



Teneo VolumeScope System Acceptance Test

Jan-2017



Teneo

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Table of Contents: SAT Teneo VolumeScope

R Revision history

1 Introduction

1.1	System Acceptance Test Certificate	1-1
1.2	Specimens.....	1-1

2 Description of the acceptance tests

2.1	Electron Beam performance	2-1
2.1.1	Microscope astigmatism.....	2-1
2.1.2	Magnification accuracy.....	2-2
2.2	High resolution measurement	2-3
2.2.1	High resolution at 30 kV in Hi-Vac.....	2-4
2.2.2	High resolution T2 at 1 kV in Hi-Vac.....	2-4
2.3	Vacuum system	2-5
2.3.1	Pump down time	2-5
2.3.2	End pressure	2-5
2.4	VolumeScope	2-6
2.4.1	High resolution T1 at 1.18 kV in Hi-Vac.....	2-6
2.4.2	High resolution T1 at 1.18 kV in Hi-Vac – FilterRing.....	2-7
2.4.3	High resolution VS DBS at 2 kV in Lo-Vac.....	2-8
2.4.4	Microtome performance tests (performed by Field Service Engineer)	2-9
2.4.5	Microtome performance tests (performed by Applications Specialist)	2-9

3 Accessories acceptance tests

3.1	Quick Loader	3-1
3.1.1	Verification of load cycle for the QuickLoader	3-1
3.1.2	Verification of unload cycle for QuickLoader	3-2
3.2	Retractable STEM detector	3-3
3.2.1	SEM-STEM Image Resolution	3-3

4 Certificate

4.1	Customer.....	4-1
4.2	System	4-1
4.3	System Acceptance Test.....	4-1
4.4	Signatures	4-1

R | System Acceptance Test: Teneo VolumeScope

R Revision history

This section outlines the revisions made to this book.

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Revision	Description of revision	Date
A	Initial Release	Mar 2016
B	Values in HR VS DBS at 2 kV in Lo-Vac corrected	May 2016
C	"To be specified" text removed, last page article edited	Jul 2016
D	HR VS DBS table corrected	Jan 2017

1 | System Acceptance Test: Teneo VolumeScope

1 Introduction

This publication is valid for the following type of microscope:

- Teneo VolumeScope

1.1 System Acceptance Test Certificate

The System Acceptance Test certificate is found at the rear in double, copies being provided for the customer and the SSD.

To carry out these acceptance tests, the following minimum configuration and accessories are needed:

- Basic, fully installed Teneo microscope.

1.2 Specimens

Delivered with the system:

- High resolution specimen S1987, PN 4022 268 02244
- Tin balls specimen, (order code 5322 695 14448)
- High resolution TEM specimen S128B, PN 5322 695 14749, delivered with R-STEM option
- Standard system test sample, PN 4035 273 15051
- Gold on Carbon (4022 297 10721)

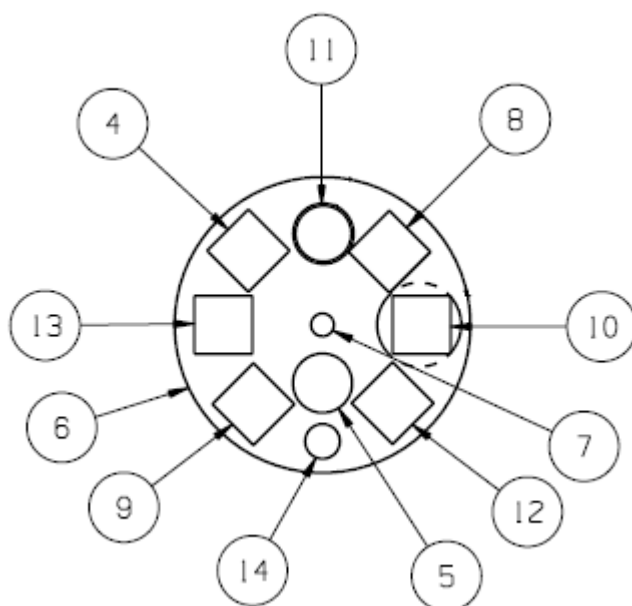


Fig. 1-1: Standard system test sample

Provided by the service engineer:

To avoid problems when carrying out the installation and acceptance tests, the local service engineer should have the following specimen:

- Magnification specimen 2160 lines / mm
(order code for specimen 2160 lines / mm and 19.7 lines / mm is 1031427)

