

THE MINISTRY OF EDUCATION AND SCIENCE OF THE RUSSIAN FEDERATION
FEDERAL STATE AUTONOMOUS EDUCATIONAL INSTITUTION
OF HIGHER EDUCATION
NATIONAL RESEARCH NUCLEAR UNIVERSITY "MEPHI"

APPROVED

First Vice-Rector of NRNU MEPHI

_____ O. V. Nagornov

" ____ " _____ 2018

COMPETENCE MODEL OF THE MASTER'S DEGREE PROGRAM

direction of training:

22.04.01 Materials Science and Technologies of Materials

Master's degree program:

Materials Design and Engineering

Moscow

2018

1. GENERAL PROVISIONS

1.1. The competence model complies with the requirements of the NRNU MEPhI Educational Standard of Higher Education in the direction **22.04.01 "Materials Science and Technologies of Materials"**.

1.2. The main users of the competence model are:

1.2.1. Associations of specialists and employers in the relevant field of professional activity.

1.2.2 Faculty teaching teams of higher education institutions responsible for high quality development, effective implementation and updating of the basic education programs, taking into account the achievements of science, technology and the social sphere in this direction of training.

1.2.3. Students mastering the educational program of the University aimed at the formation of these competencies.

1.2.4. Pro-rectors responsible within their competence for the quality of training.

1.2.5. State attestation and examination boards that assess the quality of graduates' training.

1.2.6. Authorized state executive bodies that carry out accreditation and quality control in the system of higher professional education.

1.3. The competence model is the basis for designing the content of the modules "Modeling in Materials Science" and "New Materials and Technologies" of the Master's degree program "Development of Materials for Innovative Technologies".

2. GLOSSARY

In this document, the terms and definitions are used in accordance with the RF Law "On Education", the Federal Law "On Higher and Post-Graduate Professional Education", as well as with the international documents in the field of higher education:

the type of professional activity:

- methods, techniques, the nature of the impact on the object of professional activity with the aim of its changing and transforming;

the competence:

- the ability to apply knowledge, skills and personal qualities for successful activity in a certain area;

the competence model of the graduate:

- a totality of social-personal, general-professional and special competencies that allow the graduate to effectively solve professional problems;

the direction of training:

- a totality of educational programs of various levels in one professional field;

the field of professional activity:

- a totality of objects of professional activity in their scientific, social, economic and industrial manifestation;

the object of professional activity:

- systems, objects, phenomena and processes, to which the impact is directed;

the basic educational program for preparing Master's degree students:

- a totality of educational and methodological documents including the curriculum, working programs of training courses, subjects, disciplines (modules) and other materials that ensure the upbringing and the training quality of students, as well as the programs of training and production practices, a calendar training schedule and methodological materials ensuring the implementation of the appropriate educational technology;

learning outcomes:

- acquired knowledge, skills and mastered competencies.

This document uses the following abbreviations:

HE - higher education;

CM - competence model;

GCC - general cultural competences;

GCCES - general cultural competences introduced by the NRNU MEPhI Educational Standard;

GPC - general professional competences;

GPCES - general professional competences introduced by the NRNU MEPhI Educational Standard;

PC - professional competences;

PCES - professional competences introduced by the NRNU MEPhI Educational Standard;

3. COMPETENCE MODEL

3.1. Characteristics of the professional activity of Master's degree graduates:

In connection with MEPhI's leadership strategy in the global educational market, the educational standard is based on the international recommendations of the CDIO World Initiative for mastering engineering activities in accordance with the model of *planning - designing - producing - applying* of high-tech real systems, processes and products in the global market.

Graduates prepare for activities in the field of development of advanced

technologies for the production of materials; the creation of new materials that are distinguished by a high level of specified properties; the purposeful use of high science-intensive technologies and production of high-tech industries; the development and creation of a closed nuclear fuel cycle.

3.1.1. The field of the professional activity of Master's degree graduates includes:

The development, research, modification and use (processing, operation and utilization) of materials of inorganic and organic nature for various purposes; processes of their formation, forming and structure formation, transformations at the stages of production, processing and operation;

Processes of obtaining materials, blanks, semi-finished products, parts and goods, as well as managing their quality for various fields of engineering and technology (mechanical engineering and instrument making, aviation and rocket-space technology, nuclear power, solid-state electronics, nanoindustry, medical equipment, sports and domestic appliances).

