MINISTRY OF HEALTH OF UKRAINE
O.O. BOGOMOLETS NATIONAL MEDICAL UNIVERSITY

"Approved"
at the methodological conference of hygiene and ecology department
Head of the department
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GUIDELINES
FOR STUDENTS

Subject	Hygiene and ecology
Module № 1	Assessment of the environment and its impact on the population health
Submodule № 6	Radiation hygiene
Topic of the lesson	Rules of people's radiation-absorbed dose forming in their living places, its hygienic assessment and ways of decreasing. Radiation hazard and radiation protection on nuclear energy technology objects.
Course	6
Faculty	medical
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Kiev

1. Learning objective

1.1. Extend, methodize and strengthen knowledge on radiation hazard for personnel and patients of patient care institutions during usage of radioactive nuclides and other sources of ionizing radiations in diagnostic and treatment purposes, on principles and ways of radiation protection.

1.2. Master methods and ways of radiation control of labour conditions of personnel and protection of patients in X-ray and radiological departments of hospitals.

1.3. Consolidate, extend and methodize knowledge about radiation hazard of population, and the personnel at work with radioactive nuclides and other sources of ionizing radiation.

1.4. Master methods and means of measurement of radiation levels and concentration of radioactive nuclides in the air, water, food substances, of radioactive pollution of the work surfaces, individual doses of irradiation of those working with sources of ionizing radiation, to assess their results.

2. Basics

2.1. You should know:

2.1.1. Ways of use of radioactive nuclides and other sources of ionizing radiations in hospitals with diagnostic and treatment purpose.

2.1.2. Peculiarities of biological effects of ionizing radiation.

2.1.3. Essence of radiation hazard during working with radionuclides and other sources of ionizing radiation.

2.2. You should have the following skills:

2.2.1. To measure and assess parameters which characterize radiation environment in work and adjacent premises and individual doses of personnel during work with radionuclides and other sources of ionizing radiation.

2.2.2. To carry out sanitary inspection of radiological and X-ray departments of hospitals.

3. Self-training questions

3.1. Ionizing radiation as occupational hazard for personnel of hospitals.

3.2. Ionizing radiation as risk factor for patients of hospitals during radiology and nuclear diagnostic and treatment procedures.

3.3. Structure of radiological department of hospital. Peculiarities of radiological hazard and radiation protection in each organization department (bare, sealed sources, long-focus therapy).

3.4. Characteristics of radiological hazard in X-ray diagnostic room and conditions it depends on.

3.5. Regulations of radiological hazard and benefits for personnel and patients of patient care institutions (NRSU-97, MSRU-01, other legislative documents).

3.6. Ways of decreasing of radiation exposure of personnel and patients of patient care institutions. Sanitary and technical equipment of X-ray and radiological departments.

3.7. Methods of collection and neutralization of radioactive waste during work with bare sources of ionizing radiation.

3.8. Methods and ways of sanitary control and survey during work with sources of ionizing radiation in patient care institutions.

4. Self-training assignments

4.1. Explain peculiarities of location of radiological and X-ray department in complex of buildings of hospital and their substantiations.

4.2. Explain and draw schemes of allocation of organization departments of radiological department of hospital, X-ray room.

4.3. Explain peculiarities of requirements to wards of radiological department of hospital, their difference during usage of bare and sealed sources of ionizing radiation.

4.4. Compose a program of assessment of radiological safety of personnel in every subdivision of radiological department of hospital.

4.5. Give the assessment of conditions of work of personnel of department for treatment by sealed sources of ionizing radiation by results of measurement of individual doses of irradiation using thermoluminescence dosimeter during 3 months: radiologists – 0.1-0.2 Rem (1-2 mZv), procedural nurses – 0.3-0.4 Rem (3-4 mZv), nurse responsible for distribution and storage of sources of radiation - 0.25 Rem (2.5 mZv).

4.6. Give the assessment of labour conditions in filling room of department for treatment by bare sources if there is pollution of work surfaces by β-radiating radioactive nuclides within the limits of 200-300 part/(cm^2×min).