2 | System Acceptance Test: Teneo VolumeScope

2 Description of the acceptance tests

2.1 Electron Beam performance

2.1.1 Microscope astigmatism

Preconditions:

- HiVac mode
- Specimen in eucentric position 10 mm
- Use case Standard
- Magnification ~30 000×

Procedure:

1. Set Use Case Standard, 30 kV, spot size 7.
2. Reset stigmator (right mouse button on stigmator cross).
3. Make Lens alignment.
4. Focus one edge of a tin ball (selected area).
5. Read and note the working distance in Service page alignment.
6. Focus an edge of the same tin ball rotated 90° w.r.t. the first edge.
7. Read and note the working distance in Service page alignment.
8. The difference in working distance read-outs must be according to table bellow.

Repeat for:

- Use case OptiPlan, 1 kV, spot size 7

Specification	Measured [µm]
Microscope astigmatism ≤ 100 µm at 30 kV, Standard	
Microscope astigmatism ≤ 40 µm at 1 kV, OptiPlan	

Not Applicable

Passed

Failed

Waived

FEI Service Engineer **Date Completed**

2.1.2 Magnification accuracy

- Use magnification calibration specimen.
- HV 30 kV, spot 8, Use case Standard
- Specimen in eucentric position 10 mm, slow scan > 3 μ s, scan rotation at 0°.

NOTE *Before checking the magnification make sure you have degaussed the final lens.*

1. Focus the image.
2. Rotate the stage (R) in such a way that the specimen is vertically and horizontally aligned.
3. Set approximately 20 × 20 squares of specimen grid to alignment rectangle.
4. Make image in slow scan.
5. Measure distance of 10 squares in vertical and horizontal direction by UI “Rectangle measurement”, it should be 4.63 μ m ± 3% (between 4.49 μ m and 4.77 μ m) if it is out of limits start alignment “Magnification calibration” and correct magnification.
6. Set scan rotation 90° and repeat step 5.

WD / HV / Scan rot.	Specification	Measured [μ m]
10 mm / 20 kV / 0°	measured value for X 4.63 μ m ± 3%	
	measured value for Y 4.63 μ m ± 3%	
10 mm / 20 kV / 90°	measured value for X 4.63 μ m ± 3%	
	measured value for Y 4.63 μ m ± 3%	

Not Applicable

Passed

Failed

Waived

FEI Service Engineer **Date Completed**

2.2

High resolution measurement

High resolution specification of a Scanning Electron Microscope is traditionally defined by visual separation of two gold grains on a carbon substrate. In order to achieve this a very high magnification is used (above 400 000×), that will give some image noise but allows clear measurements between the two respective particles. Although this method has been used for decades it remains extremely subjective to interpretation.

In order to assure high standards in the FEI factory system assembly and test procedure, FEI has defined a new process of high resolution specification determination that aims at removing the subjectiveness from the final assembly and test procedure. The process is as follows.

1. FEI Application specialists produce representative high resolution Gold on Carbon images. These images are typical of what our applications specialists believe are images that contain the resolution specified for the instrument in question, based on visual separation inspection.
2. The sharpness of the gold grain edges in the reference images is measured with FEI software. This program calculates the resolution across the edge of all gold grains in the image. The edge resolution depends on the contrast threshold values set in the program. An example of a threshold setting is 35/65. Threshold 35/65 was found to produce resolution values that correspond best to the resolution values determined by the visual separation method.
3. For the system acceptance test, collect high resolution images from the instrument and measure them with the software (threshold 35-65) – press Ctrl+R. If the outcome of the calculation is equal to or less the value of the specification in table below, then the system passes the high resolution test. Proper measurement must consist the image quality evaluation (CTRL-Q) that assesses how reliable the measured resolution is. The values must correspond to following:
 - a. Clipping < 2%
 - b. Resolution measurement > Valid
4. System (chamber and resolution specimen) has to be clean without any contamination. If not clean chamber at first, then clean specimen. Contamination significantly degrade resolution especially at low kV.
5. High resolution image should be taken under chamber vacuum 10^{-3} Pa.
6. If needed, use plasma cleaner to clean the chamber to avoid contamination during hires imaging.
7. Avoid sample plasma cleaning as it may damage your sample.
8. Put the resolution sample (S1987) to the heater (upper position)
 - a. Close the heater door
 - b. Switch on the heater
 - c. bake the sample for 180 minutes at minimum, preferably overnight
 - d. Switch off the heater
 - e. Immediately insert a warm sample to the SEM and pump it to Hi-Vac
 - f. Shut resolution picture according to the SAT.

