

**ENVIRONMENTAL
HEALTH & SAFETY** JOB HAZARD ANALYSIS

Scanning Electron Microscope (SEM)

Location(s):	Laboratory	Analysis By:	Sandra Prior	Date:	May 30, 2014
Division:	Arts & Sciences	Supervisor:	Varies	Frequency:	Weekly
Category:	Teaching & Research			JHA Number:	13
Title of Job:	Researcher				

REQUIRED PERSONAL PROTECTIVE EQUIPMENT (PPE)/TRAINING:

1. PPE: gloves, eye protection with side protection, cryo apron/ lab coat, enclosed shoes
2. Training: General Laboratory Safety; Lab-specific protocol training by Principal Investigator (PI); equipment-specific on SEM use

SCOPE DESCRIPTION:

A compilation of the hazards, risks and mitigations associated with Scanning Electron Microscope (SEM) use.

Hazard	Current Controls	Risk Analysis	Resulting Risk
<p>Risk Situation 1: Tripping over hoses or leads behind microscopes Notes: There may be leads and vacuum hoses on the floor behind the scanning electron microscope that are required for its</p>	<p>Current Controls: ENGINEERING: Ramp/covers over leads. Barricading. ADMINISTRATIVE & TRAINING: Restricted area signage. Inform all clients that they are not to walk</p>	<p>Risk Analysis Details Consequence: Substantial - Possible disabling injury requiring medical treatment. Exposure:</p>	<p>Risk Level: Low Suggested Action: Risk is normally acceptable</p>

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<p>operation and which are unable to be relocated.</p> <p>Hazard Event: Trip and fall, resulting in hitting the floor or equipment.</p>	<p>around the back of microscopes (access restricted to specific personnel).</p>	<p>Rare - Access to area limited to trained Engineers & CMM staff and rarely visited.</p> <p>Probability: Conceivable - This event may happen but has not occurred so far.</p>	
<p>Risk Situation 2: Slipping due to flooding</p> <p>Notes: Water spills occur occasionally in the laboratory (e.g. leaking water chiller lines) creating slippery surfaces.</p> <p>Hazard Event: Person slips and contacts equipment or floor.</p>	<p>Current Controls: ADMINISTRATIVE: Scheduled instrument maintenance / Lab monitoring. Detailed spill procedures - Use of signage to warn of wet floor. Mop/ Vacuum floors using wet/dry vacuum cleaner. Seal off area for mopping. Lab appropriate shoes</p>	<p>Risk Analysis Details</p> <p>Consequence: Substantial - Possible disabling injury requiring medical treatment.</p> <p>Exposure: Rare - Flooding and water spills occur rarely in areas where</p>	<p>Risk Level: Low</p> <p>Suggested Action: Risk is normally acceptable</p>

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	<p>required - monitored by staff.</p>	<p>slippage may result. Probability: Unusual but possible - Slippage due to water spills is an unusual event in the laboratory</p>	
<p>Risk Situation 3: Electrocution Notes: SEM contains high voltages capable of serious or fatal shocks to individual users. Hazard Event: Individual removes panel and contacts exposed high voltage cable or components.</p>	<p>Current Controls: ISOLATION: All high voltage components are enclosed and raised above floor level (to avoid water leaks/spills). ADMINISTRATION: Access restrictions. Room access restricted to users trained in correct operation of microscope. Restricted access (service personnel only) and signage at</p>	<p>Risk Analysis Details Consequence: Very serious - Most likely outcome from exposure to high voltage components is death. Exposure: Occasional - Individuals use microscope on average once a week. Probability:</p>	<p>Risk Level: Low Suggested Action: Risk is normally acceptable</p>

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	<p>rear of microscope (where most high voltage cables/components are sited). Room access restricted during service work and panels replaced as soon as practical.</p> <p>TRAINING: Instrument specific. Includes specific reference to high voltage hazard. Only instrument manager nominated and qualified service personnel are allowed to access restricted zones and remove panels or modify microscope.</p>	<p>Practically impossible - It would be practically impossible during standard operation of the microscope for an individual to receive a fatal electric shock.</p>	
<p>Risk Situation 4: Electrocution - through flooding</p>	<p>Current Controls: ISOLATION: All high voltage components are enclosed</p>	<p>Risk Analysis Details Consequence: Very serious -</p>	<p>Risk Level: Low</p>

