System of requirements to modern finishing materials in solutions of interiors in medical premises that are sources of radiation

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Abstract. This article is devoted to the detailed analysis of requirements applicable to modern finishing materials used in the interiors of health care institutions, in particular in the interiors of medical premises where the sources of radiation are located. The authors have studied a number of regulatory statutory documents in effect in the territory of the Russian Federation and analyzed the practical experience in the decoration of this category of premises at the health care capital construction facilities. Based on the theoretical material and practical experience studied by the authors, the authors single out and describe the basic requirements to modern finishing materials used in the interiors of medical premises being the sources of radiation, as well as propose the versions of visual design of medical premises where the sources of radiation are located. Keywords: interior of MRI (Magnetic Resonance Imaging) room; interior of ultrasound scan room; finishing materials; health care institutions; radiation protection in medical premises.

1 Introduction

The importance of high-quality diagnosis at early stages of a disease cannot be underestimated in modern medicine. In most cases, the early diagnosis allows detecting a disease at its initial stages and ensuring its timely and highly effective treatment. In this area, a number of regulatory acts [1,2,3,4,5,6] supporting public health system have been adopted by the Government of the Russian Federation. Owing to the government support, most of the leading health care institutions conduct technical upgrade, assembly and installation of state-of-the-art medical equipment. This largely concerns the state-of-the-art medical equipment of the departments of diagnostic radiology (X-ray radiography, magnetic resonance imaging (MRI), X-ray computerized tomography (CT), positron emission computerized tomography and positron emission magnetic resonance imaging), due to which it became possible to diagnose a variety of diseases at early stages: oncology, cardiology, neurology, gynecology, rheumatology, etc.

This paper considers the requirements to preparation of the premises that are the sources of ionizing and electromagnetic radiation, for the assembly of medical equipment.

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Paper [7] outlines the general requirements to the interior finishing of health care institutions, as well as the individual requirements to "clean rooms". However, the placement of the sources of various radiations therein implies the additional requirements to the preparation of premises for the assembly of medical equipment, for the purpose of protecting surrounding premises against physical factors unsafe for a human organism. These requirements have been developed taking into account the regulated allowable level of harmful physical factors, including in a health care institution [8]. When designing and constructing this category of premises, it is mandatory to provide special types of protection of surrounding premises against the impact of harmful physical factors, ensure the loading capacity of floor structures, and reduce density of reinforcing bars of floor structures.

Due to the effect of ionizing radiations on a human body, complex physical, chemical and biological processes can occur in tissues. Ionizing radiations cause the ionization of molecules and atoms of the substance resulting in the destruction of tissue molecules and cells. The main type of protection against ionizing radiation is physical protection associated with the use of various screens, weakening materials, etc. Depending on the type of radiation, different materials are used for shielding: plexiglass, thin layer of aluminium, glass, heavy metals such as tungsten, lead, steel.

For the avoidance of the adverse effect of radiations on the staff and population, special requirements to the finishing of premises are established [8,9,10]. Materials capable to impede X-rays are used to ensure protection against destructive effect of the sources of ionizing radiation on a human body. The indicator of protective properties of the material in relation to ionizing radiation is expressed as the thickness of a lead layer providing under specific conditions the same radiation protection as the material under consideration and is called lead equivalent. One of the most popular materials of finishing is sheet lead. Metal ductility allows putting it into the required shape quite easily. GOST related to sheet lead is 9559-89. The plates with dimensions of 500 mm x 1 000 mm are most often used. The product thickness is from 0.5 mm to 15 mm.

X-ray protective glass TF-5 is used for production of light transmitting enclosures and window glazing in the room. Its characteristics are: type — silica glass with high-class transparency; composition — not less than 60% of oxides of heavy metals (including at least 55% of lead). High-quality insulation is achieved using the special panels made of lead gypsum plasterboard. They are used for creation of partitions, they are also used in the lining of the ceiling and walls of the room. X-ray protective gypsum plasterboard is made of gypsum-filament sheets. The layer of special glue is applied to them and lead plates are fastened. The thickness of the applied plates is from 0.5 mm to 3 mm. The erection and treatment of X-ray protective gypsum plasterboard panels does not differ from usual ones, but when using them it is necessary to take into account greater weight of products. During the erection, the lead tape must be used. Sockets and switches are also fastened in lead boxes. It is allowed to use X-ray protective gypsum plasterboard panels made of alternative materials.

