario

VVSG References:

Part 1, Requirement 6.4.6-A, Operating temperature and humidity:

- "Voting systems **SHALL** be capable of operation in temperatures ranging from 5 °C to 40 °C (41 °F to 104 °F) and relative humidity from 5% to 85%, non-condensing."

Part 3, Requirement 5.1.5-A, Operating environmental testing:

- 5.1.5-A.1 Operating temperature: "All voting systems **SHALL** be tested according to the low temperature and high temperature testing specified by MIL-STD-810-D: Method 502.2, Procedure II – Operation and Method 501.2, Procedure II – Operation, with test conditions that simulate system operation."
- 5.1.5-A.2 Operating humidity: "All voting systems **SHALL** be tested according to the humidity testing specified by MIL-STD-810-D: Method 507.2, Procedure II – Natural (Hot-Humid), with test conditions that simulate system operation."

Derivation:

The test scenario is derived in part from the 2005 VVSG, Volume II, 4.6.4 "Low Temperature Test, 4.6.5 "High Temperature Test", 4.6.6 "Humidity Test", and 4.7.1 "Temperature and Power Variation Tests".

Procedure:

Prior to test: Make sure the voting equipment has been maintained at ambient conditions of temperature and humidity for at least 24 hours prior to the test.

Step 1: Perform a pre-test operational status check. If the equipment shows evidence of damage, or any examined function or feature is not working correctly, then the equipment under test is defective and testing shall be suspended until the defect is eliminated. In accordance with Part 3, Requirement 2.5.5-E, if corrective action is taken to restore the equipment to a fully operational condition within eight hours, then the testing may be resumed with a re-run of Step 1.

Step 2: Arrange the equipment in the test chamber. Connect as required and provide for power, control, and data service through the enclosure wall. Configure the equipment for operating temperature-humidity test (ports open/closed, etc.) as

specified by the manufacturer.

Step 3: Power the equipment; allow it to reach operating temperature.

Step 4: Set the chamber to 5 °C (41 °F) and 5% relative humidity (see Comment 1), observing precautions against thermal shock and condensation (see Comment 2). Allow relative humidity and equipment temperature to stabilize. All paper, including ballots, used by the system must be stabilized at the specified testing temperature and humidity levels prior to testing (see Comment 4).

Step 5: Perform an operational status check. If the equipment shows evidence of damage, or any examined function or feature is not working correctly, then the equipment under test fails the test scenario.

Step 6: Set the chamber to 5 °C (41 °F) and 85% relative humidity (see Comment 1), observing precautions against thermal shock and condensation (see Comment 2). Allow relative humidity and equipment temperature to stabilize. All paper, including ballots, used by the system must be stabilized at the specified testing temperature and humidity levels prior to testing (see Comment 4).

Step 7: Perform an operational status check. If the equipment shows evidence of damage, or any examined function or feature is not working correctly, then the equipment under test fails the test scenario.

Step 8: Set the chamber to 40 °C (104 °F) and 85% relative humidity (see Comment 1), observing precautions against thermal shock and condensation (see Comment 2). Allow relative humidity and equipment temperature to stabilize. All paper, including ballots, used by the system must be stabilized at the specified testing temperature and humidity levels prior to testing (see Comment 4).

Step 9: Perform an operational status check. If the equipment shows evidence of damage, or any examined function or feature is not working correctly, then the equipment under test fails the test scenario.

Step 10: Set the chamber to 40 °C (104 °F) and 5% relative humidity (see Comment 1), observing precautions against thermal shock and condensation (see Comment 2). Allow relative humidity and equipment temperature to stabilize. All paper, including ballots, used by the system must be stabilized at the specified testing temperature and humidity levels prior to testing (see Comment 4).

Step 11: Perform an operational status check. If the equipment shows evidence of damage, or any examined function or feature is not working correctly, then the equipment under test fails the test scenario.

Step 12: Repeat steps 4-11 two more times, so that the equipment completes three temperature-humidity test cycles (see Comment 3).