NOTE

Do not touch the resolution sample with fingers, always use appropriate tweezers.

2.2.1 High resolution at 30 kV in Hi-Vac

- Aperture is set automatically.
- Use the High resolution specimen Gold on carbon (S1987).
- Select the ETD detector (SE mode), Hi-Vac mode.
- Select the Use case Standard.
- Set WD to 2 – 3 mm and select HV = 30 kV, spot 3 – 6, magnification 600 000× – 800 000× in single display view, display resolution 1536 × 1024, dwell time 5 μs.
- Optimize image with modulator, source tilt, lens alignment, focus and stigmator.
- Set filters: Integrate 1×, Line Integration 10×.
- The resolution must be ≤ 1.0 nm.

To measure the resolution:

1. Make an image and save it
(c:\xT\images\SAT\High_resolution_30kV_GoldonCarbon_Dxxxx.tif).
2. Start the Image quality program (image.exe) on the support PC.
3. Open the stored image and measure the quality.
4. Write down the measured value in the table below.

Specification	Measured [nm]
≤ 1.0 nm at 30 kV, WD 2 – 3 mm	

Not Applicable

Passed

Failed

Waived

FEI Service Engineer Date Completed

2.2.2 High resolution T2 at 1 kV in Hi-Vac

- Aperture is set automatically.
- High resolution specimen Gold on carbon is used (S1987).
- T2 selected, Hi-Vac mode.
- Select the Use case OptiPlan.
- Go to a WD 1 – 2 mm and select HV = 1 kV, spot 3 – 6, magnification 300 000× – 450 000× in single display view, display resolution 1536 × 1024, dwell time 5 μs.
- Optimize image with modulator, source tilt, lens alignment, focus and stigmator.
- Set filters: Integrate 1×, Line Integration 10×.
- The resolution must be ≤ 1.3 nm.

To measure the resolution:

1. Make an image and save it
(c:\xT\images\SAT\High_resolution_1kV_T2_GoldonCarbon_Dxxxx.tif).
2. Start the Image quality program (image.exe) on the support PC.
3. Open the stored image and measure the quality.
4. Write down the measured value in the table below.

Specification	Measured [nm]
≤ 1.3 nm at 1 kV, WD 1 – 2 mm	

Not Applicable

Passed

Failed

Waived

FEI Service Engineer Date Completed

2.3 Vacuum system

NOTE *The pump speed is not guaranteed without nitrogen venting. The ambient conditions (temperature, humidity) affect the pumping speed remarkably in countries with high humidity while venting by air.*

2.3.1 Pump down time

NOTE *Stop measuring of time periods when chamber becomes green in vacuum diagram.*

- After venting the specimen chamber with dry nitrogen and immediate re-evacuation a high voltage enable pressure is reached within:
 - 210 seconds is guaranteed in HI-VAC mode, after system left in HI-VAC overnight.

Specifications shown can be achieved when using dry Nitrogen (N₂) during venting.

Specification	Measured [sec]
Time to $\leq 3.0 \times 10^{-2}$ Pa: ≤ 210 sec (Hi-Vac mode)	

Not Applicable

Passed

Failed

Waived

FEI Service Engineer Date Completed

2.3.2 End pressure

1. Vent the vacuum system and column with dry NITROGEN.
2. Start the vacuum system until **Vacuum OK** has been reached and HV can be switched ON.
3. Let the microscope run for 12 hours or more.
4. Measure pressures when the beam is OFF and emission is ON.

The final vacuum (Hi-Vac mode) after 12 hours (overnight) pumping must be:

- Chamber: $\leq 6 \times 10^{-4}$ Pa
- Lower IGP1: $< 1 \times 10^{-5}$ Pa
- Upper IGP2: $< 1 \times 10^{-7}$ Pa

Specification	Measured [Pa]
Final Chamber pressure $\leq 6 \times 10^{-4}$ Pa in Hi-Vac mode	
Lower IGP1 pressure $< 1 \times 10^{-5}$ Pa	
Upper IGP2 pressure $< 1 \times 10^{-7}$ Pa	

Not Applicable

Passed

Failed

Waived

FEI Service Engineer Date Completed

2.4 VolumeScope

2.4.1 High resolution T1 at 1.18 kV in Hi-Vac

- High Vacuum (uses T1 detector, no external accessory is mounted on pole piece)
- Aperture is set automatically.
- High resolution specimen Gold on carbon is used (S1987), mounted in microtome. Find a place on the sample close to grid edge where both bigger and smaller gold particles are located.
- T1 selected, Hi-Vac mode.
- Select the Use case VolumeScope.
- Go to a WD 8 mm and select HV = 1.18 kV, Iprobe = 50 pA (spot 7), magnification 200 000 – 450 000× in single display view, display resolution 1536 × 1024, dwell time 5 µs.
- Optimize image with modulator, source tilt, lens alignment, focus and stigmator.
- Set filters: Integrate 1×, Line Integration 10×.
- The resolution must be ≤ 8 nm.

