Test Report - VxScan Feature Acceptance Criteria: Paper Path, Thermal Printer

Dates of testing: May 6, 2024 - Oct 30, 2025
Updated Nov 3, 2025 by Pius Wong

Summary

This report documents a series of smaller-scale tests related to ballot paper path functions in VxScan. They address internal VotingWorks requirements as well as some VVSG requirements listed below.

Applicable VVSG Requirements

Some of the tests listed here *indirectly* support testing these VVSG requirements below, although they are not the final tests for these requirements:

- 1.2-G – Misfeed rate benchmark
- 2.7-A – Assessment of reliability
- 2.7-B – Continuous operation – typical environmental conditions
- 2.7-D – Ability to support maintenance and repair physical environment conditions – non-operating
- 2.7-E – Ability to support transport and storage physical environment conditions – non-operating
- 8.1-K – Eliminating hazards

Devices Under Test

- VxScan, v4.0, Build 0
- Ballot Receptacle prototype, LP2-1

Results

Tests were performed on each of the following design feature requirements listed below, with results informing design refinement. Followup plans are included for each test, if applicable.

1. Usability: System makes it easy to input thermal paper

- **a. Source of requirement**
  - i. VotingWorks internal requirements
- **b. Acceptance criteria**
  - **i. Description**
    1. Easy to input thermal paper.
  - **ii. Metrics Evaluated**
    1. Time to input and align thermal paper. (Assume access is already exposed.) Average from 3 people. Different brands of thermal paper may be tested.
    2. Number of steps to input and align thermal paper.
    3. Were any errors or difficulties encountered? Describe them.
    4. Is it reasonably easy to input the paper roll in the wrong orientation?
  - **iii. Acceptable Metrics**
    1. Metric #1: <1 min
    2. Metric #2: <20
    3. Metric #3: No, or yes only if the errors can be sufficiently avoided with procedural/training solutions.
    4. Metric #4: No

iv. **Unacceptable Failure Modes**
1. Metric #1: >=1 min
2. Metric #2: >=20
3. Metric #3: Yes, and there are no acceptable procedural/training solutions
4. Metric #4: Yes

v. **Source of Metrics**
1. VotingWorks internal requirements

c. **Test Results**
i. All passing metrics.
1. Quick input, <1 min
2. Few steps (insert, push to click)
3. No errors with instruction
4. No, just on input direction, and instructions supplement this.
ii. Testing performed by VotingWorks in San Francisco, CA, and Austin, TX, from May - July 2024.

d. **Summary Results**
i. Pass.

e. **Other Notes**
i. Assumes users received instruction & training. Early testing led to removal of decurling mechanism to simplify the process.

f. **Followup Plan**
i. Continued monitoring of units used internally and in the field.

g. **Followup Test Results**
i. Continued normal results as of October 2025.

2. Usability: System makes it easy to remove unused thermal paper

a. **Source of requirement**
ii. VotingWorks internal requirements

b. **Acceptance criteria**
i. **Description**
1. Easy to remove unused thermal paper.

ii. **Metrics Evaluated**
1. Time to remove unused thermal paper. (Assume access is already exposed.) Average from 3 people. Different brands of thermal paper may be tested.
2. Number of steps to remove unused thermal paper.
3. Were any errors or difficulties encountered? Describe them.

iii. **Acceptable Metrics**
1. Metric #1: <1 min
2. Metric #2: <20

3. Metric #3: No, or yes only if the errors can be sufficiently avoided with procedural/training solutions.

iv. **Unacceptable Failure Modes**

1. Metric #1: >=1 min
2. Metric #2: >=20
3. Metric #3: Yes, and there are no acceptable procedural/training solutions

v. **Source of Metrics**

1. VotingWorks internal requirements

c. **Test Results**

i. All passing metrics.

