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ENGINEERING, COMPUTING, & WEAPONS STANDARD OPERATING PROCEDURE 07

From: Dean, School of Engineering, Computing and Weapons

Subj: TESCO MIRA3 SCANNING ELECTRON MICROSCOPE OPERATING PROCEDURES

Ref: (a) NAVSEA S0420-AA-RAD-010 (RAD-010) Rev 2A ACN 1
(b) NAVMED P-5055
(c) TESCO MIRA3 SCANNING ELECTRON MICROSCOPE User's Manual
(d) USNAINST 5104.2B

Encl: (1) Facility Description
(2) Facility Radiation Safety Evaluation
(3) Operating Procedures: Surveys
(4) Operating Procedures: General Controls and Practices
(5) Operating Procedures: Startup of Machine
(6) Operating Procedures: Maintenance
(7) Emergency Procedures
(8) Authorized User Qualification Requirements

1. This SOP contains procedures for the safe operation of the TESCO MIRA3 Scanning Electron Microscope (SEM). This SOP does not address all features of the TESCO MIRA3 SEM and is not meant to be a replacement for the user's manual, reference (c). This SOP is only meant to cover radiation safety concerns and general safety of the TESCO MIRA3 SEM. The SEM Laboratory Manager may provide additional guidance on optimization of SEM use. The SEM Laboratory Manager shall not give guidance that is contrary to this SOP nor give any additional guidance on radiation safety practices not addressed in this SOP.

2. Cancellation. This SOP updates ENGRWEPSOP 07B which was signed 30 November 2023. The next 5-year review by the USNA Radiation Safety Committee and re-authorization for the TESCO MIRA3 Scanning Electron Microscope Laboratory is due 10 Dec 2030.

3. Background and Discussion. The TESCO MIRA3 SEM uses an electron beam to create detailed digital images of objects placed inside a shielded housing. This SOP establishes the responsibilities of individuals involved with the safe operation and maintenance of the SEM. The SEM is part of the SEM Laboratory, and the individuals responsible for the SEM are the SEM Laboratory Manager and the Radiation Safety Officer (RSO).

4. Responsibilities.

a. The SEM Laboratory Manager / USNA Licensee. USNA Licensees are faculty and staff who have submitted a radiation use license application and have been approved as a licensee by the RSC. USNA Licensees are considered the custodian and the principal user or lab/facility manager. Licensees may recommend additional Authorized Users for authorization by the RSC. The Licensee will only be permitted to operate under the conditions of operational instructions approved by the Radiation Safety Committee (RSC). Any modifications of operations require RSO/RSC approval prior to commencement. All non-compliance issues will be addressed directly by the Licensee/custodian of the source. The SEM Laboratory Manager shall:

- (1) Ensure the safe usage and security of the SEM in accordance with this SOP.

(2) Ensure that only personnel trained, and qualified in accordance with Enclosure (8) are involved in the operation of the SEM.

(3) Be responsible for keeping qualification, radiation survey, and operation records up to date.

(4) Ensure that the rules and regulations are rigidly adhered to at all times.

(5) Report any malfunctions or repair operations to the RSO.

(6) Investigate and report to the RSO any suspected instances of overexposure.

(7) Conduct quarterly audit and quarterly surveillance.

(8) Keep RSO informed of any issues related to management of the SEM Laboratory, to include recommending (to the RSO) the removal of Authorized User qualification as needed.

(9) Endorse qualified operators to the RSC for qualification as Authorized Users.

b. SEM Authorized User. Per reference (a), personnel working in the vicinity of the SEM are not required to be qualified as Radiation Workers. SEM Authorized Users shall:

(1) Be qualified in accordance with the requirements of Enclosure (8) of this SOP.

(2) Be familiar with the contents of this SOP and pertinent portions of all references.

(3) Avoid exposing any part of the body to direct beam, secondary, or scattered radiation, which occurs when an electron beam strikes or has passed through any material.

(4) Conduct continuous checks on equipment, while in use, and report any malfunction to the SEM Laboratory Manager.

(5) Not deliberately defeat any of the automatic interlocks or switches that are part of the instrument design.

(6) Operate the SEM using the procedures in Enclosure (4) and (5) and follow the emergency procedures in Enclosure (7) in case of an accident.

(7) Alert non-qualified operators in Ri237A of changes to the condition of the SEM, e.g. turning the beam on and off, and ensure that all non-qualified operators are given non-radiation worker training if the SEM beam is on.

c. All personnel entering the SEM laboratory shall:

(1) Control their radiation exposure in accordance with the ALARA principle – As Low As Reasonably Achievable.

(2) Operate equipment in a safe and responsible manner.

(3) Take precautions to keep his/her own radiation exposure to a minimum.

- (4) Follow all directions of the Authorized User.
- (5) Be familiar with provisions of this SOP as it relates to the work being done in Ri-237A.
- (6) Report any equipment malfunctions, lost or inadvertently overexposed dosimeters, or suspected incidence of overexposure to the Authorized User.

d. The RSO and Assistant Radiation Safety Officer (ARSO) shall:

- (1) Conduct initial training of Authorized Users as per references (a) and (b).
- (2) Provide necessary radiological training and develop training plans.
- (3) Ensure appropriate annual refresher training guidance is provided, and certify the satisfactory completion of such training in the SEM binder.
- (4) Conduct or verify required surveys of reference (a) are completed.
- (5) Provide support as necessary to ensure compliance with higher authorities.
- (6) Establish standards of radiological health requirements.
- (7) Investigate alleged or suspected incidents of overexposure and prepare the necessary reports required by the Bureau of Medicine and Surgery and the Navy's Radiological Affairs Support Office, Yorktown, Virginia.
- (8) Be able to respond on-site to a radiological incident within the time required for normal commuting (<2 hrs).

e. The RSC shall:

- (1) Qualify users submitted by the lab manager as "Authorized Users" and to work outside normal work hours. This may be performed during quarterly meetings or on an ad hoc basis.