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<p>Notes: Electron microscopes contain high voltages and are cooled by pressurized water. Water leaks may contact high voltage components.</p> <p>Hazard Event: Water cooling line breaks/ leaks causing flooding and contact with high voltage circuitry/ power board. Individual contacts electrified water.</p>	<p>Components are raised above floor level (to avoid water leaks/spills) and meet required. This includes power boards, leads and plugs.</p> <p>ADMINISTRATION: Room access restricted to users trained in correct emergency procedures.</p> <p>Restricted access (service personnel only) and signage at rear of microscope (where most high voltage cables/components are sited).</p> <p>TRAINING: Instrument specific. Includes specific reference to high</p>	<p>Most likely outcome from exposure to high voltage components is death.</p> <p>Exposure: Unusual - Water leaks do occur.</p> <p>Probability: Conceivable - It is conceivable a water leak may contact high voltage and cause electrocution but has not happened.</p>	<p>Suggested Action: Risk is normally acceptable</p>

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	<p>voltage hazard. Only instrument manager nominated and qualified service personnel are allowed to access restricted zones where potential leaks may occur.</p>		
<p>Risk Situation 5: Liquid Nitrogen spills causing cryo burns Notes: Liquid nitrogen is required for a range of purposes with the scanning electron microscope e.g. cryo-SEM, anti-contaminant traps, EDS detector dewars. Hazard Event: Cryo burns to the body.</p>	<p>Current Controls: ADMINISTRATIVE: Prescribed training and recording of competency. The routine use of LN2 requires Lab specific training, risk assessments and recorded competency for high risk activity. TRAINING: “Hands on” – conducted by competent staff member. Coverage includes,</p>	<p>Risk Analysis Details Consequence: Minor - Most likely injury would only require first aid treatment e.g. minor burn. Exposure: Frequent - Liquid nitrogen is used frequently with the electron microscope for a range of</p>	<p>Risk Level: Low Suggested Action: Risk is normally acceptable</p>

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	<p>for example, correct handling practice by a trained staff member i.e. pour slowly and be aware of potential for sudden “boiling” and spraying of LN2.</p> <p>PPE: Wearing of appropriate approved PPE, face shield AND safety glasses for eyes, cryo-gloves to protect hands, enclosed shoes with trousers covering openings into shoes.</p> <p>Training in correct use of PPE is always required.</p>	<p>different purposes.</p> <p>Probability: Conceivable - Probability is conceivable but has never happened with the current control measures</p>	
<p>Risk Situation 6: Spill of liquid nitrogen causing oxygen depletion</p> <p>Notes: Liquid nitrogen is regularly used to</p>	<p>Current Controls: ADMINISTRATIVE: Prescribed training and recording of competency. The</p>	<p>Risk Analysis Details</p> <p>Consequence: Very serious - Asphyxiation</p>	<p>Risk Level: Low</p> <p>Suggested Action: Risk is</p>

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<p>maintain diffusion pumps. Small volumes (~2 L) are used per microscope.</p> <p>Hazard Event: Large spill of liquid Nitrogen produces oxygen displacement and collapse of individual.</p>	<p>routine use of LN2 requires Lab specific training, risk assessments and recorded competency for high risk activity.</p> <p>TRAINING: Coverage includes emergency procedure for spills. Spills- leave room for 20minutes (<5 liter spill), ensure doors left open for increased ventilation. Disposal of waste in fume hood or open air - externally.</p> <p>ENGINEERING: Minimum volume containers used - task related. Low Oxygen alarm sensors. Adequate general ventilation.</p>	<p>may result from exposure.</p> <p>Exposure: Occasional - Liquid nitrogen is used in volumes capable of producing asphyxiation approximately once per week per individual.</p> <p>Probability: Conceivable - Has not happened but is conceivable.</p>	<p>normally acceptable</p>

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<p>Risk Situation 7: Ionizing radiation exposure</p> <p>Notes: Interactions between the electron beam and sample/stage generate ionizing radiation during normal operation. The relatively low kV of standard SEM beams results in low energy x-ray production. Engineering features isolate hazardous ionizing radiation from the operator to minimize exposure to this radiation.</p> <p>Hazard Event: Individual removes shielding or replaces viewing port with non-lead glass which allows ionizing radiation to escape.</p>	<p>Current Controls:</p> <p>ENGINEERING: Microscope design and shielding. Design features contain ionizing radiation when produced (eg shielding) and prevent generation of an electron beam if chamber is open (electronic safety controls).</p> <p>Time delay in chamber venting and/or double-door systems, coupled with the rapid dissipation of radiation, prevents residual hazardous radiation being present on opening.</p> <p>ADMINISTRATIVE: Restricted access policy.</p>	<p>Risk Analysis Details</p> <p>Consequence: Serious - Most likely consequence of long term exposure to this radiation is a permanent disability.</p> <p>Exposure: Occasional - Individuals use microscopes once a week on average.</p> <p>Probability: Practically impossible - It would be practically impossible for an individual to be exposed to this radiation.</p>	<p>Risk Level: Low</p> <p>Suggested Action: Risk is normally acceptable</p>

