**AL-FARABI KAZKH NATIONAL UNIVERSITY**

**APPROVED**
**at a meeting of the Academic Committee (SMC)**
**of al-Farabi Kazakh National University**
**Vice-Chancellor for Educational Work**

**_____ A.K. Khikmetov**
**Protocol №6 from «22» June 2020**

# ENTRANCE EXAMINATION PROGRAM FOR APPLICANTS TO THE PHD DOCTORATE ON THE EDUCATIONAL PROGRAM «8D07106 – THERMAL POWER ENGINEERING»

**ALMATY 2020**

The program was prepared in accordance with curriculum of the educational program «8D07106 – THERMAL POWER ENGINEERING».

The program was prepared by the Professor, Dr.Sc. (Physics and Mathematics) Askarova A.S. and Professor, Dr.Sc. (Physics and Mathematics) Bolegenova S.A.

The program was considered at a meeting of the Department of thermal physics and technical physics
Protocol № 38 from 19.05.2020.

Head of the department _____ Bolegenova S.A.

Approved at the meeting of methodical bureau of the faculty of physics and technology
Protocol № from .2020.

Chairman of the methodical bureau _____ Gabdullina A.T.

Approved at the meeting of Academic Council of the faculty
Protocol № 9 from 29.05.2020.

Chairman of the Academic Council,

Dean of the faculty _____ Davletov A.E

Scientific Secretary _____ Masheeva R.U.

## CONTENT

**1. Goals and objectives of the entrance exam for the educational program «8D07106 – THERMAL POWER ENGINEERING».**

The entrance exam is designed to determine the practical and theoretical readiness of the master degree student and is carried out to determine the conformity of knowledge, skills of students to the requirements of doctoral studies in the direction of training.

To achieve this goal, it is necessary to carry out the following tasks:

- a comprehensive and systematic study of natural sciences;
- the formation of skills of independent scientific and theoretical analysis;
- mastering the methods of studying physics;
- development of pedagogical and research skills.

The form of the entrance exam is a written exam. Examiners record their answers to the questions on the exam ticket on the answer sheets. In the case of an appeal, the basis for consideration is written entries in the answer sheet.

**2. Requirements for the level of training of persons entering the PhD program**

Requirements for applicants who want to master the educational program of doctoral studies «8D07106 – THERMAL POWER ENGINEERING»:

Applicant *must*:

- *be able to* freely navigate in the fundamental and applied issues of that field of physics, for which profile specialization was carried out within the framework of the educational program of the master degree;
- *have an idea* of the latest achievements of science and technology;
- *know* modern experimental, theoretical and numerical methods for studying physical phenomena and processes; actual problems of physics.

**3. Prerequisites of the educational program**

1. Information systems in heat power engineering and heat technology – 3 cr.
2. Scientific and technical problems of heat power engineering and heat technology – 3 cr.
3. Industrial power supply systems– 3 cr.

**4. The list of exam topics**

***Discipline «Information systems in heat power engineering and heat technology»***

**Models and types of modelling.** Types of modelling. Analog simulation. Physical modelling. Criteria equations for problems of heat conductivity, convective and radiative heat transfer. Mathematical modelling as the main method for solving problems of optimization and design of thermotechnological processes.

**Numerical methods for solving some heat engineering problems.** Numerical integration (rectangle, trapezoid, parabola, Gauss method) when calculating the heating surface area of the heat exchanger. Finding the roots of algebraic and transcendental equations in solving the criterion equations of heat and mass transfer. Solving systems of linear and nonlinear algebraic equations and ordinary differential equations describing heat engineering processes. Numerical methods and their computer implementation in solving problems of heat and mass transfer and hydrodynamics. Methods of integral relations, finite-difference methods for solving the problem of viscous flow of liquids and gases in the boundary layer with the external flow of

bodies. Application of the marching method in channel flow modelling problems. Optimization problems in thermal power engineering and power industry.

**Mathematical modelling and optimization of heat and mass transfer devices.** Mathematical description of the flow structure in the device. Models of perfect mixing and perfect displacement. The diffusion model, the cell model. Combined model. Modelling the operation of a recuperative heat exchanger. Statement of the problem of optimization of the heat exchanger. Modelling and optimization of distillation and rectification devices. Automation of mathematical modelling of heat and mass transfer devices.