Step 13: Return the chamber to ambient laboratory conditions, observing precautions against thermal shock and condensation (see Comment 2). Allow relative humidity and equipment temperature to stabilize. All paper, including ballots, used by the system must be stabilized at the ambient laboratory conditions (see Comment 4).

Step 14: Remove the equipment from the chamber.

Step 15: Perform a post-test operational status check. If the equipment shows evidence of damage, or any examined function or feature is not working correctly, then the equipment under test fails the test scenario.

Comments:

1. Unlike the Storage Humidity test which replicates natural cycles of 24-hour duration, this test checks for correct operation at only four points: (1) 5 °C (41 °F) and 5% RH, (2) 5 °C (41 °F) and 85% RH, (3) 40 °C (104 °F) and 85%, and (4) 40 °C (104 °F) and 5%. The transitions between these test points are chosen to facilitate testing and to minimize stress to the equipment being tested, within the scope of the conformance requirements.
2. To prevent thermal shock, MIL-STD-810D recommends a rate of temperature change no greater than 10 °C (18 °F) per minute. The more recent standard MIL-STD-810F recommends a rate of temperature change no greater than 3 °C (6 °F) per minute.
3. For the operational high temperature test, MIL-STD-810D (and MIL-STD-810F) recommends a minimum of three temperature cycles. This test scenario includes three temperature-humidity cycles to comply with this recommendation. For the humidity test, MIL-STD-810D (and MIL-STD-810F) recommends a minimum of 10 temperature-humidity cycles with an operational check at least every 5 cycles, but has no distinct "operating humidity" test procedure. Since voting devices are already subjected to 10 temperature-humidity cycles as part of the storage humidity test, this test scenario specifies that the operating temperature-humidity test use three temperature-humidity cycles.
4. Physical changes in paper during changes in temperature and humidity, such as expansion and warping, are significantly affected by the rate of change and by handling procedures such as stacking. When stabilizing paper to the required conditions for operating tests, it is important to follow system and paper manufacturer handling instructions, wherever these instructions are consistent with VVSG testing requirements.

5.5. Equipment Transportation and Storage

5.5.1. General Transportation and Storage Comments

General Transportation and Storage Comments

1. The following outline shows the relevance of required documentation (VVSG Part 2) to storage and transportation requirements. Note that the organization of the documentation will not necessarily match the structure of the documentation requirements list in VVSG Part 2. In evaluating the documentation, it is the responsibility of the test lab to review all documentation provided and to determine which parts are relevant to a given documentation requirement. Cross-indices may be provided by the manufacturer to match the manufacturer-supplied documentation to the VVSG Part 2 documentation requirements, but it should not be assumed that a cross-index will correctly locate all the relevant information.
    a. Quality Assurance and Configuration Management Data Package
        i. Provided by manufacturer to the certification authority
        ii. Cross-index reference: none
    b. Technical Data Package (TDP)
        i. Provided by manufacturer to the test lab
        ii. Provides device specifications and testing techniques to support the testing process
        iii. Cross-index reference: VVSG Part 2, 3.1.1.3-B "A cross-index SHALL be provided indicating the portions of the documents that are responsive to documentation requirements enumerated in Requirement Part 2, 3.1.1.1-C." Note that documentation described in other chapters of VVSG Part 2, Chapter 4: "Voting Equipment User Documentation") is regarded as part of the TDP (Part 2, 3.1.1.1-C "TDP contents", item b), so the cross-index provided by the manufacturer as part of the TDP must include references to this document as well.
        iv. Assuming that the test lab will be the ones evaluating conformance to "Precinct devices storage and transportation" specifications, the labs can use the information in the TDP to understand the needs and capabilities of the equipment as part of this assessment.
        v. See VVSG, Part 2, 3.3.1-A (e) "System hardware characteristics", "Environmental conditions"
    c. Voting Equipment User Documentation
        i. Provided by manufacturer to the users (election officials)
        ii. Also referenced by the test lab (see VVSG Part 2, Chapter 4, introductory paragraph)
        iii. Cross-index reference: Mandatory as part of the cross-index for the TDP (3.1.1.3-B), also recommended for the Voting Equipment User Documentation as a stand-alone document set (VVSG Part 2, Chapter 2, introductory paragraphs).
        iv. Specific references in User Documentation (other relevant data may be included but not listed here):

