STCW and Beyond: Minimal Requirements and Additional Knowledge for Marine Engineers

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Abstract

MET has become an international enterprise. The across the borders mobility of maritime graduates has enhanced interest in assessing the quality of the educational programs and setting the minimal requirements. The international certification has been initiated by IMO based on the Convention on Standards of Training, Certification and Watchkeeping (STCW), which was adopted in 1978, and substantially revised and updated in 1995.

The principal objectives of this paper are the analyses of the STCW interpretation in marine engineering programs, and of specifics of undergraduate program development beyond the STCW requirements.

The STCW is introduced into legislations of all maritime countries and sets the minimum level of training of seafarers. Other guidance documents assessing the required training which are discussed in the paper are the IMO Module Course 7.04 and the American Code of Federal Regulations 46 CFR. The content of this paper is based on the results of a research project sponsored in 2005-06 by the IAMU. Bearing in mind the importance of their proper interpretation, another attempt to quantify the STCW requirements in terms of academic credit hours has been undertaken.

Aside from complying with the STCW requirements, marine engineering colleges enhance their programs in order to make them more attractive for the candidates, as well as for the employers. Both, compliance with the STCW requirements and the need to further enhance the programs, might require adding new courses and projects, repackaging existing courses, and dropping certain subjects and courses. Rapid development of continuing education as a part of MET makes it necessary to set admission requirements, especially where the special certification is resulted.

Keywords: STCW, marine engineering program, certification and accreditation, admission requirement, license and degree components of the curriculum

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1. Introduction

Marine Education and Training (MET) has become an international enterprise. For various reasons, economic, demographic, cultural, and many others, the primary sea powers are simply unable to fill the requirements in ship officers with the graduates of their own maritime schools. The across the borders mobility of maritime graduates has enhanced interest in assessing the quality of the educational programs and setting the minimal requirements. Marine engineering education, in particular, has been following the major internationalization trend in engineering practice over recent decades. The fact that marine engineering graduates might easily find jobs onboard ships, as well as ashore (in shipyards, ship service and design institutions) allows them to seek employment across national borders. This international mobility of marine engineering graduates has enhanced interest in the accreditation of the institutions and programs, which educate them. Employers, maritime schools, and licensing boards all have a keen interest in the quality of education received by marine engineering graduates who are looking for an employment in another country.

For years, the maritime industry has been developing a variety of methods and procedures for assessing the educational programs in terms of their uniformity and compliance with the national and international regulations. The component of the marine engineering program which contains the subject courses and other educational activities required for a mariner's license is a subject of a substantial scrutiny by national and international organizations. First of all, it has to comply with the regulations and requirements of the National Maritime Authority, like Ministry of Transport in some European countries, USCG and similar Government bodies in other countries. These authorities approve the programs (and individual courses, when required, mainly for the continuing education), initiate and conduct the license examinations, set the requirements for training institutions.

Very substantial part of the world commercial tonnage is sailing under the foreign Registry Flags. The Maritime Authorities of these countries like Panama, Liberia, Cyprus, Bahamas, and others are involved in certifying the maritime educational centers for compliance with their requirements. Such certification makes it easier for the graduates of the accredited schools to obtain employment with the companies whose ships are sailing under the jurisdiction of the Authorities.

Classification Societies have also offered their services in assessing MET. As active maritime international organizations, the Societies have been providing an alternative type of certification, which has appeared useful specifically for the companies whose ships are classed by those societies. Their offer is that maritime schools subject themselves to a thorough inspection in order to have the programs and the schools certified. A good example has been set by DNV that bases its certification effort on their own standard developed together with several engineering and consulting companies. Ac-

cording to DNV, the **standard ensures that all educational aspects are carried out under controlled conditions and in a consistent way**, and that the Maritime School or Academy is operated according to established practices and specific requirements.

Eventually, the comprehensive international certification of the maritime schools and of their graduates has been initiated by IMO. Almost thirty years ago the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) set qualification standards for personnel on seagoing merchant ships. It was adopted in 1978 and entered into force in 1984. Currently approximately 98 percent of the world's merchant vessel tonnage belongs to 133 countries who are the participants to the Convention.