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	<p>Only certified engineers, or those directly supervised by them, are allowed to modify/repair microscope.</p> <p>TRAINING: Clients are trained to follow standard operating procedures.</p>		
<p>Risk Situation 8: Falling from ladder</p> <p>Notes: With some microscopes, climbing short ladders is required to fill traps/dewars with liquid nitrogen from height.</p> <p>Hazard Event: Person falls from ladder.</p>	<p>Current Controls:</p> <p>ENGINEERING: Appropriate ladders are to be used to fill traps and dewars – no stools.</p> <p>ADMINISTRATIVE: Procedure done by trained staff. Dedicated ladders. Clients are not routinely required to fill EDS dewars as this is done by trained staff. Ladders (of Aust. Standard)</p>	<p>Risk Analysis Details</p> <p>Consequence: Substantial - It is possible that this incident could result in a permanent or lost time injury.</p> <p>Exposure: Frequent - Dewars are filled at least 3 times per week with LN2 and this requires the use</p>	<p>Risk Level: Low</p> <p>Suggested Action: Risk is normally acceptable</p>

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	<p>dedicated to fill traps and dewars are provided. Ladders used only according to manufacturer's instructions.</p> <p>TRAINING: All staff/clients using ladders trained. Trained and tested by demonstration in ladder use in accordance with manufacturer's instructions (i.e. locked & fully extended, do not stand above second from top rung, do not reach beyond side of ladder, 3 points of contact at all times).</p>	<p>of a ladder.</p> <p>Probability: Conceivable - The probability is determined to be conceivable but has not happened.</p>	
<p>Risk Situation 9: Sample & Microscope interactions</p>	<p>Current Controls: ADMINISTRATIVE: Written safe working procedure. Restricted</p>	<p>Risk Analysis Details Consequence: Substantial -</p>	<p>Risk Level: Low</p>

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<p>Notes: Sample properties must be considered before use in the microscope. Interaction with the beam or vacuum may liberate volatile components/loose particles which may affect/ damage microscope parts. Sample size must also be considered (care must be taken with sample insertion and height adjustment to avoid detector/microscope damage). All new sample types should be discussed with trained staff before use.</p> <p>Hazard Event: Specimen is inserted into microscope and releases components or</p>	<p>access. Instruction manual provided. Access restricted to trained individuals. Samples are required to be "dried" (de-volatized) under vacuum for at least 1 day before microscope use. TRAINING: Job specific / & general OHS induction. All staff and clients are trained and tested in safe operating procedures.</p>	<p>Most likely consequence from hazard event would result in a slight disruption in overall center activities and/or a substantial financial loss (\$5,000 to \$50,000 - parts, staff/engineer time)</p> <p>Exposure: Occasional - Individuals, on average, use a microscope approximately once a week.</p> <p>Probability: Remotely possible - It would be a remote</p>	<p>Suggested Action: Risk is normally acceptable</p>

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<p>physically contacts delicate internal microscope parts which subsequently require cleaning/replacement.</p>		<p>possibility that control measures may fail and a hazard event occurs. Incidents have occurred in the past.</p>	
<p>Risk Situation 10: Ergonomic Issues Including: Visual fatigue Notes: Persons using the scanning electron microscope spend most of the session time viewing a CRT or LCD screen. Hazard Event: Eyestrain. Prolonged sitting Notes: Computer operation is usually performed in a seated posture. The chair</p>	<p>Current Controls: ADMINISTRATIVE: Bookings are restricted to 2 hours (generally) during prime time. Trainers observe and document demonstrated correct ergonomic procedures. TRAINING: Individuals trained in correct ergonomic procedures. Clients are advised: • to stretch and to take regular breaks in</p>	<p>Risk Analysis Details Consequence: Substantial - Disabling injury requiring medical treatment e.g. carpal tunnel problems. Exposure: Occasional - Individuals, on average, use a microscope approximately once a week. Use of the</p>	<p>Risk Level: Low Suggested Action: Risk is normally acceptable</p>