1. 4.4.2-C “Operations manual, operational environment details” – environmental requirements and restrictions
2. 4.4.5-A “Operations manual, operating procedures” – includes any setup procedures
3. 4.4.8 “Transportation and storage” – any special instructions for transportation and storage

v. The primary means by which users are to be informed of the transport and storage requirements, including any special instructions
    1. Test lab is expected to check these specifications and instructions for completeness, clarity, and consistency with information in the TDP

d. Instructions or specifications (if any) on equipment or transport case
    i. Test lab should check any additional documentation for consistency with the Operations manual. Any such documentation may be used in judging whether any special instructions are prominent.

e. Instructions or specifications (if any) included in packaging (printing on original shipping box or plastic bags, paper inserts, removable tags)
    i. May be used by the test lab in checking the storage or transport instructions and specifications documented elsewhere, but should not be used in judging whether any special instructions are prominent, as documentation associated with packaging is likely to be discarded when the equipment is put into use, and will not subsequently be available to users.

5.5.2. Survive Transportation

This requirement will be considered to have been satisfied if the equipment under test passes the test scenarios for Part 1: 6.4.7 D.2 and Part 1: 6.4.7 D.3.

5.5.3. Survive Storage

This requirement will be considered to have been satisfied if the equipment under test passes the test scenarios for Part 1: 6.4.7 D.1 and Part 1: 6.4.7 D.4.

5.5.4. Precinct Devices Storage

Precinct Devices Storage
Test Checklist

VVSG References:

Part 1, Requirement 6.4.7-C, Precinct devices storage:

- "Precinct tabulators and vote-capture devices ***SHALL*** be designed for storage in any enclosed facility ordinarily used as a warehouse, with prominent instructions as to any special storage requirements."

Part 3, Section 4.3, Verification of Design Requirements, introductory paragraph:

- "…Other requirements that state that the system shall prevent something from occurring are not verifiable through operational testing, so inspection (with expert judgment) is the only effective testing strategy."

Derivation:

The test checklist is new. The 2005 VVSG provided no test materials for the analogous requirement (Volume I, 4.1.2.1, Shelter Requirements).

Questions:

1. _____ Check all supplied references for (1) information on equipment specifications and requirements pertaining to storage, and (2) instructions to the users (elections officials) pertaining to storage. Does the manufacturer supplied documentation include all the information pertaining to storage required by the VVSG documentation requirements (see General Transportation and Storage Comment 1)?
2. _____ Does the documentation include specifications on minimum and maximum storage temperature and humidity limits for the equipment (see Comment 4, General Transportation and Storage Comment 1)?
3. _____ Are the requirements compatible with typical warehouse storage conditions (see Comment 1, Comment 2, Comment 3)?
4. _____ If the documentation includes any special storage requirements for the equipment, are prominent instructions that include the special storage requirements included in the user documentation for the equipment? Such instructions must be included in the Voting Equipment User Documentation, and may be repeated in other documentation (see Comment 3, General Transportation and Storage Comment 1).
5. _____ Has the equipment passed conformance testing in accordance with VVSG Part 3, 5.1.4-A.3 "Storage temperature" and 5.1.4-A.4 "Storage

humidity"?

Comments:

