



CEITEC Nano User Manual

The intent of the CEITEC Nano User Manual is to ensure that an environment is created inside the core facility in which researchers can work both safely and productively, while maintaining the integrity of the class 100 / 1,000 / 100,000 cleanroom environment and equipment.

Thus, the user manual will continuously adapt to changes to our facility as it evolves. We strongly encourage users to make us aware of how we can more effectively meet the goals of the facility. Please do not hesitate to contact us at nano@ceitec.vutbr.cz with all your comments, questions and requests.

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Table of content

1	Information for users	5
1.1	Internal User Requirements	5
1.2	Resources	5
1.2.1	Phone numbers	5
1.2.2	Material Safety Data Sheets (MSDS)	5
1.3	Ethical Rules	5
2	Access Procedures	6
2.1	Access for Academic Users	6
2.2	Access for Commercial Users	7
2.3	Access Card System	7
3	Using CEITEC Nano Equipment	8
3.1	Logbooks	8
3.2	Training and Authorization	8
3.3	Equipment Scheduling	9
3.4	Consumables for Internal (self-service) Users	9
4	CEITEC Nano Research Infrastructure	10
4.1	Operating hours	10
4.2	Laboratories	10
4.3	PC room / Shared office space for CEITEC Nano users	12
4.3.1	Rules & User Policy	12
4.4	Additional Services for Users	12
4.4.1	Locker rooms	12
4.4.2	Electrical workshop (C1.43)	13
4.4.3	Mechanical workshop (C1.55)	13
5	Prior to Entering the Cleanroom	14
5.1	Concept of the Cleanroom	14
5.2	Bringing Materials into the Cleanroom	15
5.2.1	Cleaning procedure	15
5.2.2	Electronics Allowed Inside the Cleanroom	15
5.2.3	Materials Prohibited Inside the Cleanroom	16
6	Cleanroom Gowning Procedure	17
6.1	General rules for Gowning Procedure	17
6.2	Building C – Entry Area of the Cleanroom	19
6.3	Building C – Nanocharacterization Laboratory (Class 100,000)	20
6.3.1	Entering Cleanroom – Class 100,000	20
6.3.2	Exiting Cleanroom – Class 100,000	20

6.4	Building C – Nanofabrication Laboratory (Class 100 / 1,000)	21
6.4.1	Entering Cleanroom – Class 100.....	21
6.4.2	Exiting Cleanroom – Class 100	24
6.5	Building A – Structural Analysis Laboratory (Class 100,000).....	26
7	General Behaviour Inside the Cleanroom	28
7.1	General safety rules	28
7.2	Camera system.....	29
8	Dealing with Chemicals in the Cleanrooms.....	30
8.1	Bringing Non-Stock Chemicals into CEITEC Nano	30
8.2	Handling Hazardous Chemicals.....	30
8.3	Using Hydrofluoric Acid and Piranha	31
8.4	Hazardous Waste Disposal.....	31
8.5	Using the Fume Hoods	32
9	General Emergency Procedures	33
9.1	Chemical Spill	33
9.2	Chemical Spill on Personnel.....	35
9.2.1	Skin Exposure	35
9.2.2	Exposure of eyes.....	35
9.3	HF safety	36
9.3.1	HF skin exposure.....	37
9.3.2	HF eye exposure	38
9.3.3	Other exposure – inhalation, ingestion.....	38
9.4	Liquid Nitrogen safety.....	39
9.4.1	Precautions when handling liquid nitrogen	39
9.4.2	First Aid	40
9.5	Emergency Power Shut-down.....	40
9.6	Toxic Gas Leak	41
9.6.1	Toxic Gas Monitoring System – Building C.....	41
9.6.2	Toxic Gas Monitoring System – Building A - StAn	41
9.7	Fire emergency.....	41
9.8	Emergency Evacuation Procedures.....	42
10	Enforcement	43
11	Visitor Policy	44
12	APPENDIX	45
12.1	BUDDY SYSTEM	45

1 Information for users

The CEITEC Nano research infrastructure at CEITEC Brno University of Technology is committed to the highest possible safety standards. It is our goal to operate the facility in a manner that ensures that no unacceptable risks exist for all persons operating within the space. Safety is the responsibility of everyone. We require strict adherence to all applicable health and safety regulations, and will enforce these as necessary.

1.1 Internal User Requirements

- Each academic user must have his/hers faculty sponsor sign the CEITEC Nano User Agreement (accessible through the website – <http://nano.ceitec.cz>)
- Each user must read the CEITEC Nano User Manual and complete the exam (accessible through the website – <http://nano.ceitec.cz>)
- Each user must schedule and participate in a General laboratory excursion (about 2.5 hours) with CEITEC Nano staff
- According to Czech legislation, all users of the nanofabrication lab must schedule and participate in the training of “Handling of toxic and dangerous chemical substances” (1 hour)
- Each user must be fully trained to be able to operate individual equipment independently

1.2 Resources

1.2.1 Phone numbers

- Fire/Police/Emergency Land Line: 1-1-2
- Reception Desk: (+420) 54114 9669
- CEITEC Safety Coordinator: Denisa Sigmundová (+420) 54114 9618
- Toxicological Information Center / Toxikologické informační středisko (TIS),
 - Na Bojišti 1, 120 00 Praha 2
 - tel. (+420) 224 919 293, (+420) 224 915 402

1.2.2 Material Safety Data Sheets (MSDS)

- MSDS of all materials used in CEITEC Nano laboratories are available at <http://nano.ceitec.cz/msds/>

1.3 Ethical Rules

- Each user agrees to work in the laboratory and on the research infrastructure instruments in an effective, ecological and efficient way
- If the user carries out measurements for a third party using the instruments of the research infrastructure, he or she must contact the CEITEC Nano User office C1.04:
Phone: +420 541 14 9207, e-mail: nano@ceitec.cz and negotiate the procedure first
- The CEITEC Nano staff will make every effort to meet the user's requirements based on mutual communication and collaboration
- The CEITEC Nano staff will not process the results of measurements and analyses further without getting the user's consent first

- Each user is obliged to acknowledge the CEITEC Nano research infrastructure if the measured results are made public. The form of acknowledgement is given on: <http://nano.ceitec.cz/acknowledgement/>
- Each user is responsible for his/her own data measurement and archiving thereof

2 Access Procedures

Users, who may benefit from the services of the CEITEC Nano Research Infrastructure, can be both academic users and commercial users.

2.1 Access for Academic Users

The preferred way of using the equipment in the CEITEC Nano research infrastructure for academic users is self-service access. The instruments running costs is 100% paid from the CEITEC Nano project, only administration, training fee and selected consumables is paid by the user.

Full access to CEITEC Nano via booking system	CZK
User fee for new and regular users	30 000/year

Self-service users are provided with fully independent access to all CEITEC Nano labs and to all instruments via the **Booking system**. To be allowed to work on individual instruments, an authorization procedure is required. It can be obtained after proper training.

1. Register via [Perun website](#).
2. Print the [CEITEC Nano User fee agreement & solemn declaration](#) published on the CEITEC Nano website and sign it. If you have a faculty advisor and/or sponsor have them sign it as well. Bring the agreement to the *User Office*, or scan and e-mail it to nano@ceitec.vutbr.cz.
3. Thoroughly study the [CEITEC Nano User Manual](#).
4. Pass the exam:
 - Log in to your CEITEC Nano user account and fill in the Examination form
 - Wait to receive an email, which shows your score, and whether or not you passed the exam. This procedure can take up to 3–5 working days
 - If you did not pass the exam, you have to come to CEITEC Nano for a personal interview
5. Contact the CEITEC Nano *User Office* to schedule required training and a laboratory [Safety excursion](#). The CEITEC Nano *User Office* can be reached via e-mail at nano@ceitec.vutbr.cz or by phone +420 541 14 9207:
 - a. “Handling of toxic and dangerous chemical substances” training – mandatory for all users who will be in contact with dangerous chemical compounds/solutions (for example HF in nanofabrication laboratory) – 60 min
 - b. Safety excursions – four options are available:
 - i. Full CEITEC Nano excursion – 2 hrs.
 - ii. Nanofabrication laboratory – 45 min.
 - iii. Nanocharacterization laboratory – 30 min.
 - iv. Structural analysis laboratory – 30 min.
6. After you have completed all the above mentioned requirements, you will be granted with the access card/access rights to the cleanroom and you can start with the training for individual equipment.
7. During the period of your work in CEITEC Nano RI you are obliged to send us your publications (thesis, papers, articles...) and other scientific outcomes (posters, presentations...) by email to nano@ceitec.vutbr.cz (best as PDF file). If you have not published any outcomes over the past year and you are going to prolong your access to the RI, please fill in the CEITEC Nano activity report and submit it with the new User fee agreement.

2.2 Access for Commercial Users

Please visit our websites [Services for commercial users](#) or contact us at nano@ceitec.vutbr.cz to discuss your individual needs and pricing.

2.3 Access Card System

The CEITEC Nano facility is equipped with an access card system, which limits access to authorized users. They must use a valid access card, in order to be able to enter the facility.

The access card is strictly dedicated for user's personal use!

Note: *Please do not admit anyone else than yourself into the facility for any reason other than an emergency. Should you need to admit another person into the facility due to an emergency, both the authorized user and the person who was given access to the facility must notify CEITEC Nano staff (please, see section 11 for visitor policy).*

Be sure that you understand lab rules and enforcement and when they are breached. It can result in nullification of the access privileges (please, see the section 10 for enforcement explanation).

3 Using CEITEC Nano Equipment

No user is allowed to operate any piece of CEITEC Nano equipment without supervision until he or she has completed sufficient **training AND authorization** by CEITEC Nano staff.

All equipment/processes must be carried out within the guidelines provided by CEITEC Nano's management. Materials and/or processes not in common use at the facility need to be reviewed by CEITEC Nano management, and the facility reserves the right to disallow processes that might harm equipment or disrupt other processes.

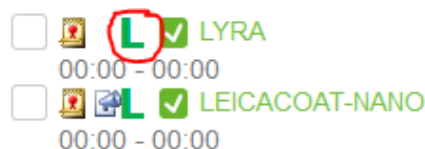
Each instrument in the CEITEC Nano facility has CEITEC Nano Core Facility expert staff in charge of maintenance and repair (Instrument Guarantor), and authorized users. To become an authorized user, please follow the procedure below.

Note: *These procedures apply to most pieces of instrumentation inside the facility. However, there are a number of more complex instruments that require more extensive training procedures.*

3.1 Logbooks

Almost every piece of CEITEC Nano equipment has a log book, either electronic or written – sometimes both. It is essential that users make a log book entry for every equipment usage.

- **The electronic logbooks** are available in the CEITEC booking system and enable users to see the records of previous usage which can be valuable for their work. Entries also enable CEITEC Nano staff to track equipment malfunction and/or equipment abuse.



To make entries to electronic logbooks are obligatory for every user. If the equipment does not have electronic logbook than entries are made in a manually written log book.

- **The manually written log book** entries enable CEITEC Nano staff to track equipment malfunction and/or equipment abuse. In addition, they also provide a record of process parameters and results for previous usage which can be valuable to new users.

3.2 Training and Authorization

To insure the safety of people in the lab and to minimize equipment down time, it is absolutely necessary that all CEITEC Nano users follow this procedure. Equipment authorization will only be done by CEITEC Nano staff:

- **Make an appointment** with CEITEC Nano staff or any authorized user of the particular piece of equipment **to obtain training on the operation of the machine**. A list of authorized users for individual equipment in the CEITEC Nano facility can be found on the wall near the specific instrument. CEITEC Nano staff will inform you if the equipment you wish to use requires extra training. Go through as many hands on training sessions as necessary until you feel comfortable operating the equipment. You are not permitted to use any equipment alone before being officially authorized. An authorized user **MUST BE WITH YOU** at all times while you are learning/practicing. Users must not only “push buttons”, they should have a good understanding of everything that happens with each part of the process.
- When you feel you understand the process thoroughly and can operate the machine independently, you may **make an appointment with the Instrument Guarantor for authorization**. To obtain the Instrument Guarantor contact details visit the equipment section of the CEITEC Nano webpage: <http://nano.ceitec.cz/equipment/>. Be sure to review your notes prior to authorization. Have your samples and/or materials ready for the authorization procedure. During the authorization procedure, the Guarantor will watch you use the system while you explain the operation of the instrument. If you demonstrate that you are sufficiently

knowledgeable with the operation of the instrument, the Guarantor will give you authorization to independently use the instrument and your name will be added to the authorized user list.