5. Review. This SOP will be in effect for the entire time that the SEM is installed at the U.S. Naval Academy. This SOP will be reviewed on an annual basis by the SEM Lab Manager and RSO to ensure that the procedures are current and in full compliance with reference (a). This SOP must be reviewed by the Radiation Safety Committee within 5 years.

6. Approval. This SOP and all references contained herein have been reviewed and approved by the RSC. Operation or maintenance of the TESCAN MIRA3 SEM in any manner or in reference to any procedure not described herein must first be approved by the RSC. Approval of such requested operation, procedure, or both will be temporary and will not constitute general approval by the RSO of the requested operation or procedure.



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**FACILITY DESCRIPTION
TESCAN MIRA3 SEM**

1. **General Description**

a. The primary purpose of the TESCAN MIRA3 SEM is to give midshipmen practical experience using an electron microscope and to evaluate microstructures of specimens to support material science courses. The TESCAN MIRA3 SEM uses an electron beam to create detailed digital images of objects placed inside a shielded housing. The SEM supports a variety of courses across several departments at USNA by allowing midshipmen to evaluate microstructure of a variety of specimens. The SEM is also extensively used for independent research courses, Bowman scholar projects, Trident scholar projects and faculty research across both the School of Engineering, Computing and Weapons and the School of Math and Science.

b. The TESCAN MIRA3 SEM is located in Ri237A in Rickover Hall in close proximity to other classrooms where materials science classes are taught. The SEM room is a lockable room but also contains equipment that is of use to personnel other than SEM Authorized Users, and as such access to Ri237A is not limited to SEM Authorized Users only. There are no other radiation sources or radioactive isotopes of any kind in the SEM room.

c. The TESCAN MIRA3 SEM requires a clean and air conditioned environment to operate at peak capacity. The SEM requires no water cooling and is cooled by air convection alone. A previously used water cooling system exists in Ri237A but has been isolated and is no longer in use.

d. Access to Ri237A is controlled by the SEM Laboratory Manager. Access to Ri237A (key or code to cypher lock) may be granted to approved personnel and the door to Ri237A may remain open. All Authorized Users of the SEM will have access to Ri237A. Personnel who are not Authorized Users of the SEM may also be granted access to use non-radiation equipment in this space. In order to control the radiological aspects of the SEM, one of three conditions must always exist in Ri237A:

(1) Ri237A is occupied by an Authorized User of the SEM

(2) The SEM software is not running (no user logged in)

(3) The SEM software is running, but both computer screens are locked to prevent any modification to current SEM conditions.

Any one of these conditions meets required radiological safety requirements. In general, the door to Ri237A shall remain shut and locked when the room is not occupied. Students and visitors may use the SEM or observe SEM operations, but only under the direct supervision of a non-student Authorized User. In these circumstances where the student or visitor is directly operating the machine, the non-student Authorized User shall coordinate with the RSO or SEM Lab Manager to provide the non-radiation worker training and record the training in the SEM binder prior to operation.

e. The door is posted with emergency contact information.

f. Images of the SEM and related equipment are shown in Figure 1 through 3.



Figure 1. TESCAN MIRA3 SEM workstation in Ri237A. The gas bottles shown are nitrogen gas used for operating pneumatic valves in the SEM.



Figure 2. Right side of Ri237A showing SEM preparatory station.



Figure 3. Left side of Ri237A showing additional SEM preparatory equipment.

Description of SEM Operation

- a. The TESCAN MIRA3 SEM is a Field Emission Gun (FEG) microscope and produces a beam of electrons from a tungsten tip by the Schottky Effect.
- b. This beam of electrons travels from the electron gun through a pneumatic gun valve into the specimen chamber which is maintained at a high vacuum.
- c. Electrons from the electron beam strike the specimen and both backscatter from the specimen and interact with the specimen to produce detectable secondary electrons. Both of these electrons are detectable by the SEM and produce an image that is representative of the specimen.
- d. The electron beam, backscattered electrons, and secondary electrons are all contained within the SEM enclosure. Interlocks prevent the beam from being on when the chamber door is open or when the chamber is not at a high vacuum. This effectively prevents all electron radiation from escaping the enclosure and significantly reduces the radiation hazard to personnel.
- e. The TESCAN MIRA3 SEM is equipped with both battery backup power and self-monitoring software that allows the SEM to gracefully secure power in case of emergency. The self-monitoring system also alerts Authorized Users of abnormalities and logs all machine relevant actions. The only action required to safely secure the SEM is to turn the beam off.
- f. The SEM cannot be manually operated in any way other than turning the entire unit off by the master on/off switch (which should not normally be done because this turns off the vacuum systems). For the purposes of this SOP, the SEM software is considered running when an individual user logs in to the MIRA3 software system. This is the only condition that allows the beam to be turned on and off. Because of this fact, logging into or out of the SEM software is considered to be a valid radiological safety control practice.
- g. Access to the SEM is controlled by password protected accounts for each individual Authorized User. The SEM cannot be turned on without this access. Additionally, logging off automatically turns the beam off. Only the SEM Laboratory Manager has supervisor access and can add, delete, or change user accounts.
- h. There are allowable conditions of SEM operation that require extended beam energization without other operator interaction, e.g. electron backscatter diffraction (EBSD) or energy dispersive X-ray spectroscopy (EDS) scans. These extended scan operations are authorized and the SEM Authorized User may leave the SEM unattended during this operation. The SEM Authorized User must ensure that conditions of paragraph 1.d of this enclosure are met. When extended scans are in progress and the SEM is unattended, the SEM Authorized User will place a temporary sign on the SEM Authorized User control desk to indicate that a scan is in progress.

