Safety instructions for Materials Science Beamline (MSB)

written by: Natalia Tsud, Tomas Skala, with contributions from Andrea Locatelli

last update: 29/08/2024

Index

1 Purpose

This document contains information on the main scientific and technical activities carried out at the Materials Science Beamline (abbreviated MSB) situated at Elettra Sincrotrone Trieste S.C.p.A. (abbreviated EST) and operated by the Charles University, Prague (abbreviated CUP) in collaboration with EST), and a series of *Operating Instructions* necessary to perform these activities in safe conditions.

This document can be downloaded directly from the beamline website:

https://www.elettra.eu/lightsources/elettra/elettra-beamlines/msb/safety.html

For anything not expressly considered below, reference is made to the laws and regulations in force, and in particular to the LEGISLATIVE DECREE 9 April 2008, no. 81.

2 Persons in charge of safety

The responsibility for the safety of workers operating at the beamline lies with the following subjects:

- the *beamline safety supervisors, i.e., the beamline managers* (those indicated in the Annex 3 agreement between CUP and EST), and the *beamline scientists*. The persons in charge supervise the various activities carried out on the beamline, ensuring the implementation of the employer's directives and giving instructions for their correct execution. The list of the MSB safety supervisors can be found at:

  https://www.elettra.eu/lightsources/elettra/elettra-beamlines/msb/safety.html

- the *Elettra Safety Managers*, in the persons of the *Group Coordinators* of the EST SPEED and IDEAS beamline groups, who organize the work activity of each Group and supervise its proper implementation, with particular attention to prevention and protection measures. Their names can be found on the web page:

  https://www.elettra.eu/it/about/contatti-dei-coordinatori-di-gruppo.html

2.1 Duties of the safety supervisors of the MSB

The MSB safety supervisors must ensure that workers (including users, external collaborators, students, trainees, etc.) use the prescribed protective equipment and follow all prescribed safety instructions.

In the absence of the safety supervisor, this responsibility is fulfilled by her/him through the prior information and training of workers and the provision of safety procedures and instructions.

3 Beamline personnel

The names and contact information of the personnel can be found on the following web page:
https://www.elettra.eu/lightsources/elettra/elettra-beamlines/msb/msb-contacts.html

3.1 Categories of workers

Subject to appropriate training, the following categories of workers are authorized to work at the experimental stations and other parts of the beamline:

- MSB researchers, namely the *coordinator* (or *responsible*), the *scientists*, and *postdocs*;
- external research staff, and in particular MSB users;
- technical staff of the MSB (i.e., the beamline technician).
- other technicians or maintainers: electrical-electronic technical staff, information-technology staff, mechanical-fluid technical staff; technical staff of the EST Mechanical, Vacuum and Optical Engineering group.
- movers.

Each worker is responsible for taking care of his or her own health and safety and that of other persons in the workplace, on whom the effects of his or her actions or omissions fall, in accordance with his or her training, instructions and means provided by the employer.

3.2 General safety prescriptions and training

Each job category is required to complete the prescribed training courses for the specific activities of the job assignment, made available through the *Virtual Unified Office* (VUO) system.

All workers are encouraged to consult EST **Risk Assessment Document** (document code: **PVAR-MAN-01**). In particular, electrical maintenance workers should take notice of the recommendations in the **PVAR-SCH-07** document, electrical-electronic technicians of those in the **PVAR-SCH-16** document, mechanical-fludistic technicians of those in the **PVAR-SCH-09** and **PVAR-SCH-19** documents. Administrative-informatics-project staff should take notice of the information provided in the **PVAR-SCH-03** document.

Important note*: it is beyond the scope of this document to report in detail on the safety requirements of electrical maintenance workers called upon to carry out routine and extraordinary maintenance operations on distribution electrical panels, or repair interventions on electrical sockets or similar devices, as there are risk assessment documents and specific safety instructions related to their activities. It is strictly prohibited for beamline scientific and technical personnel, as well as external researchers, to engage in any work activities involving electrical installations.*

4 The Materials Science Beamline

4.1 Description of the work area

MSB (see **Figure 1**) is located inside the "S" building in the area between the wall surrounding the storage ring and the outer corridor near column 28. The area occupied by MSB is separated from the adjacent beamline SYRMEP by a wall and from the adjacent beamline SAXS by the escape routes (green).

