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**Study Programmes for Electro-Technical Officers Development:  
Two-Level Based Approach**

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**Abstract:** The standards of training and certification regarding Electro-Technical Officers (ETOs) established in the new edition of the STCW Convention and Code are the first international standards for electro-technical personnel in history. Development of study programmes for ETOs is one of the most important current tasks for maritime education and training institutions. Standards established in the new edition of the STCW Convention and Code regarding ETOs include requirements for one level of ETOs qualification. These standards should be accepted as minimum standards only. These standards do not cover a range of competencies that are necessary in modern marine engineering and do not take into account that the competencies of management level appear when vessels with powerful and complex electric power plants are maintained by electro-technical groups that might include a few ETOs. Analysis of modern and nearest future needs shows us that a minimum of two levels of qualifications (ranks) for ETOs are required. A number of countries have been supporting the idea of two-level standards for ETOs during the process of comprehensive review of the STCW Convention and Code. The first level of ETOs qualification should correspond to the standards of competence for ETOs at operational levels that are presented in the Section A-III/6 of the STCW Code. The second level of ETOs qualification must ensure the next level of knowledge, understanding and proficiency in the field of work, and the next level of problem solving abilities, communication skills, autonomy and responsibility. The approach to ETOs education and training, the descriptors of qualifications, the structures of study programmes with the view of the two ETOs ranks are considered in the paper. **Keywords:** the STCW Convention and Code, Maritime Education and Training (MET), Electro-Technical Officers (ETOs), Standards, Study programme, Competencies, Qualifications.

The Manila amendments to the Annex to the International Convention on Standard of Training, Certification and Watchkeeping for Seafarers (STCW Convention) and to the Seafarers' Training, Certification and Watchkeeping Code (STCW Code) entered into force 1 January 2012 [1]. The authors have already attracted attention to the fact that one of the most important amendments to the STCW Convention and the STCW Code was the introduction of the standards of

training and certification for electro-technical personnel [2]. The necessity of the inclusion of such standards into the STCW Convention and the STCW Code was predetermined by the rapid development of electro- and electronic technologies during the last decades and the wide use of the above technologies in maritime engineering.

The new edition of the STCW Convention and STCW Code includes standards regarding electro-technical officers (Regulation III/6 of the STCW Convention and Sections A-III/6 and B-III/6 of the STCW Code) and Electro-technical ratings (Regulation III/7 of the STCW Convention and Section A-III/7 of the STCW Code).

The necessity of the implementation of the above standards into the study programmes in the near future is one of the main challenges for Maritime Education and Training (MET) and an actual issue for the maritime educational institutions. The activity of maritime higher educational institutions relates to the officers' training. In this connection the authors propose to pay attention to the standards of the training of electro-technical officers (ETOs) and to discuss the approach to the development of the corresponding study programmes in the maritime higher educational institutions.

Prior to the adoption of the above standards, the unified requirements of the competence and the level of responsibility of the electro-technical personnel were not established. Different countries and different maritime higher educational institutions trained ship electro-technical specialists in accordance with their national requirements. Besides, different shipping companies provided positions differently named and having different duties (Electrician, Electrical Engineer, Electrical Officer, Electronic Officer, etc.). In some cases the principal attention was devoted to the electrical power plants and distribution of electricity, electrical drives and so on. In the others the focus was on the electronic and control engineering.

Different approaches to the duties of electro-technical personnel and to the development of the associated training programmes before the adoption of the Manila Amendments were reflected during the process of the comprehensive review of the STCW Convention and the STCW Code. For instance, the proposals to include new definitions into the STCW Convention and work out the related standards regarding Electrical officer and Electronic officer [3], Electro-technical officer and Senior electro-technical officer [4] were submitted. As a result of lengthy discussions and the resulting convergence of the delegations' positions, the standards regarding Electro-technical officer were adopted.

After the Manila Amendments have entered into force, the training of electro-technical personnel should be provided in compliance with the adopted standards. The specification of minimum standards of competence for electro-technical officer as presented in the Table A-III/6 of the STCW Code requires knowledge, understanding and proficiency in the subject areas of mechanical engineering, electro-technology, hi-voltage technology, electronics, control engineering, computing and data processing and communication technology. It is evident that the area of competence of electro-technical officer covers a wide range of engineering and technology and requires the realization of the specific educational and training programmes, which may be classified as educational and training programmes in Combined Technology.