1. Time <1 min
2. Few steps (click release, and pull)
3. No errors

ii. Testing performed by VotingWorks in San Francisco, CA, and Austin, TX, from May - July 2024.

d. **Summary Results**

i. Pass.

e. **Other Notes**

i. Assumes users received instruction & training.

f. **Followup Plan**

i. Continued monitoring of units used internally and in the field.

g. **Followup Test Results**

i. Continued normal results as of October 2025.

3. Paper Path, thermal printer: System prints valid reports in standard conditions, for documented paper types

a. **Source of requirement**

i. VotingWorks internal requirements

b. **Acceptance criteria**

i. **Description**

1. Prints on documented thermal paper types

ii. **Metrics Evaluated**

1. Jam/error rate when MCM prints reports under normal conditions, using recommended thermal paper brand.
2. Were any actual or potential hazards or system damage observed?
3. Can we verify valid report tallies after scanning ballots?

iii. **Acceptable Metrics**

1. Metric #1: 0 misfeeds out of 500 prints, or <=1/500 misfeed rate
2. Metric #2: no
3. Metric #3: yes

iv. **Unacceptable Failure Modes**
1. Metric #1: >1/500 misfeed rate
2. Metric #2: yes
3. Metric #3: no

v. **Source of Metrics**
1. Copying misfeed threshold from ballot VVSG 1.2-G requirements for ballots, but this is not actually defined or required in VVSG for reports.

c. **Test Results**
i. All passing metrics.
ii. Testing performed by VotingWorks in San Francisco, CA, and Austin, TX, from May - July 2024.

d. **Summary Results**
i. Pass.

e. **Other Notes**
i. n/a

f. **Followup Plan**
i. Continued monitoring of units used internally and in the field.

g. **Followup Test Results**
i. Continued normal results as of October 2025.

4. Usability: System makes it easy to remove printed reports

a. **Source of requirement**
i. VotingWorks internal requirements

b. **Acceptance criteria**
i. Description
1. Easy to remove printed thermal paper.

ii. Metrics Evaluated
1. Time to remove report. (Assume access is already exposed.) Average from 3 people. Different brands of thermal paper may be tested.
2. Number of steps to remove unused thermal paper.
3. Were any errors or difficulties encountered? Describe them. This may include damage to paper/report.

iii. Acceptable Metrics
1. Metric #1: <1 min
2. Metric #2: <20
3. Metric #3: No, or yes only if the errors can be sufficiently avoided with procedural/training solutions.

iv. Unacceptable Failure Modes
1. Metric #1: >=1 min
2. Metric #2: >=20

3. Metric #3: Yes, and there are no acceptable procedural/training solutions

v. **Source of Metrics**

1. VotingWorks internal requirements

c. **Test Results**

i. All passing metrics.

ii. Tearing was OK, but when not pulling at an optimal angle may not get a clean tear

iii. Testing performed by VotingWorks in San Francisco, CA, and Austin, TX, from May - July 2024.

d. **Summary Results**

i. Pass.

e. **Other Notes**

i. Assumes users received instruction & training.

f. **Followup Plan**

i. Revised tear bar to allow cleaner tearing.

ii. Continued monitoring of units used internally and in the field.

g. **Followup Test Results**

i. Continued normal results as of October 2025. No tearing issues seen in newer units.

5. Safety & Hazard Prevention: Thermal printer features are safe for arms/hands/fingers, during use

a. **Source of requirement**

i. VVSG 8.1-K – Eliminating hazards

ii. VotingWorks internal requirements

b. **Acceptance criteria**

i. **Description**

1. Easy to remove printed thermal paper.

ii. **Metrics Evaluated**

1. Are there design features to prevent pinch points to fingers/hands around thermal printer and paper mechanism?
2. Are all parts of the thermal printer and paper mechanism that interface with the hand/fingers smooth, flat, rounded, deburred, and not sharp?
3. Is there minimal risk of injury from any cutting surfaces or edges during regular use, maintenance, and transport?
4. Is there minimal risk of injury to eyes or other body parts from components under tension/compression, or fracturing, during regular use, maintenance, and transport?

