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KONTROLNÍ SEZNAM PRO FYZIKÁLNÍ LABORATOŘ

CHECKLIST FOR SELECTED PHYSICAL LABORATORY DIRECTED TO SAFETY MANAGEMENT – LABORATORY OF LOW-TEMPERATURE PHOTO-LUMINESCENCE

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ABSTRAKT

Článek obsahuje kontrolní seznaym pro hodnocení rizik ve specifické fyzikální laboratoři.

Kľúčové slová: *chráněné zájmy (aktiva),fazikální laboratoře, bezpečí, bezpečnost, rizika, kontrolní seznamy, řízení bezpečnosti*

ABSTRACT

The paper contains the checklists for assessment of risks in specific physical laboratory.

Key words: *protected interests (assets), physical laboratories, security, safety, risks, checklists, safety management*

ÚVOD

Physical laboratories have been equipped with various substances and instruments, which require a certain level of teach-in of personnel that handles with them. Non-professional handling with equipment of laboratories may lead to damage of the instruments, which are often unique, and therefore, very expensive. In the worst case, non-professional manipulation can lead to health damage or to damage of further public interests (assets). The laboratories with: sources of radiological radiation, very hazardous chemical substances, high temperature, and high pressure instruments, belong to the most risk laboratories. In the present paper we deal with laboratory of low temperature luminescence in which the main sources or risks there are lasers and cryogenic substances. Although the risk is not as high as in laboratories with radiological radiation, there is necessary to respect exactly given procedures at attaching and turning on of instruments so that damage of health, property and other interests (assets) may not originate. In work they are described the safe procedures for individual operations (turning on |/ work / turning off) on the basis of which they are derived checklists by good practice principles derived. With regard to assessment according to the given checklists there is possible to manage laboratory safety taking note of public protected interests (assets) – lives and health of personnel and humans being in laboratory vicinity, property, laboratory equipment and experiment quality.

SOURCE OF RISKS IN PHYSICAL LABORATORIES

In physical laboratories we follow with regard to safety the both, the public protected interests (assets) – lives and health of personnel and humans in laboratory vicinity and the property and equipment of laboratory and experiment quality. Because large diversity of operations, it is not possible to create a single checklist for the scientific laboratories, nor in the case of the restriction to the laboratories of the chemical, biological, or physical. The first step at determining the safe practices in the considered laboratory is the total inventory of instruments, equipment and substances in the laboratory. It is necessary to know setup and identify risks in work state, and in sleep state. At determination of risks associated with various substances, equipment or whole apparatus we follow knowledge and experiences with a given type of instrument or substance. Extensive manuals from the manufacturer are also used at laboratory equipment operation and at risk determination.

Manuals contain the description of operation, the operation schemes and instructions of what to do during the non-standard situations, i.e. at abnormal and critical conditions.

Generally, the physical laboratories are fitted with variety types of dangerous chemicals, e.g. substances flammable, explosive, corrosive materials, poisons, carcinogens, mutagens etc. Other instruments used in physics laboratories, are sources of radiation (X-rays, the radiation chamber), the sources of high voltage, furnaces of high temperature, pumps for overpressure and under pressure and other specialized equipment.

The article pays attention to specific laboratory, which is equipped for experimental method called "low-temperature photoluminescence" (hereafter LT PL). The mentioned lab is equipped with several lasers of III and IV classes and with cryogenic liquids – liquid nitrogen (77 K = - 196 °C) and liquid helium (4 K = - 269°C). Both, lasers and cryogenic liquid, are primary sources of potential risks to the protected interests (assets). In laboratory there are further apparatus and substances which may cause damage of health or property at incorrect manipulation with them. The most prevalent sources of risks have their security tags that must be posted to the door of the laboratory, where the risks are relevant.

The safety of laboratory in the integral concept is understood as a set of measures and activities that must be respected at work in the laboratory. At present when the priority is given to integral safety the target is to manage risks by the way that magnifies the safety and the safety culture, i.e. behaviour of personnel [4].