At the same time the authors pay attention to the fact that the standards regarding electro-technical officers in the STCW Convention and the STCW Code established only one level of ETOs' qualification and responsibility – operational level. In the authors' opinion the standards established in Regulation III/6 of the STCW Convention and Sections A-III/6 and B-III/6 of the STCW Code should be accepted as minimum standards only. These standards do not cover a range of competencies that are necessary in modern marine engineering and do not take into account the situations when competencies of management level are required.

The authors have already written that delegates from a number of countries at IMO have been supporting the idea of two-level standards for ETOs [2], [5]. During the process of the comprehensive review of the STCW Convention and the STCW Code standards regarding electro-technical personnel, three levels of responsibility were proposed [2], [4]:

- Electro-technical rating (Support level);
- Electro-technical officer (Operational level);
- Senior Electro-technical officer (Management level).

Delegates from China, France, India, Malaysia, Poland, Ukraine, United Kingdom and many others consistently supported that approach. This approach assumed the arrangement of training and certification of ETOs at two levels. Analysis of modern and nearest future needs shows us that a minimum of two levels of qualifications and ranks for ETOs are required.

At least two aspects may be singled out as arguments in favor of two-level standards regarding ETOs. The first one is the complexity and multitude of the equipment relevant to the ETOs competence. The rapid development and broadening of the electronic and computer technologies application in shipboard systems predetermined the growth of the requirements to the level of the personnel qualification. The arrangement of the competent and qualitative operation and maintenance of the electronics and control systems, computer and info-communication systems as well as complex control systems requires a deep theoretical knowledge, developed cognitive skills, abstract thinking and the skills of analysis and prediction. Even today's electro-technical competencies on ships are often performed by university graduates.

On certain vessel types (special purpose vessels, vessels with powerful and complex electrical power plants) electro-technical competences are provided by electro-technical specialists' groups that might include a few electro-technical officers. A necessity of management level task realization appears in such situations. At the same time, approved 2010 Manila amendments do not require training for the tasks of management level for ETOs.

It is important to note that in some countries traditionally existing national regulations for certification of seafarers include a few ranks for electro-technical officers.

Taking into account all the above the authors propose to discuss a two-levels based approach for the development of the study programmes for ETOs in MET institutions. Such programmes should be leading to awarding two levels of qualifications (ranks) to the electro-technical officers.

The above mentioned two levels of ETOs qualification may be identified depending on the level of complexity and versatility of the professional tasks (competencies). According to that, the requirements to the study programmes leading to awarding the above qualifications may be defined. The framework requirements to such study programmes may be described by the expected learning outcomes which should be achieved by the candidates for the awarding of qualifications after successful completion of these programmes. The description of the competence systems and the associated learning outcomes giving the ground for defining the requirements to the study programmes for two levels of ETOs qualifications are given below.

The first level of ETOs qualification should correspond to the standards of competence for ETOs at the operational level that are established in the Sections A-III/6 and B-III/6 of the STCW Code. The system of competence and learning outcomes may be created on the basis of the requirements presented in the Table A-III/6 of the STCW Code. These standards include competencies at the operational level related to the functions:

- Electrical, electronic and control engineering;
- Maintenance and repair;
- Controlling the operation of the ship and care for persons on board.

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The competencies related to the function “Electrical, electronic and control engineering” at the operational level are: monitor the operation of electrical, electronic and control systems; monitor the operation of automatic control systems of propulsion and auxiliary machinery; operate generators and distribution systems; operate and maintain power systems in excess of 1,000 volts; operate computers and computer networks on ships; use English in written and oral form; use internal communication systems. The presented competence specification should have been widened by the competence “Monitor the operation of bridge navigation equipment and ship communication systems”, taking into account the duties of maintenance and repair established by the function ‘Maintenance and repair’.