2. Assessing and Standardizing Marine Engineering Curricula

The International Maritime Organization (IMO) as a specialized Agency of the United Nations prescribes the international standards concerning maritime and environmental safety. The IMO has developed a comprehensive series of conventions to establish a framework of international law covering the subject. Bearing in mind that the most important element in the safe operation of any ship is the competence and experience of its crew, a key component of this legal framework is the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), which lays down minimum standards of competence for all ranks of seafarers.

The STCW Convention prescribes minimum mandatory requirements for training, vocational qualifications, assessment and certification of seafarers. It sets the minimum levels of proficiency to be achieved by candidates, for the proper performance of functions onboard ship, in order to obtain certificates of competency. The international maritime training and certification requirements of the STCW Convention were introduced into legislations of all maritime countries, setting the minimum level of training of seafarers.

In order to have a marine engineering program accredited by either a national accreditation board, or by any International Institution, very substantial changes should be made. Compliance with all requirements might require adding new courses and projects, repackaging existing courses, and dropping certain subjects and courses. Realizing that the demand for competent seafarers will grow in the years to come, structured education and training are vital elements to meet this demand and expectations to the shipping industry. This has also been acknowledged in the revised STCW 95 Convention, which incorporates requirements to quality assurance principles in all mandatory maritime education and training and in the operation of related facilities. Among other new ideas, the revised Convention sets the STCW Code, or basic requirements which

are then enlarged upon and explained in the Code. The revised technical regulations specify minimum standards of competence for the range of certificates to be issued under STCW. The standards are presented in tables with four columns: a) 'competence' or ability to be established; b) area of 'knowledge, understanding and proficiency' within each competence; c) 'methods of demonstrating competence', and d) 'criteria for evaluating competence.'

While this paper has been prepared, an attempt has been made to quantify the specific requirements of STCW relative to the Marine Engineering program. The following three steps have been carried out. First of all, the appropriate courses and/or practical/laboratory exercises have been identified to match each competence in accordance with the required knowledge, understanding and proficiency. At the next step the approximate academic load (credit hours) for each course, laboratory session or sea project has been estimated. As a base for this exercise the proposed earlier by the author standard breakdown of a program has been used. This breakdown has been used as a skeleton of a standardized Marine Engineering program which had been developed in the research project sponsored by IAMU, and presented to AGA6 in Malmo [5]. The principal standard elements of a ME curriculum, which have been named Curriculum Components (CC) and Subject Groups (SG), are presented in Table 1. A code SG is assigned to each academic subject that allows to later summarizing the academic loads.

Table 1. *Building Blocks for License and Degree Oriented ME Program*

Program Building Blocks	
Curriculum Components (CC)	**Subject Groups (SG)**
I. Mathematics & Science	1. Mathematics
	2. Science
II. Engineering Science	1. Mechanics
	2. Materials
	3. Electrical
	4. Fluids
	5. Thermodynamics
	6. Theoretical Naval Arch.
	7. Computer Science
III. Marine Engineering	1. Drafting
	2. Propulsion Plant
	3. Machinery
	4. Practical NARC
	5. Electrical Engineering
	6. Electronics Engineering
	7. Engineering Design

IV. Operations	**1. Engineering Operations**
	2. Ship Operations
V. Safety & Medicine	
VI. Humanities & Social Sciences	**1. Social Sciences**
	2. Humanities
VII. Economics & Management	**Economics**
	Management
VIII. Physical Education	
IX. Sea Training & Internships	**1. Sea Training**
	2. Internships
X. Final Examinations	

The Table 2 lists all competences as per STCW (with our code numbers), their specific content (knowledge, understanding and proficiency) and the list of suggested academic subjects. The last two columns contain the approximate academic credit hours per each subject, and their allocation to the appropriate Subject Group (SG).