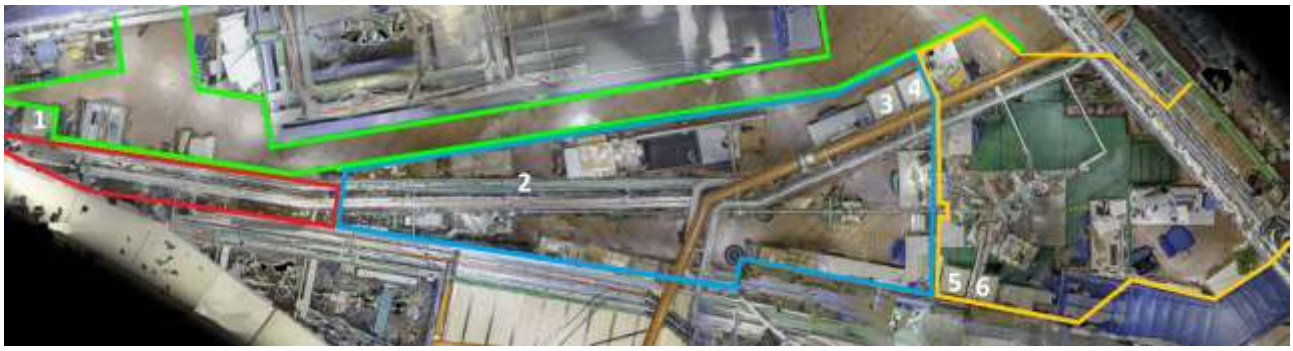

Figure 1: *Top view of MSB. Front-end and first mirror* ***hutch*** *area (red), the rest of the* ***beamline*** *area (blue),* ***end station*** *area (orange), escape route (green). Numbers indicate 6 racks containing control electronics.*

Referring to **Figure 1**, the area marked in **yellow** (1) and **red** (2) correspond to two radiation protection *hutches of* the *front-end* and the *first mirror*. They can be accessed only by authorized personnel, i.e., by those who have taken the "*radiation protection course for personnel authorized to withdraw keys of the Elettra hutches*" (document code: **GREL-PRO-22**) and are in possession of the code necessary to withdraw the *keys* from the *key-safe box* located at the exhibition area.

The area marked by the **green** line in **Figure 1** is the escape route, connecting the radiation protection *hutches* to the corridor outside the experimental hall. Escape route should be kept clear of obstructions at all times.

The **blue** and **orange** contours in **Figure 1** highlight the space dedicated to the MSB; in the **blue** one (called "beamline") the synchrotron radiation is deflected, focused, monochromatized and transported towards the **orange** one (called "end station") containing a set of vacuum chambers situated on an elevated platform where experiments approved by the CERIC-ERIC *Proposal Review Panel* are performed.

The MSB laboratory has seven workstations, at which data acquisition and analysis activities can be carried out during the experiments. Each workstation is equipped with a desk and one or more ergonomic chairs.

Instead, sample preparation and assembly takes place at another workstation set up for this purpose.

4.2 Scientific activity

The MSB operates in the 22–1000 eV spectral range and is used by a large and heterogeneous academic community active in the fields of surface and materials science, nanoscience, and solid-state physics, particularly heterogeneous catalysis. The photon energy range can be extended by a laboratory X-ray source operating at 1254 or 1487 eV.

The experimental station of the MSB houses mainly a photoelectron spectrometer to study surfaces, interfaces and thin films of metallic, oxide and semiconductor materials. It enables a wide range of experimental analytical investigation methods to be performed with chemical and structural sensitivity and using photons in UV and soft X-ray range as probe, in particular:

- X-ray Photoelectron Spectroscopy using (XPS),
- Ultraviolet Photoelectron Spectroscopy (UPS),

- Resonant Photoelectron Spectroscopy (RPES), and
- Near Edge X-ray Absorption Fine Structure (NEXAFS).

Moreover, Low Energy Electron Diffractometer (LEED) for checking the surface crystallinity is installed.

4.3 Instrumentation available

A list of the main equipment used at the beamline is provided below. The ■ symbol indicates the special marking required for marketing the products within the European Community, **man.** indicates that a manual from the manufacturer is available. Location indicates the zone or rack according to **Figure 1**.

4.3.1 User and instruction manuals

The manuals of the instrumentation available at the beamline are stored at the beamline in the drawer file cabinet located next to the staircase of the SYRMEP beamline. PDF versions of manuals of most of the instruments can be also downloaded from:

https://www.elettra.eu/lightsources/elettra/elettra-beamlines/msb/manual-beamline-overview/page-2.html#manuals

4.3.2 Beamline

The beamline vacuum chambers house the synchrotron beam transport optics from the source to the MSB end station where experiments are performed, including the related manipulators, pressure sensors, vacuum pumps and various beam-related instruments.

nr.	Description	Manufacturer	■	man.	owner	location
8	vacuum chambers	Delong, Bestec			CUP	hutch, beamline
1	prefocusing mirror assembly	Delong			CUP	hutch
2	prefocusing mirror controllers	Delong			CUP	rack 3
2	slit assemblies	Delong			CUP	beamline
1	monochromator assembly, controller	Bestec	✓	✓	CUP	beamline, rack 2
1	refocusing mirror assembly	Delong			CUP	beamline
9	Gauges	Pfeiffer	✓	✓	both	hutch, beamline
4	gauge controllers	Pfeiffer	✓	✓	both	racks 1,4
14	ion pumps	Varian		✓	both	hutch, beamline
9	ion pump controllers	Agilent, Delong	partly	✓	both	racks 1,3,4
11	electropneumatic valves	VAT	✓	✓	both	hutch, beamline
3	electropneumatic valve controllers	Elettra			EST	racks 1,4
7	manual valves	Delong, VAT, Pfeiffer	partly	partly	CUP	hutch, beamline
1	getter pump, controller	SAES	✓	✓	CUP	beamline, rack 2
1	quadrupole mass spectrometer	Pfeiffer	✓	✓	CUP	beamline
3	computers, monitors	Various	partly	partly	CUP	beamline
1	turbopumping station	Pfeiffer	✓	✓	CUP	beamline