3.1.2. Objects of the professional activity of graduates of Master's degree programs are:

Main types of modern structural and functional inorganic (metal and non-metallic) and organic (polymer and carbon) materials, composites and hybrid materials, super-hard materials, intelligent and nano-materials, films and coatings; methods and tools for testing and diagnostics, research and quality control of materials, films and coatings, semi-finished products, blanks, parts and goods, all types of research, control and testing equipment, analytical equipment, computer software for processing the results and analyzing the data obtained, modeling of materials behavior, estimation and forecasting of their operational characteristics;

Technological processes of production, processing and modification of materials and coatings, parts and goods, equipment, technological tools and accessories, technological process control systems;

Normative-technical documentation and systems for certification of materials and goods, technological processes for their production and processing, reporting documentation, records and protocols of the course and results of experiments, documentation on safety engineering and the safety of life activity.

3.2. A graduate of a Master's degree program in the training direction **22.04.01 "Materials Science and Technologies of Materials"** prepares for the following types of professional activity:

Research, calculation and analytical activities; production, design and technological activities; organizational and managerial, and innovative activities.

Specific types of professional activity, to which the graduate of a Master's degree mainly prepares, determine the content of his/her basic educational program developed by

a higher education institution in cooperation with students, scientific and pedagogical employees of a higher education institution and employers' associations.

3.3. A graduate of a Master's degree program in the training direction **22.04.01 "Materials Science and Technologies of Materials"** must be prepared to solve professional problems in accordance with the profile orientation of the main educational programs of the MA course and the types of professional activity:

Research, calculation and analytical activities:

Collection and comparative analysis of data on the existing types and grades of materials, their structure and properties, methods of the development of new materials with specified technological and functional properties as applied to the solution of assigned tasks using databases and literature sources;

Participation in the organization and implementation of projects, research and developments of new materials and compositions, scientific and applied experiments to create new processes for the production and processing of materials and goods;

Development of programs, work plans and techniques, organization and implementation of experiments, research and testing of materials, processing and analysis of their results with the aim to develop technological recommendations in implementing processes into production, the preparation of individual tasks for executors;

Preparation of scientific and technical reports, reviews, publications based on the results of performed studies on the basis of analysis and systematization of scientific, technical and patent information on the research topic, as well as opinions and conclusions on projects, including standards;

Modeling of materials and processes, research and experimental verification of theoretical data in developing of new technological processes for the production and processing of materials;

Analysis, justification and implementation of technical projects in the rational selection of materials in accordance with the specified conditions at designing of goods and technological processes of production, processing and recycling of materials, non-typical means for testing of materials, semi-finished products and goods;

Preparation of publications on R&D topics and implementation of the results of scientific and technical investigations into the real sector of economy and commercialization of developments.

Production, design and technological activities:

Participation in the production of materials with specified technological and functional properties;

Organization of workplaces, their technical equipment, maintenance and diagnostics of technological equipment;

Carrying out of the technical and economic analysis of alternative technological options, organization of technological processes of production, processing and recycling of materials, assessment and management of the quality of production, assessment of the economic efficiency of technological processes;

Preparation of tasks for the development of project materials science and (or) technological solutions, carrying out of patent research with the aim to ensure the patent purity of new solutions and determine the patentability and indicators of the technical level of materials, goods and processes being developed;

Participation in the certification of materials, semi-finished products and goods, technological processes for their production and processing;

Study of the reasons of spoilage in production and the development of proposals for its prevention and elimination, the development of measures for the multipurpose use of raw materials, the replacement of scarce materials and finding ways to recycle production waste, the choice of systems ensuring the technical and environmental safety of production;

Designing of technological processes of production, processing and recycling of materials, installations and devices, as well as technological equipment for these processes, including those with the use of automated design systems;

Carrying out of complex technological and design calculations using software products, implementation of innovative materials science and technological projects, assessment of innovative risks in the implementation of projects and the introduction of new technologies, participation in the work of a multidisciplinary team of specialists during the development of complex projects;

Development of methodological and normative documents, technical documentation, as well as proposals and activities on the implementation of developed projects and programs;

Planning, design, production and application of high-tech real systems, processes and products (materials) in the global market.