Table 2. *Estimate of STCW-Required Credit Load for Engineering License*

Comp. Code	Knowledge, understanding and proficiency	Suggested Courses and/or Practical/Lab Exercises	Credit hours	SG
Function1 - Marine engineering				
1.1	Materials for ships and equipment Processes for fabrication and repair System properties and parameters Safe working practices	Fundamentals of Materials Manufacturing Processes 1.Basic Marine Engineering 2. Machine Shop	2 2 2 1	II-2 IV-1 III-3 IV-1
1.2	Equipment design characteristics Machinery drawings and handbooks Equipment operational characteristics	Engineering Drawing	1	III-1
1.3	Electrical systems safety Design and operational characteristics of electrical systems and equipment Electrical test and measuring equipment	Basic Electrical Engineering Electrical Circuits Shipboard Electric Equipment Engineering Shop	2 1 2 1	II-3 III-5 III-5 IV-1
1.4	Maintaining an engineering watch	Basic Ship Eng. Operations ER Resource Management Engine Room Simulator	2 1 .5	IV-1 IV-1 III-2
1.5	Knowledge of English	Maritime English	3	VI-1
1.6	Main and auxiliary machinery operation	Marine Engineering (Steam) Steam Simulator	2 1	III-3 III-2
1.7	Pumping systems	Auxiliary Systems	2	III-3
Function 2: Electrical, electronic and control engineering				
2.1	Power generating plant Control systems	Electric Machines Control	2 3	III-5 III-6
Function 3: Controlling operation of ship and care for persons on board				
3.1	Ship stability Ship construction	Basic Naval Architecture Basic Ship Design	3 2	II-6 III-4

3.2	Fire prevention and fire-fighting appliances	Fire Fighting Basic Chemistry	.5 3	IV-2 I-2
Function 4: Maintenance and repair				
4.1	Marine systems Safety and emergency procedures Fundamentals of maintenance and repair	Basic Safety Basic Maintenance and Repair	1 1	 IV-1 IV-1
Function 5: Controlling operation of ship and care for persons on board				
5.1	Pollution prevention	Basic Pollution Prevention	.5	IV-2
5.2	Life-saving systems and appliances survival at sea techniques	SOLAS Personal Safety	1 1	IV-2 V-1
5.3	Medical aid	Ship Medicine	1	V-1
5.4	Safety regulations	Basic Ship Operations	1	IV-2
Total			**45.5**	

At the final step of quantifying the STCW requirements in terms of needed academic hours the data in Table 2 summarized by Subject Groups and the structure of the academic load is identified. The results are presented in Table 3. For comparison and further analysis, some additional information is also included here: a) academic structure and course load for Module Course 7.04 which has been developed for IMO by the Norwegian Maritime Directorate [6], b) sample Associate Engineer program and c) standard Bachelor in Marine Engineering Program developed by the author [5].

Table 3. *Comparison of STCW Credit Load with Marine Engineering Curricula*

Curriculum Components and Subject Groups		**STCW Approx. Credit Load**	**IMO model course**	**Associate Eng. Programw**	**BEng. Program, std**	**Add. Credits BSEng. vs. STCW**
I. Mathematics & Science		3	2	7	20	+17
1	Mathematics		0	14.0	14	
2	Science	3	2	6.0	6	
II. Engineering Science		7	21.6	22	30	+23
1	Mechanics		4.8	6.0	6	
2	Materials	2	2.9	5.0	5	
3	Electrical	2	5.8	5.0	5	
4	Fluids		1	2.0	2	
5	Thermodynamics		3.4	6.0	6	
6	Naval Architecture	3	3.7	2.0	2	
7	Computer Science		0	4.0	4	
III. Marine Engineering		18.5	19	38.5	44	+25.5
1	Drafting	1	0	4.5	4.5	
2	Propulsion Plant	1.5	3.1	9.0	9	

3	Machinery	6	1.8	12.0	12	
4	Practical Naval Architecture	2	4	4.5	4.5	
5	Electrical Engineering	5	6	5.0	5	
6	Electronics/Automation	3	4.1	6.0	6	
7	Engineering Design				3	
IV. Operations		12	8.3	5.5	12	0
1	Engineering Operations	9	6		6	
2	Ship Operations	3	2.3	6.0	6	
V. Personal Safety & Medicine		2	0	0	2	0
VI. Humanities & Social Sci.		3	0	8	18	+15
1	Social Sciences	3			6	
2	Humanities			6.0	12	
VII. Economics & Management		0	4.1	0	6	+6
1	Economics				3	
2	Management		4.1	3.0	3	
VIII. Physical Education		0	0	0	4	+4
Program Total		45.5	59	90.5	136	+90.5