1. Some warehouses are climate controlled and some are not. Warehouses without climate control will tend toward outdoor temperatures (which will vary by geographic region) with a thermal lag, and with additional intermittent solar heating effects. Implicit in the VVSG is the assumption that elections officials responsible for storage of the equipment will have a reasonable idea of the extremes to which a particular warehouse environment is likely to be subjected. Army Regulation AR 70-38, "RESEARCH, DEVELOPMENT, TEST AND EVALUATION OF MATERIEL FOR EXTREME CLIMATIC CONDITIONS, September 15, 1979" provides a guideline to typical extremes by region. Many more geographically detailed guidelines to US climatic extremes are available, for example http://www.permed.com/Climate_zones.htm (average annual minimum temperature), http://weather.yahoo.com/ (by city, records and averages), http://www.ncdc.noaa.gov/oa/climate/severeweather/extremes.html (record extremes), http://www.washingtonpost.com/wp-srv/weather/historical/historical.htm (average/record temperatures, humidity, sunshine,... - may not currently be working).
2. The requirement "***SHALL*** be designed for storage in any enclosed facility ordinarily used as a warehouse" with the use of the word "any" implies that the equipment must be designed for storage in non-climate-controlled warehouses (with more extreme temperature and humidity extremes than climate-controlled warehouses).
3. Primary environmental issues for warehouse storage are: (1) temperature extremes, (2) rate of change of temperature (thermal shock), (3) humidity extremes, and (4) condensation. Additional warehouse environmental issues may include: (1) dust in air, (2) water drip (leaks or condensation), (3) contamination of storage surface (dirt, oil, water), (4) fungus, (5) electrostatic effects (e.g. conductivity and triboelectric characteristics of flooring and equipment enclosure – is antistatic flooring needed?), (6) chemical vapors (which may be present in trace amounts from other stored items) – for example, some LCDs are susceptible to certain organic solvents, and (7) light (e.g. sunlight if the facility has windows or skylights). Equipment manufacturers are expected to provide storage requirements for the primary environmental factors, and to document any unusual requirements regarding additional environmental factors.
4. A voting device that is otherwise properly stored and transported may be subject to thermal shock and condensation if it is moved from a cold location to a warm polling place and suddenly exposed to ambient conditions. VVSG sections specifying documentation that may address this issue include:
    a. VVSG Part 2, Voting Equipment User Documentation:
        i. 4.4.5A "Operations manual, operating procedures"
        ii. 4.4.8 "Transportation and storage"

5.5.5. Design for Storage and Transportation

Design for Storage and Transportation
Test Checklist

VVSG References:

Part 1, Requirement 6.4.7-C.1, Design for storage and transportation:

- "Precinct tabulators and vote-capture devices ***SHALL***:
    a. Provide a means to safely and easily handle, transport, and install polling place equipment, such as wheels or a handle or handles; and
    b. Be capable of using, or be provided with, a protective enclosure rendering the equipment capable of withstanding (1) impact, shock, and vibration loads accompanying surface and air transportation, and (2) stacking loads accompanying storage."

Part 3, Section 4.3, Verification of Design Requirements, introductory paragraph:

- "…Other requirements that state that the system shall prevent something from occurring are not verifiable through operational testing, so inspection (with expert judgment) is the only effective testing strategy."

Derivation:

The test checklist is new. The 2005 VVSG provided no test materials for the analogous requirement (Volume I, 4.2.3, Transport and Storage of Precinct Systems).

Questions:

1. _____ Check all supplied references for (1) information on equipment specifications and requirements pertaining to storage and transportation, and (2) instructions to the users (elections officials) pertaining to storage and transportation. Does the manufacturer supplied documentation include all the information pertaining to storage and transportation required by the VVSG documentation requirements (see list of VVSG specified documentation requirements in General Transportation and Storage Comments 1)?
2. _____ Are the dimensions, weight, and other characteristics of the equipment such that it is easily handled, transported, and installed by hand, including the use of means such as wheels and handles if needed?
3. _____ Are any means included to facilitate handling of the equipment such as wheels and handles appropriate for the equipment in terms of strength, durability, and usability?

4. _____ Is the equipment provided with or capable of using a protective enclosure for storage and transport (see Comment 1)?
5. _____ Is the specified protective enclosure containing the equipment able to withstand normal stacking loads in warehouse storage conditions (see Comment 2)?
6. _____ Is the equipment in the specified protective enclosure able to pass the conformance test specified in VVSG Part 3, 5.1.4-A.2 "Vibration" and 5.1.4-A.1 "Bench handling" (see Comment 3)?

