VxScan Tests of Normal Function

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Defining “Normal Function”

This document describes essential procedures and tests to perform on VxScan v4.0 to confirm “normal” desired function. These procedures are intended to confirm functionality before and after environmental tests. Key functions are listed below, corresponding to different tests.

Terms

- BB = ballot box
- CVR = cast vote record, digital files recording vote tallies and scans
- dev = developmental software image
- EMC = electromagnetic compatibility
- MCM = main control module
- prod = production software image
- UPS = universal power supply

Key System Functions

The following functions should work normally both before and after any EMC, environmental, vibrational, and other mechanical tests on the system:

1. **Scans ballots and saves cast-vote records (CVRs)**. Ballot paper is between 8.5” x 11” to 22” paper, depending on the election tested, between 28-40lb weight, as supplied by VotingWorks.
2. **Stores ballots securely in the ballot box**.
3. **Prints accurate reports before and after scanning ballots**. Reports print on appropriate thermal paper, as supplied by VotingWorks.
4. **Rejects invalid ballots and double-sheet ballots**.
5. **Displays instructions and accurate feedback to users visually and audibly**.
6. **Accepts user inputs on a touchscreen**.

Additional functions must also be confirmed to work normally before and after environmental and vibration tests, or any test that affects the corresponding mechanical parts. These include:

7. **Main control module (MCM) attaches to and detaches from the ballot box easily**.
8. **Maintains physical security**, restricting administrative access and preventing tampering without evidence.
9. **Protects internal electronics and subsystems**.

10. **Stores emergency ballots** when the ballots cannot be processed automatically.

Key System Components

The VxScan systems also have key components that should always be inspected visually for damage, if functional tests above do not already reveal the damage. These are listed below:

1. Scanner
2. Thermal Printer
3. Computer
4. Touch/Screen
5. Power Supply (internal to MCM)
6. Uninterruptible Power Supply (external to MCM)
7. Smart Card Reader
8. Speaker + Amp
9. USB-A female receptacles
10. Cable Assemblies

Additional components should be inspected for damage following environmental tests, vibration tests, other mechanical tests, or other stress tests that affect these parts:

11. Outer case
12. Inner panels around electronics
13. Locking mechanism of main control module (MCM) on the ballot box
14. Security tie points
15. Fasteners, both external and internal
16. Wires, ports, and electrical connections
17. Ballot box

Prepare the System for Testing

Prepare Software for Testing / Image the System

The system might already have working software installed, where you can authenticate with physical smart cards, or with mock cards. If so, skip this section. If you cannot authenticate, you may need to re-image the system with new software, described below.

The VxScan system can have a *Production* (prod) version of the software, or it can have a *Development* (dev) version of the software. The prod version would be the one used in the field with customers, also requiring physical smart cards to authenticate into the system, previously configured with VxAdmin. The dev version can bypass use of physical smart cards, instead using simulated mock cards. We recommend using the dev version for testing when the

software is likely to be upgraded in a short period of time, and/or if physical smart cards aren't available.

You will still need USB drives/sticks in this process. You should only have to image the machine once for a batch of EMC, environmental, and vibration tests, unless there are important software upgrades that should be included in the system in the middle of a round of tests.

Prepare Hardware for Testing

Before the doing the tests of normal function described below, set up the ballot box (BB), main control module (MCM), and universal power supply (UPS) appropriately, following these general steps:

1. Inspect the physical system components briefly. Note any existing concerns or problems before stress tests. Discuss, fix, or address them as needed. Some issues to watch out for include:
    a. Damage: Cracks, wear, holes, cuts, scratches, deformation, corrosion
    b. Dirtiness: Residues, stickiness, markings, dust, debris, discoloration, burns
    c. Looseness: Loose fasteners, loose cables, noises indicating loose parts
    d. Seizing: Frozen joints, stuck hinges, blocked openings, part interference

2. Set up the MCM on top of the ballot box (BB), and connect it to the UPS. A guide for setting up VxScan is linked here with pictures, intended for election workers.
    a. Expand and set up the BB. Position it in reach of the UPS for power.
    b. Attach and secure the MCM on the BB.
        i. Security seals do not have to be applied – unless you are specifically testing the effectiveness of the seals or seal tie points.
        ii. Insert the thermal paper roll into the administrative access door at this time.
    c. Power the system on. Plug in the UPS into mains power and turn it on. Plug the power cable into the MCM, and then to the UPS. The MCM screen should turn on.