**FACILITY RADIATION SAFETY EVALUATION
TESCAN MIRA3 SEM**

1. General Description

- a. The TESCAN MIRA3 SEM produces an electron beam ranging from 2 keV to a maximum of 30 keV. This beam interacts with specimens to produce backscatter and secondary electrons of lower energies.
- b. The electron beam also interacts with specimens to produce low energy photons as electrons from specimens fill electron vacancies in orbits where secondary electrons are produced. These photons range up to 30 keV. The vast majority of photons produced are less than 10 keV and correspond to K, L, and M photon energies of elements in the specimen.
- c. All radiation produced in the SEM is contained within the SEM enclosure. There is no measurable field outside of the SEM enclosure above room background using available RADIACS and radiation monitoring devices. A posted TLD area monitor is no longer required based on past history and having never returned a non-zero reading.
- d. All personnel working with electron microscopes, which meet all radiation safety requirements of reference (a) section 13.4 may be classified as non-radiation workers and personnel dosimetry is not required.
- e. The SEM is exempt from NAVSEADET RASO Machine Registration requirements per reference (a).
- f. The SEM does not generate radioactive waste and therefore does not require a radioactive waste management plan.
- g. The SEM does not generate airborne radioactivity.

2. Operations

- a. Routine operations shall not be permitted when shields are removed or cabinet doors are open.
- b. Non-standard accessories shall not be installed, aligned, or operated until inspected and approved, in writing, by the RSO.
- c. Operations shall be suspended and the RSO notified when any unusual operating conditions (high beam current, dark current or extra bright beam) or suspected deficiencies are noted.
- d. Radiation surveys shall include the viewing column area, high voltage power supply, and lens column, penetrations into the column, control console, and electron beam target area (see diagram in Enclosure 3). Installed interlocks shall be tested under actual use conditions.
- e. Exposure to radiation shall be kept as low as reasonably achievable (ALARA).
- f. Non-qualified personnel must have an Authorized User present at all times when the SEM is producing radiation.

Enclosure (2)

**OPERATING PROCEDURES: SURVEYS
TESCAN MIRA3 SEM**

1. Radiation surveys should supply all of the information requested on the Radiation Survey sheet found in this enclosure.
2. A radiation survey shall be conducted per reference (a) Section 13.4.2.9:
 - a. Prior to placing a new unit in service and annually thereafter not to exceed 12 months..
 - b. Immediately after maintenance or repair. The RSO may review and accept the post maintenance survey conducted by the vendor.
 - c. After shock, earthquake, etc., or suspected deficiency.
 - d. Whenever equipment is modified or relocated.
3. The every 5-year Facility Radiation Surveys are not required per reference (a) Section 2.24.1.4.
4. The SEM shall be surveyed with a RASO approved Ion Chamber Survey Meter.
5. RADIAC survey meters shall be available at all times to be used for radiation surveys and monitoring. RADIAC survey meters shall have the ability to measure a range from zero milliroentgens per hour to 200 milliroentgens per hour.
6. Surveys shall be performed by the Laboratory Manager and reviewed by the RSO or ARSO.
7. Measurements shall be made with the unit operating at maximum voltage and beam current. Radiation surveys shall include all external areas of the SEM, paying particular attention to the area immediately around the chamber door.
8. SEM radiation levels shall not exceed 0.5 mrem per hour at a distance of five centimeters from any external surfaces according to reference (a) Section 13.4.2.4. (Note this limit is different from other analytical equipment.)
9. The operation of each RADIAC survey meter shall be checked by a battery test and RADIAC Source Check kit before use. Instruments with weak batteries or whose operability is in doubt for any reason shall be called to the attention of the RSO.

OPERATING PROCEDURES: SURVEYS (EXAMPLE)
RADIATION SURVEY AND INTERLOCK TEST LOG SHEET
TESCAN MIRA3 SEM

Date _____ Time _____ Performed by _____ Date Next Due _____

Serial Number _____ Location _____ (Building and Room Number)

Date of last annual radiation survey _____

Survey Meter

System Parameters

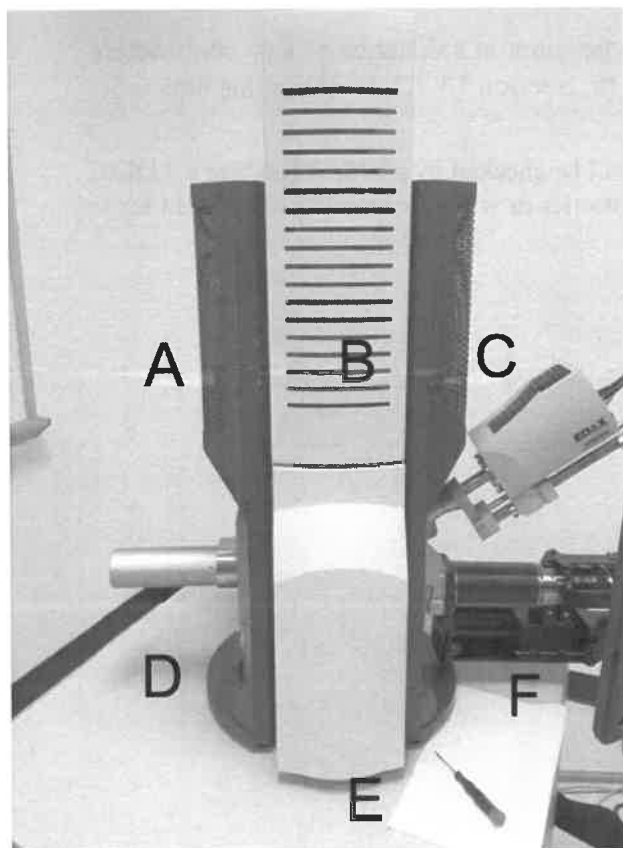
Model # _____
Serial # _____
Calibration Date _____

Beam Voltage (HV) _____ keV
Beam current (Absorb curr) _____ nA

_____ Interlock test complete. This test is conducted by verifying that venting the chamber automatically turns the electron beam off.