Comments:

1. Several of the storage and transportation environmental tests include placing the equipment in a storage/transport case. The manufacturer may or may not provide such a case.
2. Protective enclosures (cases) made of plastic materials may have different mechanical properties (such as brittleness) in different ambient conditions. For example, storage cases may be less able to withstand impact or stacking in a cold warehouse than in a "standard" indoor environment.
3. The bench handling test is normally performed on unprotected equipment to evaluate its ability to withstand maintenance and repair. The VVSG also uses the bench handling test as a proxy for the drop test, to evaluate the ability of the equipment to withstand shocks during transport. The language of 6.4.7-C.1, "a protective enclosure rendering the equipment capable of withstanding (1) impact, shock, and vibration loads accompanying surface and air transportation…" indicates a need for a bench handling test with the equipment in its case. The equipment may be able to withstand the bench handling test by itself, but if the case is damaged (breached, or rendered incapable of subsequent closure) by impact or shock during transport, it may not be able to properly protect the equipment from environmental and transport conditions in the future.

5.5.6. Storage Temperature

5.5.6.1. High Temperature

High Temperature
Test Scenario

VVSG References:

Part 1, Requirement 6.4.7-D.1, Storage temperature:

- "Voting devices **SHALL** withstand high and low storage temperatures ranging from -20 °C to 60 °C (-4 °F to 140 °F)."

Part 3, Requirement 5.1.4-A.3, Storage temperature:

- "All voting systems **SHALL** be tested in accordance with MIL-STD-810D: Method 502.2, Procedure I – Storage and Method 501.2, Procedure I – Storage. The minimum temperature **SHALL** be -4 degrees F, and the maximum temperature SHALL be 140 degrees F."

Derivation:

The test scenario is derived largely from the 2005 VVSG, Volume II, 4.6.5 "High Temperature Test".

Procedure:

Step 1: Conduct pre-test operational status check. If the equipment shows evidence of damage, or any examined function or feature is not working correctly, then the equipment under test is defective and testing cannot continue until the defect is eliminated. In accordance with Part 3, Requirement 2.5.5-E, if corrective action is taken to restore the equipment to a fully operational condition within eight hours, then the testing may be resumed with a re-run of Step 1.
Step 2: Arrange the voting equipment as for storage. Install it in the test chamber.
Step 3: Raise the internal temperature of the chamber at any convenient rate, but in any case no more rapidly than 3 °C (6 °F) per minute, until an internal chamber temperature of 60 °C (140 °F) has been reached.
Step 4: Allow the chamber temperature to stabilize. Maintain this temperature for a period of 4 hours after stabilization (see Comment 1).
Step 5: Allow the internal temperature of the chamber to return to standard laboratory conditions, at a rate not exceeding 3 °C (6 °F) per minute.
Step 6: Allow the internal temperature of the equipment to stabilize at laboratory conditions before removing it from the chamber.
Step 7: Remove the equipment from the chamber and from its containers.

Step 8: Conduct post-test operational status check. If the equipment shows evidence of damage, or any examined function or feature is not working correctly, then the equipment under test fails the test scenario.

Comments:

1. The test scenario does not closely control the length of time the equipment is at elevated temperature–the total exposure time will vary with the rate of temperature change and with the technique used to achieve temperature stabilization. The assumption is that this is a test for effects that take place quickly once the target temperature is reached, thus a slight extension of the time the equipment is at elevated temperatures will have negligible effect on test results. In any case, the test lab must log, in the test report, the elapsed time for each test step, in accordance with Part 3, Requirement 2.5.4-C of the VVSG.
2. MIL-STD-810D ordinarily calls for a minimum of 7 24-hour cycles for the high temperature test 501.2 Procedure I. The test scenario can be regarded as a tailored version of the -810D procedure. MIL-STD-810F (501.4) recognizes both 1 cycle (constant temperature test) and 7 cycle versions of the high temperature test.
3. The test scenario is compatible with both MIL-STD-810D and MIL-STD-810F.

5.5.6.2. Low Temperature

Low Temperature
Test Scenario

VVSG References:

Part 1, Requirement 6.4.7-D.1, Storage temperature:

- "Voting devices **SHALL** withstand high and low storage temperatures ranging from -20 °C to 60 °C (-4 °F to 140 °F)."

Part 3, Requirement 5.1.4-A.3, Storage temperature

- "All voting systems **SHALL** be tested in accordance with MIL-STD-810D: Method 502.2, Procedure I – Storage and Method 501.2, Procedure I – Storage. The minimum temperature **SHALL** be -4 degrees F, and the maximum temperature SHALL be 140 degrees F."