3. Open the polls. A guide for opening polls in VxScan is linked here with pictures, intended for election workers.

If you cannot set up the system due to faulty parts or system errors, that is a failure. Investigate the causes of this failure, and discuss with VotingWorks staff how to address it in order to continue tests, if possible.

Pack up Hardware after Testing

After doing the tests of normal function described below, pack up the hardware appropriately. This includes removing any ballots stored in the ballot box and emergency bin. Store the hardware in a climate-controlled location until ready for the next batch of tests.

If you cannot close down and pack up the system due to faulty parts, that is a failure. Investigate the causes of this failure, and discuss with VotingWorks staff how to address it.

A guide for closing polls is linked here with pictures, intended for election workers.

A guide for packing up is linked here with pictures, intended for election workers.

Tests of Normal Function

After preparing the hardware for testing, perform the following tests of normal function. Record data appropriately in the tests of normal function checklist template.

Always Required

1. **Scans ballots and saves cast-vote records (CVRs)**.
    a. Equipment and materials needed:
        i. Ballot paper, between 8.5” x 11” to 22”, between 28-40lb weight, white, any finish; good quality without tears or other disruptions; with printed ballot matching the election definition configured previously; marked properly with no overvotes (unless allowed by election definition); quantity: at least 10 sheets.
            1. At least one of the ballots should have a write-in candidate marked.
    b. Procedure:
        i. Scan at least 10 different individual ballot sheets (but not more than 100, to save time)
            1. If there are any ballot misfeeds (rejections or jams), note this and under what conditions.
        ii. Check the contents of the USB drive to confirm that CVRs were saved. Find at least one .json file and one image file corresponding to the scanned ballots.
            1. You may need to check the USB contents on another device.
    c. Acceptable results (PASS):
        i. All ballots scan properly.
        ii. Any ballots that are rejected will scan properly after scanner cleaning.

1. Cleaning can be done by wiping with a microfiber cloth and isopropyl alcohol

iii. CVR files are confirmed to be saved.

d. Unacceptable results (FAIL):
   i. A ballot is rejected that should have been accepted (e.g. normal ballot, correctly configured election, one at a time, etc). The ballot continues to be rejected even after scanner cleaning.
   ii. The system jams for normal paper (e.g. flat, new sheet).
   iii. A ballot is accepted that should have been rejected (e.g. double sheet, torn in half, overvote if not allowed in election definition).
   iv. CVR files missing.
e. Mixed results requiring discussion (MIXED):
   i. Rejections that are not clear if they should have been rejected.
   ii. Jams where the paper was damaged to begin with.

2. **Stores ballots securely in the ballot box**.

a. Equipment and materials needed:
   i. Ballot paper, as in Test 1 above.
b. Procedure:
   i. After completing Test 1 above, open the ballot box (BB) and inspect the ballots.
   ii. Count the number of ballots scanned, and compare that to the tally on the screen. Save this information for the next Test 3 on printing accurate reports.
c. Acceptable results (PASS):
   i. All ballots fall within the BB. None are outside.
   ii. The number of ballots tallied on screen matches the number of physical ballot sheets scanned in the ballot box.
d. Unacceptable results (FAIL):
   i. Ballots are stuck in the MCM outfeed.
   ii. Ballots can be removed from the BB when the BB is closed and secure/locked, without leaving evidence.
   iii. Ballots are damaged, when they were not damaged upon scanning.
e. Mixed results requiring discussion (MIXED):
   i. Ballots are stuck in parts of the ballot box that might promote jams or ballot damage (e.g. stuck in corners).

3. **Prints accurate reports before and after scanning ballots**.

a. Equipment and materials needed:
   i. Thermal paper rolls
b. Procedure:

i. Following Tests 1 and 2, insert the poll worker card, close the polls, and print a report. (**Note**: You must insert thermal paper or have thermal paper available for printing at this time, in order to avoid confusion about the reports. Printed reports remain in the printer queue and do not disappear from memory until printed.) Note the number of ballots scanned thus far.
ii. Inspect the printed report for print quality and accuracy. Check the tallies for at least 2 tallies against the actual ballots, e.g. “Ballot counts: hand marked vs. machine marked” and a contest tally.
iii. After inspection, remove the ballots from the ballot box and reopen the polls via the Election Manager and poll worker cards to complete the rest of the following tests.

c. Acceptable results (PASS):
   i. Report prints.
   ii. Report has accurate tally, results, and other information. Compare to the actual ballots left in the ballot box up to this point.
d. Unacceptable results (FAIL):
   i. Printer jams during printing, fails to print.
   ii. Report has inaccurate tally, results, or other information. Take special note of write-in tallies.
e. Mixed results requiring discussion (MIXED):
   i. Printer makes very loud or concerning noises.