4.3.3 End station

The end station houses a set of vacuum chambers where experiments (sample insertion, preparation and analysis) are performed, and corresponding control electronics. Most of the assembly is situated at the elevated platform.

nr.	description	Manufacturer	■	man.	owner	location
6	vacuum chambers	Lesker, Vakuum Praha			CUP	end station
4	turbopumping stations, controllers	Pfeiffer	✓	✓	CUP	end station, rack 5
2	turbomolecular pumps, controllers	Pfeiffer	✓	✓	CUP	end station, rack 5
3	scroll pumps	Anest Iwata, Edwards	✓	✓	CUP	end station
1	rotary vane pump	Edwards	✓	✓	CUP	end station
1	membrane pump	Pfeiffer	✓	✓	CUP	end station
2	titanium sublimation pumps, controllers	Leybold, Varian, AML		✓	both	end station, rack 6
2	cryopumps				CUP	end station
10	gauges	Varian, Pfeiffer	✓	✓	CUP	end station
3	gauge controllers	Prevac, Pfeiffer	✓	✓	CUP	rack 6
9	manipulators	AVC, Thermionics, MDC, Pfeiffer, Meca2000		partly	CUP	end station
44	manual valves	Swagelok, Thermionics, Lesker, MDC, HVA, Hositrad, Duniway, Huntington, Siad, Edwards, AirLiquide, Vaqtec			CUP	end station
4	e-beam evaporators, controllers	Tectra, Oxford	partly	✓	CUP	end station, racks 5,6
2	Knudsen evaporators	Elettra			CUP	end station
3	ion guns, controllers	Varian, Intervac		✓	both	end station, racks 5,6
1	X-ray source, controller, chiller	Specs	partly	✓	CUP	end station, rack 5
1	electron analyzer, detector, controllers	Specs	✓	✓	CUP	end station, rack 5
2	infrared thermometers	Micro-Epsilon		✓	CUP	end station
1	quadrupole mass spectrometer	Pfeiffer	✓	✓	CUP	end station
1	quartz crystal microbalance, controller	Lesker		✓	EST	end station, rack 6
1	low-energy electron diffractometer, controller	OCI	✓	✓	CUP	end station, rack 6
2	CMOS cameras	Lumenera		✓	CUP	end station
20	heating tapes	HemiHeating	✓		CUP	end station
2	bakeout controllers	Elettra			CUP	end station
1	dewar	Criolab		✓	EST	end station
11	LED lights	Prevac, Surface Tec, Ikea	partly		CUP	end station
5	multimeters	Metex, Uni-T	partly	partly	CUP	end station
1	picoampermeter	Keithley	✓	✓	CUP	rack 6
4	computers, monitors	various	partly	partly	CUP	end station
8	laboratory power supplies	FuG, Delta, Sorensen, Xantrex, EA	✓	✓	both	racks 5,6
3	PID regulators	Eurotherm	✓	✓	both	racks 5,6
1	potentiostat	PalmSens	✓	✓	EST	end station

4.4 Access to MSB

EST employees (**researchers**, **technicians**, **movers** etc.) have the access granted by the employer.

External research personnel wishing to perform experiments at the MSB must fill out an appropriate request for access to the EST site on the **VUO** portal (https://vuo.elettra.eu/) and pass the required safety tests. Access takes place in a very specific manner, which depends on the category and professional status of the applicant.

- **Researcher of the laboratory**: CUP employees have to yearly submit a request in VUO as "Elettra partner" which is then approved by EST.
- **Hosting researcher** (also called **User**): Participants on open access experiments (approved by CERIC-ERIC Proposal Review Panel) or in-house experiments (approved by beamline coordinators) must submit a request in VUO. The access is then evaluated and approved by CERIC-ERIC Users Office.

Various **technicians** and **movers** of the external companies have to apply using the procedure described at https://www.elettra.eu/activities/spp/information-for-external-firms.html.

5 Safety operating instructions

All members of the beamline staff are responsible for ensuring that the activities specified herein are carried out in accordance with applicable regulations and in accordance with directives issued by the Responsible for the Activity, i.e., the *beamline manager*, and Elettra's *group coordinator*. Of particular relevance are the provisions concerning the use of the prescribed Personal Protective Equipment (PPE) detailed in the following.