To measure the resolution:

1. Make an image and save it
(c:\xT\images\SAT\High_resolution_1.18kV_T1_GoldonCarbon_Dxxxx.tif).
2. Start the Image quality program (image.exe) on the support PC.
3. Open the stored image and measure the quality.
4. Write down the measured value in the table below.

Specification	Measured [nm]
≤ 8 nm at 1.18 kV, WD 8 mm	

Not Applicable

Passed

Failed

Waived

FEI Service Engineer **Date Completed**

2.4.2

High resolution T1 at 1.18 kV in Hi-Vac – FilterRing

- High Vacuum (uses T1 detector, no external accessory is mounted on pole piece)
- FilterRing Alignment (FilterRing mounted on pole piece)
- Aperture is set automatically.
- High resolution specimen Gold on carbon is used (S1987), mounted in Microtome, Filter ring mounted on pole piece. Find a place on the sample close to grid edge where both bigger and smaller gold particles are located.
- T1 selected, Hi-Vac mode.
- Select the Use case VolumeScope.
- Go to a WD 6.5 mm and select HV = 1.18 kV, Iprobe = 50 pA (spot 7), magnification 200 000 – 450 000× in single display view, display resolution 1536 × 1024, dwell time 5 µs.
- Optimize image with modulator, source tilt, lens alignment, focus and stigmator.
- Set filters: Integrate 1×, Line Integration 10×.
- The resolution must be ≤ 8 nm.

To measure the resolution:

1. Make an image and save it
(c:\xT\images\SAT\High_resolution_1.18kV_T1_FilterRing_GoldonCarbon_Dxxx.tif).
2. Start the Image quality program (image.exe) on the support PC.
3. Open the stored image and measure the quality.
4. Write down the measured value in the table below.

Specification	Measured [nm]
≤ 8 nm at 1.18 kV, WD 6.5 mm	

Not Applicable

Passed

Failed

Waived

FEI Service Engineer Date Completed

2.4.3 High resolution VS DBS at 2 kV in Lo-Vac

- Low Vacuum mode, VS-DBS detector is mounted on the pole piece.
- Aperture is set automatically.
- High resolution specimen Gold on carbon is used (S168), mounted in microtome.
- VS DBS selected, Lo-Vac mode (50 Pa)
- Select the Use case VolumeScope.
- Go to a WD 8 mm and select HV = 2 kV, Iprobe = 100 pA (spot 8), magnification 150 000 – 300 000× in single display view, display resolution 1536 × 1024, dwell time 10 μs.
- Optimize image with modulator, source tilt, lens alignment, focus and stigmator.
- Set filters: Integrate 1×, Line Integration 10×.
- The resolution must be ≤ 8 nm.

To measure the resolution:

1. Make an image and save it
(c:\xT\images\SAT\High_resolution_2kV_VSDBS_GoldonCarbon_Dxxxx.tif).
2. Start the Image quality program (image.exe) on the support PC.
3. Open the stored image and measure the quality.
4. Write down the measured value in the table below.

Specification	Measured [nm]
≤ 8 nm at 2 kV, WD 8 mm	

Not Applicable

Passed

Failed

Waived

FEI Service Engineer **Date Completed**

2.4.4 Microtome performance tests (performed by Field Service Engineer)

- Perform TAD tests (Acceptance criteria: Pass/Fail)
 - Stroke Test
 - Move Test
 - Performance Validation Test
Evaluates Error after move (3σ) of SFEED (sample Z axis) positioning on 40nm steps (test imitates the smallest specified cutting thickness). The Error after move (3σ) should be < 10 nm.
The evaluation is done automatically, the Performance Validation Test makes 40 nm steps, after test finishes, HTML report is generated which shows the performance results, read out the SFEED Error after move (3σ) value.