LABORATORY OF LT PL DESCRIPTION

A schematic representation of followed physical laboratory of the Physics Institute of Charles University in Prague for the measurement of low-temperature photoluminescence is in Figure 1. The articles [1-3] characterize the experiments performed in the LT PL. The laboratory is equipped with many tables and cupboards for storing of small material and equipment. The room is lighted up by strip lamps and light bulbs. The entry into the laboratory is either from office space, or through lifting roller from neighbouring lab. The laboratory has its own air-condition system for ensuring the good ventilation (open windows would be a source of impurities). The operating control of air-condition and supply of compressed air is followed through the next-door laboratories. The manual crane (orange line in Figure 1) and the fork lift truck are in lab for handling with heavier equipment. The distribution systems for helium gas, air, dry air, water and electricity are in the wall at the top in Figure 1, which is in association with the access corridor. The cavity in the floor covered (pale blue line in Figure 1) is used in the case of supplies to the area, which adjoin the window (Figure 1, below).

The greatest source of risk in the lab is associated with the liquid helium, which is transported to the laboratory in a special container, Dewar’s vessel, only for the specific experiment. The liquid helium is used for cooling the samples in the cryostat to the very low temperatures. The helium in a liquid state is a cryogenic liquid with temperature - 269 °C that has the low thermal capacity, so that evaporation and increasing of pressure occur, even in the case of good isolation of the containers. The Dewar’s container must be, therefore, attached to the pipe with a gaseous helium that preventing the overpressure leading to the explosion accompanied by the dispersion of the cryogenic liquid. The helium is transported through special pipe with vacuum pump between Dewar’s vessel and cryostat. The liquid nitrogen is a second cryogenic substance that is in the laboratory. This is used for cooling the detectors. Temperature of liquid nitrogen is - 196 °C. The evaporation of liquid nitrogen is directly into the air, and therefore, the good ventilation of laboratory is necessary.

The laboratory is also equipped with several lasers, the most powerful laser has the maximum intensity 5 W, and therefore, it can cause the damage to the eyes, skin, or ignition. Its beam is internally conducted to the tuneable laser (as optical drawing) and it constitutes a risk only if the cover is removed. The tuneable laser can have the intensity in the order of hundreds mW (possible damage of the skin and eyes), but in the majority it is running in intensities of tens mW. The intensities of other lasers are also tens mW, which represent a risk of damage to the eye. The most of the range of wavelength of tuneable laser is in the field of infrared radiation (eye invisible), what increases the risk associated with it.