Analysis of information in the above tables brings the following important points:

a) STCW-related subjects require one third of the total academic load in the BS in Marine Engineering program. Without a subject breakdown this share of STCW hours appears quite substantial, which suggests that there is still sufficient room for the degree-related knowledge items in the BS program.

b) Comparing the numbers with the IMO Model Course, one can conclude that while Marine Engineering subjects are equally presented, some additional subjects have been considered vital, such as 15 credit hours of engineering science and 4 hours of management. It might be argued that the knowledge, understanding and proficiency as per the STCW code deserve further evaluation towards increased requirements of science competences.

c) The license-leaning Associate degree program contains substantially more mathematics and science, which is appropriate when a college degree is granted, although an associate one. This program provides for much more Marine Engineering courses which is another ground for a discussion on sufficiency of that knowledge in the STCW requirements.

There is a wide variety of the STCW competency assessment methods and procedures in various maritime schools, and an appropriate quantification has not become an accepted practice yet. As an example, Table 4 contains the STCW courses and projects

used in USMMA for assessing the competences. This list is approved by the USCG, a licensing body in the U.S.

Table 4. *STCW Competency Courses for Class of 2007, Officer in Charge of Engineering Watch*

Courses and Projects	Credit Load		Number of Competences
	Total Credit Hours	Approximate Competence Related Hours	
ACADEMIC COURSES			
Maritime Professional Studies	2	2	1
Strength of Materials	2	1	1
Materials Engineering Lab	1	1	2
Internal Combustion Eng	3.5	2	1
Diesel Simulator	1	1	2
Intro to Marine Engineering	3.5	2	1
Naval Architecture	3	2	3
Engineering Shop	1	1	3
Marine Refrigeration	3.5	2	1
Intro to Electrical Engineering	2.5	2.5	6
Electric Machines	3.5	2.5	1
Sub-Total Academic Courses	*26.5*	*19*	*22*
SEA YEAR COURSES			
Marine Propulsion I (Diesel)	1	1	2
Marine Propulsion I (Steam)	1	1	2
Ship Systems I	2	1.5	9
Marine Propulsion II/III	2	1.5	3
Electrical Engineering	1	1	1
Ship Systems II	2	1.5	2
Maintenance Management	1	.5	1
Naval Architecture	2	1.5	1
Sub-Total Sea-Year Courses	*12*	*9.5*	*21*
Total per Program	***38.5***	***28.5***	***43***

Total number of 28.5 credit hours appears to be much less than the total academic load per STCW estimate. Apparently, additional analysis and evaluation might be required.

3. STCW and Admission Requirements

A very important subject, unfortunately almost forgotten, concerns the admission requirements into an STCW certified maritime program, and specifically, marine engineering program. Secondary school graduates enrolling in the Marine Engineering Program have very different level of readiness. If this subject is considered globally, the problem becomes even more drastic – secondary educations in different countries varies quite substantially, not only in duration, but also in content and in intensity.

In order for a student to obtain competence, for instance, in electrical equipment operations and safety, in auxiliary machinery and systems, etc., certain basic knowledge of physics is a must. However, many maritime schools are getting freshmen who had one-two quarters of physics, and even that was on a very low level. Another area where the school fundamentals are vitally needed is English. If the school programs have not provided sufficient language proficiency, the maritime school would not be able to assure that the graduate gets competence in English language. As a result, maritime school and colleges are forced to offer extensive language practicum far beyond the approved curriculum, and also various watered down mathematics and science courses. In many cases what is called a college mathematics or science course is in reality an advanced secondary school subject.