Survey points are 5 cm from the enclosure.

Readings (mR/hr) A _____ B _____ C _____ D _____ E _____ F _____ G _____



Description of survey points:

A – left side of electron gun, HV source

B – center front of electron gun, HV source

C – right side of electron gun, HV source

D – left side of chamber, SE detector penetration

E – front of chamber door

F – right side of chamber, EBSD/EDS detector penetration

G – front of control console where operator operates the SEM

G (in front of control

RSO review: _____

Enclosure (3)

OPERATING PROCEDURES: GENERAL CONTROLS AND PRACTICES TESCAN MIRA3 SEM

These procedures represent a basic outline for safely operating the TESCAN MIRA3 SEM, but do not substitute for understanding of the equipment. More detailed data collection procedures and machine adjustments for research purposes can be found in Reference (c) or other guidance from the SEM Laboratory Manager. Only Authorized Users are allowed to operate the SEM. The following procedures are drawn from reference (c).

1. General

a. Reference (a) requires that the SEM be secured when the system is not in use. The purpose of this requirement is to prevent unauthorized use of the SEM. However, because the SEM can be operationally limited and degraded over time if power to the vacuum system is frequently cycled, USNA allows the SEM to remain in a "shutdown to STANDBY" condition when the system is not in use. Trained personnel are required to be present while electron radiation production is in progress.

b. The SEM is protected from unauthorized use by individual user password protected accounts on the SEM software system which are required to conduct any SEM operation including turning the beam on or off. One of three conditions specified in Enclosure (1) must always exist in Ri237A.

c. The systems for the SEM consist of multiple computers and connections that do not directly impact radiation safety. Users must be familiar with the different computer systems in place. The SEM Lab Manager will be notified of any proposed system changes in the SEM laboratory.

2. Precautions

a. Nitrile or equivalent gloves will be worn at all times when handling specimens or stage equipment for the SEM or whenever the SEM chamber door is open. This requirement is vital to preventing foreign material from entering the SEM but has no bearing on radiation safety.

b. The SEM chamber door will be left open only long enough to install or remove specimens.

c. The SEM will remain at vacuum as much as possible. The chamber will be vented only to install or remove specimens.

d. The TESCAN MIRA3 software runs important diagnostics and provides automatic shutdown functions on a loss of power. Therefore, the MIRA3 software should be left at the login prompt as much as possible. For purposes of this SOP, the SEM is considered running once a user logs in.

e. The SEM will not normally be left unattended with the BEAM ON except during an extended scan. For short periods of time (e.g. during the course of a single operator session), the beam may be blanked rather than turned off. Beam blanking is accomplished through the SEM software and is a temporary electronic means of securing the beam without actual movement of internal isolation valves. Beam blanking is considered turning the beam off, but should only be used for short periods of time when the Authorized User stays in the vicinity of the SEM. If the Authorized User leaves Ri237A, they must lock both computer screens or log out of the SEM software system (which requires the beam to be off or which results in the beam being turned off). After completing an SEM session, the SEM should be placed in STANDBY.

f. Extreme care should be taken when installing specimens, especially specimens of unusual or large size. The IR camera must be on and verified live when loading samples or repositioning the stage. In general, the IR camera should always be on except for advanced operations (e.g. EDS and EBSD) where it interferes with operation and in those cases, the stage should not be moved.

g. There are numerous ways in which the stage may be moved, some of which could be unintentional. Authorized Users must be aware of actions that cause stage movement and must ensure

that movement operations are safe before being executed.

h. The electron backscatter detectors can be inserted or retracted. EXTREME care must be taken when inserting or removing these detectors.

i. When finished working with the SEM, the Authorized User will ensure their specimens are removed from the chamber, the workstation is clear, all settings are returned to their original positions, and the Log Book is signed noting the date/ time, settings, duration, last survey date, sample type, and any problems encountered.

(1) The current setting recorded in the log book must be the highest emission current setting (see Figure 1) during the imaging session. In order to log current properly, the reading on screen will have to be **converted from μA to mA** as current must be logged in mA per reference (a).

(2) Exposure time shall be logged as exposure time as the amount of time physically in the SEM room with the beam on. If you leave the room during the conduct of scanning or other operations, then this time shall not be counted in exposure time. An individual's exposure is dependent on the time in the room with SEM beam on and there is no risk of exposure if the individual is not in the room.



Figure 1: Display of SEM emission current.

j. The normal condition of the SEM is as follows: SEM powered on (green light lit on the front lower section), TESCAN computer ON, MIRA3 software at the login prompt, chamber empty, stage in the home position, SEM in STANDBY, and chamber at a vacuum. If the SEM is found not in this condition, inform the SEM Laboratory Manager.

k. Users must use minimal torque when tightening set screws on any SEM equipment.

l. Users must ensure that all specimens are clean and dry prior to loading in the SEM. This is usually accomplished by storing samples in a vacuum chamber (or desiccant chamber if a vacuum chamber is unavailable) overnight.

m. No USB devices of any sort (e.g. personal hard drive regardless of origin, printers, PDAs, keyboards, etc.) will be connected to any computer systems in Ri237A without the specific permission of the SEM Laboratory Manager.