Specification	Measured [nm]
Error after move (3σ) < 10 nm	

Not Applicable

Passed

Failed

Waived

FEI Service Engineer Date Completed

2.4.5 Microtome performance tests (performed by Applications Specialist)

- Perform mechanical slicing job on Volumescope sample
 - Perform 50 mechanical cuts of 40 nm thickness.
 - Acceptance criteria: No missing slices (The goal is to demonstrate there are no missing slices on specified slice thickness).

Not Applicable

Passed

Failed

Waived

FEI Service Engineer Date Completed

3 | System Acceptance Test: Teneo VolumeScope

3 Accessories acceptance tests

3.1 Quick Loader

3.1.1 Verification of load cycle for the QuickLoader

Time required to do verification:

- 2 minutes

Materials required:

- Tin ball sample (5322 695 14448)
- Stopwatch

Preconditions:

- The sample is placed on the stage adaptor on the stage
- QuickLoader is vented

To verify the time to load a sample and to make an image:

1. Open QuickLoader Glass Lid.
2. Load the shuttle onto the bayonet.
3. Close the glass lid.
4. Start recording the time.
5. Press the "Pump" button on the QuickLoader.
6. Wait till quick loader chamber is pumped down and manually open the CLV.
7. Move the Rod into the chamber and dock the shuttle into the stage adapter.
8. Disconnect the shuttle from the rod, remove the rod from the Chamber and close the CLV manually.
9. Move the sample to eucentric height and make an image with following conditions:
 - a. Electron beam: 10 kV
 - b. Magnification 2 000×
10. When image is made stop timing and record time in table below:

Specification	Measured [sec]
Time to load sample and make image < 70 sec	

Not Applicable

Passed

Failed

Waived

FEI Service Engineer Date Completed

3.1.2 Verification of unload cycle for QuickLoader

Time required to do verification:

- 2 minutes

Materials required:

- Tin ball sample (5322 695 14448)
- Stopwatch

Preconditions:

- Shuttle is placed into Stage adapter
- QuickLoader is vented

To verify the time to unload a sample:

1. Switch beam OFF.
2. Start recording the time.
3. Press the "Pump" button on the QuickLoader.
4. When the pump light blinks open the CLV manually.
5. Move the rod into the chamber and connect to the shuttle.
6. When connected remove the Rod (with Shuttle attached) out of the chamber and lock the rod into the end position, then close the CLV manually.
7. Press the "Vent" button on the QuickLoader.
8. Wait till Quick Loader chamber is vented and then open the glass lid and remove the shuttle from the rod (bayonet).
9. When the shuttle is removed stop timing and record time in the table below:

Specification	Measured [sec]
Time to unload shuttle < 60 sec	

Not Applicable

Passed

Failed

Waived

FEI Service Engineer **Date Completed**

3.2 Retractable STEM detector

3.2.1 SEM-STEM Image Resolution

Time required:

- 15 minutes

Materials required:

- High resolution AGAR S128B

Preconditions:

- STEM centering alignment completed
- Use case OptiPlan
- Stage tilt: 0°
- Magnification: 600 000× – 800 000× in single view
- Electron beam 30 kV, spot size 3 – 7
- Dwell time 5 µs
- Line integration 10×
- Working distance: approximately 5 mm
- STEM III: Dark Field
STEM III+: Custom Annular, combine all DF segments (DF1, DF2, DF3, DF4)
- Image resolution: 1536 × 1024
- Beam deceleration OFF

1. Acquire an image and save it to disk.
(c:\xT\images\SAT\SEM_STEM_resolution_Dxxxx.tif).
2. Start the Image quality program (image.exe) on the Support PC.
3. Open the stored image and measure the quality and resolution.
4. Write down the measured value in the table below.

Specification	Measured [nm]
Resolution < 0.8 nm	

Not Applicable

Passed

Failed

Waived

FEI Service Engineer **Date Completed**

4 | System Acceptance Test: Teneo VolumeScope

4 Certificate

4.1 Customer

Name / PO#

.....

Address / SO#

.....

.....

4.2 System

System series

.....

Configuration

.....

Serial number

.....

4.3 System Acceptance Test

Factory

Service

Ambient Conditions:

.....

.....

Basic Instrument:

.....

.....

Accessories:

.....

.....

4.4 Signatures

This document certifies that the Teneo VolumeScope with aforementioned serial number has been tested at the above mentioned facility and that the system has satisfactorily TESTED the performance specification as outlined in the above purchase order.

Name

Date

Service engineer:

.....

.....

Factory manager:

.....

.....