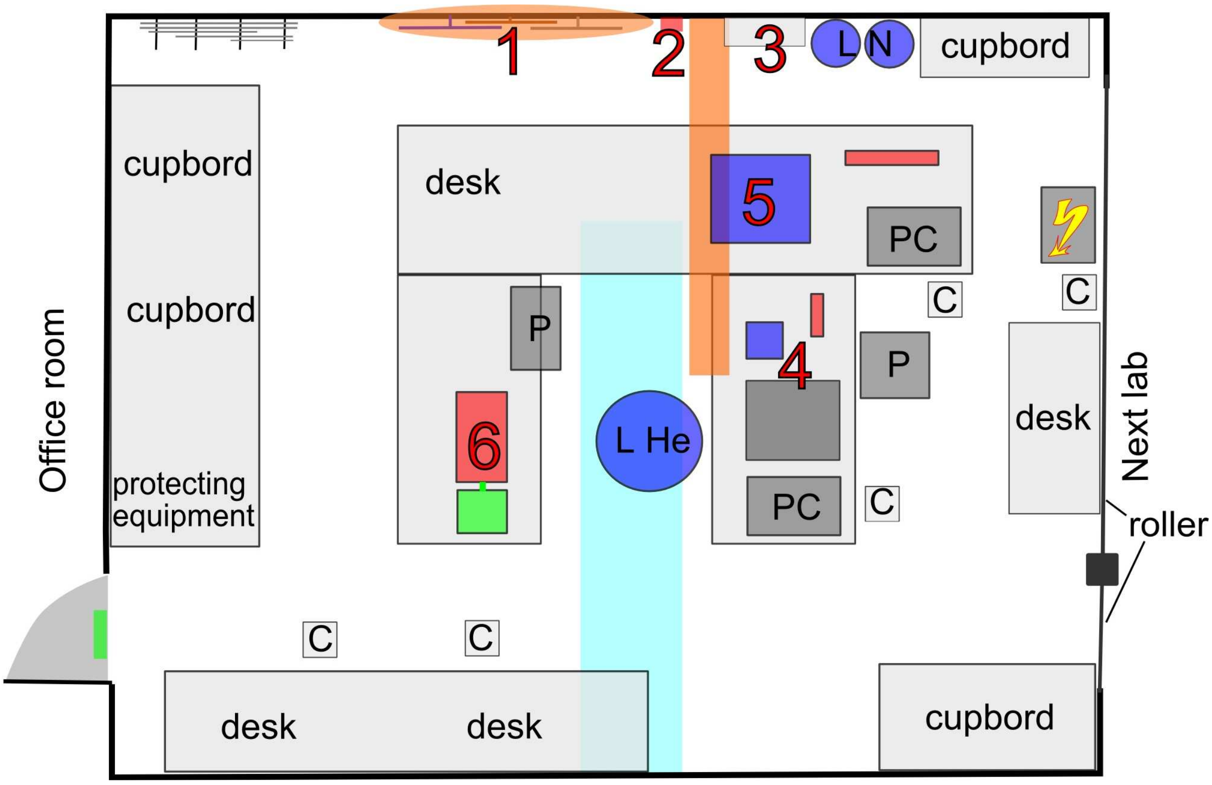

Fig. 1 - Laboratory of Low-Temperature Photoluminescence FUÚK, C- chair, P- vacuum pump,1 – input of helium gas, air and dry air, 2- switch resources to the laser, 3- helium gas flow meter, 4- basic equipment for LT PL (laser, cryostat, and detector), 5 – a large cryostat with a strong magnet (9,5 T), 6 - tuneable laser.

Vacuum pumps are further equipments of lab. They are capable to reach the high vacuum (rotary pump + molecular pump up to 10^{-4} Pa, 1 atmosphere = 10^{5} Pa). The cryogenic units are fitted with their own heating for regulation of the internal temperature, which at poor handling can lead to the destruction of the device. The cryostat 5 in Figure 1 is equipped with a superconductor magnet, which for its function needs a source of high and stable voltage. All metal objects (the risk of snapping acceleration and magnetic force) and electronics (damage to the magnetic part) must be cleared from range of strong magnetic field if the superconductor magnet 5 in Figure 1 is in operation.

The laboratory is equipped with protective devices and means to reduce the impact of the risks mentioned above. It goes on the transparent face shield, gloves for handling of frozen pipes (not intended for soaking in the cryogenic liquid), gloves must be accompanied by covered limbs (arms, legs). The oxygen-meter is also among the protective means, it measures an oxygen concentration in the atmosphere (concentration of O_2 for safe breathing is 18%). Special glasses are determined for the work with the laser, but the basic rule is, not to bend the head to a height of optical path.

CRITICAL PROCESSES FOR ENSURING THE SAFETY IN THE LT PL LABORATORY

For ensuring the safety of each system it is fundamental to identify processes at which can realise [5] the risks particularly those, at which there originate big damages, losses and harms on protected interests (assets), i.e. critical processes. With regard to present experiences with risk assessment for safety management needs we use variously detailed and professionally ambitiously checklists [4-6]. For better vision on linkages in apparatus there is in Figure 2 shown the scheme of the LT PL apparatuses. The work in the LT PL laboratory is divided into 5 processes:

1. Start of apparatus from state „cold“, the experiment turns from beginning.
2. Start of apparatus from state „warm“, the experiment was interrupted only for hours.
3. The life cycle of experiment.
4. The turning off the apparatus into state „warm“.
5. The turning off the apparatus into state „cold“.

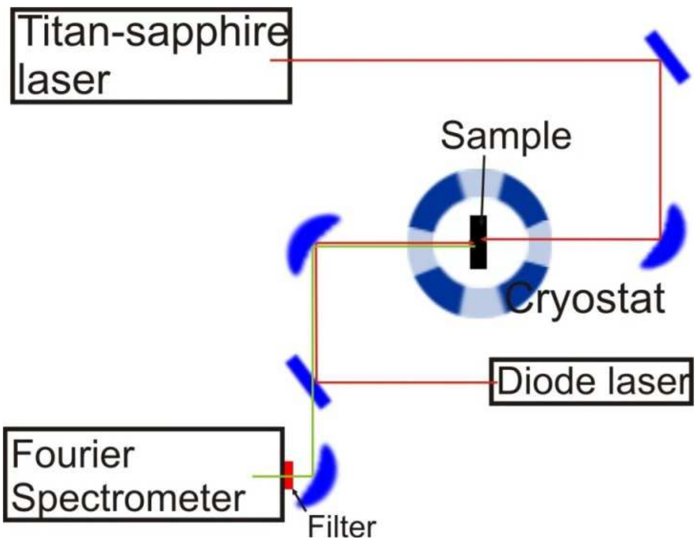

Fig. 2 - Scheme of the LT PL apparatus, sample is in cryostat; cooled to the temperature of liquid helium (4.2 K) is irritated by laser. The irritated sample then radiates the characteristic radiation corresponding to optical properties of sample that is detected by spectrometer.