OPERATING PROCEDURES: STARTUP AND SHUTDOWN OF MACHINE TESCAN MIRA3 SEM

1. Startup from Complete Shutdown (not common)

- Startup from complete shutdown may only be done by personnel qualified with Supervisor access on the TESCANA SEM (e.g. the SEM Laboratory Manager).
- Start the Uninterruptable Power Supply (UPS); ensure SEM is being powered through the UPS.
- Turn the master switch on the back of the TESCANA SEM skirt section to ON.
- Login to the TESCANA MIRA3 software under the Supervisor account
- Verify nitrogen pressure in tank is greater than 800psig and that regulator shows between 80 to 90psig. Notify SEM Lab Manager if these conditions are not met.
- Select PUMP to turn the vacuum pump ON and pump down column and chamber
- Select FEG HV Control from the SEM menu. Select "Reset unit". After the unit has been reset, select Power ON to turn on the gun. This process will take approximately 45 minutes to complete. The gun may have to be aligned after this point. See Figure 1.

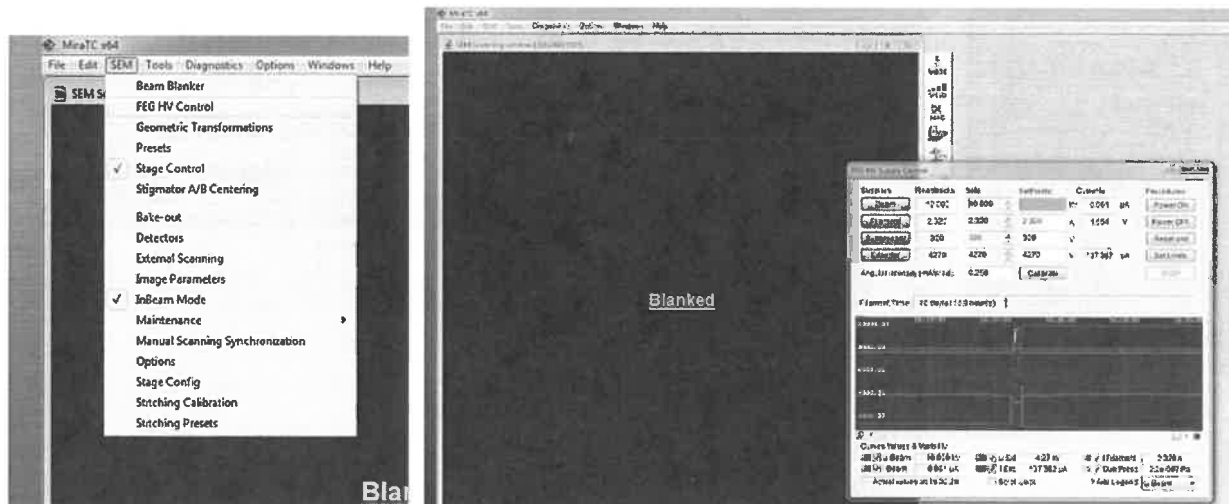


Figure 1. FEG HV Control

- After the gun warmup is complete, continue startup from STANDBY condition.
 - Annotate the Startup from complete Shutdown in the Usage Log (within the binder)
- ### 2. Complete Shutdown (not common)
- Select Power OFF from the FEG HV Supply Control menu (see above). Wait until all Readbacks read 0. This will take approximately 5 minutes.
 - If the SEM loses power for an extended period of time, the MIRA3 software will complete this same shutdown sequence.
 - If required, turn the master switch on the back of the TESCANA SEM skirt section to OFF
 - Shutdown the Uninterruptable Power Supply (UPS)

- e. Annotate the Shutdown in the Usage Log (within the binder)

3. **Startup from STANDBY Condition (normal process)**

- a. The following conditions should exist for normal startup from STANDBY:
- (1) The TESCAN PC is running.
 - (2) The MIRA3 software is running with no user logged in.
 - (3) The chamber is empty and the stage is in the HOME position. Note: This cannot be verified until the user logs in.
- b. Verify nitrogen pressure in tank is greater than 800psig and that regulator shows between 80 to 90psig. Notify SEM Lab Manager if these conditions are not met.
- c. Login to the MIRA3 software. The software will run a self-diagnostic sequence and will boot with the users last saved settings. These settings should include an IR camera window. Verify that the stage is in the HOME position ($x=0$, $y=0$, $z=40$, $Rot=0$, and $Tilt=0$). See Figure 2 and 3.

d.