Derivation:

The test scenario is derived largely from the 2005 VVSG, Volume II, 4.6.4 "Low

Temperature Test".

Procedure:

Step 1: Conduct pre-test operational status check. If the equipment shows evidence of damage, or any examined function or feature is not working correctly, then the equipment under test is defective and testing cannot continue until the defect is eliminated. In accordance with Part 3, Requirement 2.5.5-E, if corrective action is taken to restore the equipment to a fully operational condition within eight hours, then the testing may be resumed with a re-run of Step 1.

Step 2: Arrange the voting equipment as for storage. Install it in the test chamber.

Step 3: Lower the internal temperature of the chamber at any convenient rate, but not so rapidly as to cause condensation in the chamber, and in any case no more rapidly than 3 °C (6 °F) per minute, until an internal chamber temperature of -20 °C (-4 °F) has been reached.

Step 4: Allow the chamber temperature to stabilize. Maintain this temperature for a period of 24 hours after stabilization (see Comment 1).

Step 5: Allow the internal temperature of the chamber to return to standard laboratory conditions, at a rate not exceeding 3 °C (6 °F) per minute.

Step 6: Allow the internal temperature of the equipment to stabilize at laboratory conditions before removing it from the chamber.

Step 7: Remove the equipment from the chamber and from its containers.

Step 8: Conduct post-test operational status check. If the equipment shows evidence of damage, or any examined function or feature is not working correctly, then the equipment under test fails the test scenario.

Comments:

1. MIL-STD-810D calls for different minimum exposure time at low temperature for different test materials: 4 hours for general equipment (I-3.2b(1)), 72 hours for organic plastics (I-3.2b(2)), and 24 hours for restrained glass (I-3.2b(3)). The equipment to be tested may include organic plastics (molded case, printed circuit boards) and restrained glass (LCD panel). This test scenario recommends at least 24 hours exposure at the test temperature due to the critical nature of display panel physical integrity.
2. The test procedure is compatible with both MIL-STD-810D and MIL-STD-810F.

5.5.7. Bench Handling

Bench Handling
Test Scenario

VVSG References:

Part 1, Requirement 6.4.7-D.2, Bench handling:

- "Voting devices **SHALL** withstand bench handling equivalent to the procedure of MIL-STD-810D, Method 516.3, Procedure VI."

Part 3, Requirement 5.1.4-A.1, Bench handling:

- "All voting systems **SHALL** be tested in accordance with MIL-STD-810D, Method 516.3. Procedure VI."

Derivation:

The test scenario is derived largely from the 2005 VVSG, Volume II, 4.6.2 "Bench Handling Test".

Procedure:

Step 1: Conduct pre-test operational status check. If the equipment shows evidence of damage, or any examined function or feature is not working correctly, then the equipment under test is defective and testing cannot continue until the defect is eliminated. In accordance with Part 3, Requirement 2.5.5-E, if corrective action is taken to restore the equipment to a fully operational condition within eight hours, then the testing may be resumed with a re-run of Step 1.

Step 2: Place the voting equipment on a level, solid wooden test surface (see Comment 1) at least 4.24 cm (1.675 inches) thick, as for normal operation or servicing.

Step 3: Make provision, if necessary, to restrain lateral movement of the equipment or its supports at one edge of the device. Vertical rotation about that edge shall not be restrained.

Step 4: Using that edge as a pivot, raise the opposite edge to an angle of 45 degrees, to a height of four inches above the surface, or just below the point of perfect balance, whichever occurs first.

Step 5: Release the elevated edge so that it may drop to the test surface without restraint.

Step 6: Repeat steps 4 and 5 for a total of six events.

Step 7: Repeat steps 3, 4, and 5 for the other base edges, for a total of 24 drops for each device.

Step 8: Conduct post-test operational status check. If the equipment shows evidence of damage, or any examined function or feature is not working correctly, then the equipment under test fails the test scenario.