iii. **Acceptable Metrics**

1. Yes to all

iv. **Unacceptable Failure Modes**
    1. No to any
v. **Source of Metrics**
    1. VotingWorks internal requirements

c. **Test Results**
    i. All passing metrics, with most updated roll holder design.
    ii. Metric #2: Pass, even though the cutting edge is not smooth, because the plastic does not damage hands.
    iii. Testing performed by VotingWorks in San Francisco, CA, and Austin, TX, from May - July 2024.
d. **Summary Results**
    i. Pass.
e. **Other Notes**
    i. Observed to be helpful that the printer roll holder cannot be put in backward.
f. **Followup Plan**
    i. Testing in May 2024 led to the paper roll holder design to be refined to reduce any chance of fingers encountering pinch points or sharp edges. These issues were not seen by July 2024.
    ii. Continued monitoring of units used internally and in the field. Keep note especially of any reported issues with the tear bar or wiring.
g. **Followup Test Results**
    i. Continued normal results as of October 2025.

6. Safety & Hazard Prevention: Thermal printer features prevent damage to clothes, accessories

a. **Source of requirement**
    i. VVSG 8.1-K – Eliminating hazards
    ii. VotingWorks internal requirements
b. **Acceptance criteria**
    i. Description
        1. Prevents damage to clothes, accessories
    ii. Metrics Evaluated
        1. Snag tests: Load thermal paper, print report, remove report, and unload paper, under the following conditions:
            a. Wear loose long-sleeve shirt or jacket, any material.
            b. Wear short sleeves and loose arm accessory, e.g. watch or jewelry.

            Does the clothing or accessory catch on any feature?
    iii. Acceptable Metrics
        1. No to all
    iv. Unacceptable Failure Modes

1. Yes to any

v. Source of Metrics

1. VotingWorks internal requirements

c. Test Results

i. All passing metrics.
ii. Testing performed by VotingWorks in San Francisco, CA, and Austin, TX, from May - July 2024.

d. Summary Results

i. Pass.

e. Other Notes

i. n/a

f. Followup Plan

i. Continued monitoring of units used internally and in the field.

g. Followup Test Results

i. Continued normal results as of October 2025.

7. Paper path, thermal printer: System prints valid reports on thermal paper with realistic paper disruptions

a. Source of requirement

i. VotingWorks internal requirements

b. Acceptance criteria

i. Description

1. Prints on reasonably disrupted paper

ii. Metrics Evaluated

1. Attempt to print reports on each of the following types of disrupted thermal paper. Try each case at least 3x, for the multiple thermal paper brand of interest:
    a. torn (at corners, sides)
    b. slightly wrong size (not A4 size)
    c. stored in >60% humidity for 24+ hours
    d. any other disruptions of interest

   For each disrupted paper type, answer this question (y/n):
   Does the system print the report appropriately without causing failures?
   OR
   If the disruption is excessive, does the system jam appropriately, while alerting the user?

iii. Acceptable Metrics

1. Yes to all

iv. Unacceptable Failure Modes

1. No, while:
    a. System jams with difficulty removing the report.

b. Damages system.
c. Leaves significant debris in system.
d. Jams without alerts.
e. Jams for paper that only has a mild disruption.
f. System freezes for several seconds, or requiring restart.

v. Source of Metrics

1. VotingWorks internal requirements

c. Test Results

i. a) Pass, prints without issue.
   1. Testing performed by VotingWorks in Austin, TX, from May - July 2024.
ii. b, c, and d) Not yet tested; lower priority testing outside of system specifications

d. Summary Results

i. Not fully tested.

e. Other Notes

i. These tests are not required for VVSG and go beyond VotingWorks supported system use. The VxScan system uses provided thermal paper rolls that are packaged in airtight containers, and it is expected to support that use only.

f. Followup Plan

i. Treat these tests as lower priority; continue this testing after addressing all VVSG-required testing first.
ii. Continued monitoring of units used internally and in the field.

g. Followup Test Results

i. Continued normal results as of October 2025.