5. Structure and content of the lesson (duration of the lesson 160 min + 10 min break)

5.1. Preamble – 5-10 min.

5.2. Test control for assessment of students' knowledge datum level – 10-15 min

5.3. Theoretical training – 30-40 min.

5.4. Typical situational tasks "Krok-2" solution – 30-40 min.

5.5. State exams situational tasks solution – 30-40 min.

5.6. Test control for assessment of students' knowledge final level – 10-15 min.

Appendix 1

Hygienic requirements to planning, sanitary and technical, radiation protection equipment and operating regime of X-ray and radiological departments of patient care institutions

Radiation protection of personnel and radiation safety of patients during X-ray procedures.

Amongst sources of ionizing radiations, used in medical departments, the most common are X-ray diagnostic apparatuses. X-ray radiation, generated by those apparatuses, is characterized by significant penetrating power and, as a result, may pose hazard for personnel of X-ray subdivisions, patients, undergoing radiological procedures, persons that are in adjacent premises and on adjacent territory. That is why their allocation, planning and exploitation must satisfy the requirements of radiation safety.

Requirements to allocation, planning, arrangement, sanitary and technical equipment of radiological subdivisions of hospitals, radiation protection of their personnel and radiation safety of patients are stated in «Building rules and norms», «Sanitary rules and norms – X-ray departments (rooms)» (SRandN 42–129–11–4090–86), «Sanitary rules of work during medical X-ray procedures» (№ 2780–80).

Sanitary legislation does not permit allocation of radiological departments (rooms) in residential houses and child's institutions. No particular requirements to their allocation in patient care institutions are in place. But with the purpose of decrease of amount of adjacent premises for permanent sojourn of personnel and patients, advantage has been given to block-type arrangement in separate outhouse or on the ground or on the last floor of buildings.

Main premises of X-ray room are the treatment room – it is the premises, where X-ray apparatuses are located and all kinds of X-ray procedures are conducted. Existing legislation forbids their allocation under (over) wards for pregnant or children or in adjacent with them premises.

Radiation protection of adjacent territory (in case of location of X-ray room on the ground floor) and adjacent premises is provided by shielding by building structures (walls, overlapping, partitions), material and thickness of which must decrease radiation intensity to allowable level.

Weak spots in radiation protection by using building structures are doors and windows. Elimination of this defect is achieved by covering of doors by iron, leaden or lead-impregnated rubber plates; equipping windows with iron shutters (wooden with covering of iron or lead-impregnated rubber) or by raising of window-sill to 1.6 m height above floor-level.

Area of treatment room is regulated with purpose of protection of adjacent premises and it must be no less than 34 m^2 for every X-ray apparatus, which must be located such way, that the distance between focus of X-ray tube and walls would not be less than 2 m and its radiation would be directed mostly in direction of main wall. Area of treatment room is enlarged by 15 m^2 for every extra X-ray apparatus. X-ray tube is located in flask with collimator that forms work beam.

Protection of radiologist is provided by:

- lead-impregnated glass that covers fluorescent screen;
- multiple-stripe apron of lead impregnated rubber, that is hung onto screening device;
- small protective screen;
- use of individual safety means (gauntlet, apron from lead impregnated rubber (in textile cover for protection from diffusion of lead)) in special cases.

Protection of laboratory assistant of X-ray room is provided by allocation of his work place in separate adjacent premise that is called control room (panel room). This work place is provided with window of lead-impregnated glass to treatment room and with means of direct communication with doctor.

In addition to treatment room and panel room, planning of X-ray room or X-ray department must have:

- consulting room – 10 m^2;
- photographic laboratory – 6 m^2;
- booth for preparation of barium solutions – 4 m^2;
- cloakroom – 2.5m^2;
- toilet;
- waiting room (in polyclinic).

Sojourn of paramedical personnel in treatment room or panel room during radiological procedures is not allowed.

During radiological examinations persons that take part in them – personnel of other departments of hospital, alliance of patient, attendants that have to support child or infirm may stay in treatment room in conditions that dose received by them does not exceed level of irradiation of category B.

Radiation safety of patients is based on decrease of radiation exposure during X-ray examination of population especially pregnant, children and adolescent that can be achieved by complex of organizational, medical and technical measures. Organizational measures provide regulation of X-ray examination of population, restriction of annual dose of irradiation for different categories of patients, raising the level of personnel's skill and responsibility for performance of procedures.

They are given in order, sanitary regulations, and methodical instructions by Ministry of Public Health of Ukraine. All patients that are subject to X-ray examination according to their destination are divided into four categories.