3.3 Equipment Scheduling

The CEITEC Nano booking system can be accessed through your on-line user account at <https://booking.ceitec.cz>. Users are responsible for reserving equipment for training time as well.

- Please make your reservations as far in advance as possible. If you make a reservation and then will not use the equipment for any reason, please be sure to remove the reservation so that other users can schedule time.
- **Please be prompt.** You must begin your process within 15 minutes of the start of your reserved time slot. After 15 minutes you will lose your reservation privileges and the equipment is considered available to other authorized users.

3.4 Consumables for Internal (self-service) Users

We offer to our internal (self-service) users via our on-line storage a variety of consumables they might need for their work in the lab: Lab Tools, Tweezers, Wafers & Accessories, and Mask etc.

Consumable Storage:

<http://cfnano.ceitec.cz/warehouse/www/items/>

Users can send their request via the on-line wish list where they have to fill out an email contact. They will be informed when it is ready to be collected from our staff.

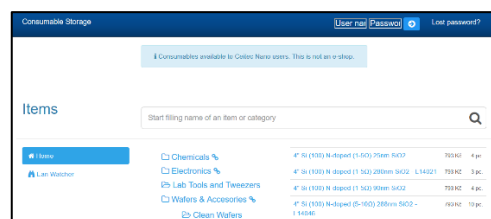


Figure 1: Consumable Storage

In the **FILTER I**, room **C1.15**, there are consumables suitable for usage in the cleanrooms available for internal (self-service) users:

Nanocharacterization Laboratory (Class 100,000)

- Green notebooks
- Blue notebooks
- Pens
- Permanent markers

Nanofabrication Laboratory (Class 100 / 1,000)

- Blue notebooks
- Individual sheets of cleanroom paper
- Pens
- Permanent markers

Structural analysis laboratory

- Blue notebooks
- Pens
- Permanent markers



Figure 2: Accessories in FILTER I, room C1.15

4 CEITEC Nano Research Infrastructure

CEITEC Nano is the joint, national, single-sited research infrastructure of the Central European Institute of Technology at the Brno University of Technology (CEITEC BUT) and Masaryk University (CEITEC MU). It is operated under CEITEC BUT, which is an independent university institute. Masaryk University (CEITEC MU) is involved in the research infrastructure via a partnership agreement.

4.1 Operating hours

The CEITEC Nano facility is open twenty-four hours a day, seven days a week, except for planned shut-downs, which are announced one month prior.

- **Main Business Hours:** Expert staff and the User Office are available for your questions and troubleshooting.
- **Buddy Hours:** Expert staff and the User Office are not available and are not required to stay in the CEITEC building

	Operating hours				
	00:00–06:00	06:00–08:00	08:00–18:00	18:00–20:00	20:00–00:00
Monday	Buddy hours	Open	Main business hours	Open	Buddy hours
Tuesday	Buddy hours	Open	Main business hours	Open	Buddy hours
Wednesday	Buddy hours	Open	Main business hours	Open	Buddy hours
Thursday	Buddy hours	Open	Main business hours	Open	Buddy hours
Friday	Buddy hours	Open	Main business hours	Open	Buddy hours
Saturday	Buddy hours				
Sunday	Buddy hours				
Bank holidays	Buddy hours				

Please go to *chapter 12.1* for more details about the Buddy hours and Buddy system

4.2 Laboratories

The CEITEC Nano facility consists of four main laboratory units:

- Nanofabrication laboratory (“Building C”)
- Nanocharacterization laboratory (“Building C”)
- Structural analysis laboratory (“Building A”)
- X-ray CT laboratory (“Building B”)

Nanofabrication and Nanocharacterization laboratory units are situated in “Building C”, Structural analysis laboratory units are situated in “Building A”. The laboratory units are divided into individual laboratories with particular scientific equipment.



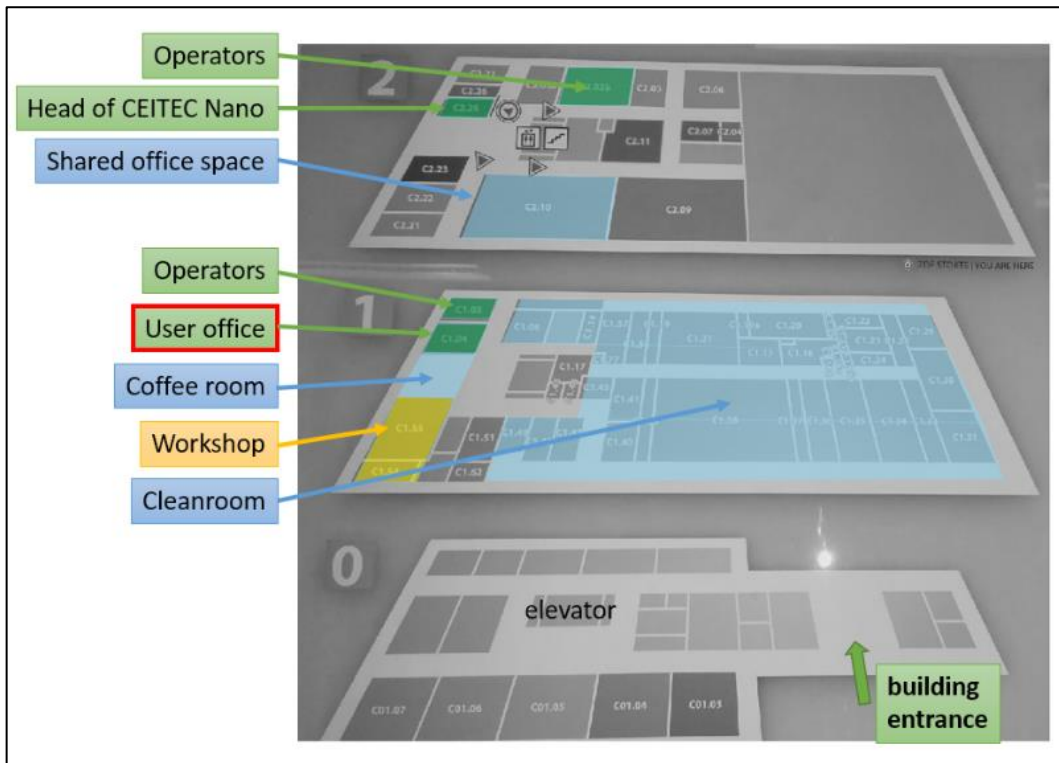


Figure 3: Floorplan of building “C” – Nanofabrication and Nanocharacterization laboratory

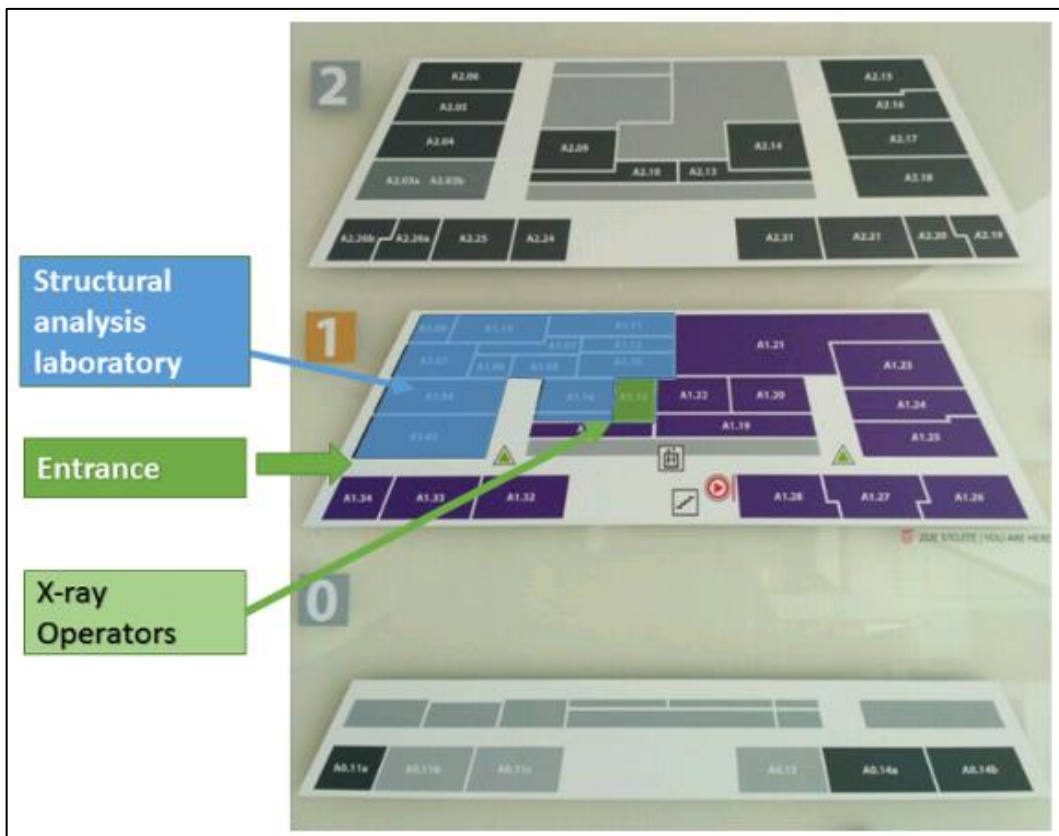


Figure 4: Floorplan of building “A” – Structural Analysis Laboratory

4.3 PC room / Shared office space for CEITEC Nano users

CEITEC Nano offers shared office space (known as the PC room) for registered users who don't have a permanent office at CEITEC BUT, or need Special Software installed in the PC room. It is located in room C2.10 and offers 16 work desks. There are 14 PC machines (CPU Intel® Core i7-6700, 16GB DDR4, MSI GTX 960 2GD5, DVD-RW, 27" LCD monitor) and a network laser printer available for all of our users. The room can be opened with the same ID card as CEITEC Nano laboratories.

4.3.1 Rules & User Policy

1. Basic rule – first come first served: there is no reservation needed except for using special software (GenISys Beamer, Tracer and Lab software), which is available via the booking system.
2. It is not allowed to install any software. In case of need, the User Office has to grant permission for installation.
3. Please login to the BUT domain using your BUT ID.
4. If you do not have BUT ID (typically MUNI or external users), use the local account
 - user: .\CEITEC NANO (no password)
5. Clean your place before you leave (do not leave any dishes or garbage on the desk)!

4.4 Additional Services for Users

The CEITEC Nano facility also provides additional services for the users.



Figure 5: Floorplan of building "C", 1st floor with workshop, electrical workshop and locker rooms

4.4.1 Locker rooms

A number of lockers and a coat rack are available to CEITEC Nano users in rooms C1.06 (men) and C1.14 (women). These lockers are intended for temporary use for cleanroom users. Users may store items that cannot be brought into the cleanroom space during their time inside the cleanroom. **Storage of chemicals is not permitted under any circumstances.**

4.4.2 Electrical workshop (C1.43)

The Electrical workshop is equipped with tools for basic rework and repairs, and a 3D printer is also available. A list of all equipment is available on the website <http://nano.ceitec.cz/mechanical-and-electrical-workshop/>. If you want to use any of the tools in this workshop, first you need to get training from a guarantor of the Electrical workshop and then fill in the logbook for every time you use any tool from the workshop.

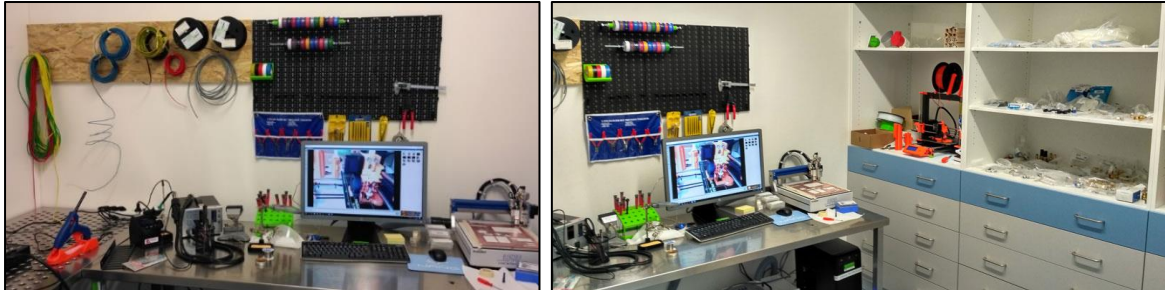


Figure 6: Electrical workshop

4.4.3 Mechanical workshop (C1.55)

The Mechanical workshop offers a wide range of machinery for the production of new parts, repairs and rebuilds. A list of equipment is available on the website <http://nano.ceitec.cz/mechanical-and-electrical-workshop/>. If you need any services, please ask the technician. It is strictly prohibited for users to use any machine by themselves.