Start of apparatus from state „cold“

Firstly there is necessary to put together the optic path, i.e. we locate individual components (lasers, cryostat, spectrometer) to their positions, if are not located there (mostly there are not moved from their places). The following steps are arranged step by step as they are followed but it is possible to carry out simultaneously operations for preparation of spectrometer and lasers, i.e.:

- turning on the PC and log in the operation system,
- turning on the spectrometer and turning on the control program for spectrometer,
- the check of spectrometer, the pilot light needs to blink green, if it emits light red, it is necessary to determine a cause and to remove difficulties,
- the preparation of spectrometer for construction of optic path: sitting the holder of special light to the focus of spectrometer; opening the input of luminescence; covering the detector before light and turning on the light; the spectrometer scheme is in Figure 3,
- the branch of optic path corresponding to the luminescence is constructed by help of movable shield so that the light picture may not be deformed, the mirrors in direction from spectrometer are set step by step, it is necessary to start with elliptical mirror for transferring the divergent light radiation to parallel bundles and it is again finished with elliptical mirror for transferring the parallel bundles to focused ones (focused to the sample),
- turning on the diode laser 4, Figure 1,
- by help of the prism that in one axis operates as mirror and in the other it is permeated, the bundle is driven to the centre of light picture from spectrometer,
- turning on the 2 laser source switch, Figure 1,
- start-up of the 6 laser cooling, Figure 1, to temperature 18 °C,
- at cooling temperature 18 °C, turning on the 6 laser, Figure 1, i.e. the heating the active medium; the 6 laser in Figure 1 has two parts – pumping laser and tuneable laser,
- after heating the active medium it is step by step enhanced the intensity of pumping laser to 3.5 W,
- turning on the control program for tuneable laser and turning on its diagnostics,
- setting the tuneable laser in wave length in domain of red light and strangulating the output gap so the intensity of output bundle might be about 1 mW,
- the laser is driven to the sample in order that it may dropped on the same point as light (maximization of collecting the characteristic radiation) but in other axis (minimization of becoming over range the detector by laser bundle), into the path there is located a space filter for elimination of laser modes of higher order (inconvenient wave length),
- turning off and removing the light in spectrometer, in front of spectrometer there is located instead of light the special filter (it only releases certain radiation in dependence of requirements of experiment).
- In the moment where the optic path is prepared, it is necessary to prepare the sample in the cryostat. To the laboratory it is transferred the Dewar’s vessel with liquid helium and it is connected with backward

pipe with gaseous helium where after the insertion we open the cap, Figure 1. The cryostat has 3 vessels, outer (thermal shield), middle (domain of flow rate of liquid helium), inner (sample space). Then:

- turning on the drawing off the vacuum by rotational pump in the outer vessel of cryostat (see 4 in Figure 1),
- in the moment when the vacuum in the cryostat outer vessel reaches 10^{-2} Pa, the turning on the molecular pump (target pressure is 10^{-4} Pa); the rotational pump has been forever in operation,
- fastening the sample to sample holder; location of holder into the sample space and in-depth closure,
- drawing the air from the sample space by help of rotational pump (it is in operation several minutes), then the sample space is several times (ca 2) filled up with gaseous helium from the pipe after opening the 1 cap in Figure 1, and again it is taken away by pump; in the end the pump is turned off and sample space and pumps are filled up with gaseous helium (ca 10^5 Pa, i.e. 1 atmosphere),
- insertion of siphon into the Dewar's vessel with helium and into the cryostat (connection of vessels). It is the most complex operation that must be done by several persons; the errors: not keeping the perpendicular angle at insertion of siphon = destruction of siphon; too fast insertion of siphon into the Dewar's vessel = too fast evaporation of helium, and therefore, it is necessary to look after the 3 flow meter in Figure 1; the air in siphon = freezing the air and non-passing the siphon (it is necessary to remove, to heat and to dry the siphon before next attempt),
- the cooling is in motion by help of rotational pump connected to the siphon with output to the helium pipe that is necessary to open – the 1cap in Figure 1. The flow rate is step by step from small values enhanced (sharp cooling might be lead to damage of cryostat).