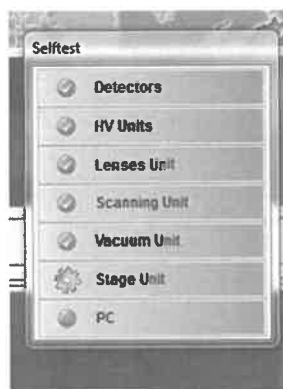


Figure 2. Diagnostics

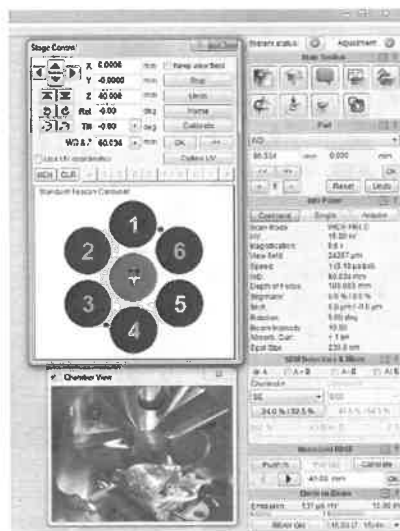


Figure 3. HOME Position and IR Camera

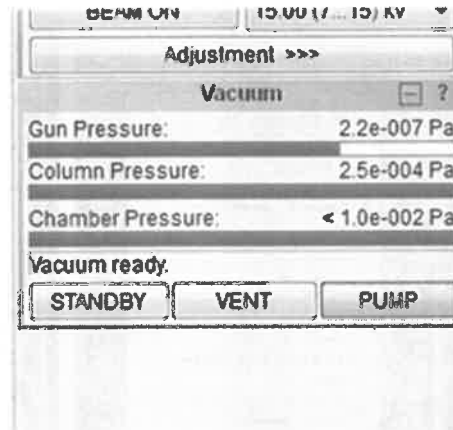


Figure 4. Vacuum and Venting

- e. When the chamber is fully vented and with gloves on any hand(s) entering the SEM chamber, open the chamber door. With the chamber vented, the SEM stage position will change from green to red. Selecting a stage position will prompt the user to ensure his hands are free from the stage before repositioning the stage. Clicking on a stage position will move the stage to the loading position for that sample (Figure 5).

- f. Load sample(s). Use minimal force on stage set screws. Ensure that the IR camera window is displayed and is live. Slowly close the stage door while monitoring the IR camera. Be very careful of large or unusual size samples. Apply gentle pressure on the chamber door when starting the pump and pump the chamber (Figure 6). This normally takes 1-3 minutes

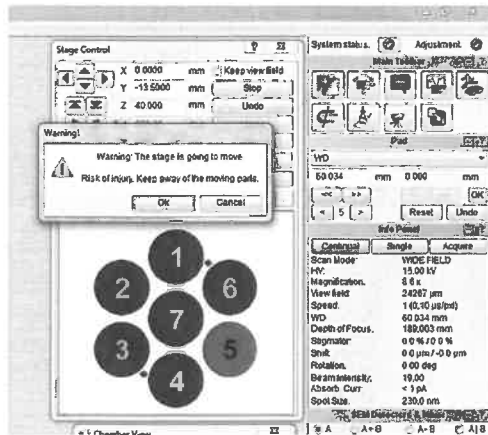


Figure 5. Stage During Chamber Venting

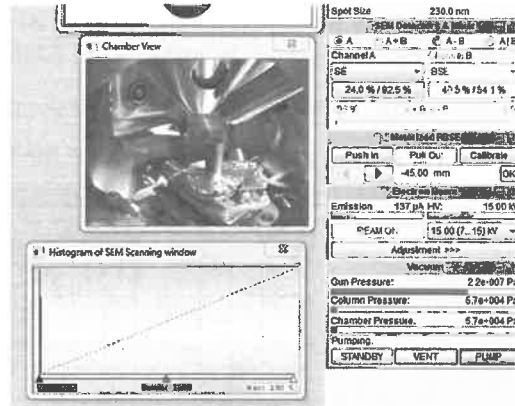


Figure 6. Pumping Chamber

g. When ready to start imaging, check the HV setting (in the info panel and normally 10 – 20 keV depending on application), and turn the beam on by clicking BEAM ON. This will open the gun valve and allow the electron beam into the chamber. An image should appear in the SEM scanning window. (Figure7).

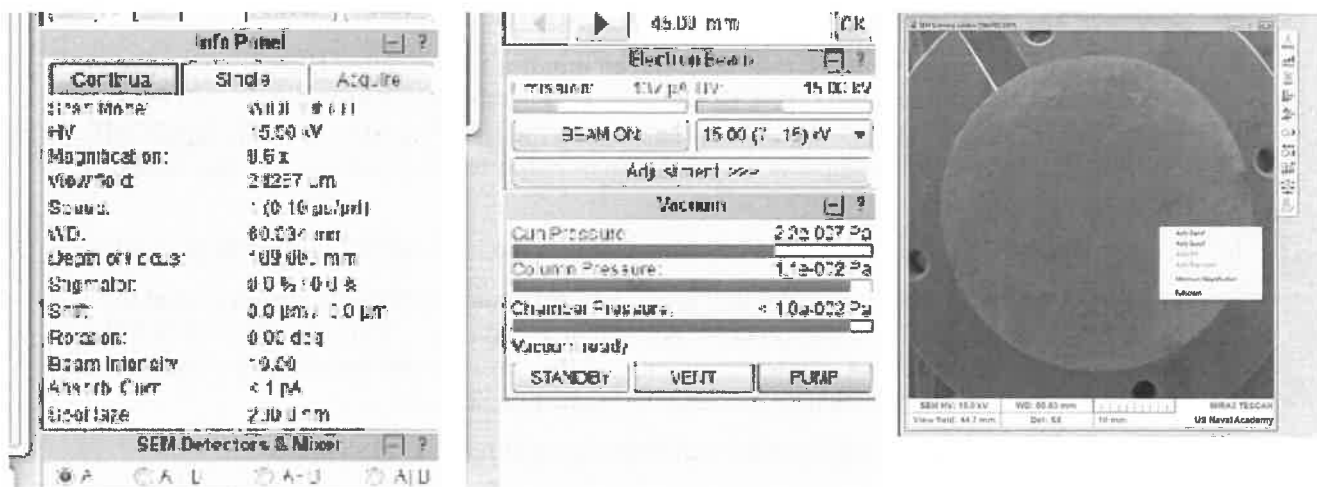


Figure 7. Imaging Setup

h. Clicking the stage position in the stage control window will position the beam on top of the selected specimen.