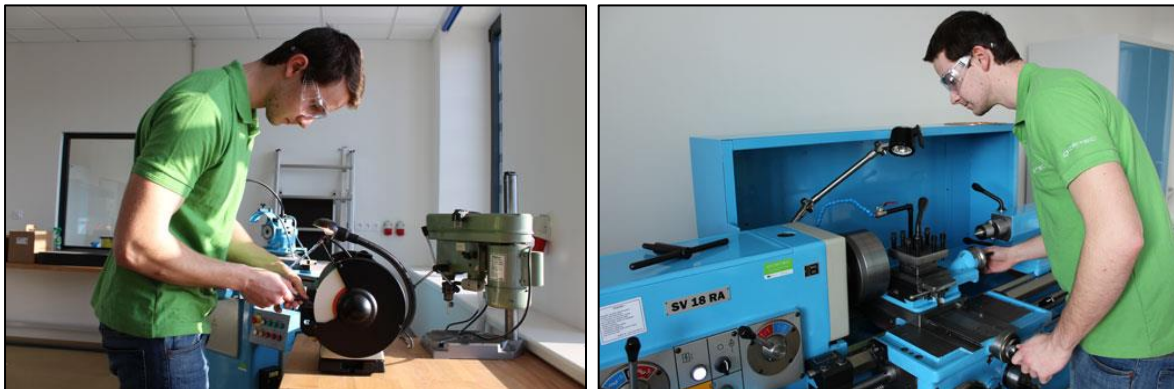


Figure 7: Mechanical workshop

5 Prior to Entering the Cleanroom

5.1 Concept of the Cleanroom

A Class 100 cleanroom is defined as having less than 100 particles of 0.5 micron or greater in size within a cubic foot of air (equivalent to ISO 5). A Class 1,000 cleanroom is defined as having less than 1,000 particles of 0.5 micron or greater in size within a cubic foot of air (equivalent to ISO 6). Similarly, a Class 100,000 cleanroom has less than 100,000 particles 0.5 micron or greater in size within a cubic foot of air (equivalent to ISO 8). This level of cleanliness is necessary to maintain the reproducibility of newly developed state-of-the-art electronic device processes. To reach this level of cleanliness, the transfer of particle and chemical contaminations must be eliminated wherever it is found. Hair and skin from people are the greatest possible sources of airborne particles within the cleanroom and thus must be covered at all times with proper cleanroom garments. Many common materials also shed particles into the air at all times and are not allowed in the cleanroom.

Table 1: ISO Classification of Particulate Matter in Room Air – Limits are in particles of 0.5 μm and larger per cubic meter (current ISO) and cubic feet (former Federal Standard No. 209E)

Class Name		Particle count	
ISO Class	U.S. FS 209E	ISO, m ³	U.S. FS 209E, ft ³
3	Class 1	35,2	1
4	Class 10	352	10
5	Class 100	3 520	100
6	Class 1 000	35 200	1000
7	Class 10 000	352 000	10 000
8	Class 100 000	3 520 000	100 000

Normal air contains hundreds of thousands of particles per cubic foot, to prevent these particles from entering the cleanroom the pressure inside the cleanroom is kept higher than outside by constantly pumping filtered air into the cleanroom. This results in a constant flow of particle free air from inside to outside of the cleanroom through all openings such as between doors and doorsills and through fume hood and gas cabinet exhausts. This airflow pattern keeps all outside air and particles from entering. But even with this pressure differential we cannot commonly open the majority of the doors that lead into the cleanroom. By opening even one door the air balancing for the entire lab is compromised, which allows the possibility of outside air – and particles – to enter. This compromises the entire cleanroom and jeopardizes particle sensitive processing in progress inside the lab. Thus, as cleanroom users, you may only use the main entry door and the subsequent air locks leading into the cleanroom to enter and exit under normal circumstances. All other doors to the cleanroom are emergency exits and are to be used only in the event of an emergency.

Even with a constant flow of filtered air from inside the cleanroom to the outside world, particles can still find their way into the space within the cleanroom. The strategy implemented to keep any particles within the cleanroom space from interfering with ongoing experiments push the particles downward. This is done by forcing filtered air into the room from above and pulling air out from below. With a constant downward flow of particles free air, the resulting laminar flow around all

objects in the room gives any dislodged particle only one option: down and out. But even with all the equipment used to keep the airborne particle count low, maintaining such a high level of cleanliness requires that the users strictly adhere to protocol, especially the gowning procedures outlined in this document.

It is important for each user to understand that their individual commitment to this protocol ultimately determines the success or failure of the facility.

All of the elaborate equipment installed to provide a microscopically clean and controlled atmosphere would be to no avail if our users do not believe in and help enforce these policies. We also understand that users are a tremendous resource for new ideas. With this in mind, we strongly encourage our users to recommend changes that may make the facility safer, cleaner, easier to use, or less expensive to maintain. Contact us at nano@ceitec.vutbr.cz with your questions, comments and recommendations. When in the cleanroom, please be aware of your knowledge limitations. It is extremely important that you ask a CEITEC Nano staff member or experienced user for help if you are unsure about the operation of these facilities.

5.2 Bringing Materials into the Cleanroom

Bringing any materials in and out of the cleanroom should be avoided whenever possible. There is storage space available in the cleanroom for users' tools and personal supplies. Once brought into the cleanroom, these tools and supplies should remain inside as long as they are needed in the cleanroom. When you are finished with your work at CEITEC Nano, please remember to remove any items that you have brought in.

5.2.1 Cleaning procedure

Clean all items that are brought into the cleanroom (e.g. cell phones, boxes with samples) to remove particles and other impurities:

- Moisten a cleanroom wipe with isopropyl alcohol. Carefully wipe all surfaces of the items.
- Wipe the length of the wiper cloth and then fold over. Repeat folding and get new wipes if necessary.

Note: *Some materials can be damaged with isopropyl alcohol (IPA), so you may need to use deionized (DI) water instead. Both are available in labelled squeeze bottles.*



Figure 8: Building C, Filter I (C 1.15) – Table for wiping down materials

5.2.2 Electronics Allowed Inside the Cleanroom

Nanocharacterization Laboratory, Structural analysis laboratory (Class 100,000)

Carefully cleaned:

- Cell phones
- Laptops

- Tablets
- Cameras
- External storage devices

Nanofabrication Laboratory (Class 100 / 1,000)

Carefully cleaned:

- Cell phones
- Cameras
- External storage devices



Figure 9: Building A, Entrance Filter (A 1.05) – Area dedicated for cleaning

5.2.3 Materials Prohibited Inside the Cleanroom

Materials that are fibrous or likely to degrade in normal use and create particulates are not allowed in the cleanroom. Materials with textured surfaces that can trap particles and cannot be cleaned are also not acceptable. Less obvious materials are polymers that outgas and release organic contaminants. Please consult CEITEC Nano staff when you are in doubt. All items that are brought into the cleanroom must be wiped with the provided isopropyl alcohol/DI water solution prior to entry. The items must be brought into and out of the cleanroom via dedicated load-lock windows located in the gowning room. The following list of materials provides some examples of prohibited materials:

- Food or drinks
- Make-Up
- Paper (only cleanroom paper is permitted)
- Wood
- Fabrics and woven materials
- Fiberglass
- Soft plastics and elastomers that are easily abraded
- Pencils, Ballpoint pens (the ink can cake, dry, and flake); only cleanroom approved writing materials are permitted)
- Erasers
- Powders
- Foam materials including some tool handles
- Solutions or suspensions that will dry out to leave powders or particulates
- Most PVC materials
- Devices with hidden surfaces that cannot be cleaned
- Any materials that can easily shred or aerosolizes to become a source of particulate

6 Cleanroom Gowning Procedure

The cleanroom garments are picked up for laundering once per week. Each week on laundry pick up day the used garments are taken down for cleaning and the previously cleaned garments are delivered, cleaned and packaged.

After each laundry cycle if you are a regular user, you should find your labelled hanger in the box next to the packaged garments. Take a clean coat/coverall from the shelf and when you are leaving the cleanroom, hang it on your labelled hanger and on the “Personal” coat-stand. This will be your personal coat/coverall for the week.

Each laundry day the coats/coveralls and hangers are removed from coat-stands and the process starts over.

In addition to the labelled hangers on the “Personal” coat-stand you will see a coat-stand labelled as “Shared”. If you are entering the cleanroom only one time during the week and do not plan to return, please use a garment from the “Shared” coat-stand. If you do not find your size in the shared section, you may obtain a new garment and hang it on an unlabelled hanger on the “Shared” coat-stand.

DO NOT USE NEW GARMENTS EACH TIME YOU ENTER THE CLEANROOM! In an effort to keep costs low, our inventory is kept at a minimum level. We cannot allow one time use of our garments.

6.1 General rules for Gowning Procedure

For some of our users is important that their measurements are performed in cleanrooms with guaranteed cleanliness according to ISO 14644 standard. Beside other criteria, the gowning requirements for ISO-8 (US FS class 100.000) and ISO-5 (US FS class 100) cleanrooms are described in the ISO standard.

1. **Remove all unnecessary clothes.** Use lockers to store items, which cannot be brought into the cleanroom. In case of doubts, see the *section 5.2.3 Materials Prohibited Inside the Cleanroom*
2. **Shoe Covers**
 - Plastic shoe covers are for *Visitors only*
 - Users must use Personal/Shared shoes
 - Only flat or very low-heeled shoes are allowed to be worn in CEITEC Nano cleanrooms. No sandals or open-toed shoes are permitted!



Figure 10: Shoe cover rule

3. Shoe rules

- No barefoot – socks are mandatory for personal and shared shoes



Socks are mandatory
for **PERSONAL** and
SHARED shoes



Figure 11: Shoe rule

4. ISO-8 (US FS class 100.000)

- Coverall + Cap in case of shorts/skirt, no makeup
- Buttoned coat + Cap in case of long trousers, no makeup
 - i. Ladies pantyhose/tights count as long trousers

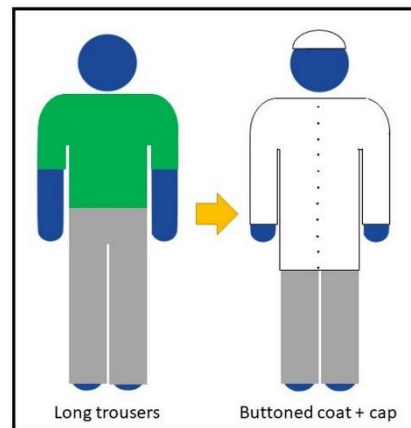
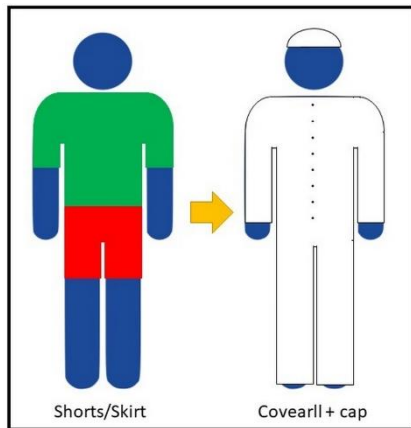


Figure 12: Gowning rules for ISO-8 cleanroom

2. ISO-5 (US FS class 100)

- Personal coverall only in case of shorts/skirt + Hood + Facemask + Shoes, no makeup
- Personal/Shared coverall in case of long trousers + Hood + Facemask + Shoes, no makeup
 - i. Ladies pantyhose/tights count as long trousers

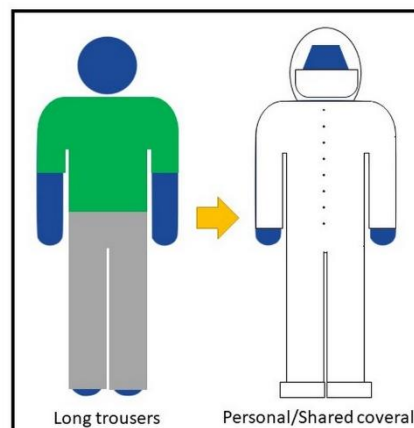
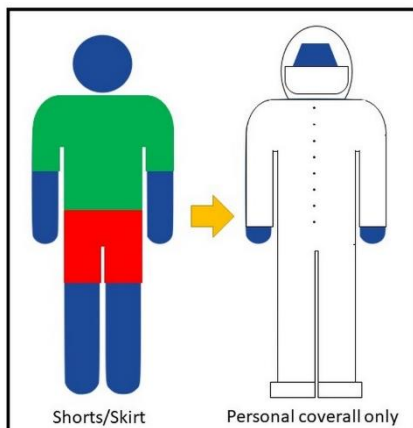