Comments:

1. MIL-STD-810D specifies the composition of the test surface, which can significantly affect the shock characteristics imparted to the test equipment.
2. This test scenario is intended both to test bench handling characteristics and as a proxy for a transit drop test (during which the equipment would be encased in protective packaging).
3. The test scenario is compatible with both MIL-STD-810D and MIL-STD-810F.

5.5.8. Vibration

Vibration
Test Scenario

VVSG References:

Part 1, Requirement 6.4.7-D.3, Vibration:

- "Voting devices **SHALL** withstand vibration equivalent to the procedure of MIL-STD-810D, Method 514.3, Category 1 – Basic Transportation, Common Carrier."

Part 3, Requirement 5.1.4-A.2, Vibration:

- "All voting systems **SHALL** be tested in accordance with MIL-STD-810D, Method 514.3, Category 1 – Basic Transportation, Common Carrier."

Derivation:

The test scenario is derived largely from the 2005 VVSG, Volume II, 4.6.3 "Vibration Test".

Procedure:

Step 1: Conduct pre-test operational status check. If the equipment shows evidence of damage, or any examined function or feature is not working correctly, then the equipment under test is defective and testing cannot continue until the defect is eliminated. In accordance with Part 3, Requirement 2.5.5-E, if corrective action is taken to restore the equipment to a fully operational condition within eight hours, then the testing may be resumed with a re-run of Step 1.

Step 2: Install the voting equipment to be tested in its transit or combination case as

prepared for transport (see Comment 1).

Step 3: Attach instrumentation as required to measure the applied excitation. Mount instrumentation as close as possible to the case / test fixture interface, to measure vibration applied to the transit or combination case.

Step 4: Mount the equipment on a vibration table with the axis of excitation along the vertical axis of the equipment (see Comment 2)

Step 5: Apply random vibration excitation as shown in **Table Va** (see Comment 3) with low frequency excitation cutoff at 10 Hz, for a period of 30 minutes.

Step 6: Repeat steps 4 and 5 for the transverse and longitudinal axes of the equipment with the excitation profiles shown in **Table Vb** and **Table Vc**, respectively. (Note: The total excitation period equals 90 minutes, with 30 minutes excitation along each axis.)

Step 7: Conduct post-test operational status check. If the equipment shows evidence of damage, or any examined function or feature is not working correctly, then the equipment under test fails the test scenario.

Hz	**g^2/Hz**
10	0.01500
40	0.01500
500	0.00015

Table Va. Break points for vertical axis vibration exposure – overall 1.04 g rms.

Hz	**g^2/Hz**
10	0.00013
20	0.00065
30	0.00065
78	0.00002
79	0.00019
120	0.00019
500	0.00001

Table Vb. Break points for transverse axis vibration exposure – overall 0.20 g rms.

Hz	**g^2/Hz**
10	0.00650
20	0.00650
120	0.00020
121	0.00300
200	0.00300
240	0.00150
340	0.00003
500	0.00015

Table Vc. Break points for longitudinal axis vibration exposure – overall 0.740 g rms.

Comments:

1. Specified vibration levels should be applied to the transit or combination case, which may contain shock absorbing devices and thus expose the contained equipment to reduced vibration.
2. The three axes described in the test scenario refer to the expected orientation of the equipment during transport, with the direction of travel along the longitudinal axis, rather than orientation with respect to the physical shape of the equipment or orientation during use. Manufacturer specifications for equipment transport and transport case may provide indication of expected orientation for transport. If there is no indication of orientation for transport, the tester may arbitrarily assign axes of orientation for the vibration test. The assignment of axes and the orientation of the equipment during the test must be documented.
3. Reference for **Tables Va**, **Vb**, and **Vc**:
    - MIL-STD-810D, dated July 19, 1983, "MILITARY STANDARD ENVIRONMENTAL TEST METHODS AND ENGINEERING GUIDELINES", Figure 514.3-1 "Basic Transportation, common carrier environment, vertical axis", Figure 514.3-2 "Basic Transportation, common carrier environment, transverse axis", and Figure 514.3-3 "Basic Transportation, common carrier environment, longitudinal axis".
    - Equivalent reference is MIL-STD-810F, Change 3, dated May 5, 2003, Table 514.5C-VII, "Break points for curves of figures 514.5C-1 through 514.5C-3", U.S. highway truck vibration exposures [for figure 514.5C-1.
4. The test scenario is compatible with both MIL-STD-810D and MIL-STD-810F.