Category A_d - patients with diagnosed or suspected oncological diseases, patients, examinations of which is conducted with purpose of differential diagnosis of congenital cardiovascular pathology, patients that get radiotherapy, patients that are examined on living indications in urgent practice. Recommended limit of annual irradiation for persons of this category is 100 mZv.

Category B_d – patients, examination of which is conducted on clinical indications at non-oncological diseases with purpose of specification of diagnose and (or) selection of treatment tactics. Recommended limit of annual irradiation for persons of that category is 20 mZv.

Category C_d – persons from risk groups including workers of enterprises with harmful conditions of work and those that pass through occupational selection for work at such enterprises, patients that are taken off the books after curative treatment of oncological diseases. Recommended limit of annual irradiation for persons of that category is 2 mZv.

Category D_d – persons that pass through all kinds of prophylactic examinations except those referred to category C_d. Recommended limit level of annual irradiation for persons of that category is 1 mZv.

Medical measures include: selection of method of examination, restriction of irradiation area to minimum values necessary for arrangement of diagnose of disease, protection of surrounding tissues by shields of lead-impregnated rubber, right selection of pose at roentgenography. Such shields (and apron of radiologist) are to be in textile covers for protection from diffusion of lead.

For decrease of gonadal dose during X-ray examination of organs of abdominal cavity, lumbosacral part of vertebral column and other organs shielding of gonads is foreseen.

Different ways of improving of X-ray image: production and use of fast X-ray films, right selection of operating mode of X-ray apparatus (conducting of examinations at minimum values of anode current and voltage on X-ray tube), use of electro-optical image amplifier that permit to get more sharp and brilliant image at dose-sparing regimen of work of apparatus, use of wide-screen Roentgen fluorography during prophylactic examinations are referred to technical measures that provide decrease of radiation exposure.

Maintenance of dark adaptation of sight of radiologist during X-ray examinations has high profile.

Channels of exhaust ventilation in treatment room must be located in upper part of premises – for removal of ionized by high voltage air and in lower part (under floor) – for removal of leaden dust.

Radiation protection of personnel and radiation safety of patients in radiological departments of hospitals

Different quantum and corpuscular irradiations are used for radiotherapy. Their sources are:

- β-, γ- radiating radioactive nuclides in a form of bare and sealed sources;
- X-ray apparatuses that are generators of quantum radiation of low and middle energies;
- betatrons and linear accelerators that generate inhibitory and corpuscular irradiations of high energies.

Existent ways of radiotherapy are divided into two basic parts: 1) ways of teleirradiation; 2) ways of contact irradiation.

In case of teleirradiation source is located at considerable distance from patient (long-distance irradiation) or at insignificant distance (short-distance irradiation). In both cases, beam of radiation is given necessary width and shape and directed onto region that is subject to irradiation.

Contact irradiation includes: application way, when sealed sources are located on body surface that is irradiated by special devices – masks, applicators; intracavitary – when source of radiation is introduced into one of body cavities and intraorganic – when source of radiation is introduced directly into tissue of tumour.

Variety of ways and methods of radiotherapy is determined by necessity of fulfillment of basic principle of radiotherapy – concentration of radiation energy in

abnormally changed tissues, combined with maximum decrease of dose in surrounding tissues and the whole body.

Radiation hazard for personnel of radiological departments, patients that receive radiotherapy, persons that can be in different premises and on territory that is adjacent to building depends on the way of radiotherapy and technical ways for its conduction.

Because of that, a number of requirements, stated in «Building rules and norms» and «Rules on work with radionuclides in establishments of Ministry of Public Health» are made for allocation of radiological departments of hospitals, organization of radiation protection of personnel and radiation safety of patients and population.

Radiological departments of hospitals are usually located in one-storey buildings with asymmetric-block planning that provides isolated location of every organization department:

- department of teletherapy;
- department for treatment by sealed sources;
- department for treatment by bare sources;
- department (laboratory) of radioactive nuclide diagnostic.

Department of teletherapy

Basic organization units of this department are treatment rooms with control rooms.

The following devices are used for teletherapy:

- roentgenotherapy units that generate radiation with energy 0.1 – 0.3 MeV;
- betatrons that generate electronic radiation with energy 15 – 30 MeV;
- γ-therapeutic unit with activity of radioactive nuclide (cobalt-60) from 1 200 to 6 000 Curie and energy of γ-radiation 1.17 and 1.33 MeV.