Figure 13: Gowning rules for ISO-5 cleanroom

6.2 Building C – Entry Area of the Cleanroom

1. Use your access card to enter a locker room (C1.06 – men, C1.14 – women).

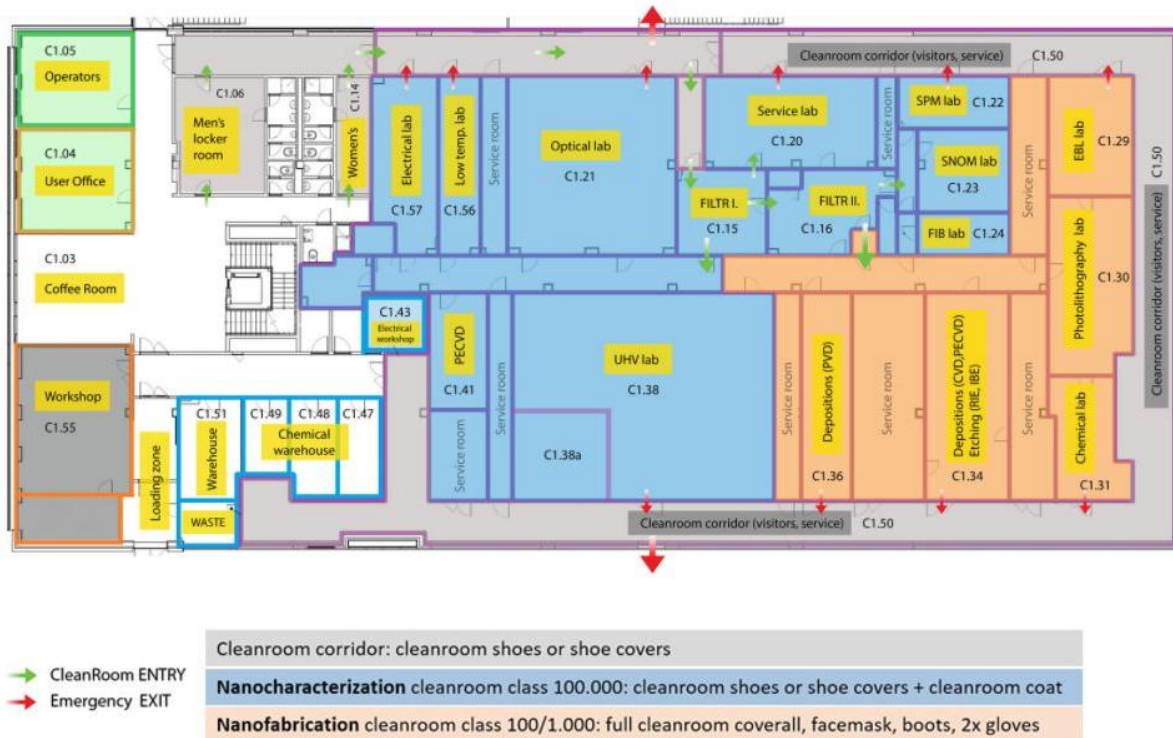


Figure 14: Building C – entrance path to the cleanroom

2. **Put on cleanroom shoes or shoe covers.** Get a pair of shoes from the rack, or pair of shoe covers from the labelled dispenser.



Figure 15: Shoe covers dispenser

3. **Step on the tacky mat.** Take at least 6 steps, 3 for each foot. Exit the locker room and follow into the clean room corridor.
4. Use your access card to proceed via room **C1.19a** to the gowning area in **FILTER I** (room **C1.15**), see **green** arrows in Fig. 10.

6.3 Building C – Nanocharacterization Laboratory (Class 100,000)

The gowning area for the Nanocharacterization laboratory is located in the **FILTER I**, room **C1.15**.

6.3.1 Entering Cleanroom – Class 100,000

1. **Clean all items** that are brought into the cleanroom (e.g. cell phones, boxes with samples)
2. **Take coat/coveralls from the “Shared” hanger or from your labelled hanger on the “Personal” hanger.** Alternatively, pick up the coat/coveralls from the shelf if this is the first visit after the laundry cycle.
3. You may want to put on a cap. They are located in marked bins next to the coat hangers.



Figure 16: Cleanroom caps

4. Enter the cleanroom via cleanroom corridor **C1.32**, or via **FILTER II** and cleanroom corridor **C1.25**.

6.3.2 Exiting Cleanroom – Class 100,000

1. Exit the cleanroom, proceed to the gowning area in **FILTER I**, room **C1.15**.
2. Remove the coat and put it on the appropriate hanger.
3. Remove the cap. If it is disposable, throw it into dispense bin. If it is textile, please, put it into the labelled box for washing.
4. Proceed to the locker rooms (**C1.06 – men, C1.14 – women**)
5. Take off the shoes, or remove shoe covers.
6. Pick up your clothes and other stuff and exit the gowning room

6.4 Building C – Nanofabrication Laboratory (Class 100 / 1,000)

The gowning area for the Nanofabrication laboratory is located in the **FILTER II**, room **C1.16**. It is divided into two parts by benches. In order to proceed from the gowning area to the cleanroom, you will need to step over the benches. Please do so only in accordance with the gowning procedure. The procedure is described below in more detail. Please follow it carefully step by step.

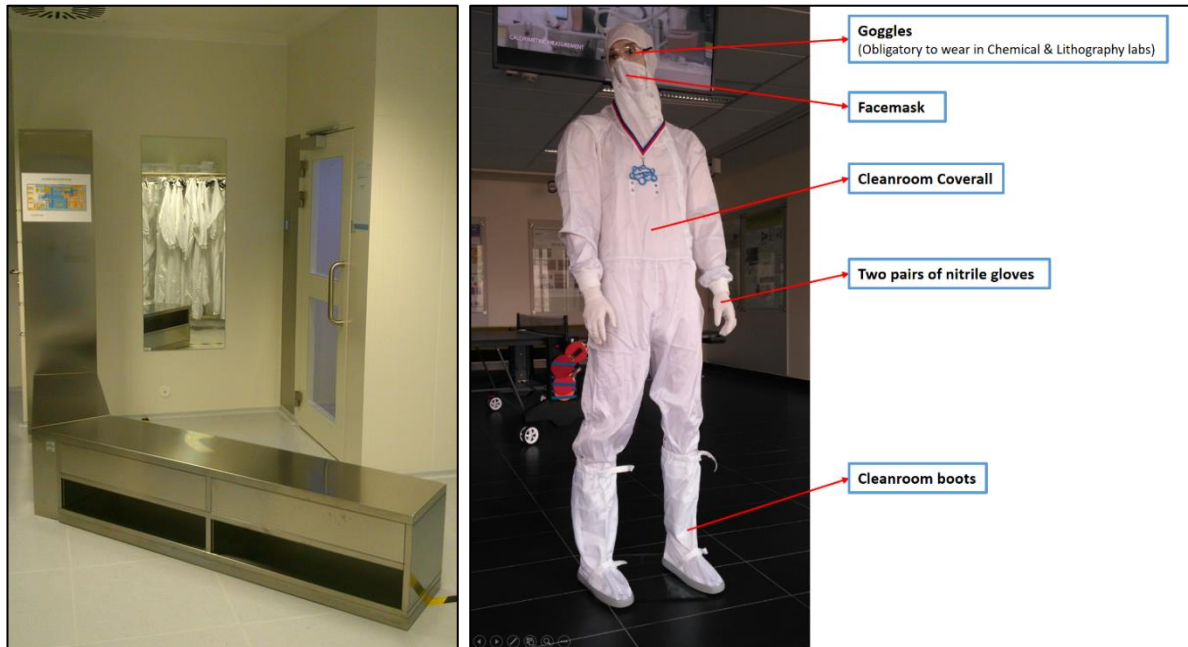


Figure 13: FILTER II – area with benches and complete cleanroom garment for class 100

6.4.1 Entering Cleanroom – Class 100

1. **Put on a pair of gloves.** Touch **ONLY** the cuffs of the gloves. Do **NOT** touch the palms or fingers of the gloves with bare hands. Oils and particulates from your skin adhere to the gloves and subsequently contaminate everything you touch. Get a pair of gloves from one of the labelled dispenser bins. Pull on the first glove holding it only by the cuff. Pull on the second glove making sure that the first glove does not touch your skin.
2. **Wipe down all materials**, which you plan to take with you into the cleanroom (*please see section 5.2.3 Materials Prohibited Inside the Cleanroom*) and put them into a load-lock window.
3. **Take coveralls from the “Shared” hanger or** from your labelled hanger on the **“Personal” hanger**. Alternatively, pick up coveralls from the shelf if this is the first visit after laundry cycle.
4. Put on coveralls:
 - Wrap the sleeves so that the coveralls do not touch the floor.
 - Put one leg in the leg of the coveralls and pull up to your ankle.
 - Put your other leg in the leg of the coveralls and pull up to your ankle.
 - Stand and pull the upper half of the coveralls up to your arms. Put your arms through the sleeves.
 - Pull the coveralls up over your shoulders. Pull the zipper up halfway.
 - Put the coveralls hood on your head. Pull up the zipper of your coveralls all the way.

Note: *DO NOT let your coveralls touch the floor because contamination from the floor will then be brought into the cleanroom on your coveralls. Always inspect your coverall for signs of contamination or wear.*

5. **Take face mask** from a marked bin next to the coveralls hangers. Attach the mask to the hood using snap fasteners, barcode orientation out and right. Fix all snap fasteners on the hood.
6. Put on cleanroom overboots:
 - Get your boots and put them on the bench.
 - Find a comfortable sitting position, but **DO NOT cross the bench!**
 - Raise one foot and pull on an overboot. Swing your booted foot onto the other side of the bench.
 - Pull the overboot over the coverall's leg until your foot is snugly in the bottom of the boot (This will help to trap any particles falling down the coverall leg inside the boot).
 - Attach the top of the overboot to the coverall's leg with snap fasteners. Clip the buckle and tighten the strap.
 - Repeat with the second foot.

Note: *DO NOT place your boots on the floor because contamination from the floor will get on the sides of the boots and be carried into the cleanroom. NEVER stand in boots on the gowning rack side of the benches! The overboots fit either foot; however, they are sized. Select the proper size according the size of your coveralls.*

7. **Check proper gowning fit in mirror.** Is your mask properly fixed? Are all snap fasteners on the hood fixed?
8. **Enter the air shower.** Rotate slowly with your hands up.
9. Enter the cleanroom.
10. Put on second pair of gloves:
 - Pull on a glove holding it only by the cuff.
 - Pull the glove cuff up over the coverall cuff as far as it will go.
 - Repeat with the other hand. If necessary, pull up the glove fingers for a snug, comfortable fit.

Note: *The palms and fingers of the second pair of gloves should not touch the first pair of gloves. While in the cleanroom, keep your hands away from your face. Oils from your face can be transferred to the gloves and subsequently to the cleanroom equipment or your samples.*

11. **Use safety goggles** for Chemical and Lithography lab.

			
Cleanroom shoes (Locker room)	First pair of gloves (FILTER I.)	Area for wiping down materials (FILTER I.)	Cleanroom coverall (FILTER II.)
			
Coverall zipped up with hood on (FILTER II.)	Face mask – barcode orientation (FILTER II.)	Face mask – fastened all snap fasteners (FILTER II.)	Putting on overboots (FILTER II.)
			
Overboots – tightened straps (FILTER II.)	Final check in mirror (FILTER II.)	Removing particles in air shower (Air shower)	Second pair of gloves and goggles (Cleanroom 100)

Figure 17: Gowning procedure for the Nanofabrication laboratory

6.4.2 Exiting Cleanroom – Class 100

1. **Put all materials**, which you plan to take with you from the cleanroom **into the load-lock window**.
2. All necessary material should be kept in the cleanroom:



Figure 18: Storage space available in the cleanroom for users' tools and personal supplies

3. Remove outer pair of gloves and dispose of them into the proper trash container.
4. Remove safety goggles and place them into the prepared container.



Figure 19: Disposal area in the cleanroom

5. Enter the gowning area via the exit from inside the cleanroom.
6. Remove overboots. **DO NOT** place them on the floor. Roll the tops of the boots around the soles. Store them together in the proper place according to their size.