4. **Rejects invalid ballots and double-sheet ballots**.

a. Equipment and materials needed:
   i. Ballot paper, as in Test 1 above – except:
      1. Make sure at least 1 of these sheets is a blank sheet or is for the wrong election (not configured for the election definition on the system).
      2. If “overvote” ballots are rejectable in the election definition, then make sure at least one ballot is marked with too many votes for a contest.
b. Procedure:
   i. Test rejection of blank/wrong ballot. Insert the ballot and observe behavior,
   ii. Test rejection of double sheets.
      1. Ensure multi-sheet detection (MSD) is on. If this was not already configured, insert the Election Manager card and log in. Click on “System Settings”, and ensure that “Disable Double Sheet Detection” is not selected. Then remove the card and re-log in as the poll worker to continue scanning ballots.
      2. Insert a single valid ballot. Observe the behavior.

3. Insert two valid ballots, stacked right on top of each other. Observe the behavior.
4. Insert two valid ballots, stacked about 50% offset from each other, where the 2nd ballot is about half on top of the 1st when scanning. Observe the behavior.
5. Insert two valid ballots, stacked about 90% offset from each other, where the 2nd ballot is inserted nearly right at the end of the 1st ballot when scanning. Observe the behavior.

iii. If applicable, test rejection of "overvote" ballot. Insert the ballot and observe behavior.

c. Acceptable results (PASS):
   i. All ballots are rejected, EXCEPT the single valid ballot.
d. Unacceptable results (FAIL):
   i. Blank/wrong ballot is accepted.
   ii. Single valid ballot is rejected as a double-sheet.
   iii. Double sheet ballots are accepted.
   iv. Overvote ballot is accepted, if they were not supposed to be accepted, as defined in the election definition.
   v. Rejected ballots clip the edge of the MCM case, increasing chance of misfeed.

5. **Displays instructions and accurate feedback to users visually and audibly**.

a. Equipment and materials needed:
   i. Ballot paper, as in Test 1 above
b. Procedure:
   i. Scan a good ballot. Check if the screen shows appropriate instructions and feedback when scanning a ballot. Listen for appropriate chimes when successfully scanned.
   ii. Scan an invalid ballot (e.g. overvote, wrong election, etc). Check if the screen shows appropriate feedback when scanning. Listen for appropriate rejection chimes when rejected.
c. Acceptable results (PASS):
   i. Gives instructions to scan a ballot.
   ii. Informs when it scans, accepts, and rejects a ballot.
   iii. Plays appropriate audio on successful scan or upon rejection.
d. Unacceptable results (FAIL):
   i. On-screen feedback and audio feedback not in sync, or doesn't make sense.
   ii. No sound; on mute.
e. Mixed results requiring discussion (MIXED):

6. **Accepts user inputs on a touchscreen**.
    a. Equipment and materials needed:
        i. Ballot paper, as in Test 1 above.
    b. Procedure:
        i. Click on the “Color/Size” button in the upper right corner, and change the screen and font settings. Scan another ballot (settings should reset after scan).
    c. Acceptable results (PASS):
        i. Screen responds to touch.
        ii. Color/Size settings can be changed.
    d. Unacceptable results (FAIL):
        i. Touchscreen doesn’t respond.
        ii. Touchscreen is slow to respond or lags.
    e. Mixed results requiring discussion (MIXED):

Sometimes Required

Test these after any environmental tests, vibrational tests, other mechanical tests, or any test that affects the corresponding parts (may not be needed for EMC tests):

7. **Main control module (MCM) attaches to and detaches from the ballot box easily**.
    a. Procedure:
        i. Attach the MCM to the BB.
        ii. Secure the MCM to the BB, and apply seals to tie points.
        iii. Detach the seals and unsecure the MCM from the BB.
        iv. Detach the MCM from the BB.
    b. Acceptable results (PASS):
        i. Attaching the MCM is easy.
        ii. Detaching the MCM is easy.
        iii. Seals can be attached and detached easily.
    c. Unacceptable results (FAIL):
        i. The MCM is difficult to attach, getting stuck or not able to aligned.
        ii. The MCM has too much play, in rotation or translation, after attaching to the BB, such that scanning is disrupted, or the BB can be stuffed with ballots.
        iii. Security seals are difficult to attach and detach.
    d. Mixed results requiring discussion (MIXED):
        i. Any unsure judgements about (b) and (c).