i. Right clicking on the SEM Scanning Window will bring up a series of helpful options. From these options, AUTO SIGNAL will automatically adjust contrast and brightness, AUTO SPEED will automatically adjust scan speed (not usually helpful), AUTO WD will attempt auto focus (will take a few seconds and results will vary), AUTO STIGMATION (not usually helpful), MINIMUM MAGNIFICATION (useful to find the sample), and FULLSCREEN (not recommended).

j. It is very important to get an initial focus using WD (Working Distance) prior to moving the stage in any direction other than x and y. Obtain a focus using techniques discussed in the user's manual. The simplest method is to find an observable feature and adjust WD to obtain a proper focus at a moderate magnification (approximately 1000x – 5000x).

k. Follow the user's manual (reference (c)) to acquire desired images.

l. For temporary interruptions in observations (e.g. less than 1 hour) but within the same user

session, the beam may be turned off by clicking BEAM ON in the electron beam window or the beam may be blanked by clicking GUN in the Beam Blanker window found in the SEM menu. See Figure 8.

- m. When complete with a session, follow the procedures to shutdown the SEM to STANDBY.
- n. Annotate startup in Usage Log (within the binder)

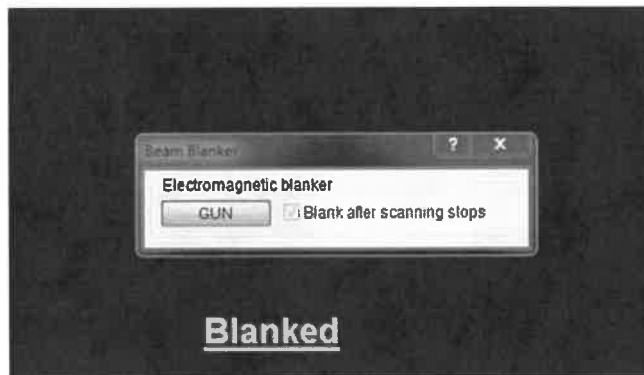


Figure 8. SEM Blanking

4. **“Shutdown to STANDBY” Condition (normal process)**
 - a. Before moving the stage to the HOME position, be mindful that selecting HOME will move the stage in all required directions (x, y, z, Rotate, and Tilt) nearly simultaneously. Ensure the stage is clear before completing this step. Move the stage to the HOME position by clicking HOME. If moving the stage in this manner is unsafe due to possible collision, move each axis manually and independently.
 - b. Turn the beam off by clicking BEAM ON (this will turn the beam off by closing the gun valve).
 - c. When ready to remove sample(s) and with gloves on any hand entering the chamber, vent the chamber by clicking VENT. This process takes about 1-3 minutes. Once the chamber is fully vented, the stage carousel position will turn red, and the stage may be moved to the load/unload position for each sample location by clicking the respective position.
 - d. While watching the IR camera, open the chamber door and remove all samples.
 - e. Close the chamber door and pump the chamber back to a vacuum. Wait for the chamber to reach a full vacuum.
 - f. Logoff the SEM by selecting LOG OFF from the File MENU. This will prompt the user to go to STANDBY. Select YES to enter STANDBY and complete the LOG OFF. See Figure 9. If the Authorized User already placed the SEM in STANDBY, the LOG OFF process will complete without a prompt to go STANDBY.

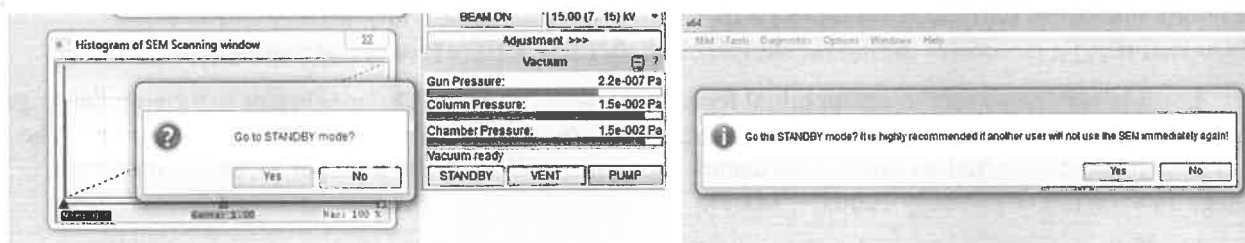


Figure 9. SEM Logoff and Standby Process

- g. The final STANDBY condition of the SEM should be.
 - (1) The TESCAN PC is running.
 - (2) The MIRA3 software at the login prompt.
 - (3) The chamber is empty and the stage is in the HOME position.
- h. Annotate Shutdown to Standby in Usage Log (within the binder).

Room Number: RI-237A

Lab Manager: _____

[illegible]

RSO review: _____

**OPERATING PROCEDURES: MAINTENANCE
TESCAN MIRA3 SEM**

All users are responsible for ensuring the cleanliness of the SEM space and the cleanliness of samples placed in the SEM chamber.

Any issues identified that may require maintenance shall be reported to the SEM Lab Manager. The SEM Lab Manager will coordinate any SEM maintenance with TESCAN service representatives based on an existing service contract.

In accordance with reference (a) and discussions with the NAVSEA DET RASO, "...any repair, modification, or maintenance must be performed by the manufacturer or authorized service center unless authorized by the manufacturer as something that can be performed by the user. Examples include instructions in the user's manual, in correspondence from the manufacturer on official letterhead, or on the manufacturer's website as something that can be performed by the end user." Additionally, RASO is only concerned with radiation producing components and email from an authorized company representative can be sufficient communication.