Figure 20: Storage space for overboots

7. Open the snap fasteners on the hood. Remove the face mask and put it into the bin marked for washing.



Figure 21: Bins for clean and used facemasks

8. Remove coveralls. DO NOT let your coveralls touch the floor.
 - Soiled garment? If you have worn your garment for more than approximately 24 hours or it has become soiled, the garment should be laundered. Place garments into the appropriate containers
9. Hang up coveralls. Avoid touching the coveralls with your clothes or bare skin. Hold the coveralls by the shoulders and lift them so they do not touch the floor. Hang them on your assigned hanger. Close the zipper.
10. Remove the outer gloves. Discard them in the trash container.
11. Gather all materials from the load-lock window.
12. Proceed to the changing rooms (C1.06 – men, C1.14 – women); take off the shoes or remove shoe covers. Pick up your clothes and other stuff and exit the gowning room.

6.5 Building A – Structural Analysis Laboratory (Class 100,000)

1. Use your access card to proceed via **Corridor A1.01a** to the gowning area in **ENTRANCE FILTER** (room **A1.05**), see **orange** arrows in Fig. 19.



Figure 22: Building A – Entrance path to the cleanroom

2. **Step on the tacky mat.** Take at least 6 steps, 3 for each foot.
3. **Remove all unnecessary clothes.** Use lockers to store items which cannot be brought into the cleanroom. If in doubt, see section 5.2.3 *Materials Prohibited Inside the Cleanroom*.



Figure 23: Entrance Filter – Lockers

4. **Put on a cap** from the dispenser on the wall
5. **Put on cleanroom shoes or shoe covers** and cross the bench.
 - Get a pair of shoes from the rack, or a pair of shoe covers from the labelled dispenser.
 - Only flat or very low-heeled shoes are allowed to be worn in CEITEC Nano cleanrooms.
No sandals or open-toed shoes are permitted!
6. **Wipe down all materials** which you plan to take with you into the cleanroom
7. **Take a coat from the “Shared” hanger**



Figure 24: Gowning procedure for the Structural analysis laboratory

7 General Behaviour Inside the Cleanroom

We strive to keep running our facility as efficiently as possible. Please help us by being committed to the preservation of resources, and to keeping to a minimum the necessity for facility staff to spend time on cleaning up after users, and for repairing things, etc. Never, however, hesitate to request staff time to help you with things that you are unsure about.

The following bullets are meant as a brief reminder of appropriate general behaviour while inside the cleanroom. The list is by no means comprehensive, but contains items we believe are of particular importance.

7.1 General safety rules

No one is permitted to work alone inside the Chemical Lab and Photolithography Lab in the Nanofabrication laboratories (Class 100) in Building C. At any given time, at least two users (not visitors) must be present.

In the cleanrooms of building C, the lights must remain switched on all the time to ensure safety checks of indoor space in all laboratories. No window blocking is allowed, except for justified reasons (e.g. optical lab): the entire facility has to be viewed through the windows in the corridor for safety reasons. For the labs in building A, it is not necessary to have the lights switched on all the time.

- Eating, drinking and gum chewing are prohibited while inside the lab.
- Any abnormalities while using the equipment must be promptly reported to CEITEC Nano staff via Logbooks in booking system (specific instruments) or via CEITEC Nano feedback system (general issues).
- Avoid sudden and fast movements (i.e., NO RUNNING). Approach corners and turns slowly, to avoid collisions with others. Remember that other users may be handling sensitive materials.
- Never open your suit while inside the cleanroom.
- Never touch your skin with your gloves. If you do, immediately put on a new pair of gloves.
- Do not walk around unnecessarily and be cautious when approaching another work area. Personnel movement is to be restricted to minimize disturbing settled particulate matter.
- If you turn it ON, remember to turn it OFF.
- If you make a mess, clean it up. Return everything to its original condition, or ideally, leave conditions a little better than you found them. This includes your entire set-up for experiments or projects.
- Excess storage in the cleanroom is not permitted.
- Be aware of supplies. If quantities of stock appear to be low, report it to the CEITEC Nano staff.
- Use special care to keep wet-benches in ultra-clean conditions.
- Hot plates (one of the main causes of cleanroom fires):
 - Never leave on when unattended
 - Make sure that the temperature is: 20 °C BELOW flash point of contents and 20 °C BELOW melting point of beaker materials.
 - Ask for help if you are unsure of any part of the process.
- Any work or tools dropped on the floor shall be considered contaminated, and must be cleaned.

- ANYTHING left unattended MUST be labelled with your NAME, PHONE NUMBER WHERE YOU REALLY CAN BE REACHED (not the number of your department's front office), WHAT IT IS THAT IS SITTING THERE, and the DATES AND TIME of when you left it AND when you will return to get it. We will THROW OUT anything not appropriately labelled... no questions asked.
- Disposal of solvent and/or photoresist-soaked materials: We have several containers in the cleanroom built specifically for the disposal of solvent-soaked materials, and require that they be used for the disposal of all such materials. The cleanroom is constantly recirculated, so all released vapours will find their way back into the space eventually for everyone to breathe. The following materials should be put in the solvent cans:
 - Any alcohols (ethanol, methanol, isopropanol, etc.)
 - Acetone
 - TCE (Trichloroethylene)
 - Chlorobenzene (especially hazardous)
 - Photoresist and related products
- Disposal of acid-soaked materials: We have several containers in the cleanroom built specifically for the disposal of acid soaked materials, and require that they be used for the disposal of all such materials. The following materials should be put in the acid cans:
 - Acetic acid
 - Buffered Oxide Etch (HF)
 - Chrome Etch
 - E-6 Metal Etch
 - Hydrochloric acid
 - Hydrofluoric acid
 - Nitric acid
 - Phosphoric acid
 - Hydrobromic acid
 - Sulfuric acid

7.2 Camera system



8 Dealing with Chemicals in the Cleanrooms

8.1 Bringing Non-Stock Chemicals into CEITEC Nano

CEITEC Nano supplies a wide variety of chemicals to the users. If you would like to bring any chemical into the CEITEC Nano labs, YOU MUST RECEIVE APPROVAL FROM CEITEC NANO STAFF BEFORE BRINGING ANY NON-STOCK CHEMICAL INTO THE FACILITY. We will need to examine the MSDS in order to provide proper storage and disposal for all non-stock chemicals. Users that bring in chemicals without notifying CEITEC Nano staff create a safety hazard for all users. Please note that certain chemicals may not be permitted to enter the facility. Requests will be handled on a case by case basis. Please contact CEITEC Nano staff via email at nano@ceitec.vutbr.cz to inquire about bringing non-stock chemicals.

8.2 Handling Hazardous Chemicals

Users must employ the utmost caution when handling any and all hazardous chemicals. It is the user's responsibility to review the MSDS and become familiar with the hazards associated for all chemicals involved in his or her processing. Near fume hoods the necessary protective gear is readily available and it is the user's responsibility to utilize it. The following protective items are available:









- Aprons
- Face shields
- Heavy acid-resistant gloves
- Goggles

When using the heavy acid-resistant gloves, always make sure your regular nitrile gloves are clean before putting the heavy ones on. If you spill a small amount of any chemical on the surface of your heavy gloves, immediately rinse it with water. Always rinse the heavy gloves when you have finished using them. If you spill a small amount of any chemical on the surface of your normal nitrile gloves, immediately rinse and replace the gloves with a new pair, discarding the dirty pair. This is to avoid spreading chemicals and chemical residue to things like door handles, buttons, etc. Remember, part of the gowning procedure is to put on two pairs of gloves. This allows you to change the external glove within the cleanroom. Never take off both pairs of gloves inside the cleanroom.

ALWAYS label your beakers so that you and other users know which beaker contains what chemical. Beaker labels are available next to all fume hoods. Proper labelling is essential since most chemicals are colourless and it is easy to confuse them. If your process requires a long period of time you may properly cover your beaker with a watch glass and leave a note with the following information (legible!):

1. Your name
2. Chemical identification
3. When you will be back to finish your process and clean up.

If you empty a bottle of any chemical you should not rinse the empty bottle. Put the cap on the bottle and place the bottle onto the shelf in the bottom part of the wet-bench. CEITEC Nano staff will pick it up and dispose of it properly. You may get a new bottle of chemical from the safety storage cabinets located in the lab(s).

Acute toxicity	Carcinogen	Health hazard
 <input type="checkbox"/>	 <input type="checkbox"/>	 <input type="checkbox"/>
Aquatic toxicity	Explosive	Corrosive
 <input type="checkbox"/>	 <input type="checkbox"/>	 <input type="checkbox"/>
Flammable	Oxidizing	
 <input type="checkbox"/>	 <input type="checkbox"/>	
Solution: _____		
Name: _____		
Phone: _____		
Started (date): _____		
Will be removed (date): _____		

8.3 Using Hydrofluoric Acid and Piranha

Extra caution must be employed when using HF (hydrofluoric acid), or any mixtures containing HF (e.g. BOE). Users MUST wear an apron, heavy nitrile gloves and face shield when using any chemical containing HF. In addition, there are polypropylene bins labelled “Secondary Containment for HF Use” located on the shelves of the fume hoods with approved HF use. These should be placed on the fume hood surface and all beakers or bottles containing HF must be placed within the secondary containment. HF waste is disposed of in a dedicated HF drain, and a sink is contained in every fume hood, where HF can be used.

Hydrogen fluoride gas is an acute poison that may immediately and permanently damage lungs and the corneas of the eyes. Hydrofluoric acid is a contact-poison with the potential for deep, initially painless burns and ensuing tissue death. By interfering with body calcium metabolism, the concentrated acid may also cause systemic toxicity and eventual cardiac arrest and fatality, after contact with as little as 160 cm² of skin. HF is particularly dangerous because, unlike other acids which cause immediate pain upon contact with skin, HF contact can cause latent burns that may take hours before they start to cause pain. If no action is taken to remedy the effects of the HF exposure, the fluorine ions will migrate through the flesh eventually reaching the bones causing serious bodily harm. Calcium Gluconate Gel is located in the first aid kit in the lab. Please follow all the required precautions and use utmost care when handling HF!!!

When using Piranha Etch (concentrated sulfuric acid and hydrogen peroxide), you must wear an apron, heavy nitrile gloves and face shield. The Piranha solution will remain active and produces gaseous by-products and heat (temperature of the fresh mixture could reach 120 °C) for several hours after the mixture is made. The solution can be disposed of only after it has cooled down to a maximum of 40 °C. Never drain fresh or active piranha solution into waste; it can lead to an explosion!!!

8.4 Hazardous Waste Disposal

It is imperative that users only put the correct chemicals in the waste sinks. Failure to do so will result in a possibly violent reaction between incompatible chemicals. Acids and bases are disposed of in the alkali sink of the fume hood. It is possible to run water dilution of the wasted chemicals when disposed. HF containing chemicals have a separate HF sink, also with the possibility of water dilution.

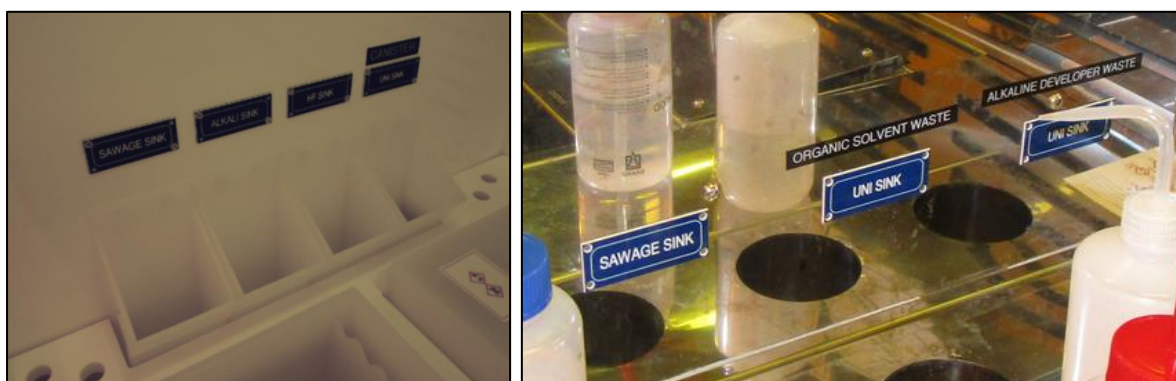


Figure 25: Waste sinks in Fume Hoods – Chemical lab, Building C

Sawage sink is available at all fume hoods. This one can be used only for very small amounts of non-toxic chemicals, which are diluted by the water. E.g., this sink can be used for rinse water, when cleaning the lab ware. Organic solvents can be disposed of only in stainless steel fume hoods. They have dedicated sinks connected to local waste canisters.