Regarding the Protection and Safety Standards governing the activities in the EST Experimental Hall, we invite the reader to take notice of the document "Radiological Risk in the Elettra Experimental Hall" (document code: **RPFO-SCH-05**). Access to the hutches is allowed only to authorized personnel, see "Key management of Elettra hutches - General rules for beamline personnel" (document code: **GREL-PRO-22**). In order to allow safe access for maintenance personnel working under emergency conditions or on call, any interference hazards should be clearly marked on access doors to these areas. Non-emergency access by unauthorized internal or external personnel, on the other hand, must be agreed upon with the beamline manager and always take place in the presence of authorized personnel.

5.1 Special health conditions of the worker.

The performance of certain work activities described below may be incompatible with special physical or medical conditions. Workers are urged to promptly notify the beamline coordinator or the safety supervisor of any resulting limitations.

In the special case of pregnancy conditions, it is recommended that only those activities that can be assimilated to office work (described in Section 5.2), i.e. work at the computer, and in particular data acquisition or data analysis operations, should be performed. Particular attention should be paid to the observance of breaks.

Pregnant or post-partum workers must absolutely refrain from activities that expose them to electrical, chemical or radiological hazards or involve the risk of injury, or the performance of physical exertion. Please refer to Elettra's procedure **"Pregnant and Postpartum Workers. Protection from health risks in the workplace"** (document code: **PVAR-IOP-01**).

5.2 Work at the computer (data acquisition and analysis, etc.)

Task Description: all work activities that require the use of personal computers or workstations, and in particular:

- data acquisition;
- data analysis;
- software development;
- CAD drawing;
- document preparation, e.g. scientific articles, email correspondence, etc.

Associated risks:

- demand for high visual attention in carrying out the operation;
    - no PPE is provided; current regulations require a break of 15 minutes for every 120 minutes of continuous activity;
    - appropriate training must be provided;
- repetitive movements, fixed postures, uncomfortable positions. Skeletal-muscular damage is possible. It is required to:
    - Maintain an ergonomically correct posture;

- slips, falls at level. Possible tripping on access stairs. It is required to:
    - Take special care when walking up or downstairs to access the elevated platform of the end station.

Authorized worker categories:

- MSB researchers;
- MSB users *only after appropriate training by the MSB researchers.*
    - *The activity of data acquisition should not be confused with that of manual operation of the experimental apparatus, which requires more training and experience and may pose risks to the operator.*
    - *Damage to the instrumentation and thus a negative impact on the outcome of the ongoing experiment is possible. CUP and EST reserve the right to seek compensation for damages incurred in case of negligent or irresponsible conduct.*
    - *MSB users must not change any parameters influencing the radiation protection which is allowed only to authorized personnel.*

5.3 Installation, use and removal of high-voltage instrumentation

Task Description: work activities involving the installation and use of scientific instrumentation whose internal parts can reach voltages from 50 volts up to several thousand volts, for example:

- electron beam evaporators;
- ion guns;
- Penning- or Bayard-Alpert-type pressure sensors;
- quadrupole mass spectrometers (QMS);
- ion pumps;
- electron analyzers

Associated risks: electrocution. The following requirements should be followed:

- consult the manuals and strictly follow the installation instructions;
- check the integrity of the controller–instrument cabling;
- connect and disconnect the instrument only when the power supply is off;
- follow the instructions for proper grounding of the instrument and its controller.

Authorized worker categories:

- MSB researchers;
- MSB users *only after appropriate training and authorization by the MSB researchers Instructions received must be followed strictly*;
- other technicians.

5.4 Installation, use and removal of low voltage instrumentation

Task description: installation, use and removal of scientific instrumentation operating at low voltage (< 50 V). High currents (*), up to 10 A, may be present in some cases. Examples follow:

- capacitance and Pirani-type pressure sensors;
- filaments for heating samples or Knudsen-type evaporators;
- filaments of the titanium sublimation pumps;

- chamber illumination;
- potentiostats.

Associated risks: burns. Possible explosion due to the electric arc following the accidental interruption of electric circuit continuity. The following requirements should be followed:

- consult the manuals and strictly follow the installation instructions;
- check the integrity of controller–instrument cabling;
- connect and disconnect the instrument only when the power supply is off, being sure that no current is flowing through the cable connecting the controller to the instrument;
- pay special attention to connections between laboratory cables equipped with banana plugs.

Authorized worker categories:

- MSB researchers;
- MSB users *only after appropriate training and authorization by the MSB researchers. Instructions received must be followed strictly*;
- other technicians.

5.5 Small repairs of electronic instrumentation

Task Description: replacement of damaged electronic components, such as fuses or capacitors, or replacement of entire electronic boards:

Associated risks: electrocution. The following requirements should be followed*:*

- before carrying out the repair, consult the manuals and strictly follow the instructions therein. Contact the manufacturer if in doubt;
- always disconnect the equipment from the power source before operating on it;
- always pay attention to the residual charge of the capacitors, since it persists even after the instrument is turned off. Wait sufficient time for the capacitors to discharge completely;
- in case of using the soldering iron, choose a suitable workstation. There is a fire hazard from using the soldering iron. Remove flammable objects from the work table. Turn off the soldering iron immediately after completing the repair;
- after completing the repair, inform the beamline coordinator and agree with him/her on the tests to be performed.