Whereas the sample is cooled in cryostat to the temperature 4.2 K, the last preparations are finishing:

- linking and cooling the detectors – germanium (Ge) and antimonid indium (InSb) by liquid nitrogen,
- enhancing the intensity of pumping laser (only if it is necessary) to maximally 5 W,
- setting the necessary parameters of experiment in the control programs for spectrometer and tuneable laser in dependence on experiment,

After the sample cooling to a necessary temperature the experiment can be started.

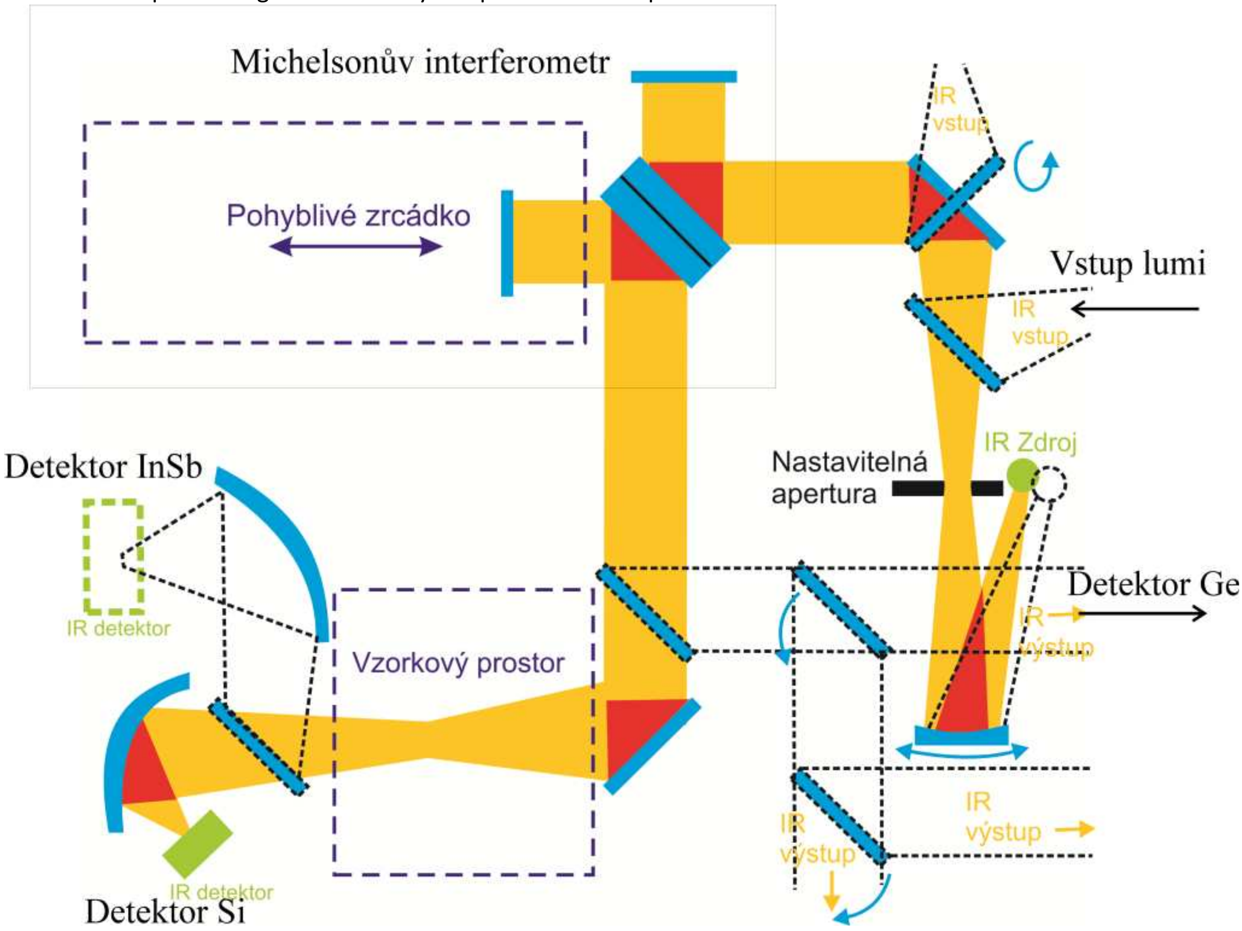

Fig. 3 - Scheme of Fourier spectrometer with trade mark Bruker.