Figure 26: Waste canisters – Sample preparation room 2, Building A

8.5 Using the Fume Hoods

The fume hoods allow users to handle materials that generate hazardous vapours by containing and venting these vapours out of the breathing space of the lab. The fume hood is the only place that hazardous chemicals should be handled in open containers. Each hood is clearly labelled as to what chemicals may be used in each hood. The stainless-steel fume hoods are for the use of flammable chemicals since the steel will not burn. However; we cannot use acids and bases in the stainless-steel hoods because, over time, these chemicals will corrode the metal. For this reason, we must use the polypropylene fume hoods for acids and bases. Use of the wrong type of chemical in a given fume hood presents a serious safety hazard for all users in the area since incompatible chemicals may mix and create a dangerous reaction. Please use the proper chemicals in the proper fume hoods at all times. If you are unsure about which hood to use, please ask CEITEC Nano staff.



Figure 27: Fume Hoods in the Chemical lab

In order for the fume hoods to effectively exhaust harmful vapours the sash must be positioned at or below the marks on each side of the fume hood and the fume hood exhaust ports (perforated surface near the front and sides of the bench) must be unobstructed by cleanroom wipes, hotplates, waste bottles, etc. With these two conditions met, the fume hood will function properly. If they are not met the fume hood will release vapours into the breathing space which may cause injury.

Note: *Never allow your head to enter the plane of the hood opening – keep the sash below your face*

9 General Emergency Procedures

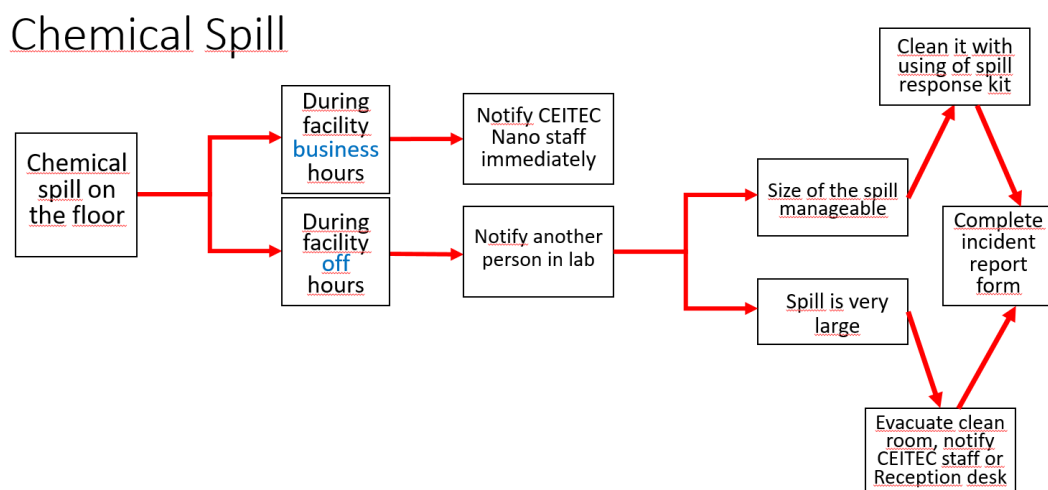
The CEITEC Nano core facility environment contains many potential hazards, posed primarily by the chemicals used.

Important: It is each user's responsibility to read through the MSDS sheets associated with the chemicals they plan to use and to familiarize themselves with their potential hazards prior to using them. MSDS of all chemicals provided by CEITEC Nano can be found on the CEITEC Nano webpage under the training section.

The buddy system is invoked for selected labs inside CEITEC Nano.

9.1 Chemical Spill

A number of chemicals are present in the CEITEC Nano core facility that pose a potential for serious injury, major equipment damage or even death. It is necessary to know how to react quickly and properly in response to any spill to avoid possibly serious consequences. The following procedures are only intended as general guidelines. Always use common sense when handling a particular situation:



1. If you are in the facility during **normal business hours**:
 - a. Notify CEITEC Nano staff immediately
 - b. Place a sign near the spill before leaving the area to contact CEITEC Nano staff so that other users are aware.
2. If you are in the facility during **off hours**:
 - a. Notify another person in the lab that there is a chemical spill and that you plan to clean it up. A spill response kit can be found in the lab. It is plainly marked and contains the following items:
 - Acid neutralizer
 - Base neutralizer
 - HF acid neutralizer
 - pH test paper
 - Two pairs of acid resistant gloves
 - Two pairs of vapour-resistant goggles
 - Scrapers
 - Large scoop / brush
 - Large sponges
 - Trash bags



Figure 28: Spill kit in Chemical lab (C 1.31) and in Sample Preparation room 2 (A 1.04)

- b. Retrieve the spill response kit:
 - If the chemical is an acid or a base, put on acid gloves and goggles before attempting to clean up the spill.
 - Isolate the area around the spill.
 - Select the proper equipment for the spill. Select the proper neutralizer for the chemical (note: solvents do not require a neutralizer).
- c. Clean the spill:
 - Apply the appropriate neutralizer on the chemical spill. Be sure to cover the entire spill.
 - Watch the colour of the spill as you add neutralizer (Note that the spill can get hot during neutralization): Use pH paper to verify that a pH of 7 has been achieved, indicating complete neutralization.
 - Once the spill has cooled, place the absorbent sponges on the spill until all of the liquid is absorbed.
 - In case of a solvent spill, do not attempt to neutralize. Soak up the chemical as quickly as possible to reduce damage to the floor. Do not use water on the floor until the chemical has been soaked up.
 - Do not remove your safety equipment until you are completely finished. There may still be some active chemical on the floor. When the spill has been completely absorbed, place the absorbent sponges in a double trash bag. Place the bag in one of the fume hoods and alert CEITEC Nano staff to its presence. If glass is involved, place the glass in a separate sharps container and label it as "SHARPS" along with the name of the chemical the glass contained.
 - Wipe down the entire spill with a mop and DI water. When finished, place the mop head in a fume hood sink and rinse it thoroughly with DI water.
- d. Inform CEITEC Nano staff and complete an incident report form.

If the chemical spill is very large and you feel you cannot handle it, alert others to its presence and evacuate the cleanroom. Notify CEITEC Nano staff if possible or the Reception desk: (+420) 541 149 669

9.2 Chemical Spill on Personnel

9.2.1 Skin Exposure

In case of significant, general external exposure, immediately use a safety shower located in the rooms C1.31 (chemical processes), C1.40 (service room), C1.48 and C1.49 (chemicals storage). Remove clothing while under the shower and flush for at least 15 minutes. Seek medical attention as soon as possible.

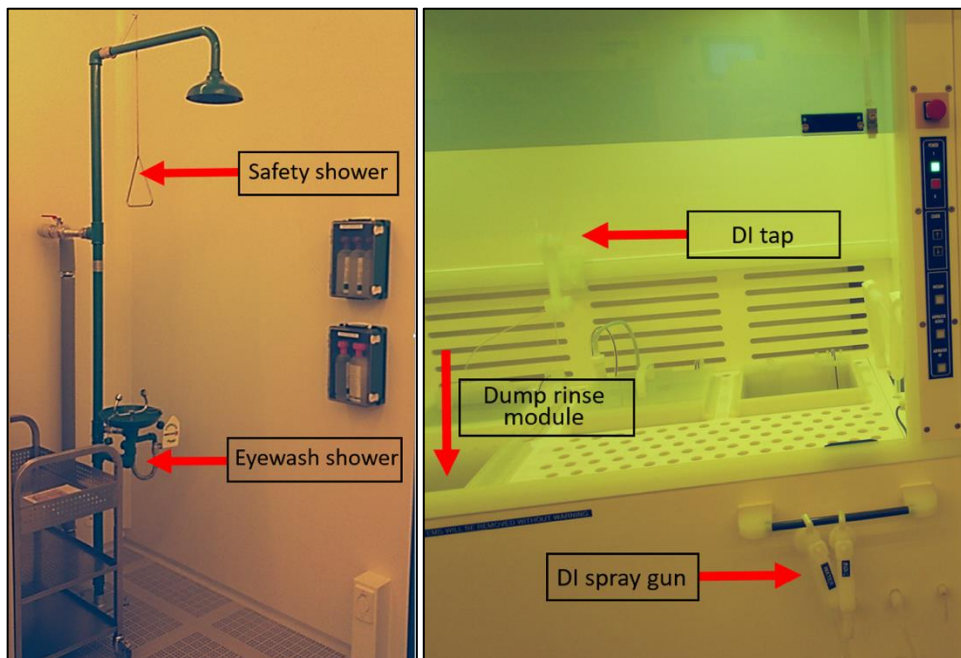


Figure 29: Safety showers in Chemical lab

In case of localized external exposure (small area of contact such as on an extremity (e.g. hand)) a DI spray gun, DI tap, or even a dump rinse module at a fume hood, may serve if these are the closest sources of water. Flush the affected areas with water for at least 15 minutes. Seek medical attention if necessary.

9.2.2 Exposure of eyes

In case of exposure of the eyes (corrosives are especially serious!), flush immediately, either with an eyewash bottle or with the built-in eyewash shower in the wet process lab. If using an eyewash bottle first, continue with flushing at the eyewash shower when the bottle is emptied. There are three HEXAFLUORINE eyewash bottles (à 500 ml) beside the fume hood for the HF injuries and one DIPHOTERINE eyewash bottle intended for neutralizing other acids and bases injuring the eyes.

Apply these flushing solutions at the first time, afterwards you may continue with the normal saline solution flushing which is placed in the same plastic box as HEXAFLUORINE and DIPHOTERINE. Eyes should be rolled up and down, and side to side, continuously, to allow clean water to flush behind the eyeball. The eyeballs sit rather loosely in their sockets, a splashed chemical can work its way around the eye to damage the optic nerve. Flush both eyes with water for at least 15 minutes. Both eyes should be held open with the thumb and forefinger. While the victim is at the eyewash, someone else should be calling the doctor (call 155) for further instructions. Upon any exposure to corrosives, the victim should be taken to the emergency centre for evaluation and treatment.

In addition to the eye wash equipment inside, eye wash stations are also located in the corridor surrounding the cleanroom. You may use these eye wash stations in case of any trouble with the eye wash equipment inside the cleanroom, or if you need additional flushing after the eye wash stations inside the cleanroom are emptied. Chemicals in the facility of the hazard class "corrosive" include primarily:

- a. The following acids and their mixtures -- sulfuric (H_2SO_4), nitric (HNO_3), acetic (CH_3COOH), hydrofluoric (HF), buffered oxide etchants (BOE -- pre-mixed ammonium fluoride and hydrofluoric acid).
- b. The following bases and their mixtures -- potassium hydroxide (KOH), tetramethyl ammonium hydroxide (TMAH).

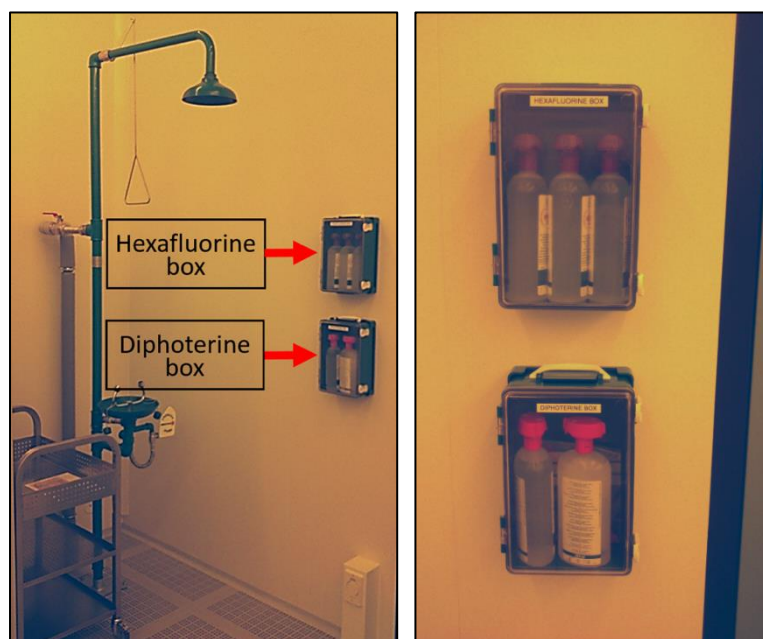


Figure 30: Solutions for emergency washing of eyes in Chemical lab

9.3 HF safety

Hydrofluoric acid (HF) is an aqueous solution of hydrogen fluoride gas. It is a colourless, volatile liquid, which is very poisonous (Acute toxicity 1). It can be handled only with and within plastic labware, as it dissolves metals and oxides contained in ordinary glass. Although it is only a weak acid considering its ability to release H^+ cation, it is very corrosive and therefore dangerous to human beings because of the presence of fluoride anion. Strong acid concentrations (over 50 %) cause immediate, severe, burning pain and a whitish discoloration of the skin which usually proceeds to blister formation. In contrast, the effects of more diluted solutions may be delayed. The latency period for symptoms (redness, swelling, and blistering) to appear after exposure to aqueous HF solutions in the 20 – 50 % range may be up to eight hours. Solutions less than 20 % may not produce symptoms for up to 24 hours.