Authorized worker categories:

- MSB researchers;
- other technicians.

MSB users ARE NOT AUTHORIZED to carry out this type of activity.

5.6 Maintenance operations in the racks

Task description: these are repair/replacement of instruments (e.g., controllers and power supplies) installed in the control racks 1–6 of the beamline or end station, or repair/replacement of signal or serial/ethernet communication cables.

Associated risks: electrocution. The following requirements should be followed:

- strictly observe electrical safety regulations;
- take into account what is stated in Sections 5.3, 5.4 and 5.5.

- before carrying out the installation or repair of any equipment, consult the manuals and scrupulously follow the instructions given therein. Contact the manufacturer if in doubt;
- always disconnect the equipment from the power supply before working on it; if necessary, disconnect the power supply to the rack;
- always pay attention to the residual charge of the capacitors, since it persists even after the instrument is turned off. Wait sufficient time for the capacitors to discharge completely;
- be careful not to damage the cables of other instruments, especially those carrying high voltage (ion gauges, ion pumps); if necessary, turn off these instruments and move or remove their cables;
- after completing the repair, inform the beamline coordinator and agree on the tests to be performed.

Authorized worker categories:

- MSB researchers;
- MSB technician;
- other technicians.

MSB users ARE NOT AUTHORIZED to carry out this type of activity.

5.7 Electrical maintenance

Task description: routine maintenance operations of electric appliances, such as:

- electrical repairs in racks or on the electrical distribution boards;
- installation/repair of electrical sockets or socket panels;
- maintenance of electrical panels; testing of proper functioning of circuit breakers.

Associated risk: electrocution. The following requirements should be followed:

- strictly comply with electrical safety regulations;
- take note of the recommendations given in EST internal document **PVAR-SCH-07**.

Authorized worker categories:

- maintenance workers (electrical-electronic technicians of the EST Infrastructure Group).

All other work categories ARE NOT AUTHORIZED to perform this type of activity.

5.8 Installation/removal of heavy or bulky instrumentation

Description: these are activities that must be performed with the support of the EST movers. Typically, these are the transport, installation or removal of encumbered or heavy parts of the beamlines instrumentation or experimental stations, for example:

- vacuum chambers;
- manipulators;
- scientific instruments of relevant weight and size;
- ion or turbomolecular pumps of significant weight and size.

Associated risks: manual handling of loads; shocks, hits, impacts. The following requirements should be followed:

- agree with the beamline coordinator on a plan for safe assembly/disassembly;
- request the intervention of removals personnel;

- always make use of the overhead crane for lifting vacuum chambers and heavy objects. Where it is not possible to intervene with the overhead crane, use a pallet jack;
- work in pairs to reduce the load and corresponding strain;
- always wear the prescribed PPE:
  - protective gloves, for example, leather gloves or cut-resistant gloves;
  - safety shoes;
  - protective helmet (only in case of overhead crane use).

Authorized worker categories:

- MSB researchers;
- MSB technician;
- movers.

MSB users ARE NOT AUTHORIZED to carry out this type of activity.

5.9 Installation/removal of vacuum equipment and instrumentation

Task Description: installing or removing parts of the instrumentation of the beamline or end station, without use of the overhead crane and without support from EST movers. For example, this involves performing the following tasks:

- installation or removal of scientific instruments (weighing up to 20 kg), vacuum pumps;
- installation or removal of small to medium-sized vacuum instrumentation (weighing up to 20 kg);
- assembly or disassembly of various instrumentation, e.g., manipulators (weighing up to 20 kg);
- installation or removal of instrumentation in *racks* (weighing up to 20 kg);

Associated *risk*:

- manual handling of loads. The following requirements should be followed:
  - work in pairs to reduce the load and corresponding strain;
- shocks, hits, impacts. We recommend:
  - wear the following PPE: protective gloves, for example, leather gloves or cut-resistant gloves.
- slips, falls at level, tripping. It is recommended to:
  - keep the floor free of sharp objects, highlight any obstacle.

Authorized worker categories:

- MSB researchers;
- MSB users *only after appropriate training and authorization by the MSB researcher*;
- MSB technician;
- movers.

5.10 Minor maintenance work on vacuum chambers

Task Description: routine maintenance operations of vacuum chambers and/or their vacuum components, for example:

- installation/removal or assembly/disassembly of instrumentation or parts and components of vacuum systems, e.g., *gate-valves*, *leak valves*, linear manipulators (*z-translators*), pressure sensors, ion cannons;
- opening/closing flanges to allow repairs and routine maintenance operations inside in the

vacuum systems of the beamline or experimental stations;

Associated risk: shocks, hits, impacts;

Authorized worker categories:

- MSB researchers;
- MSB users *only after appropriate training and authorization by the MSB researchers*;
- MSB technician.