Accordingly the above competences the study programme should provide the following learning outcomes:

- Comprehensive knowledge and understanding of electro-technology fundamentals, electrical machines theory, electronics and automation theory and ability to use their basic laws;
- Knowledge and understanding of operation principles of electrical motors and electrical drives, electrical propulsion; electro-hydraulic and electro-pneumatic control systems;
- Knowledge of electrical materials technology, high-voltage technology and basics of metrology;
- Knowledge and understanding of the basics of ship construction, mechanical engineering systems and heat-transmission;
- Knowledge of construction and understanding of operation principles of ships electrical power plants and electrical distribution systems, procedures for operating generators, and ability to make coupling, load sharing and changing over generators and operate distribution systems;
- Knowledge of the hazards of electricity, safety requirements and precautions procedures;
- Knowledge of construction computer systems and computer networks, control systems, internal and external communication systems, bridge navigation equipment, understanding main principles and features of data processing;
- Knowledge of instrumentation and construction alarm and monitoring systems;
- Ability to interpret sensors and instrument readings for appreciation of equipment condition;
- Knowledge of procedures and ability to prepare control systems, navigation equipment and communication systems for operation;
- Knowledge and ability to use English;

The competencies related to the function “Maintenance and repair” at the operational level are: Maintenance and repair of electrical and electronic equipment; Maintenance and repair of automation and control systems of main propulsion and auxiliary machinery; Maintenance and repair of bridge navigation equipment and ship communication systems; Maintenance and repair of electrical, electronic and control systems of deck machinery and cargo-handling equipment; Maintenance and repair of control and safety systems of hotel equipment.

The learning outcomes corresponding to the competences of the “Maintenance and repair” function may be defined as following:

- Ability to interpret electrical and electronic diagrams and use them for maintenance and repair;
- Knowledge of typical procedures for detection of electric malfunctions and location of faults;

- Knowledge of construction, operation principles and features of electrical testing and measuring equipment and instruments;
- Knowledge and ability to use ship's computer-based maintenance planning systems;
- Knowledge of the typical maintenance and repair procedures for electrical and electronic equipment, navigation equipment, communication systems, different kinds of control systems and appropriate practical experience;

The competencies related to the function "Controlling the operation of the ship and care for persons on board" at the operational level are: Ensure compliance with pollution prevention requirements; Prevent, control and fight fire on board; Operate life-saving appliances; Apply medical first aid on board ship; Application of leadership and team-working skills; Contribute to the safety of personnel and ship. The majority of these competences is traditional for the officers at operational levels and is not directly connected with electrical, electronic equipment and control systems.

Let us pay attention to the competence "Application of leadership and team-working skills" as it is related to the arrangement of operation, maintenance and repair of electrical and electronic equipment. Taking into account knowledge, understanding and proficiency necessary for the realization of this competence and given in table A-III/6 of the STCW Code, the expected programme learning outcomes may be represented as following:

- Ability to communicate effectively about professional activities, problems and solutions with ratings, officers and supervisors;
- Knowledge and ability to apply decision-making techniques;
- Ability to plan and structure work process and instruct others,
- Ability to manage resources and small groups of personnel;
- Ability to evaluate and improve performance of self and subordinated personnel.

The qualification and study programme learning outcomes described above do not include the ability to solve complicated and complex professional tasks and management tasks. At the same time as it was shown above, such tasks may arise on board in a number of cases. Solving such problems may become an item of the competence standard for an ETO with higher qualifications than that defined in Sections A-III/6 and B-III/6 of the STCW Code. Such qualifications should correspond to the qualifications of Senior ETOs.

The specifications of competences which, in the authors' opinion, meet such qualifications and expected learning outcomes which may define the contents of study programme for Senior ETO are given below. It is expected that the candidates studying this programme have formerly achieved the learning outcomes corresponding to the ETO qualification as established in the Sections A-III/6 and B-III/6 of the STCW Code.

Proposed below are competencies and learning outcomes grouped according to the three functions, as well as in the case of the standards regarding ETO as presented in the table A-III/6 of the STCW Code.

The specification of competencies for Senior ETO qualification should be as follows:

**Function "Electrical, electronic and control engineering"**

- Monitor and evaluate electrical power generation and consumption;
- Monitor and adjustment all electrical, electronic equipment and control systems, evaluate and predict their condition;
- Plan, schedule and manage complex activities for ensuring working condition of electrical and electronic equipment and control systems,
- Operate special purpose electrical equipment and integrated control systems;
- Operate safety power systems in excess of 1000 Volts;

- Operate all kinds of electrical and electronic equipment, electrical power plants in unpredictable and emergency situations.