Start of apparatus from state „warm“

In state “warm” we have to set the optic path and pumping laser is turned on at intensity 0 W. The cryostat outer vessel is pumped to vacuum with pressure 10^{-4} Pa and the Dewar’s vessel with liquid helium is connected with the cryostat. If it is necessary to exchange the sample we close the helium supply to sample space, we open the sample space and take out the holder of sample, we exchange the sample on holder and return the holder into the sample space, that we well closed.
The further progress is:

- drawing the air from the sample space by help of rotational pump (it is in operation several minutes), then the sample space is several times (ca 2) filled up with gaseous helium from pipe after opening the 1 cap in Figure 1, and again is taken away by pump, in the end the pump is turned off and sample space and pump are filled up with gaseous helium (ca 10^5 Pa, i.e. 1 *atmosphere*). In case that the sample was not changed it is enough one drawing and filling up the sample space,
- opening the cooling by rotational pump linked to siphon with output to helium pipe. The flow rate is step by step from small values enhanced (fast cooling might lead to damage of cryostat),
- gradual increase of performance of pumping laser to 3.5 up to 5 W,
- insertion and cooling the detectors – germanium (Ge) and indium antimonite (InSb) by liquid nitrogen,
- setting up the necessary experiment parameters in control programs for spectrometer and tuneable laser in dependence on experiment.

The life cycle of experiment

The experiment is going on at dark (turned off, battened windows), and therefore, it is necessary in advance the space to look in order that injury may be prevented. The experiment consists of series of individual measurements with duration ca several minutes that are mutually arranged. Between individual measurements it comes up to the change of several parameters of apparatus in dependence on followed quantities. The part of changes is realised by the PC but other part must be performed manually with help of hand-held lamp, and therefore, it is necessary the space well to know and to maintain it spick and span. During the experiment there is necessary to remember the principles for manipulation with lasers of class III and IV and with cryogen liquids. In case if it is necessary to carry out a deeper intervention into apparatus, it is better to secure the lasers and to turn on the quality lights (fluorescent lamps).

Turning off to state „warm“

The procedure is the following:

- turning off the rotation pump that pumping the liquid helium into the cryostat,
- reduction of intensity of pumping laser under 1 W and turning off its pumping,
- disconnecting the Ge and InSb detectors,
- turning off the 4 diode laser, see Figure 1,
- opening the intake of helium from pipe to the sample space,
- setting the quiescent regime in the control program for spectrometer.

The warming the sample space is best to leave to gradually warming through the night by influence of outer medium. The warming may be accelerated by heating in the cryostat that is for regulation of temperature, but the faster temperature changes the higher probability of damage. There is also good to cover mirrors from dust.

Turning off the experiment to the state „cold“

The procedure is the following:

- firstly we perform operations described in the foregoing paragraph,
- the 6 laser in Figure 1, firstly turning off the laser (power off / on), after several minutes turning off the cooling and at the end turning off the 2 switch in Figure 1,
- turning off the spectrometer,
- in program for spectrometer control the deposit of obtained spectra, closing all programs and turning off the PC.

The further operations it is either necessary or recommended to carry out the next day:

- taking out the siphon connecting the cryostat with the Dewar's vessel with liquid helium and carrying out the Dewar's vessel,
- turning off the vacuum pumping in outer cryostat vessel (firstly the molecular pump and up to the rotating one),
- closing the feed of gaseous helium into the sample space, taking away the holder with sample and cleaning the sample,
- closing the 1 feed in Figure 1, above all the helium feeds.

Dismantling the optic path (mirrors) and other parts of apparatus (lasers, cryostat, and spectrometer) is better to carry out only in case if we need individual parts or space on table for another experiment. Leaving the mentioned parts on their places ensures better comparability among the individual measurements. However, at leaving the optic path we must check it at further start of experiment in accordance with sooner described procedure.

CHECKLISTS FOR LT PL LABORATORY

At management of safety of the LT PL laboratory it is important at checklist application to compile the qualified order of questions connected with the critical items of processes and to determine the value scale [6].

The checklists we process with regard to demands of a good practice [5]. Mostly, the multiple degree scale is used at assessment by help of checklist. In practice at industry where the profit is one of the protected assets there are often some defects tolerated and they are removed step by step so production needs not be stopped, and therefore, the assessment of defect's relevance is required. For assessment of safety at scientific laboratory it is the most suitable to use a logic scale, YES / NOT or 1 / 0, because an arbitrary deviation from in advance stipulated procedures lead to derogation minimally one protected asset. The experiment which is performed at low defects in the apparatus loses the credibility and it becomes unavailable for research. Therefore, it is required its correct fulfilment and at safety assessment then fulfilment of demands of all questions of checklist.