5.11 Small fluid-mechanical maintenance operations

Task description: minor fluid-mechanical maintenance, such as:

- water leak repairs;
- installation or replacement of faucets, rigid pipes, hoses, and flow switches.

Associated risk: shocks, hits, impacts;

- take notice of the recommendations in the EST internal documents **PVAR-SCH-09 and PVAR-SCH-19**.

Associated risk: electrocution;

- take notice of the recommendations in the EST internal document **PVAR-SCH-07** and in **Section 6.3**.

Authorized worker categories:

- maintenance workers (mechanical-fluidistic technicians of the Infrastructure Group).

All other work categories ARE NOT AUTHORIZED to perform this type of activity.

5.12 Elevation work on cable channels or vacuum chambers

Task description: operations performed in elevation on ladders or scaffolds, such as:

- laying or removing cables from cable trays;
- maintenance operations of the internal or external parts (e.g., manipulators) of the vacuum chambers of the beamline.

Associated risk: slip or fall from elevated positions. The following requirements should be followed:

- whenever possible, secure to solid supports;
- work in pairs; one of the two must hold the ladder firmly.

The following **PROHIBITIONS** must also be observed:

- *work in elevation in positions that allow viewing inside the beamline shielding walls when the beam-stopper is open.*
- *working at elevation above 3 meters at a distance of less than 5 meters from the ring screens during machine physics shifts.*

Authorized worker categories:

- MSB researchers;
- MSB technician;
- other technicians.

MSB users ARE NOT AUTHORIZED to carry out this type of activity.

5.13 Cleaning of ultra-high vacuum components and tools

Task description: these are operations carried out in the course of routine or extraordinary maintenance of vacuum chambers and/or their parts and components:

- cleaning of small metal parts, such as parts of specimen holders, manipulators, and sensors. Cleaning is done by immersion in isopropanol or acetone;
- cleaning of the tools used for assembly/disassembly of parts in ultra-high vacuum;
- material removal using filings or sandpaper, resulting in the formation of metal dust.

  Associated *risks*:

  - inhalation of gases or vapors. The following requirements should be followed:
    - avoid prolonged exposure to solvent vapors; if so, work under a fume hood;
    - wear latex gloves;
  - inhalation of dust or fibers. The following requirements should be followed:
    - working under a fume hood;
    - wear latex gloves and lab coat;
    - wear FFP2 or FFP3 mask during all material removal operations.

Authorized worker categories:

- MSB researchers;
- MSB users *only after appropriate training and authorization by the MSB researchers*;
- MSB technician.

5.14 Maintenance of primary pumps

Task description: this is a routine maintenance operation, typically to be carried out once every one to two years, necessary to restore the pristine pumping speed of *scroll* or diaphragm pumps. Seals/membranes are changed and mechanical cleaning is carried out using brushes, vacuum cleaners, and wet cloths.

Associated risks: inhalation of dust. The following requirements should be followed:

- refer to the manual provided with the pump maintenance kit. Follow the manufacturer's recommended instructions;
- work under a fume hood or outside;
- wear latex gloves;
- wear FFP2 or FFP3 mask during the entire duration of cleaning operations.

Authorized worker categories:

- MSB researchers;
- MSB technician.

MSB users ARE NOT AUTHORIZED to carry out this type of activity.

5.15 Bake-out of vacuum chambers

Task description: to achieve the usual ultra-high vacuum conditions, vacuum chambers are baked out at temperatures typically between 100 and 150 °C. Bake-out preparation consists of the following operations, each of which presents specific risks:

- Use of resistive heating tapes.

Associated risks:

- shocks, hits, impacts. Prescriptions:
  - PPE is not required but work gloves are recommended;
- exposure to heat, burns during disassembly due to residual heat. The following requirements should be followed:
  - wear heat protective gloves during disassembly operations
- electrocution. The following requirements should be followed:
  - always use only [redacted]-marked tapes;
  - verify the electrical integrity of the heating tapes by multimeter before use.
- inhalation of dust/fibers:
  - it is prohibited to use fiber-glass coated heating tapes, or fiber-glass sheets.
- **interference risk: signal with appropriate signs the danger from hot parts in order to prevent burns to personnel assigned to other tasks.**

Work activities related to *bake-out* operations can be conducted by the following categories of workers:

- MSB researchers;
- MSB users *only after appropriate training and authorization by the MSB researchers*.

5.16 Powder sample preparation

Task description: powders or nanoparticles are deposited on metallic or semiconductor samples for example by *gluing them on a tape* or by fixing them under pressure.

Associated risks: inhalation of dust and/or fibers. The following requirements should be followed:

- consult the safety datasheet of the substance and take necessary precautions;
- carry out the preparations in the EST User Support Laboratory, always working under the fume hood;
- wear prescribed PPE: chemistry lab coat, latex gloves, goggles, FFP2 or FFP3 mask during the entire duration of preparation operations.