The origin of the fluoride ions penetration is the acid attack. If the acid is not removed thoroughly, then it keeps destroying the corneal epithelium or the epidermis, and thus it facilitates deeper tissular destruction by the fluoride ions. Fluoride ion forms a strong bond to Ca^{2+} cation. It reaches to bones and leaches calcium (causing hypocalcemia) and may tie up calcium in nerve cells as well. This disruption of nerve condition can be life threatening when disrupting a heart function. Systemic hypocalcemia should be considered a risk whenever the body surface area of skin burns from concentrated HF (over 38 %) exceeds 25 in² (160 cm²), or about the size of the palm of your hand. Concentrated HF burns can be fatal if only 2 % of the body surface area is exposed. If contact with HF is suspected, treat the incident as an HF exposure.

CALCIUM GLUCONATE gel is used as an antidote for HF exposure to skin. Tubes of calcium gluconate are located in the first aid kit in the lab, along with instructions on its use. It is for external use only and must not be used for exposure to the eyes. Although calcium gluconate mainly acts on chelation of fluoride ions, it has only a limited effect on the acid (does not neutralize the H⁺ ions). Besides calcium gluconate, there is a universal product for rinsing the HF affected body area called HEXAFLUORINE. It has a multiple action mechanism: sweeping effect (like water), hypertonicity (unlike water – make HF to come out of the tissues and stops its penetration), chelation of F⁻ and absorption of H⁺. There are 3 bottles of HEXAFLUORINE (500 ml) placed in the plastic box next to the safety shower in the chemical lab C1.31. Additionally, 1 bottle with HEXAFLUORINE will be placed on the way from the laboratory to the locker rooms. Ocular extender is available on each bottle for eye washing.



Figure 31: First aid kit and Calcium gluconate gel in Chemical lab

9.3.1 HF skin exposure

Follow these specific procedures in case of HF skin exposure:

1. IMMEDIATELY rinse the affected body area with high flow cold running water (e.g., shower) for max. 1 minute. Be careful to wash away the acid from all parts of your body, especially finger/toe nails, where acid can get trapped. While rinsing, remove all contaminated clothing as well as anything that could trap HF.
2. After initial rinsing with water use HEXAFLUORINE (3 x 500 ml is available next to the safety shower) to wash off the remaining HF and to prevent penetrating it deeper into tissues. Speed and thoroughness in washing off the acid is essential. Rinse with HEXAFLUORINE and water for at least 5 minutes. If no HEXAFLUORINE is available, flush with high flow water for 15 minutes.
3. Call a colleague for help.
4. Obtain CALCIUM GLUCONATE gel (available inside the first aid kit in the lab).
5. Puncture the tube using the inverted tube cap. Apply gel over the entire affected area.
6. Using gloves, gently massage the gel into the skin. Elevate burned extremities, if possible.
7. Take the gel with you when transporting to emergency medical facility and continue to apply fresh gel repeatedly while waiting to be treated.
8. At the medical facility, tell them you have Hydrofluoric Acid on you.
9. Following treatment, the injury must be reported to CEITEC Nano staff. An incident record form will be filled at the User Office C1.04.

Note: *Calcium gluconate gel should not be used until complete (at least 5 minutes) washing of the skin with water and HEXAFLUORINE is done. After the pain has subsided, the calcium gluconate gel should be rubbed-in for 30 minutes at 3 or 4 hour intervals. If the skin burns*

are deep or extensive, calcium gluconate gel, 2.5%, should be massaged into the skin for 3 to 4 days, 4 to 6 times daily.

Never take pain medication for HF burns. Decreased pain is the best indication that treatment is effective.

9.3.2 HF eye exposure

Follow these specific procedures in case of HF eye exposure:

1. IMMEDIATELY wash the eyes with cool flowing water (eye wash station or sterile eye wash solution). Eyes should be rolled up and down, and side to side, continuously, to allow clean water to flush behind the eyeball. Both eyes should be held open with the thumb and forefinger.
2. Start flushing the eyes with HEXAFLUORINE within the first 5 minutes and then continue the flushing with HEXAFLUORINE preferably. If no HEXAFLUORINE is available, flush with water for 15 minutes.
3. While washing, someone else should call medical emergency (155) for assistance. Use eye wash bottle and/or ice packs until medical facility is reached.
4. Following treatment, the injury must be reported to CEITEC Nano staff.

Note: *No oils or ointments should be used. Inflammation may be decreased by the use of corticosteroid solutions for ophthalmic use. An eye specialist should be consulted immediately.*

9.3.3 Other exposure – inhalation, ingestion

Follow these specific procedures in case of HF inhalation:

1. Immediately move affected person to fresh air and call 155 for medical assistance.
2. Keep victim warm, comfortable and quiet.
3. If breathing has stopped, begin CPR at once. Make sure mouth and throat are free of foreign material.
4. 100% oxygen (10 to 12 L/min flow rate) should be administered as soon as possible by a trained individual.
5. A nebulized solution of 2.5% calcium gluconate may be administered with oxygen by inhalation.
6. Do not give stimulants unless instructed to do so by a physician.
7. The victim should be examined by a doctor and held for observation for at least 24 hours. The reason is that inhalation of HF fumes may cause swelling in the respiratory tract up to 24 hours after exposure. A person who has inhaled HF vapours may require prophylactic oxygen treatment. Vapour exposure can cause skin and mucous membrane burns and damage to pulmonary tissue. Vapour burns to the skin are treated the same as liquid HF burns.

Follow these specific procedures in case of HF ingestion:

1. Do not induce vomiting. Never give anything by mouth to an unconscious person.
2. Have the victim drink large amounts of room temperature water as quickly as possible to dilute the acid.
3. Call 155 for medical assistance.
4. Have the victim drink several glasses of milk or several ounces of milk of magnesia, Mylanta, Maalox or similar products, or eat up to 30 Tums, Caltrate or other antacid tablets. The calcium or magnesium in these substances may act as an antidote. Avoid administering bicarbonates at all costs: the carbon dioxide by-product could severely injure the victim.
5. Proceed to a physician for appropriate follow-up and/or treatment.

9.4 Liquid Nitrogen safety

Liquid Nitrogen (LN2) is extremely cold: $77.3\text{K} = -196\text{C} = -320\text{F}$ at atmospheric pressure. This can cause severe frost bite. On vaporization it expands by a factor of 700; one litter of liquid nitrogen becomes 700 litters of nitrogen gas. This can cause the explosion of a sealed container, or it can displace oxygen in the room and cause suffocation without warning.

9.4.1 Precautions when handling liquid nitrogen

1. Treat liquid nitrogen and any object cooled with liquid nitrogen with respect.
2. Take care not to allow liquid nitrogen to be trapped in clothing near the skin. Use of an apron is recommended.
3. When working with LN2 wear **closed toe shoes** and **long pants**, **safety glasses** or a face shield and **gloves**. Gloves should be loose fitting, so they could be thrown off if liquid were to pour inside them.



Figure 32: Dealing with liquid nitrogen – TEM laboratory (on the left picture the face shield is missing)

4. Use only approved unsealed containers. Never pour it into a coffee thermos. Never seal it in any container (it will explode).
5. Never dip a hollow tube into liquid nitrogen; it may spurt liquid.
6. Never use liquid nitrogen in a small poorly ventilated room, and never dispose of it by pouring it on the floor. It could displace enough oxygen to cause suffocation. Nitrogen gas is colourless and odourless – the cloud that forms when you pour liquid nitrogen is condensed water vapour from the air, not nitrogen gas.
7. Do not store liquid nitrogen for long periods in an uncovered container (on the other hand, never totally seal a container). Because the boiling point of oxygen, 90.1K , is above that of nitrogen, oxygen can condense from the air into the liquid nitrogen. If the air over the nitrogen circulates, this liquid oxygen can build up to levels which may cause violent reactions with organic materials; even materials which are ordinarily non-flammable. For example, a severe clothing fire could result from ignition in the presence of liquid oxygen.

9.4.2 First Aid

Suffocation

If a person seems to become dizzy or loses consciousness while working with liquid nitrogen, move to a well-ventilated area immediately. If breathing has stopped, apply artificial respiration. If breathing is difficult, give oxygen. Call a physician. Keep warm and rested.

Frost bite

If exposed to liquid or cold gas, restore tissue to normal body temperature, 98.6F (37C), followed by protection of the injured tissue from further damage and infection. Remove or loosen clothing that may constrict blood circulation to the frozen area. Call a physician. Rapid warming of the affected part is best achieved by using water at 42°C. Under no circumstances should the water be over 44°C, nor should the frozen part be rubbed either before or after rewarming. The patient should neither smoke, nor drink alcohol.

9.5 Emergency Power Shut-down

Emergency power shutdown switch for the whole lab is located at the ground floor of the C building, next to the entrance lobby.

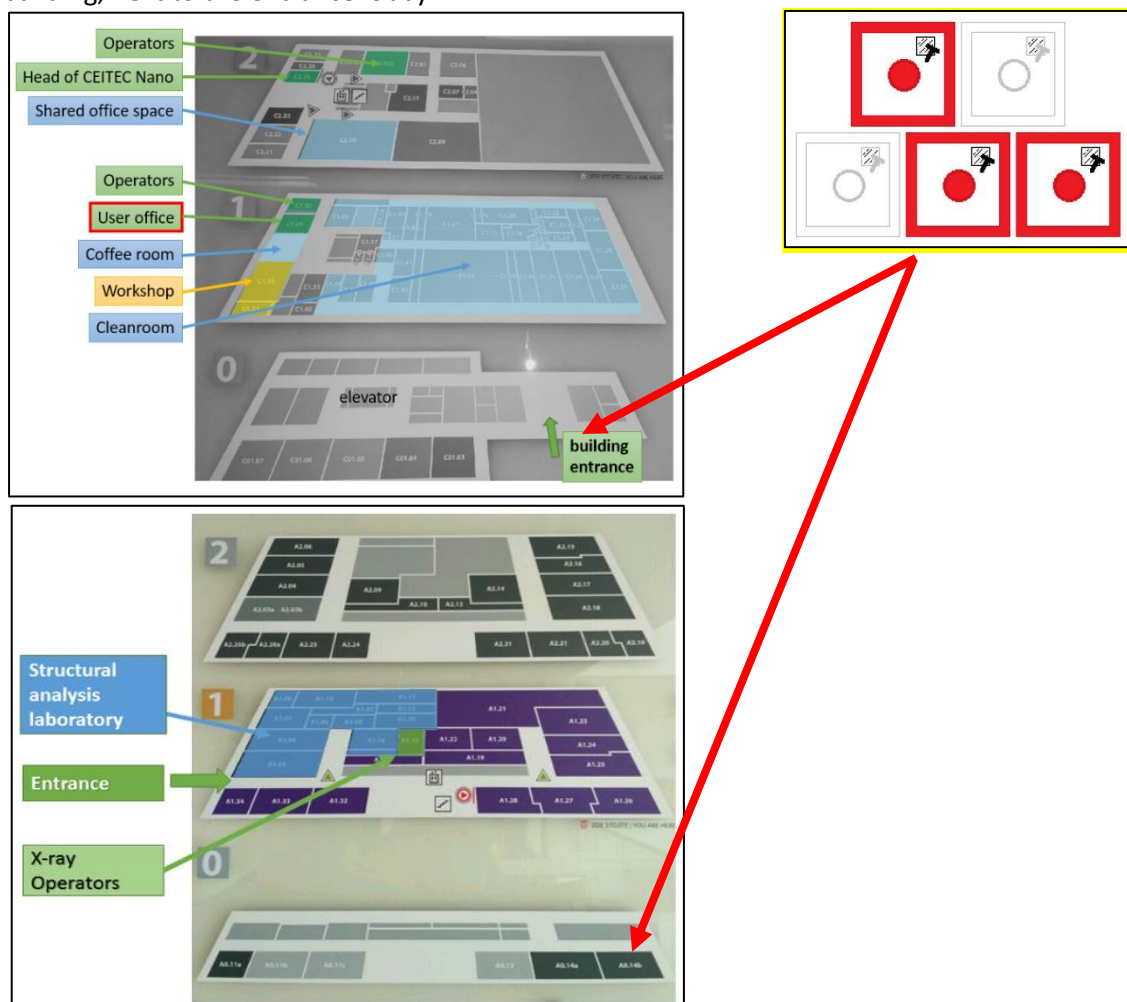


Figure 33: Emergency power shutdown switch – Building C and Building A

9.6 Toxic Gas Leak

Several toxic gasses are used in the CEITEC Nano facility. These gasses are kept in gas cabinets designed to contain leaks that might occur from the cylinders. However, it is possible that there may be a leak associated with equipment that employs these toxic gases or the gas lines running between the cabinets and the equipment. This would result in a release of toxic gas into the breathing space of the lab.