Organizational and managerial activity:

Organization and management of work of the primary industrial, design or research division, the operational planning of work of its personnel and wage funds, an analysis of the costs and results of the division's activity, the making of scientific and technical, and organizational and managerial decisions on the division's activities;

Management of technological processes in accordance with official duties, ensuring of the technical and environmental safety of production in the area of one's own professional activity;

Organization in the division of work on the improvement, modernization and unification of manufactured goods and their elements, as well as on the development of

projects of standards and certificates, certification of processes, equipment and materials, participation in holding events for creation of the quality system;

Organization of work of the team of executors, divisions or groups, making of executive decisions in conditions of various opinions, determination of the order of work implementation, organization of upgrading the skills of the employees of divisions in the field of innovative activity;

Providing of links (as a representative of the workshop, department, laboratory or enterprise) with co-executors of a specific industrial, research or scientific and technical program (project), as well as with other divisions of the enterprise or other enterprises;

A search for optimal solutions, when creating products, with consideration for the requirements of quality, reliability and cost, as well as times of execution, the safety of life and environmental cleanliness;

Prevention of industrial injuries, occupational diseases, prevention of environmental violations in the division;

Organization of work on the implementation of author supervision in manufacturing, mounting, adjustment, testing and commissioning of manufactured goods and facilities;

Carrying out of marketing studies and preparation of business plans for the manufacture and sale of competitive goods and technologies, the development of plans and programs for organization of innovative activity;

The implementation of the results of scientific and technical investigations into the real sector of the economy and the commercialization of developments.

3.4. Competences of the Master's degree program.

3.4.1. A graduate must have the following general cultural competencies (GCC):

The ability to abstract thinking, analysis, synthesis (GCC-1);

The readiness to act in non-standard situations, bear social and ethical responsibility for the decisions made (GCC-2);

The readiness for self-development, self-realization and the use of creative potential (GCC-3);

The ability to use the state language of the Russian Federation and a foreign language as a means of business communication, precisely and clearly state problems and solutions, argue conclusions (GCC-4);

The ability to prepare and present presentations of plans and results of one's own and team activity (GCC-5);

The readiness to form and defend one's own judgments and scientific positions, analyze and make conclusions on social, ethical, scientific and technical problems arising

in professional activity, including environmental consequences (GCC-6);

The readiness to independently carry out investigations using modern equipment and instruments (in accordance with the objectives of the Master's degree program) and set new research tasks (GCC-7);

The readiness to critically evaluate one's own advantages and disadvantages, outline ways and choose means to develop advantages or eliminate disadvantages (GCCES -1).

3.4.2. A graduate of the Master's degree program must have the following **general professional competencies (GPC)**:

The readiness for communication in oral and written forms in the state language of the Russian Federation and a foreign language to solve problems of professional activity (GPC-1);

The readiness to lead the team in the sphere of one's own professional activity and tolerantly accept social, ethnic, confessional and cultural differences (GPC-2);

The ability to develop independently the basic knowledge of theoretical and applied sciences in professional activity during the modeling and theoretical and experimental research of materials and processes (GPC-3);

The ability to apply the basic provisions and methods of social, humanitarian and economic sciences in solving professional problems with regard to the consequences for society, economy and ecology (GPC-4);

The readiness to apply principles of the rational use of natural resources and the environmental protection in solving professional problems (GPC-5);

The ability to perform marketing research and develop a feasibility study of innovative solutions in professional activity (GPC-6);

The readiness to carry out a patent search, investigate the patentability and indicators of the technical level of developments and use procedures for the intellectual property protection (GPC-7);

The readiness to carry out an expertise of processes, materials and test methods (GPC-8);

The ability to independently master new research methods and change the scientific, scientific and pedagogical, and production profile of one's own professional activity (GPC-9).