**Mathematical modelling and optimization of heat supply systems for industrial enterprises.** Simulation models of heat supply systems for industrial enterprises (HSSIE) and their features. The accuracy of the implementation of mathematical models HSSIE. Automation of mathematical modelling HSSIE. Mathematical models of steam, condensate and water heat networks. The use of mathematical models to study the hydraulic and thermal modes of networks. Mathematical models of boilers and their elements. The use of mathematical models of thermal power plants for the analysis of thermal schemes, equipment operating modes and economic indicators. General methods and principles of approach to solving optimization problems of complex energy systems and installations.

**Modelling and optimization of processes in the main equipment of thermal power plants.** Numerical calculation of the steam expansion process in the turbine stage and in the turbine as a whole. Calculation of a steam turbine unit with a regeneration system. Numerical calculation of combustion process in the boiler unit, the equilibrium composition of combustion products. Methods, their accuracy and implementation on a computer. Optimization of the speed of the heat carrier and the diameter of the pipes in the heat exchanger. Optimization of gas turbine plant parameters. Optimization of load distribution between TPP units and energy characteristics of steam turbines and boiler units. Equations for determining the characteristics of heating turbines.

**Application software packages for solving heat engineering problems.** Application software packages (ASP) and data banks (DB) of heat technology: analysis, use and development. Structure and properties of application software packages (ASP). Development and testing of the ASP. Capabilities of the ASP and its operation management. The use of ASP for CAD. Using the Visio system for the design of thermal circuits.

**Automated systems of scientific research.** Heat engineering reference and information systems and data banks. Automated systems for data and thermodynamic properties of substances. Complexes of application programs for modelling hydrodynamic processes, heat and mass transfer. Automated systems for modelling heat and power equipment.

***Discipline «Scientific and technical problems of heat power engineering and heat technology»***

**Scientific and technical problems of thermal power engineering and heat technology.** Special issues of heat and mass transfer. Methods of heat and mass transfer intensification. Mathematical modelling and numerical methods for solving heat and mass transfer problems. Special questions of the theory of combustion. Predictive analysis of energy technologies and structures. Mathematical modelling in predictive analysis.

**Current state and perspective directions of heat and electric energy.** Current state and promising methods and methods for obtaining and converting heat and electric energy. Problems and prospects of development and improvement of the main equipment of power stations and technological schemes. Problems and prospects for the development and improvement of methods and methods for preparing and burning fuel, using secondary energy resources and industrial waste as energy fuel. Ensuring the reliability of power equipment operation. Optimization of the development of power systems and power plants. Problems of reconstruction and modernization of heat power equipment of heat power facilities and structures.

**Alternative and renewable energy sources.** Problems and prospects of using non-traditional and renewable energy sources for energy supply to integrated and Autonomous consumers. Environmental problems of heat power engineering.

**Energy sector development.** Analysis of trends and patterns of energy development (globalization, liberalization, diversification, decentralization, modernization). Development of energy policy and mechanisms for its implementation. Energy security of the country.

**Calculation of energy characteristics.** Heat and hydraulic calculation of the heat exchanger. Methods of reconstruction of boilers in connection with the transfer to another type of fuel. Calculation of energy characteristics of heat-technological productions. Calculation of energy use efficiency indicators in the fuel and energy sector and production sectors. Calculation of solar power installations. Calculation of bioenergy installations. Preparation of energy passports for industrial enterprises and housing and utilities facilities..

### *Discipline «Industrial power supply systems»*

**Power plants.** The reasons for the creation of energy systems. Electrical networks and receivers of electrical energy. Load graphs and power quality. Power systems and power stations. Electric network. Electrical energy receivers. Graphs of electrical energy loads. Quality of electrical energy.

**Supply system.** Supply system. Heat supply system. Problems of heat supply systems. Calculation of power supply systems. Method for calculating power supply systems.

**Thermal energy.** Sources of heat energy. Heat networks and their equipment. Consumers of heat energy. Methods for calculating the amount of heat from heat sources.

**Water supply.** Heating and hot water supply. Ventilation and air conditioning.

**Fuel supply.** Fuel supply with solid fuel. The fuel supply while the liquid fuel. Fuel supply with gaseous fuel. Centralized and decentralized methods of producing artificial cold.

**5. List of recommended literature**

**Basic:**

1. А.С.Аскарова, С.А.Болегенова, В.П.Кашкаров, И.В.Локтионова. Теплофизика реологических жидкостей. Учебное пособие для магистрантов. Алматы: КазНУ им.аль-Фараби, 2004. – 146 с.