8. Paper path, thermal printer: System handles thermal printer jams appropriately, or fails gracefully

a. Source of requirement

i. VotingWorks internal requirements

b. Acceptance criteria

i. Description

1. Paper jams can be removed.
2. Paper jams do not cause system damage or failure.

ii. Metrics Evaluated

1. Intentionally try to cause thermal paper jams using acceptable thermal paper types. Try to cause the following types of jams, at least 3x each:
   a. pull the thermal paper as it prints from the start, up or to the side

b. let the report print, then try to pull it out mid-print, up or to the side
c. push the paper back into the thermal printer as it prints
d. input badly crumpled roll of paper
e. input badly curled roll of paper at leading edge
f. insert badly torn roll of paper at leading edge
g. insert very wet paper roll (water, alcohol)
h. insert paper roll that is folded at leading edge
i. insert out-of-spec thermal paper (wrong brand, size, weight, etc)

For each disrupted paper type, answer these questions (y/n):

- If the system jams, can the jam be removed easily?
- Does the system continue to work normally after clearing the jam?

iii. Acceptable Metrics

1. Yes to all
2. Each case must not damage the system.
3. The paper itself can get damaged/spoiled further, if it does not spoil an entire roll or many sheets.

iv. Unacceptable Failure Modes

1. No, while:
   a. System jams with difficulty removing the report.
   b. Damages system.
   c. Damages entire roll of thermal paper or many sheets.
   d. Leaves significant debris in system.
   e. Jams without alerts.
   f. Jams for paper that only has a mild disruption.
   g. System freezes for several seconds, or requiring restart.

v. Source of Metrics

1. VotingWorks internal requirements

c. Test Results

i. Not yet full tested; lower priority testing outside of system specifications

d. Summary Results

i. Not fully tested.

e. Other Notes

i. These tests are not required for VVSG and go beyond VotingWorks supported system use.

f. Followup Plan

i. Treat these tests as lower priority; continue this testing after addressing all VVSG-required testing first.
ii. Continued monitoring of units used internally and in the field.

g. Followup Test Results

i. Continued normal results as of October 2025.

9. Paper path, thermal printer: System handles unexpected inputs appropriately
    a. **Source of requirement**
        i. VotingWorks internal requirements
    b. **Acceptance criteria**
        i. **Description**
            1. Rejects unexpected inputs into the thermal printer.
            2. Fails gracefully at unexpected inputs into the infeed.
        ii. **Metrics Evaluated**
            1. Attempt to insert the following into the thermal printer, and observe the system.
                a. plain paper
                b. plastic sheet
                c. fabric / clothing
                d. thermal paper with tape on it
                e. cleaning sheet for a scanner
                f. other items that might unintentionally go in by users
                g. other items that might go in by bad actors

               For each case, does the system avoid catastrophic damage?
        iii. **Acceptable Metrics**
            1. Yes to all
            2. The system can error out, jam, etc, as long as it does not cause any hazards or permanently destructive damage.
        iv. **Unacceptable Failure Modes**
            1. No to any
            2. Hazards, permanent damage
        v. **Source of Metrics**
            1. VotingWorks internal requirements
    c. **Test Results**
        i. Not yet full tested; lower priority testing outside of system specifications
    d. **Summary Results**
        i. Not fully tested.
    e. **Other Notes**
        i. These tests could possibly be destructive. They are not required for VVSG and go beyond VotingWorks supported system use.
    f. **Followup Plan**
        i. Treat these tests as lower priority; continue this testing after addressing all VVSG-required testing first.
        ii. Continued monitoring of units used internally and in the field.
    g. **Followup Test Results**
        i. Continued normal results as of October 2025.