The work activity related to the powder sample preparation can be carried out by the following categories of workers:

- MSB researchers*, only after having carried out a thorough risk analysis, if necessary also with the support of the line users;*
- MSB users, *only after carrying out a thorough risk analysis and agreeing security measures with line personnel.*

5.17 Mounting and insertion of samples into the experimental chambers

Task description: mounting samples on sample holders and introducing them into the *load lock* of the end station for pumping and subsequent transfer under high vacuum conditions to the analysis chamber.

Associated risks:

- inhalation of dust, fibers. The following requirements should be followed:
  - consult the safety datasheet of the substance and take necessary precautions;
  - use latex gloves; if necessary, wear an FFP2 or FFP3 mask;

- repetitive movements, uncomfortable postures. Temporary incongruous postures may cause musculoskeletal disorders. There are no special prescriptions.

Sample assembly activity can be conducted by the following categories of workers:

- MSB researchers;
- MSB users *only after appropriate training and approval by the MSB researches. Instructions received must be followed strictly. Damage to the instrumentation and thus a negative impact on the outcome of the ongoing experiment is possible (unintentional venting of the experimental apparatus, damage of manipulator or its electrical contacts etc.)*.

5.18 Activities with liquid nitrogen

Task description: scientific experiments sometimes require cooling the sample or the cryopumps by the use of liquid nitrogen cryostats. Operation of a cryostat requires certain preparatory activities to be carried out, each of which is characterized by a specific risk:

- Dewar filling at the distribution station.

  Associated risks:

  - exposure to cold due to accidental contact with low-temperature liquid or gaseous nitrogen. Injuries from frostbite or burns are possible. The following requirements should be followed:
    - wear the following PPE: cryogenic gloves, protective goggles;
    - it is advisable to have taken the "*Azoto Elettra*" course or equivalent course on the use of cryogenic gases and liquids;
    - training and information: refer to EST internal Safety Procedure **PRSI-PRO-03**;
- Transportation of the *dewar* to the MSB end station.

  Associated risks:

  - shocks, hits, impacts; crushing due to the possible tipping over of the *dewar* at the access ramp to the EST experimental hall. The following requirements should be followed:
    - training and information: refer to EST internal **PRSI-PRO-03** Safety Procedure.
- Filling the cryostats of the manipulator or cryopumps:

  Associated risks:

  - exposure to cold. The following requirements should be followed:
    - use cryogenic gloves and protective goggles.

Work activities related to these operations can be conducted by the following categories of workers:

- MSB researchers;
- MSB users *only after appropriate training and authorization by the MSB researchers. Instructions received must be followed strictly*.

5.19 Experiments with non-toxic gases or liquids

Task description: gas-line preparation, evacuation, and filling using

- mini-bottles (1-liter capacity at 12-bar pressure) of gaseous O_2, H_2, CO_2, Ar, or
- steel bottles (14–50-liter capacity at 200-bar pressure) of gaseous Ar
- quartz flasks with liquid H_2O.

Associated risks: not significant. The gases and liquids are nontoxic and/or are used in minute

quantities, on the order of a few tens of thousands of L (Langmuir).

Gas-line preparation instructions:

- connect the bottle or the quartz flask to the *gas-line*; large bottles must be rigidly fixed to a stable support;
- ensure that the drains of all primary pumps are connected to the EST gas exhaust system;
- test the vacuum tightness of the *gas-line* section on which the container is connected;
- fill the gas-line with gas or vapors and perform the necessary rinsing operations;
- finished the experiment, evacuate *the gas-line* before removing the mini-bottle.

Work activities related to *gas-line* preparation can be carried out by the following categories of workers, subject to appropriate training (damage to the experimental apparatus is possible):

- MSB researchers;
- MSB users *only after appropriate training and authorization by the MSB researchers. Instructions received must be followed strictly*.

5.20 Experiments with toxic or corrosive gases

Task description: gas-line preparation, evacuation, and filling using

- mini-bottles (1-liter capacity at 12-bar pressure) of gaseous CO, Ar, or
- quartz flasks for liquid methanol, ethanol, isopropanol, acetone, formic acid, acetic acid.

Associated risks: inhalation of vapors or gases. The experiments are performed under vacuum conditions at pressures below $2\text{-}10^{-6}$ mbar, dosing very low quantities, on the order of a few tens of thousands of L (Langmuir). The following requirements should be followed in order.

***Interference risk*: any gas/vapor leaks could affect the nearest laboratories and beamlines. Act with utmost care, strictly observing all the steps listed below:**

- make sure the central gas extraction system is working properly;
- consult the safety data sheet of the gas and take necessary precautions, e.g., use of gas mask;
- ensure that the drains of all primary pumps are connected to the suction system;
- test the vacuum tightness of the gas-line section on which the container is connected;
- fill the line with gas or vapors to perform the necessary gas-line flushing operations;
- once the experiment is finished, close the cylinder and evacuate the gas-line. Pump for a long time before venting and detach the cylinder from the gas-line;

In case of accidental gas leakage in large amount, inform the control room (8922) to request evacuation of the experimental room by loudspeaker. If possible, intercept the leak and stop it without endangering your own safety. Open the gates of the experimental room to favor air exchange.