Teleirradiation can be static and mobile. In case of static irradiation, source of radiation during session of irradiation is in fixed position relative to patient, mobile irradiation is characterized by removal of source in relation to patient in the process of irradiation, that can be rotary, sectored and tangent.

Radiation hazard in department of teletherapy is characterized by possibility of only external irradiation of personnel and patients.

Radiation protection of adjacent premises and territory that is adjacent to block of teletherapy is provided by:

- building structures of lead with wall thickness more than 1 m;
- organization of treatment rooms without daylight;
- rational formation of beam of radiation, generated by source with help of different devices – apertures, filters, collimators to put it into certain measures and shapes for maximum decrease of penetrability in adjacent premises;
- equipping of unavailability zone on adjacent territory.

Radiation protection of personnel is provided by:

- sojourn of personnel in control room (protection by shielding);
- application of technical ways of observation and language contact with patients during procedures;
- equipping the labyrinth-like entrance into the treatment room;
- regulations of continuance of working day (protection by time).

Radiation safety of patients is provided by:

- rational selection of way of irradiation;
- rational formation of beam of radiation in order to decrease possibility of deleterious effects on healthy tissues.

Department for treatment by sealed sources

Contact methods of irradiation (application, intracavitary, interstitial) when sources of irradiation in form of radionuclide preparations are located in direct contact with surface of pathologic process or are introduced right into tumour, are used in this department.

Sealed sources are radioactive nuclides, physical state of which (metal), or envelope they are in prevent the possibility of pollution of environment with them (including tissues of patient). In most cases sealed sources have shape of cylinders with noses or needles with rounded and sharpened ends, short shanks, small balls that contain γ- radiating radioactive nuclides – cobalt-60, cesium-137, tantalum-182, iridium-192 or β-radiating radioactive nuclides – phosphorus-32, strontium-90, yttrium-90, promethium-147, thallium-204.

In case of application method of irradiation, special fixing device (colpostat, endostat) must be introduced into cavity and the source of irradiation only after that. Then the source of irradiation can be installed without participation of medical personnel by programmed automatic systems or by unmanned manipulators.

Basic structural units of department for treatment by sealed sources are block of radionuclide security that contains: depository of sources of irradiation, treatment room, manipulation room, and radiological wards, domestic and other premises.

Radiation hazard in this department is characterized by possibility of external irradiation only.

Radiation protection of adjacent premises and territory is provided by:

- usual building structure, thickness of which must correspond to requirements of existing legislation;
- regulation of summary activity of radionuclide sources in radiological wards;
- equipping of zone of unavailability on adjacent territory.

Radiation protection of personnel is provided by:

- use of all ways of radiation protection (protection by distance, by time, by amount, by shields (all manipulations with sources must be conducted only in protective housing and behind shields, entrance in manipulation room must have protective wall of concrete from inside));
- maintenance of regulations on radiation safety and sanitary regulations during work with sources of irradiation.

Radiation safety of patients is provided by:

- rational selection of way of irradiation;
- maintenance of existing rules of conduction of radiotherapy.

Department for treatment by bare sources

Bare sources are radioactive nuclides, during work with which the pollution of environment – air, hands, clothes, other surfaces is possible. Open sources are β-, γ-radiating substances in powder–like form and in form of true solutions, colloidal solutions, suspensions that are introduced in tumours through injection needles. Radioactive nuclides of iodine are introduced into organism by alimentary tract.

Department of treatment by bare sources contains:

- block of radionuclide security that contains: depository of sources of irradiation, filling room, treatment room, washing room, rooms of temporarily storing of radioactive waste, settling bowls of collecting system;
- radiological wards;
- sanitary and domestic premises.

Radiation hazard in department for treatment by bare sources is characterized by possibility of external and internal irradiation of personnel, possibility of ejection of radioactive nuclides behind the borders of department.

In this connection, special requirements are made to equipping of premises of block of radionuclide provision, radiological wards, water-supply, sewerage, sanitary and domestic premises, operating mode, rules of personal hygiene, working clothes, special air discharge purification systems, filtering of air.

Character of those requirements depends on class of work with radioactive nuclides.