In the already built premises of the room, protection against ionizing radiation can be provided with the use of the barite plaster. Cement with water are added to the barite concentrate, then a thick layer of the resulting mixture is applied to the floor, walls and ceiling of the premises. Protection of patients and medical staff against scattered X-radiation is provided by X-ray protective doors. They are installed between a control room and a procedural zone, separating them from each other. Steel profile, fire-resistant polyurethane foam and lead sheets are used for production of a door frame. In the console rooms, X-ray protective windows are installed. They are made of a lead frame and glazed with lead glass. The X-ray protective shutters made of a dense steel profile, lead sheets and two-layer plastic with an X-ray protective layer are installed from the outer side of windows.

In this paper, we will also consider the features of interiors for the medical premises equipped with MR-imaging units.

Magnetic resonance imaging is a safe imaging method for soft-tissue structures. Magnetic resonance imaging cannot do harm to a human organism since it has nothing in common with radiation.

Open and closed tomographic scanners are used for conducting diagnostic testing. A sliding table on which a patient lies moves to a tunnel-type construction. Then the electromagnetic field is created around his body, which allows to carry out detailed scanning. Thus, the principal impact on the interiors of the premises is made by the electromagnetic field, protection against which is also carried out by means of shielding with the use of the so-called Faraday cage.

The Faraday cage is a device designed for shielding of equipment against external electromagnetic fields. It usually represents a cage made of well electrically conductive material.

The operating principle of the Faraday cage is rather simple: when the closed electroconductive shell enters the electrical field, free electrons of the shell start moving under the influence of this field. As a result, the opposite sides of the cage acquire the charges, the field of which compensates the external field.

However, the Faraday cage protects only against the electric field. The static magnetic field will penetrate inside. The varying electric field creates a varying magnetic field, which, in turn, generates the varying electric field. Therefore, if the varying electric field is blocked by means of the Faraday cage, then the varying magnetic field will also not be generated.

The ability of the Faraday cage to shield electromagnetic radiation is determined by:

- the thickness of material of which it is made;
- the thickness of skin effect;
- the ratio of the dimensions of apertures therein to the wave length of external radiation.

We will consider separately the requirements to the solution of the interiors for ultrasound scan rooms. Ultrasound scan is a reliable and highly-demanded method of functional diagnostics. This method of human testing allows obtaining information without causing harm to the patient.

The ultrasound scan room must consist of several spaces:

- for the diagnostics process itself – a room with an area of at least 18 square meters per one unit of equipment (one space – one ultrasound machine);
- a dressing room for patients (cubicle) – a room with an area of at least __ square meters;
- a procedure waiting room – at least 1.2 square meters per one patient.

Recommendations for finishing walls and ceilings:

- wall color – light tones;
- it is forbidden to use ceramic tiles for wall cladding; to improve sound insulation, it is recommended to use sound-absorbing materials for finishing of the ceiling and walls. The noise level must not exceed 50 dBA;
- natural daylight from windows must fall on the workplace from the left. The workplace is located sidewise towards the light;
- artificial lighting – uniform, not creating glares on working surfaces: monitors, keyboard, etc.;
- it is recommended to use the fluorescent lamps which are the most appropriate according to all required characteristics;

- the room must be equipped with the necessary furniture set: a patient couch; a document handling desk; a doctor's desk; a filing cabinet; chairs;
- the ultrasound scan room must have: an ultrasonic apparatus (hand-carried or stationary scanner); a computer having Internet access; a tonometer for measurement of blood pressure; bactericidal air irradiators; a phonendoscope, etc.

Ultrasound scan does not have an adverse impact on the human organism, being one of the most informative diagnostic techniques.

The interiors of the rooms with ionizing radiation are presented below.