**OPERATING PROCEDURES: EMERGENCY PROCEDURES
TESCAN MIRA3 SEM**

The safest condition of the SEM is the BEAM OFF and the MIRA3 software running. The MIRA3 software provides both monitoring and automatic safe shutdown capability of the SEM. The USNA Emergency Response Plan is available in Ri-237A (located at the entrance). Reference (d) (or current USNA Radiological Safety Manual) CH 11 outlines the available Operating and Emergency Procedures.

In the event of an emergency, the following procedures must be followed.

1. Turn the BEAM OFF.
2. If time and conditions permit, place the SEM in STANDBY.
3. Leave Ri237A and ensure the door locks unless the emergency is in Ri237A.
4. Notify other emergency contacts, such as fire or police departments, if appropriate.
5. Notify the RSO and the SEM Laboratory Manager.
6. Make appropriate log entries when secured from emergency situation.

**AUTHORIZED USER QUALIFICATION REQUIREMENTS
TESCAN MIRA3 SEM**

1. A qualification program shall include, as a minimum:
 - a. Radiation health requirements in accordance with references (a) and (b).
 - b. Radiation safety requirements in accordance with references (a) and (b) which include:
 - (1) Sources of radiation in areas they may frequent.
 - (2) Potential hazards associated with radiation sources in areas they may enter.
 - (3) Biological effects and risks associated with exposure to ionizing radiation from internal or external sources.
 - (4) Use and meaning of radiation warning signs and barriers.
 - (5) Procedures to avoid and reduce radiation exposures.
 - (6) Personnel dosimetry, bioassay and/or internal monitoring requirements.
 - (7) Biological effects of exposure to the embryo/fetus if the person will receive greater than 100 mrem per year.
 - (8) Each individual is responsible for tracking his/her own radiation exposure and exposure reports that are provided by the command.
 - (9) The SEM Laboratory Manager will direct an Authorized User Training Program. Candidates will be required to demonstrate the knowledge and skills required to safely operate the instrument before becoming an Authorized User. The training program may be tailored to the experience of the person being qualified. The SEM Laboratory Manager (or one representative designated by the SEM Laboratory Manager) will administer this training program. The SEM Laboratory Manager will designate this representative in writing, maintain this record in the SEM Binder, and notify the RSO & RSC. If the SEM Laboratory Manager is from the School of Engineering, Computing and Weapons, it is recommended that the "designated representative" be the other school (i.e., School of Mathematics and Science) with authorized users.
 - c. Knowledge of operating procedures in accordance with reference (c).
 - d. A full understanding of this SOP.
2. An Authorized User must be recommended by the SEM Laboratory Manager as a Qualified Operator and approved by the RSO and RSC. The list of Authorized Users shall be maintained on the local authorization. The SEM Laboratory Manager shall manage the enabling and disabling of accounts on the SEM computer.
3. Midshipmen may complete the Authorized User Training Program and become an Authorized User. This may be an important consideration for midshipmen who participate in research programs requiring use of the instrument on a continuous and recurring basis (Bowman or Trident Scholar or other Independent Research Student).
4. Authorized Users will be required to review this SOP and the non-radiation worker training on an annual basis (not to exceed one year). Non-radiation worker initial and refresher training and annual reviews of the SOP shall be documented and records maintained in the SEM binder per RSO guidance.
5. Authorized Users who fail to meet minimum annual training requirements will have their SEM accounts disabled by the SEM Laboratory Manager. The SEM Laboratory Manager may re-enable these accounts after the annual review of training documents is complete by the individual in question.
6. Authorized Users who do not use the instrument for more than 12 months from qualification will

Enclosure (8)

have their SEM accounts disabled by the SEM Laboratory Manager. These individuals will be required to hold refresher training with the SEM Laboratory Manager (or a designated representative from the School of Engineering, Computing, and Weapons or the School of Mathematics and Science) before their accounts may be re-enabled.

**AUTHORIZED USER QUALIFICATION REQUIREMENTS:
QUALIFICATION CARD (EXAMPLE)
TESCAN MIRA3 SEM (S/N 115-0054)**

Name: _____

Table 1. Ionizing Radiation Producing Machine Information.		
Manufacturer	Model	Serial Number
Tescan	Mira3	115-0054

Table 2. Qualifications. Authorized users shall not be permitted to operate or maintain any electron microscope equipment unless such user has received initial training and has demonstrated competence in identification of equipment radiation hazards, operating and emergency procedures, warning system, safety precautions, and reporting of actual or suspected overexposures. Additional qualifications specific to operating the SEM are listed in the table below.	
Description	Laboratory Manager Initial
Identify major components of the SEM both externally and internally using IR camera.	
Safely load and unload samples from the SEM maintaining cleanliness including maintaining sample clearances required to prevent damage to other detectors and in the chamber.	
Turn the beam on and off	
Safely maneuver the stage with a specimen loaded	
Return the SEM to STANDBY condition	
Read and understand the SEM SOP (annual requirement).	
Understands radiation safety hazards, warning systems and safety precautions associated with the instrument.	
Summarize Individuals Qualifications and Training (include years):	

Table 3. Annual Review.			
Name (Print)	Name (Signature)	Date of Review	Laboratory Manager Initials

AUTHORIZED USER QUALIFICATION REQUIREMENTS:

QUALIFICATION CARD (EXAMPLE)
TESCAN MIRA3 SEM (S/N 115-0054)

Name: _____

1. Qualified by Laboratory Manager.

_____	_____	_____
Print	Sign	Date

2. Lab Director Authorization.

_____	_____	_____
Print	Sign	Date

3. School of Engineering, Computing and Weapons Dean Authorization.

_____	_____	_____
Print	Sign	Date

4. (A)RSO Review.

_____	_____	_____
Print	Sign	Date

5. RSC Vote on Authorization.

_____	_____	_____
Print	Sign	Date