3.4.3. A graduate of the Master's degree program must have **professional competencies (PC)** corresponding to the type (s) of professional activity, to which the Master's degree program is oriented:

In research, calculation and analytical activities:

The readiness to use modern information and communication technologies, global information resources in research, calculation and analytical activities in the field of

materials science and technology of materials (PC-1);

The ability to use methods of modeling and optimization, standardization and certification for the assessment and prediction of the properties of materials and the efficiency of technological processes (PC-2);

The ability to understand the physical and chemical processes occurring in materials during their production, processing and modification, use knowledge of the methods of research, analysis, diagnostics and modeling of the properties of substances (materials) in research and calculations, carry out complex studies with the use of standard and certification tests (PC -3);

The ability to practically use modern ideas of the influence of micro- and nano-structure on the properties of materials, their interaction with the environment, fields, energy particles and radiation (PC-4);

The ability to independently collect data, study, analyze and summarize scientific and technical information on the subject of research, and develop and use technical documentation in professional activity (PC-5);

The readiness to use the knowledge of the main provisions of patent legislation and copyright of the Russian Federation, normative documents on the questions of intellectual property in preparation of documents for patenting and registration of know-how (PC-6);

The ability to carry out mathematical modeling of physical processes of the interaction of radiation and charged particles with nuclear fuel atoms on the basis of standard packages of computer-aided design and research (PCES-1);

The readiness to participate in the organization and implementation of projects, research and developments of new materials and compositions, scientific and applied experiments on the development of new processes for the production and processing of materials and goods, the development of technological recommendations for the implementation of processes into production (PCES-2);

In production, design and technological activities:

The readiness to select materials for given operating conditions, taking into account the requirements of reliability and durability, profitability and environmental consequences of their use on the basis of knowledge on the main types of inorganic and organic materials of various purposes, including nanomaterials (PC-7);

The ability to independently develop methods and means of the automation of production processes, choose equipment and tools, methods and procedures of labor organization that ensure effective, technically and environmentally safe production (PC-8);

The readiness for professional operation of modern equipment and instruments in accordance with the objectives of the Master's degree program (PC-9);

The ability to use normative and methodological materials on the technological

preparation of production, on the quality, standardization and certification of goods and processes in technological processes and operations, taking into account their designation of implementation methods and the resource support on the basis of economic analysis (PC-10);

The ability to independently use technical means to measure and control the main parameters of technological processes, the structure and properties of materials and their goods, and to plan and carry out research and developments (PC-11);

The readiness to apply engineering knowledge for the development and implementation of projects that meet specified requirements, including requirements of economic efficiency, technical and environmental safety (PC-12);

The ability to apply the design methodology (PC-13);

The readiness to independently design technological processes for the production of material and its goods with specified characteristics (PC-14);

The ability to calculate and design technological tools with the use of modern application programs and computer graphics, network technologies and databases (PC-15);

The readiness to manage scientific research and/or technological processes in accordance with official duties, ensure technical and environmental safety of the experiment in the area of one's own professional activity (PCES-3);

The readiness to carry out technical and economic analysis of new processes of the treatment and recycling of materials, evaluation and management of the product quality, assessment of the economic efficiency of technological processes; the ability to carry out complex technological and design calculations using software products (PCES-4);

In organizational and managerial, and innovative activities:

The readiness to use the main categories and concepts of general and production management in professional activity (PC-16);

The ability to analyze the technological process as an object of management, conduct the cost estimation of the main production resources, generalize, analyze and use information about the resources of the enterprise (PC-17);

The readiness to implement the quality management system in the sphere of professional activity (PC-18);

The readiness to apply knowledge, skills and habits of the management of high-tech innovative business, including small one, in professional activity (PC-19);

The ability to perform operational planning of the work for primary production units, manage technological processes, assess risks and determine measures for ensuring the environmental and technical safety of the materials, equipment and technologies being developed (PC-20);

The readiness to choose the most rational ways of protection and order in the actions of a small collective in emergency situations (PC-21).

The ability to prepare publications on the topic of R&D and implementation of the results of scientific and technical investigation into the real sector of economy and commercialization of developments (PCES-5).

Competence model is considered and approved by the Academic Council
of the Institute of Nuclear Physics and Engineering

as of _____, Protocol No. _____.

Head of the Bachelor's degree program "Materials Design and Engineering "

Acting Head of the Department of Materials Science

_____ /B.A. Kalin/

AGREED:

Representatives of employers:

Deputy Director

A.A. Baikov Institute of Metallurgy and Materials Science
of the Russian Academy of Sciences (IMET RAS)

_____ /S.V. Simakov/

Deputy Director

Stock Company «A.A. Bochvar High-Technology Research Institute
of Inorganic Materials» (SC «VNIINM»)

_____ /V.V. Novikov/