All work activities related to gas-line preparation MUST BE performed by the following categories of workers, after adequate training and authorization:

- MSB researchers.

MSB users ARE NOT AUTHORIZED to carry out this type of activity.

5.21 Using the X-ray source for experiments

Task description: Using the soft X-rays generated by the dual-anode laboratory X-ray source.

Associated risks: exposure to ionizing radiation. The following requirements should be followed in order:

- protective cover of the X-ray source must be properly installed;
- lead-glass shields on the viewports on the analysis chamber must be properly installed;
- X-ray source must not be operated without dedicates water cooling; if the chiller is not operating properly, the controller does not allow to switch the X-ray source on; the water flow sensor must not be bridged.

Work activities related to these operations can be conducted by the following categories of workers:

- MSB researchers;
- MSB users *only after appropriate training and authorization by the MSB researchers. Instructions received must be followed strictly.*

6 Electrical Safety Standards

Electrical and electronic equipment in operation at the beamline experimental stations expose operators to electrical hazards. This risk is reduced by complying with current regulations and following the guidelines and prohibitions below:

6.1 Recommended electrical safety guidelines

- Comply with safety signs and related regulations.
- Ensure that the electrical system or equipment has the necessary approvals and certifications, if necessary contact the competent personnel.
- Be sure of the location of the electrical panel supplying power to the area in which you are working so that you can promptly de-energize the system if necessary.
- Use electrical systems in accordance with their intended use and respective operating manuals.
- Ensure that the power cords of electrical appliances are adequately protected from mechanical (passing people, sharp objects, etc.), thermal (heat sources) or chemical (corrosive substances) actions.
- Make sure the power has been turned off before performing any simple operation on the facilities (including changing a bulb) or equipment.
- Always make sure the electrical system is disconnected (after operating the appropriate switch) before unplugging.
- Disconnect the equipment from the power source before starting periodic cleaning.
- Plug the equipment into the nearest outlet, avoiding the use of extension cords as much as possible.
- Do not overload outlets with too many electrical devices, always checking that the total current load intensity does not exceed the limits of the outlet itself.
- German-type (Schuko) plugs can be inserted into Italian-type sockets only by means of an adapter that transfers the ground connection made via the side plates to a central plug. It is absolutely forbidden to forcibly insert Schuko plugs into Italian sockets.
- Avoid subjecting all parts of electrical systems to mechanical or impact actions (passing trolleys, etc.).
- Do not pull the power cord to disconnect an electrical appliance from the outlet, but hold the plug.

- Do not tamper with electrical equipment (qualified personnel must be requested for any need in accordance with EST and CUP procedures).

6.2 Prohibitions

- Prohibition of tampering with electrical appliances.
- Prohibition to install or use private electrical equipment or materials.
- Prohibition to intervene in case of failure on switchboards or electrical panels.
- Prohibition of covering or concealing the controls and electrical panels with cabinets or other furnishings (allow inspection and timely intervention in case of anomalies).
- Prohibition of removing the electric cables from cable trays.
- Prohibition of overloading outlets with too many electrical devices.
- Prohibition of depositing flammable substances in the vicinity of equipment.
- Prohibition of depositing containers filled with liquids on the devices.
- Prohibition of exposing equipment to excessive radiation or heat sources.
- Prohibition of preventing proper ventilation of equipment by covering ventilation openings.
- Prohibition of touching facilities and/or equipment if you have wet hands or shoes.
- Prohibition on the use of water for extinguishing fires of electrical origin.

6.3 Behavior to be followed in case of water leakage

The electron beam evaporators and turbomolecular pumps in use at the end station require cooling water. Some of the beamline chambers also need water, which is used to cool the monochromator optics, the entrance slits and the prefocusing mirror. Such water is demineralized, and therefore non-conductive.

Given the presence of high voltage in many pieces of equipment, the risk of electrocution cannot be completely ruled out. For this reason, it is important to avoid putting yourself or others in a dangerous condition. The following recommendations must be followed:

1. Consult the beamline safety supervisor, if she/he is on site.
2. Don't get caught up in rush or panic.
3. Avoid stepping on wet areas.
4. Avoid touching wet areas with your hands.
5. Prevent flooding by closing the cooling circuit subject to leakage.
6. DO NOT dry wet areas with paper or cloths, unless you have turned off power to all *racks* and utilities. Cordon off the area so as to prevent third parties from accessing it.

7 Emergency management

Various and of different severity are the emergencies that can happen in the laboratory. They must be handled according to the EST Emergency Plan (see EST internal procedure GEEM-PRO-02-rev03EN).