9.6.1 Toxic Gas Monitoring System – Building C

1. If you see that the red signs „NEVSTUPOVAT“ (Do not enter) or „OPUSŤTE PROSTOR“ (Leave the area) are ON, do not enter the lab or leave the lab if you are already working in it. In this case you can quickly finish your work and close the gas cylinders and other gas lines connected to your device before you leave.



Figure 34: Signal panels are activated when alarm level is reached.

2. If you hear the alarm siren besides the active red signs, leave the lab immediately through **EMERGENCY EXITS!** For the emergency evacuation follow procedures described in chapter 9.8.

9.6.2 Toxic Gas Monitoring System – Building A - StAn

Due to problems with current system of gas leakage detection (DEGA) we are now using mobile gas detectors (see figure) for that purpose. Types of alarms and their indications:

Type	Indication		What to do
Low Alarm	Siren:	1 beep per second	Inform the staff
	Flashlight:	1 flashing per second	
	Vibration:	1 vibration per second	
High Alarm	Siren:	2 beeps per second	Leave the lab immediately Inform the staff
	Flashlight:	2 flashings per second	
	Vibration:	2 vibrations per second	



9.7 Fire emergency

In case of fire, evacuate the cleanroom and building immediately through the nearest emergency exits without de-gowning. Do not try to extinguish any fire in a fume hood. The burning polypropylene material will not be extinguishable and the resulting smoke is highly toxic.

For the emergency evacuation follow procedures described in chapter 9.8.

9.8 Emergency Evacuation Procedures

Some emergency situations will require evacuation from the building. If evacuation is necessary, please proceed to the nearest emergency exit. Leave the building and gather at the parking lot in front of CEITEC administrative building S.

- If you are inside the cleanroom, proceed to the nearest emergency exit without cleanroom garment de-gowning

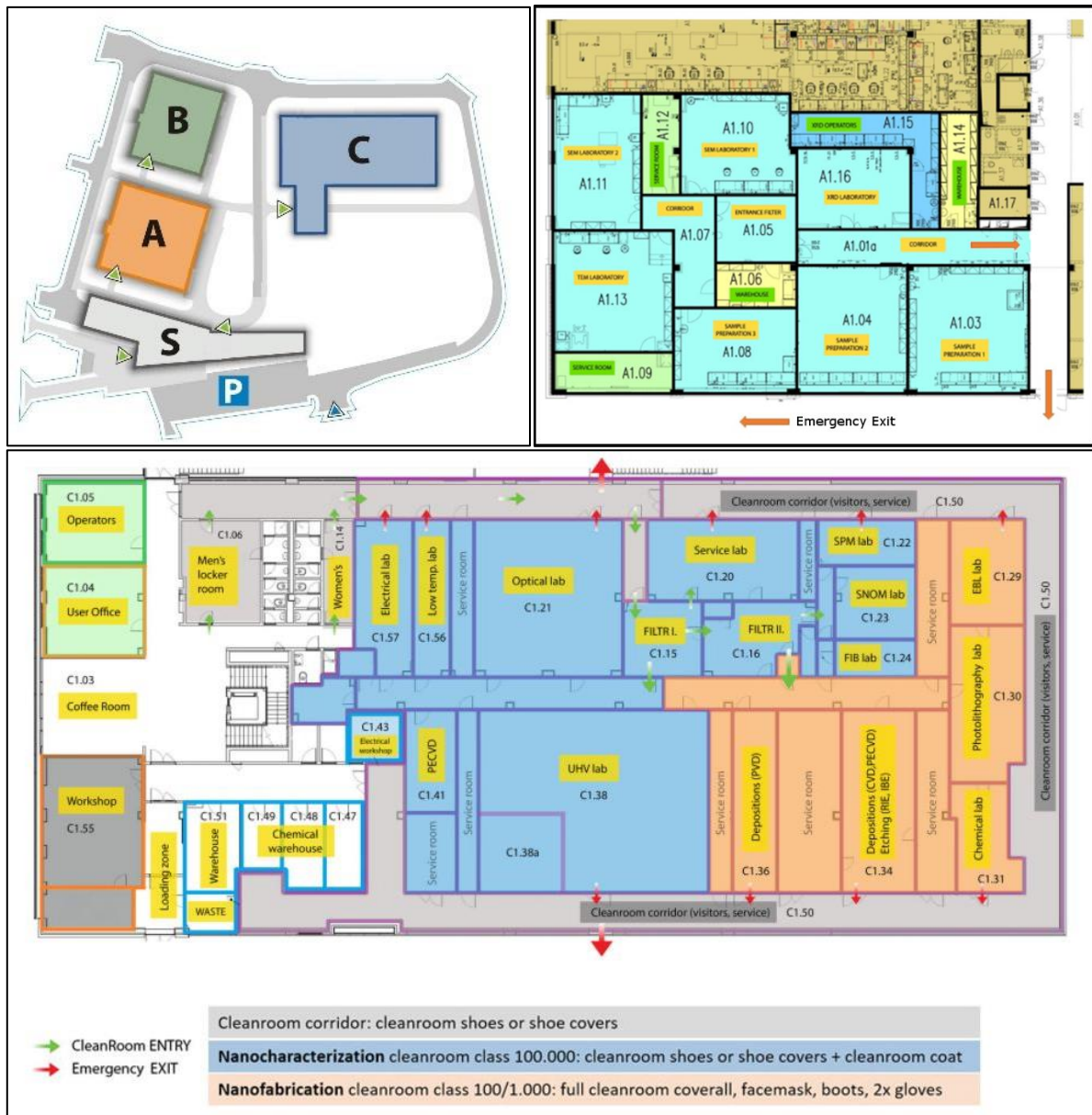


Figure 35: Evacuation area and emergency exits – Building A and Building C

10 Enforcement

We embrace the idea of a user facility and recognize that the success of the facility depends on making it a friendly and accessible environment for the users. Although we hope to never have to penalize users for not following the policies outlined above, the user must recognize that the successful operation of the facility depends on strict adherence to these policies. Adherence to these policies is essential for maintaining a clean and safe environment; it is in everyone's best interest to follow them. Unfortunately, we must prepare for breaches of cleanroom policy.

We reserve the right to invoke the following penalties:

1. **First offense:** Verbal warning
2. **Second offense:** Written warning
3. **Third offense:** Suspension from the cleanroom for 3 weeks

For listed transgressions:

- **Failure to create an entry in the logbook for a particular piece of equipment**
- **Failure to properly label chemicals**
- **Not following proper gowning/de-gowning procedure**
- **Not cleaning up after use of the facility**

In case of a serious breach of security rules (see below) we reserve the right to **suspend the user from the cleanroom for 3 weeks without prior warning!**

- Not wearing proper safety equipment (Safety glasses, face shield, gloves while working with acids/bases at wet-benches, cleanroom attire). **Regular prescription eyeglasses do not qualify as safety glasses!**
- Use of any cleanroom equipment without being an authorized user for the equipment.
- Granting access to an unauthorized user to use equipment. No user can grant access to an unauthorized user to use equipment without his/her constant supervision. Authorized users are allowed to train other users on the equipment.
- Using the facility without swiping your access card.
- Using the facility with someone else's access card without being an authorized user and/or not under supervision.
- Using equipment reserved for another user. A user may not use any equipment reserved by another user for the first 15 minutes of the first hour the equipment is reserved. After that time, the equipment may be used until the next reservation. If a user's run exceeds a scheduled time, the next user who has reserved the equipment should try to reach a compromise with the previous user. The machine does, however, belong to the user who reserved it, and he/she may ask the previous user to terminate their run.
- Using equipment when it is undergoing maintenance and is marked not to be used or "Machine Down". Under no circumstances is a user allowed to perform any maintenance on any equipment.
- Not leaving the cleanroom during an emergency. During an emergency, the emergency lights and/or siren will go off. The lights are located in visible places throughout the cleanroom. In such a situation, every user must immediately leave the cleanroom. Users should not take time to de-gown.
- Installing software on any computers or modifying equipment settings on equipment dedicated computers.
- Removing supplies and/or equipment from the facility.
- Using/bringing unauthorized chemicals inside the facility

11 Visitor Policy

Whenever possible, visitors should remain outside of the cleanrooms. An authorized user must escort the visitor **AT ALL TIMES**. The escort is responsible for ensuring that the visitor adheres to gowning requirements and follows the facility policies and procedures. The escort should ensure that all visitors are **registered at the reception (building S)** and fill in and sign the attendance sheet (available on the table next to the User Office) and hand it to the User Office.



Figure 36: Attendance sheet available next to the User Office

We report the visitor statistics to Ministry of Education, Youth and Sports of the Czech Republic. Proper filling in of the attendance sheets is essential for financing the facility.

12 APPENDIX

12.1 BUDDY SYSTEM

We would like to keep NON-STOP operation in our cleanroom laboratories. However, this is only possible if the basic safety rules are adhered to. We would like to remind you that in some parts of the cleanroom laboratories the BUDDY SYSTEM applies outside the main operating hours. Please adhere to the rules; it is all about your own safety! In the event of a violation of the safety rules and the BUDDY SYSTEM, we will immediately remove your access rights to the cleanroom laboratories.

Here is the summary of a basic safety rules and duties associated with the BUDDY SYSTEM:

1. **Entrance to the Cleanroom Laboratories - building C (100+100,000) and Building A (StAn):**
 - Your **BUT card will NOT work for entry into the lab during the BUDDY hours** - all users and expert staff must **pick up the entrance card** at the reception desk (building S) and sign up. The card will be returned at the reception desk and the departure time will be recorded at the same time when leaving.
 - Persons who are already inside the Cleanroom laboratories on a weekday and stay longer than 6:00 pm are required to leave the laboratory by 8:00 pm at the latest, to pick up the card at the reception and sign – then they can continue to work.

2. **Entrance to the office and PC room (building A+C):**
 - There is no time limit for entering the office. Please follow the rule to sign up in the reception desk if you are planning to work outside the main operating hours. It is important, that the security guys know about your presence in the building.

3. **BUDDY System in BUDDY Hours:**
 - You do not need a BUDDY to work in the StAn lab (building A) and 100,000 lab (building C) just register at the reception desk and pick up your entry card.
 - If you enter the Cleanroom Lab 100 (Building C) during BUDDY HOURS you must be in contact with your BUDDY, you must be able to tell who your BUDDY is and where your BUDDY is. Person located in Building C is also acceptable as a BUDDY, so he/she does not have to be directly in the lab with you - but it is necessary to arrange some check-in system (checking the camera, phone in the lab, etc.). **Write your BUDDY in the workbook at the reception desk** and pick up the card for her/him to enter the laboratories (if she/he does not already have one). Please register to our CEITEC Nano Users WhatsApp group ([HERE](#)) where you can try to find your Buddy if you need one. You can also use it to:
 - find experienced user to get training for specific instrument
 - share experiences and knowledge with others
 - offer your reservation someone else in case of cancelation
 - inform other users about the instrument malfunction
 - hare your ideas how to improve CEITEC Nano RI for all of usThe WhatsApp group is open only for CEITEC Nano Users and of course it is voluntary. The administrators of this WhatsApp group are the members of CEITEC Nano User Committee

In addition to what is mentioned above, we recommend having **your BUDDY in the laboratory** directly with you **when you are going to do potentially dangerous work** – working with chemicals, high voltages, etc.