10. Paper path, thermal printer: System prints valid reports in hotter environmental conditions.
    a. **Source of requirement**
        i. 1.1.6-F – Ability to clear mis-fed ballots
        ii. 1.2-G – Misfeed rate benchmark
        iii. 2.7-A – Assessment of reliability
        iv. 2.7-B – Continuous operation – typical environmental conditions
    b. **Acceptance criteria**
        i. **Description**
            1. Prints on supported thermal paper in a hotter environment
        ii. **Metrics Evaluated**
            1. Jam/error rate when MCM prints reports under hotter conditions (95°F ambient temperature).
            2. Were any actual or potential hazards or system damage observed?
            3. Can we verify valid report tallies after scanning ballots?
        iii. **Acceptable Metrics**
            1. Metric #1: 0 jams/errors out ot 20 prints, or <=1/500 misfeed rate
            2. Metric #2: no
            3. Metric #3: yes
        iv. **Unacceptable Failure Modes**
            1. Metric #1: 1+ jams/errors, or >1/500 misfeed rate
            2. Metric #2: yes
            3. Metric #3: no
        v. **Source of Metrics**
            1. Copying misfeed threshold from ballot VVSG 1.2-G requirements for ballots, but this is not actually defined or required in VVSG for reports.
    c. **Test Results**
        i. All passing results; 0 jams/errors
        ii. Testing performed by VotingWorks in Austin, TX, Jul 15, 2024 to Aug 10, 2024.
    d. **Summary Results**
        i. Pass
    e. **Other Notes**
        i. n/a
    f. **Followup Plan**
        i. Continued monitoring of units used internally and in the field.
    g. **Followup Test Results**
        i. Continued normal results as of October 2025.

11. Shock testing: Thermal printer parts resist damage to benchtop drops during use and maintenance.
    a. **Source of requirement**
        i. VotingWorks internal requirements
        ii. VVSG 2.7-D – Ability to support maintenance and repair physical environment conditions – non-operating
    b. **Acceptance criteria**
        i. **Description**
            1. Thermal printer parts resist damage to benchtop drops during use and maintenance.
        ii. **Metrics Evaluated**
            1. Take the major components of the removable thermal printer mechanism (printer roll fixture, etc). Drop them according to benchtop drop tests standards for all sides/edges (lifting one edge 4", or 45 degrees, or perfect balance point), and examine the damage. Does it resist damage from the drop?
        iii. **Acceptable Metrics**
            1. Yes
            2. Damage is cosmetic only; component still usable.
            3. No hazards to body.
        iv. **Unacceptable Failure Modes**
            1. No
            2. Broken parts, lost debris, deformation, etc
        v. **Source of Metrics**
            1. VotingWorks internal requirements
    c. **Test Results**
        i. See larger document: ***Test Report - VxScan Drop Test, Bench Handling***.
        ii. Evaluation performed by VotingWorks in Austin, TX.
    d. **Summary Results**
        i. Pass
    e. **Other Notes**
        i. n/a
    f. **Followup Plan**
        i. Continued monitoring of units used internally and in the field.
    g. **Followup Test Results**
        i. Continued normal results as of October 2025.

12. Transit Testing: Thermal printer parts resist damage from vibrations during travel.
    a. **Source of requirement**

i. VotingWorks internal requirements
i. 2.7-E – Ability to support transport and storage physical environment conditions – non-operating

b. Acceptance criteria

i. Description

1. Inspection of thermal printer components following transit.

ii. Metrics Evaluated

1. Examine the thermal printer mechanism following air travel and travel in car.
    a. Are there any loose parts, fasteners, or wires?
    b. Is there any evidence of damage due to vibration or repeated high-frequency wear motion?

iii. Acceptable Metrics

1. No to all

iv. Unacceptable Failure Modes

1. Yes to any

v. Source of Metrics

1. VotingWorks internal requirements

c. Test Results

i. Pass, in 20+ shipments.
i. Evaluation performed by VotingWorks staff across several sites after cross-country shipping from May 2024 to October 2025.

d. Summary Results

i. Pass

e. Other Notes

i. n/a

f. Followup Plan

i. Continued monitoring of units used internally and in the field.
ii. If additional questions arise, then do additional simulated transit vibration testing on multi-axis rigs

g. Followup Test Results

i. Continued normal results as of October 2025.