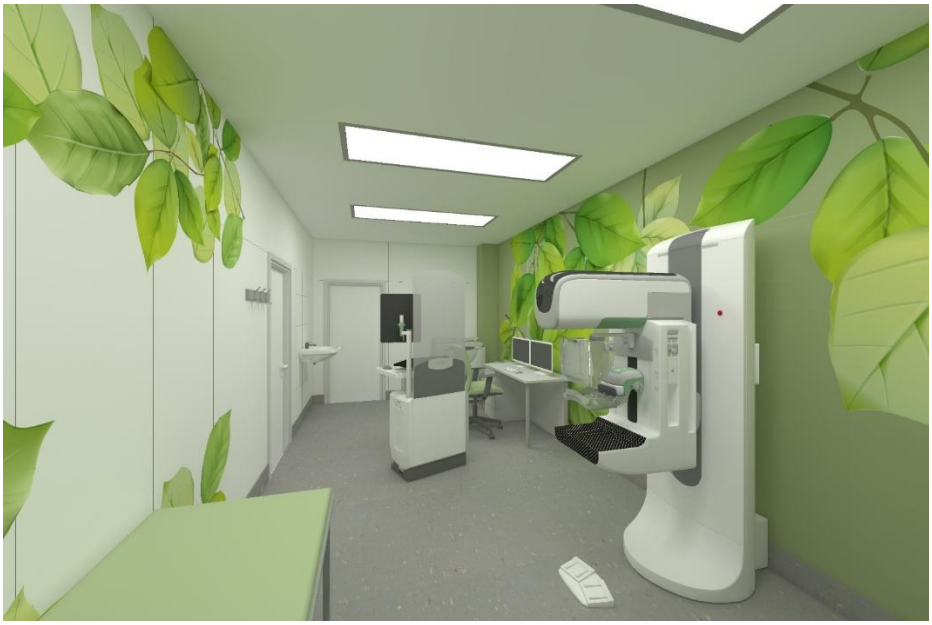

Fig. 1. Mammography Room.

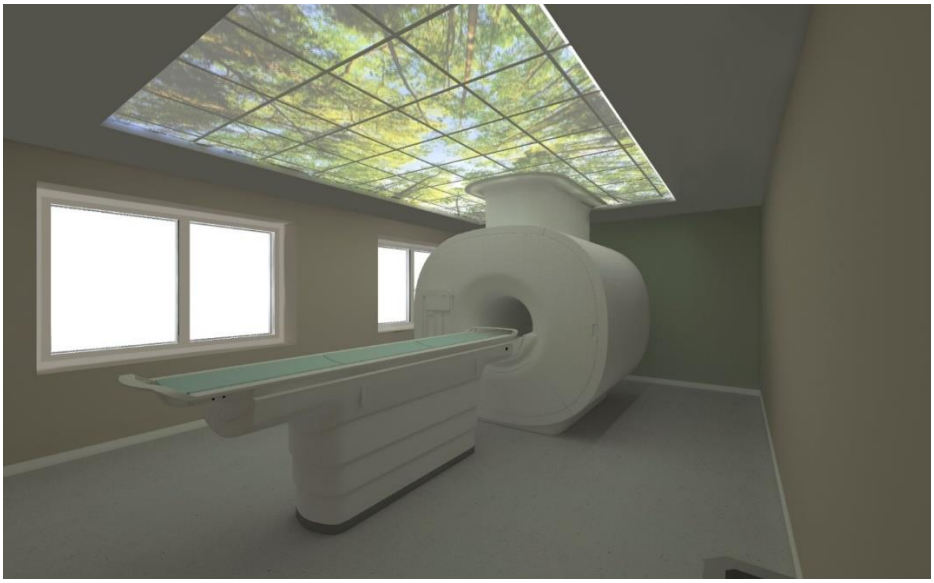

Fig. 2. Magnetic Resonance Imaging Room.

Fig. 3. Ultrasound Scan Room.

Fig. 4. Radiologist Room.

References

1. *Resolution of the Government of the Russian Federation No. 1649, "On Approval of the State Program of the Russian Federation "Development of Healthcare""* (2017)
2. *State Program "Development and introduction of innovative methods of diagnosis, prophylaxis, and treatment, as well as the basics of personalized medicine"*
3. *Decree of the President of the Russian Federation No. 254, "On the Strategy for Healthcare Development in the Russian Federation for the period until 2025"* (2019)

4. *Order of the Ministry of Health of the Russian Federation No. 186, "On Approval of the Concept of Predictive, Preventive and Personalized Medicine"* (2018)
5. *Federal Project "Development of the network of national medical research centers and introduction of innovative medical technologies"*
6. *Resolution of the Moscow Government No. 2401-PP, "O the Territorial Program of State Guarantees of Free Medical Assistance to Citizens in the City of Moscow for 2021 and for the Planning Period of 2022 and 2023"* (2020)
7. A.E. Balakina, Yu. Lempl, Innovations and investments **5**, 197-202 (2021)
8. *SanPiN 2.1.3.2630-10. Sanitary and epidemiological requirements to organizations carrying out medical activities* (2020)
9. *OSPORB-99/2010, Basic Sanitary Rules for Radiation Safety*
10. *SanPiN 2.6.1.1192–03. "Hygienic Requirements to the Design and Operation of X-Ray Apparatus and Conduct of Radiological Studies"*
11. *Federal Law No. 3-FZ "On Radiation Safety of the Population"* (1996)
12. *SP 2.6.1.758-99 Radiation Safety Standards (NRB-99) / Sanitary and Epidemiological Rules No. 2.6.1.758-99* (1999)