The produced checklists are divided into sets with several questions, with following the several protected assets:

- human lives and health, public security (red / dark grey),
- property, laboratory facility (orange / medially grey),
- experiment quality and usability of results (yellow / white grey).

There is necessary to precede problems connected with the first two given assets, the problems connected with experiment quality may be often solved retrospectively, however with big time loss, when sometimes it is necessary to get the apparatus state to the stadium corresponding to the incomplete question. Hereafter, we give three checklists:

- experiment preparation and experiment start, table 1,
- experiment operation, table 2,
- experiment termination and apparatus turn off, table 3.

For apparatus start from regimes "cold" and "warm" we use the common checklist because also in case if part of experiment is prepared it is necessary to verify the apparatus state. The checklist for turn off is so composed of two parts, the first is turn off to state "warm" and the other to turn off from state "warm" to state "cold.

Table 1. Checklist for experiment preparation and start.

Questions	Answer: 0/1
Is the optic path correctly assembled?	
- Is the OPUS program for spectrometer control started?	
- If the OPUS program announces any problem, is it corrected?	
- Were the mirrors located according to the manual?	
- Are the used lasers focused to site of collection of luminescence?	
Was the tuneable laser started up by correct way?	
- Is the source for tuneable laser turned on?	
- Is the tuneable laser cooled down to 18 °C?	
- Is turned on the SCS program for control of tuneable laser?	
- Were the laser diagnostics performed by help the SCS program?	
- Is the pumping laser performance in range 3.5 W - 5 W?	
Is the diode laser turned on?	
- Is the diode laser cooling turned on?	
- Is the diode laser radiation turned on?	
Is the cryostat prepared for experiment?	
- Is the outer vessel drained to 10^{-4} Pa?	
- Is the sample located in the sample space?	
- Is the sample space filled up by pure gaseous helium?	
- Is put and secured the Dewar's vessel with liquid helium?	
- Is the siphon inserted between cryostat and Dewar's vessel free?	
Are all pumps turned on correctly?	
- Are all pumps ensured the correct drainage of pumped substance?	
- Are the valves opened on the access and the drainage to the pump?	
Has been under way correctly the cooling the sample space?	
- Is turned on the thermometer in the cryostat for the cooling monitoring?	
- Is on the beginning set the slower flow rate of liquid helium on flow meter?	
- Does the cooling substance funnelled through the siphon? (it is necessary to wait a moment after pump turn on)	
Are the detectors prepared?	
- Is in front of Si detector located the red filter f9?	
- Is cooled the Ge detector by liquid nitrogen and is turned into the source?	
- Is cooled the InSb detector by liquid nitrogen?	

From Table 1 it follows that at start process there is the most relevant for the experiment operator live, health and security the setting and ensuring the Dewar's vessel with liquid helium and for experiment progress the correct setting the lasers and the correct activity of pumps; the other activities performed incorrectly cause the direct damages on property and indirect on other protected interests.

Table 2. Checklist for experiment operation

Questions	**Answer: 0/1**
Are the optic parameters of experiment correctly set?	
- Are correctly set the parameters in the OPUS program?	
- Are the wave length and intensity of used laser set on the required value?	
- Are the filters located in the optic path according to the experiment demands?	
- Is the measured optic spectrum in the OPUS program in expected quality?	
Is the sample cooled on required temperature?	
- Is the flow rate of cooled helium optimal?	
- In case of use of heating is heat in cryostat optimal?	
- Is the under pressure in the sample space?	
Are ensured the conditions in vicinity of experiment?	
- Is space around the apparatus cleaned up for safe movement?	
- Is prohibited the impact of inconvenient radiation into spectrometer?	
Is the experiment governed by correct way?	
- Are the measurements arranged into series according to followed dependences?	
- Is led the protocol on experiment in the OPUS program and in the experiment book?	
Is the operating personnel acquainted with danger at experiment and does it order it?	
- Does it respect the instructions on correct manipulation with cryogenic substances?	
- Does it respect the instructions on correct behaviour in the room with active laser?	
- Does it informed on risks connected with under pressure in vessels?	