**Function “Maintenance and repair”**

- Plan, schedule and manage maintenance and repair activities;
- Testing integrated control and monitoring systems
- Manage troubleshooting restoration of electrical and electronic equipment and control systems to operating condition;
- Detect and identify causes of malfunctions in electrical and electronic equipment;
- Organize recovery of electrical power plants and integrated control systems after accidents;
- Ensure safe working practices;

**Function “Controlling the operation of the ship and care for persons on board”**

- Manage and supervise complex activities of electro-technical personnel;
- Monitor and control compliance with legislative requirements and measures relating to electrical and electronic equipment and systems to ensure safety of life at sea and protection of the maritime environment.
- Manage development of professional knowledge and skills of electro-technical personnel;
- Organize training of shipboard personnel relating to operation of electrical and electronic equipment including emergency situations;
- Develop emergency and damage control plans and handle emergency situations relating to electrical equipment.

According to the description of qualification proposed above, the study programme for Senior ETO may be described by the following learning outcomes.

**Relating to the function “Electrical, electronic and control engineering”**

- Advanced knowledge of electro-technology, electronics and power electronics, electrical machines theory and automation theory, high-voltage technology;
- Knowledge of the forefront of metrology, computing and info-communication technology;
- Knowledge of design features and system configurations of integrated control systems;
- Knowledge of design features of power systems in excess of 1000 Volts;
- Knowledge of design features of electrical and electronic equipment, control and monitoring systems for special purpose ships;
- Knowledge of marine electrical engineering practice;
- Knowledge of the basics of the theory of reliability and ability to apply them for analysis and prediction of equipment and systems condition and provision of their reliable operation;
- Ability to gather and interpret relevant data for appreciation of equipment condition and operate it with incomplete or limited information;
- Ability to learn autonomously the operation principles of new and/or special-purpose electrical or electronic equipment and systems;

**Relating to the function “Maintenance and repair”**

- Knowledge of the classification societies’ requirements concerning ships electrical, electronic and control systems;
- Knowledge of safe working practices;
- Knowledge and ability to use software for testing control and monitoring systems;



- Knowledge and understanding of interrelations of malfunctions in electrical and electronic equipment and systems and regularities of malfunctions;
- Ability to troubleshooting of electrical and electronic equipment, control monitoring systems;
- Ability to plan maintenance and repairs procedures basing on the monitoring and prediction data including procedures with non-prescribed algorithms.

**Relating to the function “Controlling the operation of the ship and care for persons on board”**

- Knowledge and understanding of basic personnel management principles;
- Knowledge of shipboard resource management;
- Knowledge of international maritime conventions and recommendations and national legislative requirements relating to ensuring safety of life at sea and protection of the maritime environment;
- Ability to apply task and workload management;
- Ability to train shipboard personnel;
- Ability to communicate effectively information, problems, ideas and solutions on board and ashore;
- Knowledge and ability to apply decision-making techniques to solve complex and unpredictable problems relating to electrical and electronic equipment and systems;

Looking over competences and corresponding learning outcomes described above, the qualification of ETO at the operational level may be identified as the qualification requiring:

- Comprehensive, specialized theoretical and factual knowledge within specialized field of work and basic knowledge of the interfaced fields;
- Ability to solve typical problems within specialized field of work where there is unpredictable change.

At the same time, general requirements to the Senior ETO qualification may be described as follows:

- Advanced and forefront knowledge within their specialized field of work;
- Abilities to manage complex professional activities and to solve complex and unpredictable problems within specialized field of work.

The above descriptions of two proposed qualifications of ETOs allow us to compare them with other professional qualifications and qualifications established in different education systems.

In the authors’ view, qualification of ETOs at the operational level corresponds to the general qualification description of level 5 of the European Qualifications Framework (EQF) for lifelong learning. At the same time, this qualification may be partially associated with level 6 of the EQF. The qualification of such levels in the European education area is associated with study programmes of short cycle of higher education as minimum.

In its turn, the proposed Senior ETO qualification corresponds to the general qualification description of the level 6 of the EQF. Qualifications of this level are usually associated with study programmes of the first cycle of higher education and require a Bachelor degree as a minimum.

The authors are of the opinion that, despite of absence of standards regarding Senior ETO in the current edition of the STCW Convention and the STCW Code, MET institutions must take into account the possibility of the emergence of such standards in the imminent future and have to produce common approaches towards developing the appropriate study programmes now.

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