8. **Maintains physical security**, restricting administrative access and preventing tampering without evidence.
    a. Procedure:
        i. Attempt to stuff ballots into the BB or MCM in a fully set up and secured system.
        ii. Inspect the poll worker door (administrative access door). Look for vulnerabilities in overcoming its locks and seals.
        iii. Look for exposed data ports (e.g. USB ports) when the poll worker door is closed.
    b. Acceptable results (PASS):
        i. No opportunity to stuff ballots into the BB or MCM.
        ii. No vulnerabilities seen in the pollworker door.
        iii. No exposed data ports seen when the poll worker door is closed.
    c. Unacceptable results (FAIL):
        i. Can stuff a ballot into the BB or MCM when fully set up and secured.
        ii. Broken poll worker door, or other door vulnerabilities found.
        iii. USB port accessible when the poll worker door is closed/sealed.
    d. Mixed results requiring discussion (MIXED):

9. **Protects internal electronics and subsystems**.
    a. Procedure:
        i. Inspect the protective panels and case enclosing the internals. Look for any damage or openings.
        ii. Open the poll worker door and inspect the visible electronics. Look for any damage to the internal electronics.
        iii. If any damage is found, investigate further, potentially opening up the system to find more details.
    b. Acceptable results (PASS):
        i. No damage found.
    c. Unacceptable results (FAIL):
        i. Damage to protective panels/case that exposes internal electronics.
        ii. Damage to internal electronics found.
    d. Mixed results requiring discussion (MIXED):
        i. Cosmetic damage found.
        ii. Inconclusive wear or other damage found that could lead to bigger failures in future use cycles.

10. **Stores emergency ballots** when the ballots cannot be processed automatically.
    a. Equipment and materials needed:
        i. Ballot paper, as in Test 1 above.

b. Procedure:
    i. Insert a few emergency ballots into the emergency ballot bin.
    ii. Open the BB up to remove the emergency ballots.
c. Acceptable results (PASS):
    i. Ballots fall into the emergency ballot bin without obstruction or complications.
    ii. Ballots can be removed without complications.
d. Unacceptable results (FAIL):
    i. Emergency ballot bin is damaged.
    ii. Ballots get stuck in emergency ballot bin.
    iii. Emergency bin is stuck or non-functional.

Inspection of Parts

Following the tests above, think about the following parts of the system. Inspect them if needed. Were any problems encountered with these parts that were not already recorded in the previous tests? Do any of these parts show damage?

1. Scanner
2. Thermal Printer
3. Computer
4. Touch/Screen
5. Power Supply (internal to MCM)
6. Uninterruptible Power Supply (external to MCM)
7. JavaCard Reader
8. Speaker + Amp
9. USB-A female receptacles
10. Cable Assemblies
11. Outer case
12. Inner panels around electronics
13. Locking mechanism of main control module (MCM) on the ballot box
14. Security tie points
15. Fasteners, both external and internal
16. Wires, ports, and electrical connections
17. Ballot box

Quick Tests, <1 minute

For doing very quick tests of normal function, for example between ESD gun tests, the following tests are recommended:

- Scan a valid ballot. (Test 1 above, but for a single valid ballot)

- Print a report. (Test 3 above, but for a single report)

If no problems arise, that's a quick indicator that the system still works. If any problems arise, more in-depth analysis can be done.

Investigating Beyond What's in This Document

The key functions and components listed here cover much of the VotingWorks product requirements and government regulations for voting equipment (VVSG). However, **this document is not comprehensive** for indicating normal function. It only summarizes tests of normal function, requiring some tradeoffs to be done relatively quickly. If there is time to investigate more, and if there is a need to be more thorough, specific, or reliable, then please do so using engineering judgment.