According to MASRU-01 all works with bare sources are divided into 3 classes. Class of work depends on two conditions:

- groups of radiation hazard, to which radioactive nuclide belongs (MSRU-01 all radioactive nuclides depending on possible radiation hazard, made by them are divided into 4 groups: group A – radioactive nuclides with particularly high radiation hazard; group B – radioactive nuclides with high radiation hazard; group C – radioactive nuclides with moderate radiation hazard; group D – radioactive nuclides with small radiation hazard);
- activity of radioactive nuclide at the workplace.

Radiation protection of personnel is provided by:

- use of all ways of protection from external irradiation;
- maintenance of requirements of radiation asepsis, that prevent possibility of internal irradiation;
- maintenance of rules of personal hygiene. Radiation safety of patients is provided by maintenance of requirements of radiation asepsis inside the department.

Finally it has to be marked that all methods of protection from ionizing radiation (by amount, by distance, by time, by shield) can be divided into legislative (normative) and organizational and technical.

Protection by amount is legislatively regulated by NRSU-97(dose limit, allowable levels of entrance of radioactive nuclides into organism by inhalation, alimentary track, allowable concentrations of radioactive nuclides in the air, drinking water, allowable levels of pollution by radioactive nuclides of working surfaces, clothes, hands of personnel, regulated activities of radioactive nuclides at workplaces and other).

Protection by time is legislatively regulated by decrease of working time of personnel (category A), increase of continuance of leave and more earlier retiring on a pension.

Protection by distance and shielding is provided legislatively by construction regulations; rules that provide for proper standards of area, capacity of corresponding premises, their technical equipment and others.

Appendix 2

Scheme of sanitary inspection of radiological department of hospital

1. Name and address of hospital or polyclinic, allocation of rooms (building, floor, adjacent premises).
2. Presence and condition of paper maintenance (register of dosimetry, instructions etc.).
3. Planning of rooms (list of rooms, their area).
4. Type of X-ray apparatus, voltage and current strength in tube.
5. Destination of X-ray apparatus (diagnostic, therapeutical, photofluorographic, defectographic). Immovable, unidirectional, various directional working beam.
6. Presence and type of ventilation in treatment room, upper and lower exhaust ducts. Natural and artificial lighting.
7. Protection from X-ray radiation of work places of radiologist, X-ray technician and adjacent premises (protective screens, lead-impregnated glass, walls, windows, individual safety methods). Calculations of effectiveness of their protection.
8. Presence and type of Ionometers, personal dosimeters, their logbooks, dates of examinations.
9. Degree of preparation of personnel (special education, improvement).

Scheme of hygienic estimation of radiation protection in radiological department of hospital

1. **General characteristic of radiological department of hospital.**

1.1.Name of patient care institution, its departmental submission, address.

1.2.Characteristic and assessment of allocation of building of radiological department on the area, type of building, presence of zone of unavailability, presence of control area, its measures.

1.3.Structure of department, peculiarities of allocation and planning of its subdivisions, functional connection between them.

1.4.Assessment of radiation environment on territory of control zone and outside of it by determination of absorbed dose rate in the air of γ-radiation and radioactive pollution of soil.

2. **Department of teletherapy.**

2.1. Allocation and planning of department, basic premises, characteristic of devices used for radiotherapy.

2.2. Radiation protection of control room, adjacent premises and territory from γ-radiation (presence of protective shroud on radiating device, materials and thickness of walls in treatment room, presence of protective labyrinth at entrance, protective doors, their freeze, presence of attentive light alarm).

2.3. Observing system for irradiation of patients.

2.4. Characteristic and assessment of ways of protection of patients from accessory irradiation.

2.5. Assessment of effectiveness of radiation protection in control room and other adjacent premises by calculation method and measurement of absorbed dose rate in the air.

3. Departments for treatment by sealed sources.

3.1. Allocation and planning of department.

3.2. Sources of irradiation that used in department, their activity, methods of application of sources to patients (manual-linear and consistent).

3.3. Characteristic of radiation dangerous premises (depository for sources of irradiation, radiomanipulation room, radiotreatment room), their accordance to hygienic requirements.

3.4. Conditions of storage and transportation of sources of irradiation.

3.5. Ways of radiation protection of personnel in depository for sources of irradiation, radiomanipulation room, radiotreatment room.

3.6. Radiation protection of adjacent premises and territory.

3.7. Assessment of effectiveness of radiation protection by necessary calculations and measurement of absorbed dose rate in the air of workplace, behind shields, in adjacent premises, on adjacent territory.