It appears necessary to set certain admission requirements in conjunction with each STCW competence, a kind of admission competences. Similar to the STCW format, for each of these admission competences the following information might be identified: a) knowledge, understanding and proficiency, b) methods for demonstrating competence, and c) criteria for evaluating competence, or rather methods and procedures of pre-admission testing. Some maritime schools are utilizing various types of screening candidates in order to find out what additional classes and tutoring should be provided. The way it is done now not directly aimed towards STCW competences

4. Assessing the Results of STCW Certification

Among the most important provisions of the STCW 95 is the introduction of quality standards systems (QSS), as an oversight of training, assessment, and certification to ensure that training, certification and other procedures are continuously monitored by means of a quality standards system. STCW, as amended, will require all training and assessment activities to be "continuously monitored through a quality standards system to ensure achievement of defined objectives, including those concerning the qualifications and experience of instructors and assessors." The 1995 amendments require those responsible for instruction and assessment of the competence of seafarers to be quali-

fied for the type and level of training or assessment involved. Persons performing these roles are expected to have received guidance in instructional techniques and assessment methods. The U.S. Coast Guard has drafted policy guidance for use in qualifying and managing training and assessment personnel.

However, another quite important component appears to be missing from the QSS – evaluation of the results of the competency assessment, or using the STCW terminology, "... to ensure achievement of defined objectives". The primary objective of MET is the level of competency of the graduates, and the assessment of this level is required. The engineering community has developed a comprehensive system of such assessment. The principal engineering accreditation institutions, the American Accreditation Board for Engineering and Technology (ABET) and the British Institute of Marine Engineering (IMarEST) base their accreditations on a program outcome assessment by a group of experts. The method is quite comprehensive, although very structured and formalized. The industry uses less formalized and structured approach, although also based on the expert evaluation. For instance, DNV has created a SEASKILL Committee of Experts made up of members from the Industry with in-depth knowledge and experience in the specific areas and in STCW standards. This Committee is involved in certification of the maritime educational programs "with an objective to ensure uniform quality of training in the maritime industry, regardless of location, operation and training methods".

It is a firm believe of this author, that a similar system might be created by the maritime educational institutions. In most of cases, it should be an appendix to the existing program assessment system. For example, all U.S. Maritime Institutions are periodically accredited by regional accreditation bodies which are assessing the schools of a certain area, on the outcome assessment basis.

To be accredited a substantial ground work has to be carried out. The programs must have defined Competence Educational Objectives developed with input from the key constituencies (typically current students, alumni, and employers); they must regularly evaluate their progress at achieving those objectives; and must continuously improve their educational program based on that evaluation. The core of the competency assessment process should be the evaluation of the outcomes, based on surveys of graduates, shipping companies, and also current students. Specific assessment tools should be created, and numerical goals established. The level of success of the school or academy is found by comparing those goals with the outcome assessment results.

The following are the suggested steps in setting the outcome assessment system:

a. First of all, a permanent Committee has to be established with a task to define the procedures and to set a system of continuous assessment of objectives and outcomes, and for applying the results for the program improvement,
b. The next step is to develop a set of the objectives. This task requires to clearly identify the constituency, to survey the constituency in order to find out what

the needs are, to create the Industry Advisory Board to steer the program in the direction of continuous assessment of the objectives and re-emphasizing the specific areas when the change is required

c. The longest and the most labor-consuming component is the actual development of the system, including the outcomes themselves and the tools for their assessment.

5. References and Bibliography

1. International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1995 Amendments, IMO, 1995
2. Guidance on STCW Quality Standards Systems (QSS) for Merchant Mariners courses or training programs, U.S. Coast Guard, 1997
3. Websites of Maritime Universities, Academies and Schools
4. Butman B., Harbach J., Study on Accreditation of Marine Engineering Programs, IAMU, AGA6, Malmo, 2005
5. Butman B., Study in Standardizing of Marine Engineering Curriculum, IAMU, AGA6, Malmo, 2005
6. Engineer Officer in Charge of a Watch, Module Course 7-04, IMO, 1999
7. ABET accreditation documentation and procedures, Accreditation Board for Engineering and Technology, Criteria 2000
8. DNV official Website
9. Satya, Rating of Rating of educational institutions in India by independent agencies - a working model to follow, March 2008 (website)
10. M. Pourzanjani, et. al., Maritime Education and Training (MET) in the European Union, JAMU Journal, Vol. 2, N. 2