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<p>design and adjustment directly affect the person’s posture when viewing the computer screen and operating the input devices (eg mouse or hand gesture touch pad, keyboard, voice activation software). Poor chair design or adjustment will result in awkward postures and will increase the risk of musculoskeletal injury particularly to the back and shoulders when sitting for most of the hours worked.</p> <p>Hazard Event: Prolonged periods of uninterrupted sitting results in lower back, neck and shoulder pain during and after task completion. A chair</p>	<p>accordance with organizations screen based equipment guidelines.</p> <ul style="list-style-type: none"> • to change between sitting and standing postures to offset static loads on muscles and change compressive forces on intervertebral discs. 	<p>keyboard and mouse occurs frequently during operation of the electron microscope.</p> <p>Probability: Remotely possible - It would be a remote possibility that control measures may fail and a hazard event occurs. Incidents have occurred in the past.</p>	

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<p>without seat height adjustment, backrest angle tilt and backrest height is used; awkward and unsupported posture results.</p> <p>Keyboard, mouse and joystick use</p> <p>Notes: Use of a keyboard, mouse, joystick to enter and manipulate information on a computer screen is a major feature of EM work. Addition of ancillary equipment, not designed for specific work station, may increase the effects of keyboard overuse.</p> <p>Hazard Event: Continuous keyboard mouse or joystick use without rest breaks due to a high volume of</p>			

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work. Strain of the shoulder, forearm and wrist.			

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Chemical Risk Assessment

The Chemical risk assessment should complement the Standard Risk Assessment. It is more of a “hands on” assessment relating to the chemical component of the task and contains MSDS information.

Substances and Properties	Summary of existing controls and effectiveness	Risk Control	Risk Analysis Details
<p>1 - Liquid nitrogen Form: liquid Conc: concentrated Haz Substance: Yes DG Class: 2.2 - Non flammable, non toxic gas Health Effects: Asphyxiant Hazardous Reactions: Cryogenic Route of Exposure: Inhalation, Eye & skin contact Evidence of Exposure: none Storage Location: 30 liter dewar in</p>	<p>Engineering: general ventilation.</p> <p>Administrative: Appropriate signage. Small volume dispensers provided.</p> <p>PPE: cryo-gloves, eye protection with side protection, cryo apron/ lab coat, enclosed shoes.</p>	<p>Elimination or substitution of hazardous chemical/s: not possible as liquid nitrogen is an essential requirement.</p> <p>Required engineering controls: Oxygen sensors. Other engineering controls: General ventilation General air conditioning in large rooms or open areas is suitable.</p>	<p>Consequence: Very serious - Asphyxiation may result from exposure. Exposure: Occasional - Liquid nitrogen is used in volumes capable of producing asphyxiation approximately once per week per individual. Probability: Conceivable - Has not happened but is conceivable. Risk is: Significant but</p>

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Substances and Properties	Summary of existing controls and effectiveness	Risk Control	Risk Analysis Details
<p>lab</p> <p>Waste disposal procedures: Evaporated in well ventilated areas – Fume hood or external to building. SPILLS: Evacuate area immediately.</p> <p>Storage incompatibilities: Nil.</p> <p>Special safety instructions: Skin: For cold burns, immerse in cold water. Inhaled: Fresh air, rest, keep warm, if breathing shallow, see medical help - give oxygen.</p>	<p>Training: Correct handling procedures.</p> <p>Current Controls are: Effective and maintained well.</p>	<p>Administrative controls (including training requirements): Training (job specific / general OHS induction). All staff and clients are trained in correct handling procedures. Written emergency procedures. Posted on site. Written safe working procedure. General liquid Nitrogen use risk assessment and SOP.</p> <p>Personal protective</p>	<p>controlled - As a general guide, if you are working with a hazardous substance, it will always be "a significant risk" – but it can be a controlled risk.</p>

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Substances and Properties	Summary of existing controls and effectiveness	Risk Control	Risk Analysis Details
		<p>equipment: Gloves: Cryo-gloves Eye protection: Safety glasses with side protection. Face shield for large volume work Coat/apron: Cryo-apron/ lab coat Footwear: Enclosed shoes Other: Long pants (cuffs over shoes) recommended attire for large volume work.</p>	

Note: Adapted from the Australian Microscopy & Microanalysis Research Facility
<http://www.ammrf.org.au/myscope/sem/practice/safety/example2.php#show>
<http://www.ammrf.org.au/myscope/>