2. А.С.Аскарова, В.П.Кашкаров, Е.И.Лаврищева, И.В.Локтионова. Теплофизика проводящих сред. Учебное пособие для магистрантов. Алматы: КазНУ им.аль-Фараби, 2004. – 179 с.

3. Шульман З.П., Берковский Б.М. Пограничный слой неньютоновских жидкостей. – Минск. Наука и Техника, 1966. – 238 с.

4. Шульман З.П. Конвективный тепломассоперенос реологически сложных жидкостей. –М. Энергия. 1975. – 352с.

5. Астсрита Дж., Маруччи Дж. Основы гидродинамики неньютоноских жидкостей. –М. «Мирң. 1978. – 310с.

6. Кашкаров В.П. Учебное пособие «Гидродинамика неньютоновских жидкости», 120 с., КазГУ, Алматы,1988

7. Кашкаров В.П. Магнитная гидродинамика. Учебное пособие. Алма-Ата,1989.- 121 с

8. Ландау Л.Д., Лифшиц Е.М. Электродинамика сплошных сред. Изд. 2-е, М.: Наука, 1982. - 624 с.

9. Новиков И.И. Прикладная магнитная гидродинамика.М.: Атомиздат, 1969.- 360с.

10. Куликовский А.Г., Любимов Г.А. Магнитная гидродинамика. М.:ФМЛ, 1962.- 248 с.

11. Блинов Е.А., Джаншиев С.И., Зайцев Г.З., Можаева С.В. Энергоснабжение: учебное пособие для вузов; - СПб.: СЗТУ, 2004 - 117 с.

12. Юренев В.Н. Промышленные электростанции. Москва, Госэнергоиздат, 1963, 137 с.

13. Лабунцов Д.А. Физические основы энергетики. М.: Изд-во МЭИ, 2000, 388с.

14. Кордон М.Я., Симакин В.И., Горешник И.Д. Теплотехника. Пенза, ПГУ, 2005, 167с.

15. Васильков Ю.В. Компьютерные технологии вычислений в математическом моделировании. – М.: ВШ, 2001. – 256 с.

16. Журнал «Энергетика и топливные ресурсы Казахстана».

17. Дукенбаев К., Нурикен Е. Энергетика Казахстана (технический аспект). – Алматы, 2001. – 312 с.

18. Табунщиков Ю.А., Бродач М.М., Шилкин Н.В. Энергоэффективные здания. – М.: АВОК-ПРЕСС, 2003. – 200 с.

19. Дукенбаев К. Энергетика Казахстана. Условия и механизмы устойчивого развития. - Алматы, 2004. – 604 с.

20. Стерман Л.С. Тепловые и атомные электрические станции. - М.: МЭИ, 2000. – 408 с.

21. Белосельский Б.С. Технология топлива и энергетических масел: Учебник для вузов. – М.: МЭИ, 2003. – 340 с.

22. Борисова Н.Г. Энергосбережение и использование нетрадиционных источников энергии: Конспект лекций. – Алматы: АИЭС, 2003. – 76 с.

**Additional:**

1. Промышленная теплоэнергетика и теплотехника: Справочник / Под общ.ред. В.А. Григорьева и В.М. Зорина. - М.: Энергоатомиздат, 1991. – 588 с.

2. Основные процессы и аппараты химической технологии: Пособие по проектированию / Под ред. Ю.И. Дытнерского. – М.: Химия, 1991. – 496 с.

3. Бажан П.И., Каневец Г.Е., Селивестров В.М. Справочник по теплообменным аппаратам. – М.: Машиностроение, 1989. – 365 с.

4. Теплотехнические расчеты при автоматизированном проектировании нагревательных и термических печей. – М.: Черметинформация, 1999. – 185 с.

5. Математическое моделирование и оптимизация систем тепло-, водо-, нефте- и газоснабжения. / Под ред. Меренкова А.П. – Н.: Наука, 1992. – 234 с.

6. Энергосбережение в системах теплоснабжения, вентиляции и кондиционирования воздуха. Справочное пособие. – М.: Стройиздат, 1990. – 624 с.

7. Системы солнечного тепло- и хладоснабжения / Под ред. Э.В. Сарницкого. - М.: Стройиздат, 1990. – 328 с.

8. Энергоактивные здания / Под ред. Э.В. Сарницкого. - М.: Стройиздат, 1988. – 376 с.