5.5.9. Storage Humidity

Storage Humidity
Test Scenario

VVSG References:

Part 1, Requirement 6.4.7-D.4, Storage humidity:

- "Voting devices **SHALL** withstand uncontrolled humidity equivalent to the procedure of MIL-STD-810D, Method 507.2, Procedure I – Natural Hot-Humid."

Part 3, Requirement 5.1.4-A.4, Storage humidity:

- "All voting systems **SHALL** be tested in accordance with humidity testing specified by MIL-STD-810D: Method 507.2, Procedure II – Natural (Hot-Humid), with test conditions that simulate a storage environment."

Derivation:

The test scenario is derived largely from the 2005 VVSG, Volume II, 4.6.6 "Humidity Test".

Procedure:

Prior to test: Make sure the voting equipment has been maintained at ambient conditions of temperature and humidity for at least 24 hours prior to the test.

Step 1: Conduct pre-test operational status check. If the equipment shows evidence of damage, or any examined function or feature is not working correctly, then the equipment under test is defective and testing cannot continue until the defect is eliminated. In accordance with Part 3, Requirement 2.5.5-E, if corrective action is taken to restore the equipment to a fully operational condition within eight hours, then the testing may be resumed with a re-run of Step 1.
Step 2: Arrange the voting equipment as for storage. Install it in the test chamber.
Step 3: Adjust the chamber conditions to those given in **Table SH**.
Step 4: Perform a 24-hour cycle with the time and temperature-humidity values specified in **Table SH** (see Comment 1).
Step 5: Repeat Step 4 until 5, 24-hour cycles have been completed.
Step 6: Continue with the test commencing with the conditions specified for time = 0000 hours.
Step 7: At any convenient time in the interval between time = 120 hours and time = 124 hours, place the equipment in an operational configuration, and perform an operational status check.
Step 8: If the equipment satisfactorily completes the status check, continue with the sixth 24-hour cycle.
Step 9: Perform 4 additional 24-hour cycles, terminating the test at time = 240 hours.
Step 10: Remove the equipment from the test chamber.
Step 11: Conduct post-test operational status check. Begin the status check within 15 minutes of the completion of the final 24-hour cycle (see Comment 2). If the equipment shows evidence of damage, or any examined function or feature is not working correctly, then the equipment under test fails the test scenario.

Time (24 hour cycle)	Temperature °C	Temperature °F	Relative Humidity %
0000 (= 2400)	31	88	88
0100	31	88	88
0200	31	88	88
0300	31	88	88
0400	31	88	88
0500	31	88	88
0600	32	90	85
0700	34	93	80
0800	36	96	76
0900	37	98	73

1000	38	100	69
1100	39	102	65
1200	40	104	62
1300	41	105	59
1400	41	105	59
1500	41	105	59
1600	41	105	59
1700	39	102	65
1800	37	99	69
1900	36	97	73
2000	34	94	79
2100	33	91	85
2200	32	90	85
2300	32	89	88

Table SH. Test chamber conditions for storage humidity test.

Comments:

1. Two references for **Table SH**:
    - MIL-STD-810D, dated July 19, 1983, "MILITARY STANDARD ENVIRONMENTAL TEST METHODS AND ENGINEERING GUIDELINES", Table 507.2-I, Natural Hot-Humid cycle (Cycle 1).
    - AR 70-38: Army Regulation 70-38, "RESEARCH, DEVELOPMENT, TEST AND EVALUATION OF MATERIEL FOR EXTREME CLIMATIC CONDITIONS, September 15, 1979", Table 2-3, "Hot Climatic Design Type; Hot-Humid Daily Cycle of Temperature, Solar Radiation, and Humidity", Operational Conditions.
2. The 15-minute time window for start of the operational status check after the final 24-hour cycle is to assure uniform testing conditions.
3. The test procedure is compatible with both MIL-STD-810D and MIL-STD-810F.