4. Department for treatment by open sources.

4.1. Allocation of department, characteristic of use of radioactive nuclides, class of radiation hazard it belongs to.

4.2. Characteristic of radiation dangerous premises (depository of radioactive nuclides, filling room, treatment room, washing room, radiological wards) their accordance to permitted class of works, sanitary improvement (covering of walls, floor, exhaust hoods, ventilation, collection, removal and sterilization of solid and liquid radioactive waste).

4.3. Presence of means of radiation protection: protective shields, boxes, remote instruments.

4.4. Presence of individual radiation protection devices for personnel: working clothes, overalls, aprons, arm-bands, breathing masks and others.

4.5. Sanitary and domestic premises for personnel.

4.6. Results of measurements and assessment of level of radioactive pollution of workrooms and other premises.

5. Acquaintance with documentations of radiological department, its types.

Analysis and assessment of materials of radiological and medical control during previous year and current year.

Situational tasks

1. In weighing-and-filling room of department of bare IR sources treatment was measured individual doses of personnel irradiation level during 1 quarter with thermoluminescent dosimeters. Results:

- radiologist – 3 mZv;
- treatment nurse – 5 mZv;
- chargeable for keeping and giving out sources of IR – 2,5 mZv.

Was ascertained pollution of working surfaces of permanent residence premises with betta-radionuclides – 2100-2200 part/cm^2*min.

1. Assess results of instrumental examinations.
2. Make a conclusion about working conditions in exanimate premises.
3. List legislative documents with regulate work of such premises.
4. Measure individual dose of external irradiation with photodosimeter ИФКУ - II

2. Work off a program of dosimeter control for radiological department of hospital where bare sources of IR are used. Firs of all explain structure of this department, risk factors and their mode of action.

In program you must name and explain:

1. Objects of dosimeter control;
2. Dosimeter values which will be measured, their units;
3. Dosimeter devices;
4. The most probable variants of dosimeter control results assessment and recommendations about prevention

8. Literature

5.1. Principal:

6.1.1. Загальна гігієна. Пропедевтика гігієни. /є.г.гончарук, ю.і.кундієв, в.г.бардов та ін. / за ред. Є.г.гончарука. – к.: вища школа, 1995. – с. 254-270.

6.1.2. Общая гигиена. Пропедевтика гигиены. /е.и.гончарук, ю.и.кундиев, в.г.бардов и др. – к.: вища школа, 2000 – с. 307-333.

6.1.3. Ильин л.а., кириллов в.ф., коренков и.п. радиационная гигиена. – м., медицина, 1999. – с. 157-175.

6.1.4. Кириллов в.ф., архангельский в.и., коренков и.п. руководство к практическим занятиям по радиационной гигиене. – м., 2001. – с. 130-152.

6.1.5. Загальна гігієна. Посібник до практичних занять. /і.і.даценко, о.б.денисюк, с.л.долошицький та ін./ за ред. І.і.даценко. – 2 видання: львів.: "світ", 2001 – с. 416-421.

6.1.6. Lecture materials.

6.2. Additional:

6.2.1. Нікберг і.і. радіаційна гігієна. – к.: здоров'я, 1999. – с. 78-104, 105-115.

6.2.2. Гігієна та екологія людини: навчальний посібник до практичних занять. /за ред. В.я. уманського. – донецьк: „норд комп'ютер", 2004, - с. 207-214.

6.2.3. Норми радіаційної безпеки україни (нрбу-97). Постанова моз україни №62 від 01.12.1997 р., - 121 с.

6.2.4. Основні санітарні правила забезпечення радіаційної безпеки україни (оспрбу-05). – наказ моз україни №54 від 02.02.2005 р. – 141 с.

9. Equipment required for the lesson

1. Natural or training project of radiological department of hospital.
2. Natural or training project of X-ray department of hospital.
3. Ionometer (microroentgenometer) medical mobile, mobile activity meter.
4. Quotation from legislative normative documents (BNandR, SanNandR) on planning and exploitation of X-ray and radiological departments of hospital, Norms of Radiation Safety of Ukraine-97 (NRSU), MSR-99 (Main sanitary rules-99) and others.
5. Samples of shielding materials.
6. Situational tasks for students' self-training work.