9. Справочник по теплообменникам. – М.: Энергоатомиздат, 1987. – Т. 1. – 561 с.

10. Справочник по теплообменникам. – М.: Энергоатомиздат, 1987. – Т. 2. – 352 с.

**6. Scale for assessing the results of the entrance exam in the PhD educational program of «8D07106 – THERMAL POWER ENGINEERING»**

| Letter Grade | Grade Point Value | Percentage | Conventional grade | Competency Scale |
|---|---|---|---|---|
| A | 4,0 | 95-100 | Excellent | This assessment is given if the applicant:<br>1) has an idea: about the main stages of development and a paradigm shift in the evolution of science; about scientific schools and industry knowledge; on scientific concepts of world and Kazakhstani science in the general field; on the implementation of scientific developments in practice.<br>2) knows and understands: current trends, directions and patterns of development of domestic science in the context of globalization and internationalization; foreign languages and international cooperation.<br>3) can: organize, plan and implement the process of scientific research; analyze, evaluate and compare various theoretical concepts in the field of research and draw conclusions; analyze and process information from various sources; plan and predict your further professional development.<br>4) has the skills of: critical analysis, evaluation and comparison of various scientific theories and ideas; analytical and experimental scientific activity; planning and forecasting research results; oratory and public speaking at international scientific forums, conferences and seminars. |

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| A- | 3,67 | 90-94 | | This assessment is given if the applicant:<br>1) has an idea: about scientific schools of the corresponding branch of knowledge, their theoretical and practical developments; on the scientific concepts of Kazakhstani science in the relevant field; on the mechanism for introducing scientific research into practical activities.<br>2) knows and understands: current trends, directions and patterns of development of domestic science in the context of globalization and internationalization; perfectly knows a foreign language for the implementation of scientific communication and international cooperation.<br>3) can: organize, plan and implement the process of scientific research; analyze, evaluate and compare various theoretical concepts in the field of research and draw conclusions; analyze and process information from various sources; plan and predict your further professional development.<br>4) has the skills: evaluation and comparison of various scientific theories and ideas; analytical and experimental scientific activity; planning and forecasting research results; oratory and public speaking at international scientific forums, conferences and seminars. |

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| B+ | 3,33 | 85-89 | Good | This assessment is given if the applicant:<br>1) has an idea: about scientific schools of the corresponding branch of knowledge, their theoretical and practical developments; about scientific concepts of Kazakhstan science in the relevant field.<br>2) knows and understands: current trends, directions and patterns of development of science in the context of globalization and internationalization; knows a foreign language for the implementation of scientific communication and international cooperation.<br>3) knows how to: organize and implement the process of scientific research; analyze and compare various theoretical concepts in the field of research and draw conclusions; analyze information from various sources; plan and predict your further professional development.<br>4) has the skills: assessment of various scientific theories and ideas; analytical and experimental scientific activity; planning and forecasting research results; oratory and public speaking at international scientific forums, conferences and seminars. |
| B | 3,0 | 80-84 | | This assessment is given if the applicant:<br>1) has an idea: about scientific schools of the corresponding branch of knowledge, their theoretical and practical developments.<br>2) knows and understands: current trends, directions and patterns of development of science in the context of globalization and internationalization; knows a foreign language for the implementation of scientific communication and international cooperation.<br>3) knows how to: organize and implement the process of scientific research; analyze and compare various theoretical concepts in the field of research and draw conclusions; analyze information from various sources; plan and predict your further professional development.<br>4) has the skills: assessment and comparison of analytical and experimental scientific activities; planning and forecasting research results; oratory and public speaking at international scientific forums, conferences and seminars. |

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|---|---|---|---|---|
| B- | 2,67 | 75-79 | | This assessment is given if the applicant:<br>1) has an idea: about scientific schools of the corresponding branch of knowledge, their theoretical developments; about scientific concepts of Kazakhstan science in the relevant field.<br>2) knows and understands: current trends, directions and patterns of development of science in the context of globalization and internationalization; knows a foreign language for the implementation of scientific communication and international cooperation.<br>3) knows how to: organize and implement the process of scientific research; analyze various theoretical concepts in the field of research; analyze information from various sources; plan your further professional development.<br>4) has the skills: assessment and comparison of analytical and experimental scientific activities; oratory and public speaking at international scientific forums, conferences and seminars. |