Table 3. Checklist for experiment termination and apparatus turn off

Questions	**Answer: 0/1**
Is the tuneable laser turned off into the state "warm"?	
- Is turned down the performance of pumping laser under 1 W?	
- Is the pumping laser turned down?	
- Is closed valve between tuneable and pumping lasers?	
Is the cryostat turned down into state "warm"?	
- Is the cooling turned down?	
- Is opened the valve of sample space to the pipe of gaseous helium?	
Is the spectrometer turned down into state "warm"?	
- Is the quiescence regime set in the OPUS program?	
- Are turned off the inputs into spectrometer?	
- Is disconnected the source of the Ge detector?	
Id the Dewar's vessel with liquid helium prepared for carrying away?	
- Is a sufficient temperature in the sample space?	
- Is the siphon removed and is it closed siphon mouth?	
- Are closed all valves between the Dewar's vessel and the pipe?	
Is the tuneable laser completely turned off?	
- Is turned down the energy source of tuneable laser?	
- Is turned down the tuneable laser cooling?	
- Is turned down the tuneable laser?	
Is the cryostat completely turned off?	
- Is the temperature in all cryostat vessels equal to the external temperature?	
- Is turned off the vacuum pumping in the external vessel?	
- Is the sample removed from the space sample and is squared away?	
- Is the pressure in all cryostat vessels equal to external pressure?	
- Are all outputs from cryostat sealed?	
Are turned off and closed also other peripheries of experiment?	
- Was the Dewar's vessel with liquid helium carried away?	
- Are all stoppers of gases turned off?	
- Are the PC programs turned off, is the PC turned off?	
- Is the diode laser completely turned off?	
- Is the spectrometer completely turned off?	
- Are the equipment and tools squared away?	

From Table 2 it follows that at experiment there are the most relevant factors for the experiment operator live, health and security the following items: the order among apparatuses; observing the instructions connected with: the cryogen liquids handling; the activities of active laser; and the pressure vessels. The experiment quality is above all given by respecting the good practice procedure. If correct principles are not respected at other activities the harms on laboratory equipment may be caused.

From Table 3 it follows that after the experiment termination at apparatus introduction to the quiescent regime there is the most relevant for the experiment operator live, health and security the activity connected with taking away the Dewar's vessel with liquid helium. For the protection of other protected assets there is important the correct turn off of lasers, spectrometer, cryostat and pumps. From the viewpoint of integral safety there is necessary to ensure the squaring away the equipment, tools and protected means that were used during the experiment in order that the laboratory activity could continue further without interruption.

CONCLUSION

The work in physical laboratory in which there are implemented the unique experiments for which there are not known the safety instructions, requires to respect the principles of good practice, i.e.: all instruments and tools have clearly determined places; the tables with apparatus are well accessible, i.e. there are free lanes. The laboratory personnel are well acquainted with dangers, the operation of individual instruments and with handling with used dangerous substances. It has knowledge on all electric energy sources and on supply of other substances (water, air, gaseous helium), and it is capable to determine when caps are opened and when are closed, and simultaneously it well knows when it is necessary to open it and when to close it. For acquisition of described pieces of knowledge it has been mostly instructed by more experienced worker who has knowledge on dangers and processes being under way at preparation, run and termination of experiment. Meanwhile, it may happen that there is not presented more experienced employee in time when experiment operator has not rooted all operations. Then, it is well to have in laboratory the written safety manual that remind him / her individual steps, their correct carrying out and succession. The form of assist safety manual can be different. With regard to present knowledge it is broadly accepted that the checklist is very suitable for discussed purpose. It is necessary to become aware that basic knowledge in the field of study is quite fundamental and to them the experiment operator and other supply personnel responsibilities also belong.

REFERENCES

[1] Procházka J.: Photoluminescence Spectroscopy of CdTe, WDS`08, part III, 2008, 55.

[2] Procházka, J., Hlídek, P., Franc, J., Grill, R., Belas, E., Bugár, M., Babentsov, V., James, R. B.: Selective pair luminescence in the 1.4-eV band of CdTe:In, Journal of Applied Physics, 110, 2011, 093103.

[3] Procházka J.: Charakterizace krystalů CdTe a CdZnTe optickými metodami, Disertační práce, FUUK.

[4] Procházková D.: Strategické řízení bezpečnosti území a organizace, ISBN: 978-80-01-04844-3. ČVUT, Praha 2011.

[5] Procházková D.: Analýza a řízení rizik, ISBN 978-80-01-04841-2 ČVUT, Praha 2011.

[6] Procházková D.: Metody, nástroje a techniky pro rizikové inženýrství, ISBN 978-80-01-04842-9 ČVUT, Praha 2011.

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